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Function-Centered Rehabilitation Increases Work Days in Patients With Nonacute Nonspecific Low Back Pain: 1-Year Results From a Randomized Controlled Trial

Jan Kool, PhD, Stefan Bachmann, MD, Peter Oesch, MSc, Otto Knuesel, MD, Ton Ambergen, PhD, Rob de Bie, PhD, Piet van den Brandt, PhD


Objective: To compare the effect of function-centered treatment (FCT) and pain-centered treatment (PCT) on the number of work days, permanent disability, and the unemployment rate.

Design: Randomized controlled trial.

Setting: Inpatient rehabilitation center.

Participants: Patients (N=174; 79% male; mean age, 42y) with previous sick leave of 6 weeks or more.

Interventions: FCT (4h/d for 3wk) emphasized activity despite pain by using work simulation, strength, endurance, and cardiovascular training. PCT (2.5h/d for 3wk) emphasized pain reduction and included passive and active mobilization, stretching, strength training, and a 4-hour mini back school with education and exercise. Analysis was by intention to treat.

Main Outcome Measures: Work days, return to work, rate of patients receiving financial compensation for permanent disability, and unemployment rate. Effect sizes (Cohen d) were defined as small (0.2–0.5), moderate (0.5–0.8), and large (>0.8).

Results: After 1 year, the FCT group had significantly more work days (mean, 118; median, 39.5; interquartile range [IQR], 0–198) than the PCT group (mean, 74; median, 0; IQR, 0–160; Mann-Whitney U test, P=0.011). The odds ratio of returning to work in the FCT group relative to the PCT group was 2.1 (95% confidence interval, 1.1–3.9). The differences in unemployment rates and in the numbers of patients receiving compensation for permanent disability were not significant.

Conclusions: FCT is more effective than PCT for increasing work days.

Key Words: Exercise therapy; Low back pain; Occupational diseases; Outcome assessment (health care); Randomized controlled trial; Rehabilitation; Sick leave; Vocational rehabilitation.

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EXERCISE, MULTIDISCIPLINARY rehabilitation, and functional restoration reduce sick days in patients with subacute and chronic low back pain (LBP) if compared with usual care.1,2 Choosing the most appropriate type of exercise and rehabilitation program is difficult. The results of most pragmatic trials comparing different treatments and methods of exercises are inconclusive.1,2 Rehabilitation programs that focus on pain reduction and include exercise are still widely used. Exercise of moderate intensity is supported by passive pain-modulating treatments such as hot packs, electrotherapy, or massage. Activity and exercises that increase pain are avoided. In contrast, rehabilitation based on work hardening and graded activity programs encourages patients to continue their activities even if pain increases.2,3 It further remains unclear whether treatments shown to be effective in studies are also effective in populations with a different cultural background. In a meta-analysis4 evaluating the effect of exercise on sick leave in patients with nonacute LBP (duration >6wk), 8 of 14 studies excluded patients with insufficient knowledge of the national language. As a consequence, the validity of these results for populations with a different cultural background is limited.

The major costs of LBP are caused by work absenteeism and permanent disability. The total expenses of the Swiss Disability Insurance rose from SFr 4 billion in 1990 to SFr 11 billion in 2005.5 Compared with 10 other European countries, Switzerland showed the highest rate of increase.6 Patients with health problems who are unlikely to return to their previous work are referred to the Swiss Disability Insurance, usually by their physician. The Swiss Disability Insurance uses work adaptation and professional training to keep persons at work. The possibilities for work adaptation are restricted because many patients have low education levels and very limited knowledge of the national language. In the third place, incentives for employers to prevent LBP-related disability and keep persons at work are insufficient. Patients with permanent disability receive a 100% disability allowance from the Swiss Disability Insurance if their work-related disability exceeds 70%. In most cases, disability is less than 70%, leading to a 25%, 50%, or 75% disability allowance.

We conducted a pragmatic randomized controlled trial (RCT) in persons with nonacute nonspecific LBP.7 During a 3-week inpatient rehabilitation program, patients received either function-centered treatment (FCT) or pain-centered treatment (PCT). We analyzed work absenteeism, and the primary outcome was the number of work days in the follow-up year. The results after 3 months have been published previously.7 There was a significant benefit for the FCT group compared with the PCT group in the number of work days (25.9d vs 15.8d; effect size, 36; P=0.029). A follow-up duration of 3
months is too short for conclusions about the effectiveness of an intervention aiming at improving work-related outcome. Consequently, 1-year results are presented that analyze whether the 3 months of benefit of the FCT group, compared with that of the PCT group, was maintained 1 year after the treatment.

This publication presents the results of work days, unemployment, and permanent disability during the follow-up year in patients with nonacute nonspecific LBP who received 3 weeks of either FCT or PCT.

METHODS

Methods and results regarding compliance and satisfaction have been more extensively described in the publication about the results after 3 months.5

Design

We conducted an RCT. Between January 2000 and May 2003, we recruited and treated patients in the center for work-related rehabilitation in Valens, Switzerland. Randomization was concealed and assessment of the primary outcome, work days, was blinded. Independent teams of therapists treated patients 6 days a week during 3 weeks. Patients could not be blinded to treatment, but they received no detailed information about the difference between the 2 treatments. The study was approved by the ethical committee of Canton St Gallen, Switzerland.

Inclusion and Exclusion Criteria

Eligible patients between 20 and 55 years of age with a primary diagnosis of nonacute (duration, ≥6wk) nonspecific LBP and at least 6 weeks of sick leave in the previous 6 months were considered for participation in the study. Patients with a comorbidity interfering with treatment or working capacity were excluded. Patients with 2 or more positive predictive tests for non-return to work were excluded.7,8 We included patients with different nationalities to evaluate the relative effectiveness of the treatments in subgroups with different cultural and psychosocial backgrounds.

Treatment

Function-centered treatment. The multidisciplinary team providing FCT consisted of a rheumatologist, a physical and occupational therapist trained in ergonomics, a sports therapist, a social worker, and a nurse. FCT was based on work hardening and functional restoration programs for 4 hours a day. The primary goal was to increase work-related capacity while emphasizing improving self-efficacy. The rheumatologist informed patients about the benign character of nonspecific LBP. Treatment was based on the patient’s job demands; revealed in a work-related assessment; and consisted of work simulation, strength and endurance training through isokinetic exercise, cardiovascular training performed by walking and aqua aerobics, sports therapy, and self-exercise. Patients were encouraged to continue their activities even if their pain increased. The work certificate after rehabilitation was based on the patient’s work-related physical capacity and on medical findings.

Pain-centered treatment. The PCT team consisted of a rheumatologist, a physiotherapist, and a nurse, and the primary goal was pain reduction. The secondary goal was to decrease disability and improve return to work. The duration of treatment was 3 weeks and 2.5 hours a day. Physical therapy used individually selected mobilization, stretching, strength training, and a 4-hour mini back school with education and exercise.

Low-intensity movement therapy in the pool as well as progressive muscle relaxation using systematic contraction and relaxation of specific muscle groups further enhanced relaxation. Passive pain-modulating treatments such as hot packs, electrotherapy, or massage were used daily. In contrast to the FCT group, patients in the PCT group were told to stop activities when pain increased. After rehabilitation, the physician of the rehabilitation center determined the patients’ working capacity. His work certificate was based on his medical findings.

In both groups, a rheumatologist prescribed medications such as analgesics and nonsteroidal anti-inflammatory drugs and might also apply local infiltrations in the musculature and other soft tissue of the lumbar region with 5 to 10mL of 0.5% lidocaine and 40mg of triamcinolone. If required, a psychologist offered counseling. After rehabilitation, treatment and sickness certification were at the discretion of the patient’s primary physician.

Compliance and Satisfaction With Treatment

We reported the evaluation of compliance and satisfaction with treatment in more detail in the study concerning results after 3 months.7 We monitored patients’ compliance by recording attendance at scheduled appointments and length of stay. All patients expressed their satisfaction with treatment on a numeric rating scale from 0 (extremely dissatisfied) to 10 (perfectly satisfied). We also assessed the therapists’ and physicians’ compliance with FCT and PCT. A researcher audiotaped the verbal information the therapist or physician gave to patients on 25 consecutive occasions. Seven blinded experts independently rated the goals formulated, information about the treatment plan, explanation of the source of the complaints, and advice about coping with pain. Adequate adherence to the protocol was arbitrarily defined as an average overall score of more than 7.5 on a visual analog scale (VAS) from 0 (not at all according to the treatment protocol) to 10 (perfectly according to the treatment protocol).

Outcome Measurement

The primary outcome was the number of calendar work days in the follow-up year. Secondary outcomes were the rate of patients receiving unemployment benefits or permanent disability allowances. After 3 and 12 months, we sent questionnaires to the employer, known to be a valid source of information about sick leave.9 We also sent questionnaires to the patients’ primary physician who determines fitness for work to increase data completeness. We compared the information from the employer and the physician to increase accuracy. The questionnaires assessed work absenteeism and adaptation of working hours per day. We accounted for time-reduced work. For example, a work day with 30% time reduction was counted as 0.7 work day. Information about disability allowances was obtained from the Swiss Disability Insurance. Depending on the level of disability, patients may receive a disability allowance of 25%, 50%, 75%, or 100%. Partial disability allowances were analyzed in the same manner as time-reduced work. Primary physicians, employers, and the Disability Insurance were blinded to the patients’ group assignment because they were not informed in detail about the applied treatment during the 3-week rehabilitation.

Health Care Utilization

We assessed the use of health care with questionnaires sent to the health insurance companies of the patients.
FUNCTION-CENTERED TREATMENT AND WORK DAYS, Kool

Statistics

We performed a power calculation before the study started (power, .80; type I error, .05) indicating that 90 patients per group were needed to detect a difference of 40 workdays (standard deviation [SD], 95). We used SPSS and Stata for statistical analysis. Analysis was based on the intention-to-treat principle.

We compared the median number of work days during the follow-up year in the FCT and PCT groups with a Mann-Whitney U test. Dispersion was determined by means of the interquartile range (IQR) representing the 25th and 75th percentile values. We determined effect sizes (Cohen d) defined as small (0.2–0.5), moderate (0.5–0.8), and large (>0.8). We analyzed the influence of baseline differences and covariates on the number of work days in the 2 treatment groups. Covariates of interest were the duration of sick leave before treatment, age, cultural background, education, workload, and job qualification. Because a large proportion of patients in this study had zero work days during the follow-up year, we used negative-binomial logistic hurdle regression. This approach is particularly useful for the analysis of count data with an excess of zero counts. In a first step, logistic regression was used for analyzing the proportion of patients returning to work, defined as 1 or more days of work. Results are given as odds ratios (ORs) of returning to work in which the odds of returning to work for patients in the FCT group are compared with those of the PCT group.

In the second step of the analysis, the negative-binomial part of the model is used for analyzing the number of work days among those patients who have returned to work, defined as having worked during at least 1 day after treatment. The result parameter of the second step of the analysis is the incidence rate ratio (IRR). Here an incidence rate is proportional to the expected number of work days in a certain period conditional on having had at least 1 work day. The IRR is the quotient of 2 incidence rates. For example, the incidence rate for the FCT group is compared with the incidence rate for the PCT group.

We analyzed the effect of treatment and the influence of covariates on receiving a disability allowance with ordinal regression by using a proportional odds model with treatment as independent factor. We determined the ORs for unemployment after 1 year in the FCT compared with the PCT group. Logistic regression was used to evaluate the influence of treatment and covariates on the unemployment rate.

RESULTS

Participants

Figure 1 shows the participants of the study, and table 1 displays the baseline comparability of the 2 groups. Because recruitment rate was lower than expected, the duration of the study was prolonged for 4 months, and 174 instead of the initially planned 180 patients were included. There were no significant differences between the groups for most variables with the exception that more persons in the FCT group were referred for surgery. Both patients were included in the analysis. Patients’ satisfaction with treatment was the same in the FCT and PCT group, indicating that the effort to keep patients unaware of any expected treatment advantage was successful.

Outcome Measurements

Work days. We obtained completed questionnaires from 87% of the employers and 81% of the primary physicians. Differences in reporting between physicians and employers occurred in 12% of the cases. The research assistant contacted the involved persons and resolved these discrepancies. We retrieved the number of work days and the time restriction in the 1-year follow-up period for 82 of 87 (94%) and 84 of 87 (97%) of the patients in the FCT and PCT groups, respectively. The number of work days accounting for time-reduced work was significantly larger in the FCT group (mean ± SD, 118 ± 134; median, 39.5; IQR, 0–198) compared with the PCT group (mean, 74 ± 114; median, 0; IQR, 0–160; Mann-Whitney U test, P = .011). The effect size was .35, representing a small effect.

Negative-binomial logistic hurdle regression confirmed the effect of FCT compared with PCT. The first part of the analysis showed that the treatment effect was caused by a larger proportion of patients who returned to work in the FCT group (59.8%) than in the PCT group (41.4%). The OR of returning to work in the FCT group compared with the PCT group was 2.11 (95% confidence interval [CI], 1.150–3.853; P = .016). The second part of the negative-binomial logistic hurdle regression showed no difference in number of working days other patients were treated as intended. During rehabilitation, 1 patient was diagnosed with a necrosis of the femoral head and referred for surgery. Both patients were included in the analysis. Patients’ satisfaction with treatment was the same in the FCT and PCT group, indicating that the effort to keep patients unaware of any expected treatment advantage was successful.

Fig 1. Flowchart of subjects through each stage of the study from initial screening to 1-year follow-up assessment. Abbreviation: FU, follow-up.
including covariates into the model did not change the results. The logistic regression part of the model showed a significant positive effect of FCT compared with PCT. The OR of returning to work was 2.57 for patients in the FCT compared with the PCT group (P<.011) (table 3). There was a negative effect for litigation, longer sick leave before treatment, and southeast European cultural background in both groups. Education, workload, and job qualification were not associated with the number of working days. The negative-binomial regression part of the model showed that significantly

between both groups among those patients who had at least 1 working day; the IRR was not significant (IRR=1.10, 95% CI, 0.776–1.568; P=.566).

Because of baseline differences between the 2 treatment groups, litigation was entered into the model. In addition, we investigated the effect of the potential covariates sick leave before treatment, age, sex, education, job qualification, and cultural background. Including covariates into the model did

Table 1: Patient Characteristics Before Treatment

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>FCT (n=87)</th>
<th>PCT (n=87)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age ± SD (y)</td>
<td>41.6±8.4</td>
<td>42.5±8.4</td>
</tr>
<tr>
<td>Sex (men/women)</td>
<td>69/18</td>
<td>68/19</td>
</tr>
<tr>
<td>Diagnosis, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low back and leg pain (ICD-10 M 54.4)</td>
<td>73 (84)</td>
<td>71 (81)</td>
</tr>
<tr>
<td>Low back pain (ICD-10 M 54.5)</td>
<td>14 (16)</td>
<td>16 (19)</td>
</tr>
<tr>
<td>Pain medication, n (%)</td>
<td>67 (77)</td>
<td>62 (71)</td>
</tr>
<tr>
<td>Mean BMI ± SD</td>
<td>26.7±4.2</td>
<td>27.2±4.0</td>
</tr>
<tr>
<td>Marital status, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>63 (72)</td>
<td>67 (77)</td>
</tr>
<tr>
<td>Single</td>
<td>13 (15)</td>
<td>10 (11.5)</td>
</tr>
<tr>
<td>Divorced</td>
<td>11 (13)</td>
<td>10 (11.5)</td>
</tr>
<tr>
<td>Living arrangement, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alone</td>
<td>15 (17)</td>
<td>16 (18)</td>
</tr>
<tr>
<td>With partner or family</td>
<td>67 (77)</td>
<td>68 (78)</td>
</tr>
<tr>
<td>Living alone, family lives in original country</td>
<td>5 (6)</td>
<td>3 (3.5)</td>
</tr>
<tr>
<td>Mean children ± SD (n)</td>
<td>2.0±1.3</td>
<td>2.0±1.4</td>
</tr>
<tr>
<td>Citizenship status, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swiss citizen</td>
<td>38 (44)</td>
<td>35 (40)</td>
</tr>
<tr>
<td>Permanent immigrant citizen</td>
<td>40 (46)</td>
<td>42 (48)</td>
</tr>
<tr>
<td>Permit depending on employment</td>
<td>8 (9)</td>
<td>9 (10)</td>
</tr>
<tr>
<td>Limited permit (&lt;1y)</td>
<td>1 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Cultural background, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>38 (44)</td>
<td>35 (40)</td>
</tr>
<tr>
<td>Southeast Europe</td>
<td>31 (35)</td>
<td>39 (45)</td>
</tr>
<tr>
<td>Southwest Europe</td>
<td>18 (21)</td>
<td>13 (15)</td>
</tr>
<tr>
<td>Education, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 years (primary school)</td>
<td>11 (13)</td>
<td>14 (16)</td>
</tr>
<tr>
<td>7–9 years</td>
<td>66 (76)</td>
<td>66 (76)</td>
</tr>
<tr>
<td>&gt;9 years</td>
<td>10 (11)</td>
<td>7 (8)</td>
</tr>
<tr>
<td>No professional education</td>
<td>38 (44)</td>
<td>42 (48)</td>
</tr>
<tr>
<td>Unemployed, n (%)</td>
<td>18 (21)</td>
<td>20 (23)</td>
</tr>
<tr>
<td>Qualification at last job, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unskilled worker</td>
<td>38 (44)</td>
<td>42 (48)</td>
</tr>
<tr>
<td>Skilled worker</td>
<td>38 (44)</td>
<td>33 (38)</td>
</tr>
<tr>
<td>Foreman</td>
<td>8 (9)</td>
<td>8 (9)</td>
</tr>
<tr>
<td>Independent worker</td>
<td>3 (3)</td>
<td>4 (4)</td>
</tr>
<tr>
<td>Mean salary ± SD (SFr)</td>
<td>4501±1271</td>
<td>4522±1248</td>
</tr>
<tr>
<td>Heavy work: workload &gt;10kg, n (%)</td>
<td>68 (78)</td>
<td>68 (78)</td>
</tr>
<tr>
<td>Mean work satisfaction ± SD</td>
<td>1.8±2.1</td>
<td>2.4±2.9</td>
</tr>
<tr>
<td>Mean sick leave 2y before</td>
<td>184±156</td>
<td>199±135</td>
</tr>
<tr>
<td>treatment ± SD (calendar days)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work-related litigation,* n (%)</td>
<td>16 (18)</td>
<td>9 (10)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; ICD, International Classification of Diseases.
*Mann-Whitney U test, P=.039.

Table 2: Treatment Duration, Compliance, and Satisfaction (no significant differences)

<table>
<thead>
<tr>
<th>Variable</th>
<th>FCT</th>
<th>PCT</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean treatment duration ± SD (d)</td>
<td>22.2±3.7</td>
<td>22.3±3.8</td>
<td>.586</td>
</tr>
<tr>
<td>Protocol compliance therapists (range, 0–10), median (IQR)</td>
<td>8 (5–8)</td>
<td>7 (5–8)</td>
<td>.219</td>
</tr>
<tr>
<td>Treatment compliance patients (range, 0–8), median (IQR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient satisfaction (range, 1–7), median (IQR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>6 (4–7)</td>
<td>6 (4–7)</td>
<td>.421</td>
</tr>
<tr>
<td>Explanations about complaints</td>
<td>5 (3–7)</td>
<td>5 (3–6)</td>
<td>.421</td>
</tr>
<tr>
<td>Advice about coping with complaints</td>
<td>6 (4–7)</td>
<td>6 (5–7)</td>
<td>.574</td>
</tr>
<tr>
<td>Increased ability to control complaints</td>
<td>5 (3–7)</td>
<td>5 (3–7)</td>
<td>.421</td>
</tr>
</tbody>
</table>

Table 3: The Effect of FCT and Covariates on Work Days During the Follow-Up Year Proportion of Patients Returning to Work (logistic regression)

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment FCT vs PCT</td>
<td>2.566</td>
<td>(1.242–5.301)</td>
<td>.011</td>
</tr>
<tr>
<td>Litigation</td>
<td>0.224</td>
<td>(0.068–0.737)</td>
<td>.014</td>
</tr>
<tr>
<td>Previous sick leave (mo)</td>
<td>0.910</td>
<td>(0.841–0.986)</td>
<td>.021</td>
</tr>
<tr>
<td>Male</td>
<td>0.858</td>
<td>(0.312–2.359)</td>
<td>.767</td>
</tr>
<tr>
<td>Cultural background SE</td>
<td>0.303</td>
<td>(0.125–0.734)</td>
<td>.008</td>
</tr>
<tr>
<td>Europe/Switzerland</td>
<td>0.513</td>
<td>(0.178–1.485)</td>
<td>.219</td>
</tr>
<tr>
<td>Age (y)</td>
<td>0.993</td>
<td>(0.951–1.037)</td>
<td>.746</td>
</tr>
<tr>
<td>Education 6y/&gt;6y</td>
<td>0.308</td>
<td>(0.061–1.555)</td>
<td>.154</td>
</tr>
<tr>
<td>Job qualification unskilled/other</td>
<td>0.298</td>
<td>(0.080–1.110)</td>
<td>.071</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Work Days Among Those Patients Who Returned to Work (negative binomial regression)</th>
<th>Variable</th>
<th>IRR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment FCT vs PCT</td>
<td>1.165</td>
<td>(0.819–1.657)</td>
<td>.396</td>
<td></td>
</tr>
<tr>
<td>Litigation</td>
<td>0.707</td>
<td>(0.318–1.568)</td>
<td>.393</td>
<td></td>
</tr>
<tr>
<td>Previous sick leave (mo)</td>
<td>0.962</td>
<td>(0.918–1.009)</td>
<td>.111</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.361</td>
<td>(0.880–2.014)</td>
<td>.166</td>
<td></td>
</tr>
<tr>
<td>Cultural background SE Europe/Switzerland</td>
<td>0.668</td>
<td>(0.419–1.062)</td>
<td>.088</td>
<td></td>
</tr>
<tr>
<td>Cultural background SW Europe/Switzerland</td>
<td>0.909</td>
<td>(0.523–1.578)</td>
<td>.734</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>1.005</td>
<td>(0.984–1.027)</td>
<td>.654</td>
<td></td>
</tr>
<tr>
<td>Education 6y/&gt;6y</td>
<td>0.620</td>
<td>(0.268–1.433)</td>
<td>.263</td>
<td></td>
</tr>
<tr>
<td>Job qualification unskilled/other</td>
<td>1.168</td>
<td>(0.683–2.000)</td>
<td>.570</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: OR, odds ratio of returning to work; SE, southeast; SW, southwest.
more patients returned to work from the FCT group (59.8% in the FCT, 41.4% in the PCT group). Among those patients who returned to work for 1 or more days, neither treatment nor any of the evaluated covariates were significantly associated with the number of working days (see table 3).

Disability and Unemployment

After 1 year, 32 of 87 patients in the FCT group and 38 of 87 patients in the PCT group received a permanent disability allowance, either full (100%) or partial (25%–75%). Ordinal regression showed that receiving a higher disability allowance was independent of treatment (P = .199). Receiving a higher disability allowance was significantly associated with increasing age but not with litigation, sex, workload, education, job qualification, sick leave before treatment, and cultural background. Including these covariates did not change the results.

There was no difference in the unemployment rate after 1 year in the FCT and PCT group (FCT 37/87 [43%] vs PCT 45/87 [52%]; OR = .69, 95% CI, 0.38–1.26; P = .225). A higher unemployment rate was generally observed in patients who were older (P = .010), came from southeast Europe (P = .002), or had a lower education level (P = .026). Unemployment was independent of litigation, previous sick leave, sex, and job qualification. Logistic regression with unemployment as the dichotomous dependent variable, treatment as main effect, and correction for covariates did not change the results (P = .245).

Health Care Use in the Follow-Up Period

We assessed health care use in the follow-up period by means of a questionnaire sent to the health insurance provider. The return rate was 78%. Interventions after rehabilitation were comparable in the FCT and PCT group. Diagnostic procedures, mainly radiography, magnetic resonance imaging, and computed tomography, were used in 44% and 39% of the patients, respectively. Medications, mainly analgesics and antidepressants, were used by 90% and 94% of the patients. Physical and occupational therapy was prescribed to 83% and 78% of the patients.

DISCUSSION

This is the first study in Switzerland showing a significant increase in the mean number of work days during the follow-up year after FCT compared with PCT (118 vs 74d, effect size, .35).

The results show that the effect during the first 3 months was maintained until 1 year after treatment. Although the formal effect size statistic only indicates a small effect, gaining over 40 days of additional work can be considered a substantial improvement given the large cost per lost work day. Work days during the follow-up year in both treatment groups were negatively influenced by litigation, longer sick leave before treatment, and southeast European cultural background without an interaction with treatment. There was no significant effect of treatment on the unemployment rate or on the number of patients receiving a permanent disability allowance.

Strengths of this study were the relatively large number of patients, applicability of the treatment to patients with other cultural backgrounds, and limited knowledge of the Swiss national language. The population under study was representative for the population in Switzerland at risk to develop permanent LBP disability. The studied group was characterized by a long duration of LBP and sick leave and a large proportion of predominantly male workers with a low education level. We did not exclude patients with minimal knowledge of the German or Italian language. The results of this study are important because a recent meta-analysis concluded that it remained unclear whether exercise reduces work absenteeism.12 Compared with a study in Sweden by Lindström et al,3 our study included fewer patients with other nationalities (58% vs 75%). In our study, the off-work duration was longer and pain intensity was higher (5.6 points vs 3.3 points, on a 10-point scale). Our results are in accordance with other research indicating that exercise is safe and reduces disability.13

Study Limitations

Limitations of our study are that we did not use a workplace intervention, which might have improved the results. We did not assess psychologic comorbidity and several other factors that potentially influenced the outcome. Randomization as used in this study remains essential to generate comparable groups regarding known and unknown predictive factors. The rehabilitation team of the FCT group also included a social worker. Part of the difference in outcome could be caused by this factor. There was no difference between groups in the use of psychologic counseling. Less than 10% of the patients in both groups were referred and received on average two 30-minute sessions.

Blinding was not possible in patients and in the members of the multidisciplinary teams. The best available alternative was to keep patients unaware of the treatment of the other group and of any expected treatment advantage. The excellent treatment compliance in both groups and the comparable patient satisfaction indicate that this attempt was probably successful.

The effect of the FCT on the number of disability allowances and the unemployment rate after 1 year was not significant. This is in accordance with the 3 months of results and with the results of a previous meta-analysis.4 Insufficient power may be an important reason for the nonsignificant difference in the unemployment rate and in the number of patients receiving a disability allowance. The power of this study to detect a 20% reduction in disability allowances is only .19 corresponding with a type II error probability of 81%. Accounting for each day of work absence with $155 (U.S. $21314), the savings during the follow-up year are €6200 (U.S. $8520). The cost of rehabilitation paid by health insurance is $220 (U.S. $303) per day or €4900 (U.S. $6749) per patient in the FCT and PCT groups.

The unemployment rate after 1 year was high in both groups. The duration of unemployment benefits is limited to 2 years. After this period, patients may either receive a disability allowance or social benefits. The difference in the proportion of patients at work between groups was maintained until 1 year after treatment. Therefore, we plan a 3-year follow-up and cost-effectiveness analysis.

Further research is needed to identify the essential elements of treatment based on risk-factor assessment during the acute phase of LBP.15 Outpatient programs that may be more cost-effective must be developed. In view of the fact that the majority of patients in this study did not return to work, a further reduction of work-related disability is urgently needed. Improvements in outcome may be reached by earlier interventions and by combining rehabilitation and workplace interventions. In addition, politicians and insurance companies in Switzerland should establish legal and financial incentives for workers, employers, and involved insurances to reduce long-term work-related disability. These incentives are nearly nonexistent in Switzerland.
CONCLUSIONS

Compared with PCT, FCT significantly increased the average number of work days during the follow-up year. The benefit was 40 days, and the effect size was .35. In both treatment groups, work days were negatively influenced by litigation, longer sick leave before treatment, and southeast European cultural background. Treatment had no effect on the unemployment rate or the number of patients receiving a permanent disability allowance, but this result must be interpreted with caution because the study was underpowered for this outcome.

Acknowledgment: The study enrolled subjects before 2005 and hence was not registered in a trial registry.

References


Suppliers

a. Version 13; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.
b. Version 9; StataCorp, 4905 Lakeway Dr, College Station, TX 77845.
Effect of a Home Leisure Education Program After Stroke: A Randomized Controlled Trial

Johanne Desrosiers, PhD, Luc Noreau, PhD, Annie Rochette, PhD, Hélène Carboneau, MA, Lyne Fontaine, BA, Chantal Viscogliosi, MA, Gina Bravo, PhD


Objective: To evaluate the effect of a leisure education program on participation in and satisfaction with leisure activities (leisure-related outcomes), and well-being, depressive symptoms, and quality of life (primary outcomes) after stroke.

Design: Randomized controlled trial.

Setting: Home and community.

Participants: Sixty-two people with stroke.

Intervention: Experimental participants (n=33) received the leisure education program at home once a week for 8 to 12 weeks. Control participants (n=29) were visited at home at a similar frequency. Participants were evaluated before and after the program by a blinded assessor.

Main Outcome Measures: Change from preintervention to postintervention in: minutes of leisure activity per day, number of leisure activities, the Leisure Satisfaction Scale, the Individualized Leisure Profile, the General Well-Being Schedule (GWBS), the Center for Epidemiological Studies Depression Scale, and the Stroke-Adapted Sickness Impact Profile (SA-SIP30).

Results: There was a statistically significant difference in change scores between the groups for satisfaction with leisure with a mean difference of 11.9 points (95% confidence interval [CI], 4.2–19.5) and participation in active leisure with a mean difference of 14.0 minutes (95% CI, 3.2–24.9). There was also a statistically significant difference between groups for improvement in depressive symptoms with a mean difference of −7.2 (95% CI, −12.5 to −1.9). Differences between groups were not statistically significant on the SA-SIP30 (0.2, 95% CI, −1.3 to 1.8) and GWBS (2.2; 95% CI, −5.6 to 10.0).

Conclusions: The results indicate the effectiveness of the leisure education program for improving participation in leisure activities, improving satisfaction with leisure and reducing depression in people with stroke.

Key Words: Depressive symptoms; Leisure activities; Quality of life; Rehabilitation; Stroke.

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MANY PEOPLE WHO have had a stroke will have difficulty resuming their previous activities and roles and will be exposed to restrictions in participation in several life domains. A significant decline in leisure participation after stroke has been observed, especially in “active” leisure pursuits with a potential impact on quality of life (QOL).

Leisure refers to activities performed in a context of freedom and spontaneity. Although it may be enjoyed for its own sake, purely for pleasure and freedom, leisure can also have important health benefits. Participation in and satisfaction with leisure have been found to be indicators of QOL and well-being. Depressive symptoms that are frequently observed after stroke are associated with lower QOL and less variety in leisure activities.

To our knowledge, the literature reports only 5 randomized clinical studies designed to determine the effect of leisure rehabilitation for people with stroke. These studies had conflicting results regarding the effects of leisure therapy, some reporting improvement in mood, leisure participation, and satisfaction, whereas others did not find such outcomes.

In the study by Jongbloed and Morgan, the absence of change could be attributable to the control participants who also discussed the topic of leisure with the therapist, as well as to the limited intervention duration and frequency. However, the well-designed multicenter study carried out by Parker et al, based on the positive results of Drummond and Walker’s study, did not find better outcomes on a leisure questionnaire. Their program, like others, was mainly based on the practice of leisure activities. Except for a pilot study, the effect of a leisure education program, which goes beyond the practice of leisure activities and emphasizes empowerment, has not been previously studied.

The purpose of this study was to evaluate the effect of a home leisure education program with an emphasis on empowerment for people with stroke. The leisure-related outcomes were leisure participation and satisfaction related to this participation. The primary outcomes were general well-being, depressive symptoms, and health-related QOL (HRQOL).

METHODS

Design

This study was a randomized controlled trial with blinded assessment of outcomes. Experimental participants received the leisure education program at home. Control participants were visited at home for a similar number of visits.

Participants and Randomization

A total of 62 people entered the trial carried out in 2002 and 2003. We recruited them after a review of medical charts of...
people who were previously admitted with stroke to a rehabilitation or acute care facility up to 5 years before the study. They were randomized to 2 groups, with 33 in the experimental group and 29 in the control group. In addition to the clinical diagnosis of stroke, inclusion criteria were: (1) living in the community and (2) self-report of some problems with leisure participation or satisfaction. People were asked to talk about their leisure activities and had to identify a loss of satisfaction with or participation in leisure, when compared with the pre-stroke period. We excluded people with: (1) cognitive problems (score ≤5th percentile on the Modified Mini-Mental State [3MS] Examination, according to age and schooling), (2) language comprehension problems as judged by whether the person could participate in a simple conversation, and (3) severe comorbidities (lower-limb amputation; degenerative neurologic conditions such as Parkinson’s and multiple sclerosis; cancer; severe hearing or visual loss). This study was approved by the research ethics committee of the facility where they were recruited. All patients provided informed consent. A general evaluation of the eligibility criteria was made during a phone call, and visits to the participants’ own environments confirmed their eligibility.

We evaluated the participants prior to randomization (baseline [t1]) and after the end of the program (t2). An occupational therapist, not involved in the program and blinded to group assignment, was responsible for administering the outcome measures at t1 and t2.

After baseline assessment, we randomly assigned the participants to the control and experimental groups. The concealed allocation schedule was computer-generated with blocking and stratification based on functional independence (Système de mesure de l’autonomie fonctionnelle [SMAF], score, <15 or ≥15) and time since stroke (<1y or ≥1y).

### Study Procedures

The experimental intervention was provided by 2 study personnel: another occupational therapist and a recreational therapist. The recreational therapist was responsible for the intervention (see below) whereas the occupational therapist acted as a consultant, her role being to facilitate leisure participation, mainly by adapting the material or the environment. The control group participants were also visited by the recreational therapist but the topics discussed were unrelated to leisure (eg, family, cooking, politics, news, everyday life). The therapists met the participants once a week (8–12wk), theoretically for 60 minutes, but the duration for the experimental group was slightly longer because the leisure activities took place both at home and in the community, whereas the control intervention was carried out at home.

### Experimental Program: Leisure Education Program

The program objectives were to enhance the participants’ personal empowerment with a view to optimizing leisure experiences. The program was divided into 3 components. First, leisure awareness, which is defined as the perception and knowledge people have of their leisure activities and how important they consider them. Self-awareness relates to people’s perception of themselves, and their values, attitudes, and capacities in regard to leisure activities. Finally, competency development encompasses the perceived and real constraints identified by the person and knowledge of alternatives to achieve autonomy in leisure activities. The program is divided into 12 steps (fig 1). The maximum duration of the intervention for a participant usually does not exceed 12 sessions. The recreational therapist judged that a person had reached the end of the program when the following 2 conditions were present: (1) the participant had gone through all the steps in the program and (2) the person had integrated significant leisure activities in her/his life.

#### Baseline measures

We measured sociodemographic variables (table 1) at baseline. For stratification purposes, we used

### Table 1: Participants’ Characteristics by Group at Baseline (t1)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Experimental Group (n=29)</th>
<th>Control Group (n=27)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>70.0±10.2</td>
<td>70.0±12.0</td>
<td>.98</td>
</tr>
<tr>
<td>Mental functions (3MS; /100)</td>
<td>86.9±9.4</td>
<td>88.0±7.6</td>
<td>.65</td>
</tr>
<tr>
<td>Functional independence (SMAF; /87)</td>
<td>18.4±8.5</td>
<td>21.3±12.5</td>
<td>.32</td>
</tr>
<tr>
<td>Comorbidities</td>
<td>11.0±5.1</td>
<td>10.7±5.9</td>
<td>.86</td>
</tr>
<tr>
<td>Time since stroke (mo)</td>
<td>24.5±25.7</td>
<td>32.7±37.8</td>
<td>.39</td>
</tr>
<tr>
<td>Categorical variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex (men)</td>
<td>16 (57.1)</td>
<td>12 (42.9)</td>
<td>.42</td>
</tr>
<tr>
<td>Stroke side (left)</td>
<td>14 (48.3)</td>
<td>15 (51.7)</td>
<td>.57</td>
</tr>
<tr>
<td>Stroke type (ischemic)</td>
<td>26 (93.1)</td>
<td>23 (85.1)</td>
<td>.70</td>
</tr>
<tr>
<td>First stroke (yes)</td>
<td>18 (62.1)</td>
<td>20 (74.1)</td>
<td>.29</td>
</tr>
</tbody>
</table>

NOTE: Values are mean ± SD or frequency (%). *P value associated with t test for the continuous variables and chi-square test or Fisher exact test for the categorical variables
the SMAF to assess functional independence in 29 activities of daily living (ADLs), mobility, communication, mental functions, and domestic tasks.22 A higher score indicates more disability. The comorbidity index24 was also assessed. A higher score indicates more numerous or more severe comorbid conditions.

Leisure-related outcome measures. Participation in leisure was estimated in terms of duration (in minutes per day) for each leisure activity and recorded with the time budget technique,25 which determines the person’s daily leisure activities on a weekly basis (7 consecutive days) via a logbook. These activities were classified as passive and active leisure. The passive leisure score referred to the duration of activities that were done at home and required no active involvement (eg, listening to music, watching television, stroking one’s pet). The active leisure score included participation in social activities (eg, restaurant with friends, singing in a choir), entertainment and activities outside the home (eg, shopping for pleasure, car ride), physical activities (eg, bowling, taking a walk, exercising for pleasure), spirituality (eg, going to church, attending a conference), games, arts and crafts (eg, computer, playing cards, painting), and ADLs for pleasure (eg, small jobs inside and outside, looking after one’s bird). In addition, the number of different activities performed was calculated. The reliability of this method of measurement is not known.

Satisfaction with leisure was estimated with 2 questionnaires. The Leisure Satisfaction Scale26 measures the degree to which people’s personal needs are met through their leisure activities (24 items scored from 1 to 5; higher scores indicate greater satisfaction). Content validity was verified with 160 professionals working in the leisure field. The reliability study (internal consistency) showed a Cronbach α coefficient of .93, with a range of .85 to .92 for the subcategories. In addition, we used 2 sections of the Individualized Leisure Profile27,28 related to satisfaction with: (1) needs and expectations in regard to leisure (14 items; Cronbach α=.92), and (2) use of spare time (10 items; α=.90). Each item is scored on a scale from 0 to 3, a higher score indicating a higher level of satisfaction.

Primary outcome measures. We used the General Well-Being Schedule29 to evaluate perceived well-being and symptoms of distress. The 18 items of this questionnaire measure 6 dimensions: anxiety, depression, positive well-being, emotional control, vitality, and general health. A 6-level (0 to 5) ordinal scale that varies with each question is used to answer the first 14 items. For the last 4 items, a visual analog scale from 0 to 10 with opposite feelings at each end of the scale is used. A higher score (maximum, 110) indicates a higher level of well-being. Three categories of score have been defined: severe distress (0–60); moderate distress (61–72); and positive well-being (>72).30 This tool has good test-retest reliability (intraclass correlation coefficient, .82).31

Depressive symptoms were estimated with the Center for Epidemiological Studies Depression Scale (CES-D).32 This questionnaire comprises 20 items rated from 0 to 3, with a lower score suggesting a lower level of depressive symptoms. This tool has been found to be reliable (interrater: r=.96) and valid as a screening tool for assessing depression in people with stroke,33 as well as specific and sensitive.34,35

Finally, we used the Stroke-Adapted Sickness Impact Profile (SA-SIP30)36 to evaluate HRQOL. The SA-SIP30 comprises 30 items divided into psychosocial and physical components. One point is given when an item is checked. Higher scores indicate poorer health. The SA-SIP30 is reliable (internal consistency of the total score, .85)36 and responsive to change.37 Construct and convergent validity have been demonstrated by comparison with the original SIP developed by Bergner et al.38

Statistical Analyses and Sample Size
We determined the comparability of the groups at baseline using t tests for independent samples (continuous variables) or chi-square tests (categorical variables). Differences between pretest and post-test (intragroup) were compared using the paired t test. Between group differences were examined by calculating and comparing the mean change scores for each dependent variable. Statistical testing was done using an independent groups t test. The analyses were not carried out with the principle of intention to treat because the participants who dropped out were not available for re-evaluation.

We aimed at recruiting 26 participants per group to detect a moderate to large effect (.70) according to Cohen’s criteria with a statistical power of 80% and a 2-sided α error of 5%.39 The standardized difference (effect size, .70) was based on a preliminary study in which variability in participants’ QOL data had a standard deviation (SD) of 2.9 and a minimum clinically significant difference of approximately 2.19 We also used well-being data from a study carried out with persons with stroke who received day hospital services that showed an SD of 13 and minimal clinically significant difference of approximately 8.40

RESULTS
The flowchart of the participants is presented in figure 2. The 42 eligible people who refused to participate did not differ from those who agreed: age, 72.4±12.1 years versus 70.8±10.8 years (P=.48); and sex ratio of women to men of 20 to 22 versus 32 to 30 (P=.69).

Four participants dropped out, all from the experimental group, and 2 participants from the control group were not measured at t2 for technical reasons, leaving 29 and 27 participants respectively for the analyses. The reasons for dropping out were sickness (n=2) and refusal to continue after the first session (n=2). The dropouts had more functional disabilities
than those who participated, as estimated with the SMAF (36.5 ± 10.9 vs 19.8 ± 6.5; \(P = .008\)). The experimental and control groups were equivalent at baseline (see Table 1) with the exception of HRQOL, which was lower in the control group.

The experimental group received more sessions (range, 8–12; mean, 10.1 ± 1.2) than the control group (range, 8–11; mean, 9.5 ± 0.9) \( (P = .035)\) as well as a longer duration per session (mean, 76.9 min vs 65.8 min; \(P < .001\)).

### Leisure-Related Outcomes

Participation in and satisfaction with leisure are presented in Table 2. Daily duration of active and passive leisure activities was similar at t1. However, at t2, the experimental group had more active than passive leisure activities. The difference between groups was significant for the active leisure activity duration as well as for the number of activities, as indicated by the 95% confidence intervals (CIs). There was no difference between the groups in the duration of passive leisure activities. Satisfaction with leisure increased only in the experimental group and the differences between the groups were statistically significant, except for satisfaction with the use of spare time.

### Primary Outcomes

The well-being of the experimental group increased during the program but the differences between groups was not significant (see Table 2). Both groups statistically improved their HRQOL but no difference was found between them. However, only the experimental group significantly reduced their depressive symptoms after the program and statistical testing between groups was significant (95% CI, −12.5 to −1.9; \(P = .01\)).

### DISCUSSION

The purpose of this study was to evaluate the impact of a home leisure education program focusing on empowerment for people who had a stroke. Many clinical guidelines for stroke, such as that published by Duncan et al.\(^{41}\), recommend that people who had a stroke. Many clinical guidelines for stroke, home leisure education program focusing on empowerment for the program but the differences between groups was not significant, except for satisfaction with the use of spare time.

The main finding of the study was that some dimensions of leisure improved after the program, with a concurrent impact on depressive symptoms. After the leisure education program, persons in the experimental group increased their participation in active leisure activities and were more satisfied with their leisure activities. The significant increase in time involved in active leisure activities in the experimental group tends to support the view that the leisure program stimulated people to enhance their leisure participation. However, one can argue that the mean difference of 14 minutes a day found between the groups is modest and not clinically significant, particularly if we consider the lower 95% CI (3.2 min). The program did not focus directly on increasing the amount of leisure time but mainly targeted a form of personal empowerment of the participants by offering an education process that, one would hope, would lead to personal management of leisure participation. This kind of program was thus more likely to increase satisfaction, which is generally more important than the amount of leisure activities.\(^{42,43}\)

After the program, the experimental group presented fewer depressive symptoms than those who did not receive the program. The magnitude of the improvement in the experimental group is high and appears to be clinically important, although the lower 95% CI is only 2 points. Based on the threshold score of 16 for depression in the CES-D, both groups were considered depressed at t1 but not at t2, especially the experimental group, who considerably reduced (nearly 50%) their depressive symptoms.

#### Table 2: Comparison of Groups on the Leisure-Related and Primary Outcome Measures

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Total Mean Comparison</th>
<th>Mean Difference</th>
<th>Group Comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participation in leisure</td>
<td>36.6 ± 24.1</td>
<td>29.8 ± 18.6</td>
<td>6.8 (14.6 to 18.8)</td>
</tr>
<tr>
<td>Active activities (min)</td>
<td>41.7 ± 17.1</td>
<td>59.9 ± 20.4</td>
<td>18.2 (35.6 to 48.9)</td>
</tr>
<tr>
<td>Passive activities (min)</td>
<td>8.3 ± 2.9</td>
<td>10.6 ± 3.3</td>
<td>2.3 (3.7 to 4.8)</td>
</tr>
<tr>
<td>Active leisure activities</td>
<td>7.6 ± 14.9</td>
<td>78.5 ± 17.2</td>
<td>70.9 ± 17.7</td>
</tr>
<tr>
<td>Satisfaction with leisure needs</td>
<td>10.2 ± 6.2</td>
<td>19.6 ± 4.7</td>
<td>9.4 (16.5 to 22.4)</td>
</tr>
<tr>
<td>Individualized Leisure Profile</td>
<td>14.8 ± 6.4</td>
<td>26.8 ± 6.9</td>
<td>12.1 (20.6 to 33.6)</td>
</tr>
<tr>
<td>Satisfaction with leisure participation</td>
<td>7.6 ± 1.5</td>
<td>23.4 ± 16.7</td>
<td>15.8 ± 17.7</td>
</tr>
<tr>
<td>Satisfaction with use of spare time (110)</td>
<td>65.8 ± 18.2</td>
<td>72.4 ± 16.9</td>
<td>66.5 ± 18.2</td>
</tr>
<tr>
<td>Satisfaction with leisure use of time (130)</td>
<td>19.5 ± 12.1</td>
<td>9.6 ± 6.9</td>
<td>10.7 ± 12.1</td>
</tr>
<tr>
<td>General Well-Being Schedule (110)</td>
<td>8.1 ± 3.6</td>
<td>6.9 ± 3.4</td>
<td>1.2 (2.0 to 2.4)</td>
</tr>
<tr>
<td>CES-D (130)</td>
<td>9.2 ± 3.4</td>
<td>1.6 ± 2.4</td>
<td>7.6 (13.0 to 19.2)</td>
</tr>
<tr>
<td>HRQOL</td>
<td>116.6 ± 4.6</td>
<td>110.1 ± 3.9</td>
<td>6.5 (10.4 to 25.0)</td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>8.1 ± 3.6</td>
<td>6.9 ± 3.4</td>
<td>1.2 (2.0 to 2.4)</td>
</tr>
<tr>
<td>Abbreviation: CI, confidence interval.*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(P < .05\) associated with paired \(t\) test.
No statistically or clinically significant differences were found between the groups’ well-being (2 points on a scale of 110) or HRQOL (0.2 points on a scale of 30). The concept of well-being is, to some extent, related to depression, but well-being is also associated with other components such as vitality and general health, which could have remained relatively stable over time. This is consistent with the HRQOL scores, which were rather stable (small differences, even though statistically significant) over time for both groups. Also, even though no significant difference between the groups was found in regard to well-being, at pretest both groups were classified in the moderate distress category, whereas at post-test they had moved into the positive well-being category (>72). These results can also be discussed in relation to previous randomized studies. In the study by Jongbloed and Morgan, carried out with 40 people who had had a stroke in the previous 15 months, participants in the experimental and control groups were visited 5 times by an occupational therapist for 60 minutes. No difference was found between the 2 groups in regard to leisure participation and satisfaction as well as depressive symptoms. These nonsignificant results might be attributable to an unexpected positive impact on the control group participants, who also had discussions with the therapist about leisure or, conversely, to the limited duration and frequency of the intervention, which was not sufficient to modify leisure patterns.

Drummond and Walker’s clinical trial that randomly assigned 60 participants to 3 groups—(1) leisure rehabilitation program at home (experimental group), (2) occupational therapy at home, and (3) no visits—reported a significantly higher participation rate in social and leisure activities in the experimental group than in the others (P = .001) and the difference remained significant 6 months poststroke (P = .01). The leisure rehabilitation program also had a positive effect on the participants’ psychologic well-being 3 months after discharge from hospital.

After such promising results, Parker et al studied the effects of a leisure-based occupational therapy intervention on mood, leisure participation, and independence in ADLs in people who had had a stroke. In this multicenter study, 466 people were divided into 3 groups: (1) leisure, (2) ADLs, and (3) control. Contrary to the previous study, none of the outcomes that were measured at 6 and 12 months after discharge from hospital improved or differed between the groups. The diversity in the content of the programs that were investigated might explain the differences in the results of these studies. Although different, all these programs were based on the practice of leisure activities, which was not the case in our educational program. Indeed, in the leisure education program, only a part is devoted to some leisure practice. The program is mainly based on an educational process that aims to enhance the empowerment of participants in optimizing their leisure. By recognizing the importance of leisure in their lives, by having a better perception of their value and residual abilities, and by developing competency in using and integrating resources related to leisure, participants might achieve a higher level of engagement in leisure.

**Study Strengths**

This study has some important strengths that support its findings. The experimental design, blinded assessments, and the use of valid and reliable primary measures minimized potential biases. The placebo intervention ensured that all participants received a similar degree of attention over the course of the study and thus the increased benefits of the experimental group can be more reasonably attributed to the leisure education program.

**Study Limitations**

Some study limitations must also be considered. The reliability of the method of measurement of leisure duration and number of activities is not known; hence, random error may have reduced the responsiveness of this measure. There was a slight difference in duration and frequency of the interventions between the groups because parts of the experimental program were carried out in the community. A dropout bias is also possible because those who stopped participating in the experimental group had lower functional independence than those who did not. The lack of a follow-up at 6 months and 1 year should also be considered a limitation.

**CONCLUSIONS**

The ultimate purpose of the stroke rehabilitation process is to help people optimize resumption of premorbid activities. We found that an empowerment-focused home leisure education program had a positive effect on leisure satisfaction and participation, with benefits for mood in community-dwelling persons with stroke. Further research is needed to replicate our findings and longer term follow-up assessments are needed to evaluate the durability of the effects.

**Acknowledgment:** We thank Lise Trottier, MSc, for her help with the statistical analyses.

**References**

Sensory Retraining of the Lower Limb After Acute Stroke: A Randomized Controlled Pilot Trial

Elizabeth A. Lynch, BAppSc, Susan L. Hillier, PhD, Kathy Stiller, PhD, Rachel R. Campanella, BAppSc, Penny H. Fisher, BPhysio


Objective: To determine the effects of a sensory retraining protocol on sensation, postural control, and gait in acute stroke subjects.

Design: Randomized controlled pilot trial.

Setting: Inpatient rehabilitation hospital.

Participants: Twenty-one subjects with sensory deficits in the feet, undergoing rehabilitation for stroke.

Intervention: Sensory retraining of the more affected lower limb versus relaxation (sham intervention).

Main Outcome Measures: Light touch at the sole of the foot (Semmes-Weinstein monofilaments), proprioception (Distal Proprioception Test), postural control (Berg Balance Scale), and gait (timed, Iowa Level of Assistance Scale).

Results: Significant improvements (P<.05) over time were found in light touch at 3 points of the feet and in postural control, timed gait, and walking aid. No significant time effects were observed in proprioception or amount of assistance required to walk. No significant differences were detected between groups in any of the outcome variables, apart from light touch at the first metatarsal. The study had poor power (13%) to detect group effects due to the small sample size.

Conclusions: Results of this pilot study are unable to support or refute the routine use of sensory retraining of the lower limb for people during inpatient rehabilitation after stroke. Further research with a larger sample size is required.

Key Words: Cerebrovascular accident; Foot; Hemiplegia; Rehabilitation; Sensation disorders.

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Sensory impairments are common after stroke, occurring in approximately 60% of stroke patients. Sensory dysfunction in the lower limb after stroke has been related to reductions in standing balance, gait speed, balance during ambulation, and gait symmetry. When left untreated, sensation tends to improve in the first 3 months following stroke, but stroke survivors are frequently left with a degree of sensory impairment affecting a range of sensory modalities.

Several studies have shown promising results in the treatment of upper-limb sensation after stroke using sensory retraining with significant improvements in sensation reported in all the trials. Three of the 4 studies were conducted on subjects with chronic stroke, whereas only one was conducted during the initial rehabilitation period. Sensory retraining uses concentration and exposure to different sensory inputs to enhance sensory awareness. Examples of sensory retraining techniques are discrimination of texture, shape, or weight, training joint position sense, object recognition activities, detection of touch, and education about the sensory loss.

Two studies were identified that evaluated sensory retraining in the lower limb after stroke. Morioka and Yagi trained hardness discrimination in stroke subjects in rehabilitation and reported significant improvements in postural control, but sensation in the form of 2 point discrimination, did not change significantly over the assessment period. The hardness discrimination training was conducted in standing, which could have confounded the results because simply spending time in standing has been shown to significantly improve postural control in stroke patients. Hillier and Dunsford used 3 multiple baseline experiments to investigate a 2-week program of sensory retraining of the feet in chronic stroke patients (>2y post-stroke). These authors found that light touch sensation significantly improved in the feet of 2 of the 3 subjects over the study period, but proprioception did not change significantly. Measures of postural control were not significantly affected in the 3 subjects, but the remaining subject showed a significant improvement in single-limb stance.

Thus, although there is some evidence that sensory retraining for stroke patients with sensory dysfunction of the feet is effective, more research is required, particularly in the acute period after stroke, to measure its effectiveness. Consequently, the aim of the present study was to investigate the effect of sensory retraining of the lower limb of acute stroke patients involved in rehabilitation using measures of sensation, standing balance, and gait. Subjects during the acute phase after stroke were specifically selected because the intention of the study was to investigate the theory that “earlier is better” with regard to sensory retraining.

METHODS

Ethics approval was obtained from the Royal Adelaide Hospital and the University of South Australia.

Participants

We recruited participants from 2 wards at Hampstead Rehabilitation Centre, a public inpatient rehabilitation center. To be included, patients met the following criteria: (1) receiving inpatient rehabilitation following a first ever stroke; (2) sensory dysfunction of the lower limb evident on physiotherapy (PT) assessment and by subjective report; (3) medically stable; (4) able to stand and walk 10m with no more than 1 person assisting; (5) gave informed consent. Patients were excluded if
they showed any of the following: (1) unwillingness to partic-
ipate in the study; (2) inability to understand or respond to
questions or instructions in English; (3) pre-existing sensory
deficits from previous strokes or peripheral neuropathies; and
(4) used a walking aid other than a single-point stick prior to
the stroke. Any participant who developed a medical or other
complication which prevented more than 3 PT treatments dur-
ing the experimental phase was withdrawn from the trial.

Sample Size

We chose an anticipated sample size of 32 based on research
using the Berg Balance Scale (BBS) in acute stroke subjects,13
which indicated that for an effect size of 6 points, 16 patients
per group were required to show a significance level of 0.5 (ie,
α=.05) and statistical power of .80 (ie, β=.20). However, after
21 subjects had been recruited to the current trial, the circum-
stances of service delivery changed on the unit, so further
recruitment was not possible.

Research Design

A randomized controlled design was applied. After screen-
ning and signing consent forms, participants were randomly
allocated to either the sensory retraining group or the relaxation
(control) group by means of a random numbers table. Parici-
pants completed 10 sensory retraining or relaxation sessions in
addition to standard care over a 2-week period. Subjects were
blinded to the intervention of interest, the therapist providing
the sensory retraining and relaxation treatments was blinded to
the assessment results, and the assessors were blinded to sub-
jects’ group allocations.

All participants received the same standard PT care, which
consisted of 1 hour a day in a group session, working on
lower-limb strength, balance and cardiovascular fitness, with a
further 30 to 60 minutes a day in an individual session depend-
ing on patient need. Standard therapy sessions were based on
the Motor Relearning Program.14

Sensory Retraining Intervention

Ten 30-minute sensory retraining sessions were provided by
the primary investigator over a 2-week period. The total treat-
ment time was divided evenly between: education regarding
sensation and sensory retraining; practice in detection and
localization of touch at 7 points on the soles of the feet;
hardness, texture and temperature discrimination by placing the
feet on a variety of floor surfaces while sitting and standing
with vision obscured; and proprioception training of the big toe
and/or ankle (analogous to proprioceptive training at the wrist
used in upper-limb sensory retraining9).

The principles of sensory retraining were similar to those
used in previous research9,10,12 and included education regard-
ing the nature and extent of sensory loss; specific, graded
stimulation tasks with an emphasis on tasks the subject was
able to do (in this case, light touch detection and localization
training was tailored for the individual to focus on areas of
sensory deficit); attentive exploration of the stimuli by the
subject; prevention of visual dominance; comparison with the
nonaffected side; quantitative feedback on outcome and per-
formance and summary feedback.

Control Group: Relaxation Techniques

Subjects in the control group were asked to close their eyes
and were assisted to stand for the same periods of time as the
treatment group spent doing the floor-surface discrimination
intervention. The rest of the 30-minute session was spent with
eyes closed in supine, performing guided relaxation techniques.

Assessment Procedure

Assessments were conducted by 1 of 2 physiotherapists who
were blinded to participants’ group allocation. Assessments
were conducted prior to treatment, on completion of treatment,
and then at a 2-week follow-up. Because this was an explor-
atory pilot trial, multiple outcomes were assessed to confirm
likely areas of change.

Assessment of light touch and proprioception was problem-
atic, because we could identify no clinically applicable out-
come tools that had been examined for reliability, sensitivity,
or validity in the assessment of sensation in stroke survivors.
Light touch at 7 points on the soles of the feet (big toe, little
toe, first metatarsal, fifth metatarsal, lateral border of the foot,
medial border of the foot and heel) was assessed using
Semmes-Weinstein monofilaments.15 This involved applica-
tion of calibrated monofilaments to the soles of the feet; sub-
jects were asked to report when they detected a stimulus, and
the smallest monofilament detected by the subject was re-
corded. This method of sensory assessment has been found to
be reliable in the assessment of diabetic subjects16,17 but has
not been studied specifically in the stroke population. Propri-
opception of the big toe was assessed using the Distal Proprio-
ception Test (DPT)6,18 and given a score out of 10. This
involved the assessor passively moving subjects’ big toes to a
position up or down and each subject was asked to identify
the position and the number of correct responses was re-
corded. Although the DPT is widely used in the clinical
setting, no research investigating its reliability or sensitivity
was identified.

We measured postural control using the BBS,19 a series of
14 static and dynamic balance tasks which has shown good
reliability20 and sensitivity13,21,22 in the acute stroke population
during rehabilitation, and correlates significantly with labora-
tory-based postural control assessments of stroke subjects.23,24

Gait assessment consisted of measuring the time taken to
walk the middle 10m of a 14-m walking track,25 and the
amount of therapist assistance and mobility aid required to
walk was measured by the Iowa Level of Assistance Scale
(ILAS).26 The assessment of gait speed in stroke subjects in
rehabilitation is reliable,25 sensitive to change,27-31 and corre-
lated significantly to community ambulation27 as well as other
postural control outcome measures.33,34 The ILAS grades the
amount of therapist assistance according to the number of
points of contact required from the therapist to complete the
task safely, and records the walking aid used. It is a valid and
reliable tool for use in orthopedic patients,26 but we have not
found its reliability and sensitivity to change in the stroke
population to be reported in the literature to date.

Reliability of assessments. Inter- and intrarater reliability
were assessed for all the outcome variables by video-recording
3 randomly selected assessments. The 2 assessing physiother-
apists independently scored the 3 performances. The video-
recorded assessments were then presented in a randomized
order and rescoring by both assessors 2 weeks later.

Statistical Analysis

We performed the analyses using the SPSS statistical soft-
ware.8 Data were collected following the principles of intention
to treat (ITT) and were plotted in histograms and analyzed for
normality. In a number of cases (ie, proprioception, BBS, timed
gait), data were not distributed normally and were adjusted
using Johnson transformations.35 The transformed data were
analyzed to determine whether the assumption of normality
could be rejected, and if not (ie, if data were distributed
normally), mixed-model analyses were conducted to determine

RESULTS

Twenty-one subjects were recruited over a 9-month period, with 10 in the sensory retraining group, and 11 in the control treatment group (fig 1). One subject in the sensory retraining group was withdrawn because he developed an acute illness requiring readmission to the acute hospital. His data were collected at follow-up and included in the analysis following the ITT principle.

Results from a retrospective power calculation showed that the current study was strongly (99.7%) powered to detect changes in the chosen outcome variables over time. However, the study was poorly powered to detect changes between groups, with only a 13% chance of detecting a group effect. Therefore, the results from the current study must be viewed with caution; in the cases where no group effects were detected, it is possible that such an effect existed but was not detected due to insufficient subject numbers.

The demographic characteristics and time spent in PT of the 21 subjects are shown in table 1. Most subjects were men (n = 16 [76.2%]), and the majority (n = 18 [85.7%]) had cerebral infarcts. All subjects (N = 21 [100%]) reported that they were independently mobile in the community prior to their stroke.

Statistical analysis indicated that there were no significant differences between groups with regard to any of the demographic variables or the baseline outcome measures, indicating that the 2 groups were comparable preintervention. Time spent in PT did not differ significantly between the 2 groups.

The Cohen κ was performed to determine intrarater reliability over all the categories measured by the 2 assessors. Both the weighted and unweighted statistics were very high (κ = .968, .985, respectively; P < .001), indicating almost perfect agreement between the 2 assessors. The analysis of intrarater reliability using the Wilcoxon signed-rank test showed excellent intrarater reliability for both assessors with each assessor having a P value of greater than .999.

Light Touch Sensation

All 7 points of the foot showed significant differences in light touch thresholds between the 2 feet (P range, .000–.029), with the affected foot significantly more impaired than the less affected foot (Mann-Whitney U tests).

Ordinal regression analyses indicated that light touch improved significantly over time at 3 points of the affected foot: the heel (P = .026), the lateral border of the foot (P = .024), and

Table 1: Demographic Characteristics of Subjects

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Sensory Retraining (n=10)</th>
<th>Relaxation (n=11)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age ± SD (range), y</td>
<td>61.0±15.8 (21–77)</td>
<td>62.0±12.3 (38–82)</td>
<td>.944*</td>
</tr>
<tr>
<td>Mean duration of stroke when recruited to study (range), d</td>
<td>48.7±31.1 (19–122)</td>
<td>47.8±27.7 (13–112)</td>
<td>.751*</td>
</tr>
<tr>
<td>Mean MMSE score age ± SD (range)</td>
<td>28.5±1.0 (27–30)</td>
<td>28±1.7 (24–30)</td>
<td>.880*</td>
</tr>
<tr>
<td>Sex (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men (n)</td>
<td>7</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Women (n)</td>
<td>3</td>
<td>2</td>
<td>.387*</td>
</tr>
<tr>
<td>Side of CVA (n)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of CVA (n)</td>
<td></td>
<td></td>
<td>1.000*</td>
</tr>
<tr>
<td>Infarction</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Treatment details</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean total time in group PT ± SD (range), min</td>
<td>843.5±247.4 (375.0–1110.0)</td>
<td>943.2±244.3 (540.0–1320.0)</td>
<td>.459*</td>
</tr>
<tr>
<td>Mean total time in individual PT ± SD (range), min</td>
<td>571±176 (290–930)</td>
<td>524±192 (160–960)</td>
<td>.622*</td>
</tr>
<tr>
<td>Mean daily time in group PT ± SD (range), min</td>
<td>42.0±10.9 (15.6–51.4)</td>
<td>47.4±8.0 (27.0–60.0)</td>
<td>.245*</td>
</tr>
<tr>
<td>Mean daily time in individual PT ± SD (range), min</td>
<td>28.7±8.5 (19.3–44.2)</td>
<td>26.8±8.2 (11.0–45.7)</td>
<td>.778*</td>
</tr>
</tbody>
</table>

Abbreviations: CVA, cerebrovascular accident; MMSE, Mini-Mental State Examination; SD, standard deviation.

*Analysis conducted using the Fisher exact test.
†Analysis conducted using the Mann-Whitney U test.

the big toe ($P = .011$). Sensation did not differ significantly between groups at these 3 points of the feet at any of the measured time points. Time had no significant effect on sensation at the remaining 4 points of the feet (ie, the little toe, medial border of the foot, first and fifth metatarsals). A significant difference in light touch sensation at the first metatarsal was detected between the 2 groups at follow-up (groups were comparable at baseline), with the sensory retraining group showing significantly improved detection of light touch than the relaxation group ($P = .011$). This between-group difference was not observed at any other point of the foot.

Significant differences remained between the affected and less-affected foot after the 4-week period, even in the 3 points of the feet that had shown significant improvements in sensation over time (Mann-Whitney $U$ tests: big toe, $P = .001$, lateral border of the foot, $P = .005$; heel, $P = .045$).

**Proprioception**

There was no significant difference over time in scores on the DPT at the big toe ($P = .55$), and no significant difference was detected between groups ($P = .057$) (ordinal regression analysis).

**Balance**

Figure 2 shows the mean BBS scores (out of 56) of groups over time, where assessment 1 was conducted prior to the intervention, assessment 2 on completion of the sensory retraining and relaxation program, and assessment 3 at follow-up. Scores improved significantly from baseline to the end of treatment in both groups ($P < .005$), but there was no significant difference in scores between groups at the end of treatment and follow-up (mixed-model analysis). No significant difference was found between groups at any time period.

**Timed Gait**

The time and group comparisons of the mean 10-m timed gait data are shown in figure 3. Time had a significant effect on timed gait scores ($P = .012$), whereas group allocation ($P = .337$) did not have a significant effect (mixed-model analysis).

**Use of Walking Aid**

Ordinal regression analyses were conducted on the walking aid data and showed that time significantly affected the walking aid used over the 10-m walk ($P = .023$), whereas group allocation did not ($P = .475$). The coefficient of time was negative ($-.045$), indicating that the scores decreased over time, that is, the walking aids required became progressively less supportive over time.

**Level of Assistance**

The data regarding the “points of contact” subscale on the ILAS were highly skewed, so they were analyzed using ordinal regression. Neither time ($P = .376$) nor group allocation ($P = .114$) significantly affected the scores, that is, no significant change was observed over time or between groups in the amount of assistance subjects required from the therapist to walk 10m.

**DISCUSSION**

This pilot study found that a standardized protocol of sensory retraining of the feet was not significantly more effective than relaxation in improving sensation, balance, or walking ability in a sample of acute stroke subjects.

In previous studies investigating the effectiveness of sensory retraining, repeated-measure (single-case study) designs have been used more often than experimental designs with control groups, because stroke subjects are a highly heterogeneous subject group and therefore difficult to compare with one another as is required in an experimental design. However, a repeated measures design was considered problematic for this study, because some subjects require numerous (>10) baseline assessments to reach baseline stability. Indeed, in 1 study, baseline stability was never achieved, which then compromised the validity of the results. In addition, it was considered that a design using a sham treatment group would control for the confounding variable of natural recovery of sensation expected in this population of acute stroke survivors.

The additional treatments (ie, sensory retraining or relaxation) were well tolerated, with subjects anecdotally reporting benefits from both the sensory retraining and the relaxation sessions. Relaxation was considered by the investigators to be a suitable “sham” treatment, because a literature search did not identify any studies advocating the use of relaxation to improve function after stroke. However, because there was no true control group that received standard rehabilitation only, it is possible that both sensory retraining and relaxation were equally beneficial in the rehabilitation of people with stroke. However, it is just as possible that neither treatment was more beneficial than standard care.

Significant changes were found over time in light touch sensation in 3 points of the foot: at the heel, the lateral border of the foot, and the big toe. During the gait cycle, the center of pressure of the foot proceeds from the heel with initial contact, moves through the lateral side of the mid-foot to be spread across the metatarsals, and then progresses to the big toe and second toe in terminal stance. Therefore, it could be hypothesized that sensation in these 3 areas improved as a direct result.
of the sensory input received when undergoing standing and walking retraining, which all subjects received as part of the standard rehabilitation. In contrast, sensation in the other 4 areas of the feet (medial border of the foot, first and fifth metatarsals, little toe), which received less pressure or a more diffuse pattern of pressure during the gait cycle did not change significantly over the assessment period.

No significant differences in sensation were found between groups at the various points of the feet, with the exception of the first metatarsal, where the sensory retraining group showed the ability to perceive significantly lower thresholds than the relaxation group at follow-up. It was unclear why this 1 point of the foot was significantly affected by group allocation, but the other 6 points of the foot were not. It may be that the first metatarsal is the most responsive point of the foot to sensory retraining, and likely to be affected by the discrimination activities more than other areas of the foot. However, this hypothesis was not corroborated by the results of Hillier and Dunsford,12 in which only 1 of the 3 subjects showed improvements in light touch sensation at the first metatarsal after a period of sensory retraining. Alternatively, it may be that this statistical significance occurred purely as a result of the multiple comparisons performed.

The lack of improvement in sensation over time in 4 of the 7 points of the foot was unexpected, because the natural course of recovery after a stroke has been shown to include recovery of light touch sensation, even in the absence of sensation-directed treatment.6 The disparity between the lack of change in light touch sensation following sensory retraining of the feet in the current study and the results of Hillier and Dunsford,12 who reported significant improvements in light touch after the training period in 2 of the 3 chronic stroke subjects, may have been due to the difference in the target population. It may be that sensation is more responsive to training later after stroke. Another possible difference between the 2 study populations is their ability to maintain attention levels, which has been reported as important in order to maximize the effects of sensory retraining.9,10 Subjects in the study by Hillier and Dunsford12 may have been able to attend to the retraining tasks better because they were only receiving 1 form of therapy during the assessment and treatment period. In contrast, subjects in the current study had on average more than 100 minutes a day in PT alone, in addition to other therapies, which may have reduced their attention levels in the retraining sessions, thereby potentially reducing the effectiveness of sensory retraining. Similarly, because subjects in the current study were only weeks or months after their stroke, they may have still been experiencing more cognitive impairment than the chronic subjects in the study by Hillier and Dunsford.12 This cannot be confirmed or refuted because the only cognitive test applied in the current study was a Mini-Mental State Examination, which is a screening tool and is not always sufficiently sensitive to detect subtle cognitive impairments or attention deficits in the stroke population6,11 and no cognitive assessment or screen was conducted by Hillier and Dunsford.12

A final theory regarding the lack of significant improvement in light touch sensation at 4 points of the foot in the current study is that the assessment period used may not have been long enough to allow significant changes to occur, because the improvements in light touch sensation previously reported5 occurred over a 3-month period whereas the current study measured sensation over 4 weeks.

Proprioception of the affected big toe, measured using the DPT, did not show significant improvement over time in either group in the current study and no significant differences were found between groups. This finding was unexpected, given the natural course of recovery in proprioception after stroke reported in the literature.6 Despite the DPT being used commonly in the clinical setting in the assessment of stroke patients1,6,18 no studies were identified that assessed the repeatability of the DPT scores over time in a stable population group, or the sensitivity of the instrument to detect changes in stroke patients undergoing rehabilitation. The study by Hillier and Dunsford12 found that scores of proprioception using the DPT were quite erratic in the 2 subjects with decreased proprioceptive ability, whereas the 1 subject who scored full marks on the DPT continued with 100% accuracy throughout each assessment. A similar fluctuation in results was found in the present study, with 4 of the 21 subjects showing decreases in the DPT scores from baseline to follow-up, and 2 subjects who initially scored full marks at baseline, falling to 1 and 5 correct responses out of 10 two weeks later. This suggests that the stability of the DPT within individual subjects may be questionable, even though the interrater and intrarater reliability of the DPT in the current study was found to be excellent. In addition, the results of the current study showed that the DPT was not sensitive to change in stroke subjects in rehabilitation over a 4-week period.

Scores on the BBS improved significantly over time in both groups, but no significant differences were detected between groups at any of the assessment periods. Other studies that have assessed the effect of sensory training on postural control have had conflicting results. Morioka and Yagi10 trained hardness discrimination in the feet of people with stroke undergoing rehabilitation and found significant gains in postural control as measured by decreased postural sway after training compared with a control group. In contrast, Hillier and Dunsford12 used a 3SPACE tracker to assess postural control in 3 subjects, but found no significant difference after the sensory training period with the exception of improvement in one of the outcome measures in 1 participant. The varying responses to sensory retraining may be explained by the fact that Morioka and Yagi10 trained hardness discrimination, whereas this was not specifically targeted in either the current study or that of Hillier and Dunsford12 and perhaps hardness discrimination is a more important component of postural control than other forms of sensation. Alternatively, as outlined earlier, the improvements observed by Morioka and Yagi10 may be due to increased time practicing standing rather than the sensory retraining activities.

The BBS13,19-24 and timed gait25,27-34 have been reported previously as being reliable measures that are sensitive to change in stroke patients in rehabilitation. The ILAS, originally designed for use in orthopedic patients, had not been analyzed in the stroke population prior to the current study. The walking aid subsection of the ILAS, which showed similar patterns over time and between groups as the BBS and timed gait, was deemed to be a useful outcome assessment tool in stroke subjects in rehabilitation, but the “points of contact” required to complete the 10-m walk was not shown to be sensitive to change in this sample.

The results regarding timed gait, the walking aid used to walk, and postural control, which all showed similar patterns of change in the absence of significant group effects, would suggest that the improvements in postural control and gait were more likely to result from a combination of time and the standard rehabilitation program received by both groups rather than the addition of sensory retraining. However, this cannot be conclusively stated, given the low power of the current study to detect group effects.

The sensory retraining intervention in the current study was not as effective as interventions previously reported in the stroke
Study Limitations

A final limitation was that it was clearly impossible for the administering therapist to be blinded to group allocation. However, subjects and assessors were blinded to minimize the occurrence of any bias.

CONCLUSIONS

The protocol used in the current pilot study to retrain sensation in the feet of people with stroke undergoing inpatient rehabilitation was not found to be more effective than a control group receiving relaxation in improving sensation, balance, or walking ability. No firm recommendations regarding sensory retraining of the feet for stroke subjects undergoing rehabilitation can be made at this point due to the methodologic limitations of the current study and further research is warranted, using larger subject numbers, and implementing a revised retraining protocol. In addition, the use of measures such as DPT and the “points of contact” subsection of the ILAS may be of limited use in the stroke population.

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References


Supplier

a. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.
Construct and Predictive Validity of a Self-Reported Measure of Preclinical Mobility Limitation

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Objectives: To validate self-reported preclinical mobility limitation concept and self-report assessment method against muscle power and walking speed, and to study the predictive validity of preclinical mobility limitation with respect to future risk of manifest mobility limitation.

Design: Observational prospective cohort study and cross-sectional analysis.

Setting: Research laboratory and community.

Participants: A total of 632 community-living (age range, 75–81y) women and men took part in the baseline assessments and 302 persons in the semi-annual interviews on mobility limitation over 2 years.

Interventions: Not applicable.

Main Outcome Measures: Walking speed, muscle power, and self-reported preclinical and manifest mobility limitation. Preclinical mobility limitation was defined as self-reported tiredness or modification of task performance without task difficulty. At baseline, 4 subgroups were created according to self-reported preclinical mobility limitation in any of 3 mobility tasks (walking 2km, walking 0.5km, climbing up stairs): no limitation, preclinical limitation, and minor and major manifest limitation.

Results: At baseline, participants with preclinical mobility limitation showed intermediate levels of walking speed and muscle power, compared with those with no limitation or manifest mobility limitation. Participants reporting baseline preclinical mobility limitation had 3- to 6-fold higher age- and sex-adjusted risk of progressing to major manifest mobility limitation during the 2-year follow-up compared with participants with no limitation at baseline, whereas the risk among those with minor limitation at baseline was 14- to 18-fold higher compared with those with no limitation.

Conclusions: The self-report assessment tool proved to be a valid measure to capture the early signs of disability and may serve as an inexpensive tool for identifying those nondisabled persons at high risk for future disability.

Key Words: Aging; Disabled persons; Muscles; Rehabilitation; Walking.

MOBILITY DIFFICULTIES ARE common among older people, increasing the risk of further disability and development of dependency, and are an important public health concern. Difficulties in mobility are often the first noticeable signs of decline in functional ability.

In the perspective of primary prevention, it is important to identify people who are as yet nondisabled but are at high risk for future functional decline by characterizing an early functional state associated with increased risk for subsequent disability. Earlier findings have shown that poor performance in objective measures of physical performance—such as lower-extremity muscle strength and walking speed—are highly predictive of subsequent disability and dependency among nondisabled older adults and thus may be considered as a criterion standard in terms of impairment level assessment relevant in the disablement process. In certain circumstances, however, we also need valid self-report measures, because they do not require a specific place or equipment, and because they may be administered, for example, through phone interview or questionnaire. Most existing self-report instruments primarily assess difficulty, inability, or degree of assistance required to perform specific tasks of mobility, household management or personal care. Thus, these measures may not be sensitive enough to recognize early steps in the course of disability. In early stages of functional decline prior to the onset of task difficulty, older persons may be able to compensate for underlying disease by modifying their task performance and thereby maintain their function without the perception of difficulty. This stage of functional decline, that is, changes in method, frequency, or time used in task performance or increased tiredness, has been proposed as preclinical disability. There is some evidence that persons with preclinical disability have an increased risk for disability.

The aim of this study was to validate the self-reported preclinical mobility limitation concept and assessment tool among Finnish older population by investigating (1) whether self-reported modification of task performance or increased tiredness without task difficulty, that is, preclinical mobility limitation, is associated with decrements in objective measures of muscle power and maximal walking speed and (2) whether preclinical mobility limitation is predictive of occurrence of major difficulties in performing the task, that is, manifest mobility limitation.

METHODS

Design

This observational study is based on analyses of baseline data and 2-year follow-up on the development of mobility...
Participants

The original target population consisted of all 75- to 81-year-old registered residents of the City of Jyväskylä, Central Finland, living in the city center area in March 2003 (N=1310). Subjects’ selection procedure has been described in details elsewhere.17 To be eligible to this study, persons had to be able to walk 500m without assistance, have Mini-Mental State Examination (MMSE)18 score greater than 21, have no medical contraindications for physical activity, and be only moderately physically active or sedentary. Persons with specific physical activities were excluded from the study. After screening we had 632 participants in the cross-sectional analysis and 314 participants in the SCAMOB control group for the follow-up of the naturally occurring changes in function. Participants without the outcome of major manifest limitation at the baseline were followed up for the development of mobility limitation in 2-km walk (n=266), 0.5-km walk (n=302), and climbing up stairs (n=295). The study was approved by the Ethics Committee of the Central Finland Health Care District. All participants gave their written informed consent before the study.

Measurements

Background characteristics. Information on self-reported physician-diagnosed chronic conditions lasting over 3 months and prescription medication was collected during the face-to-face interviews at the participant’s home. During the study-center visit, the study nurse checked the responses concerning chronic diseases and prescription medications filled in by the interviewers at home interviews. Depression was measured with Center for Epidemiologic Studies Depression Scale (CES-D)19 and cognitive impairment was assessed with the MMSE.18

Maximal walking speed. We measured walking speed over 10m in the study-center corridor. Participants were allowed 2- to 3-m acceleration before the start line and they were encouraged to walk as fast as possible without risking their health. Timing was done using a stopwatch. Participants wore walking shoes or sneakers, and use of a walking aid was allowed if needed. Walking speed has previously been shown to be a reliable and valid measurement of functional performance among older people.6 The test-retest coefficient of variation (CV) for maximal walking speed in our study center was 4.6%.20

Leg extensor muscle power. At baseline, we measured leg extensor muscle power of a single leg using Nottingham Leg Extensor Power Rig.21 At testing, the participant was seated with arms folded, 1 foot was placed on the pedal attached to a flywheel, and the other foot rested on the floor. After 2 to 3 practice trials, each participant was asked to push the pedal as hard and fast as possible. Five to 9 maximal efforts per leg, separated by 30-second rests, were conducted.22,23 In this study, the best performance of dominant leg was used as the measure of maximal power. Muscle power measurement with the Nottingham power rig has been validated and found to be safe and acceptable among older people.24 The test-retest CV in our study center was 8%.22

Preclinical and manifest mobility limitation. The questions on mobility were formulated according to the hypothesis that the progression of major manifest mobility limitation develops through stages of preclinical mobility limitation and minor manifest mobility limitation (fig 1). Self-reported mobility was studied using a structured interview regarding walking 2.0km, walking 0.5km, and climbing up 1 flight of stairs. The questions were formulated as follows: “Do you have difficulty in . . .” and 5 alternative response options were given: (1) able to manage without difficulty, (2) able to manage with some difficulty, (3) able to manage with great deal of difficulty, (4) able to manage only with help of another person, and (5) unable to manage even with help. To identify persons at an early stage of mobility limitation, that is, preclinical mobility limitation, additional questions were posed to participants who reported no task difficulty. The questions concerned the modification of task performance and the alternatives given were resting in the middle of the performance, using an aid, taking support from handrails, having reduced the frequency of performing the task, having slowed down performance of the task, experiencing tiredness when performing the task, or some other change in carrying out the task.

Subgroup division. At baseline 4 subgroups for each mobility task were created according to self-reported mobility difficulties and task modification: (1) no limitation (no mobility difficulties and no modification), (2) preclinical limitation (no mobility difficulty and ≥1 modification), (3) minor manifest limitation (some difficulty), and (4) major manifest limitation (great deal of difficulty, need for help of another person or not able to manage even with help) (see fig 1).

Reliability of mobility assessment. We assessed test-retest reliability for the mobility and preclinical limitation questions among a sample of 29 people of similar age by replicating the questions in an interval of 2 weeks. The agreement of self-reports between 2 different days for the question on the 2-km walk was 93%; for the 0.5-km walk, 97%; and for climbing up 1 flight of stairs, 100%. The task modification questions agreement ranged from 93% to 100% for the 2-km walk, from 97% to 100% for the 0.5-km walk, and from 72% to 100% for walking up 1 flight of stairs.

limitations. In the cross-sectional analyses, the validation of preclinical mobility limitation assessment tool was done against the criterion standard, that is, muscle power and walking speed, using the baseline data of the 2-year randomized controlled trial Screening and Counseling for Physical Activity and Mobility in Older People (SCAMOB)17 (ISRCTN 07330512). The predictive validity of preclinical mobility limitation was studied as risk for developing future manifest mobility limitation in the SCAMOB control group, where the naturally occurring changes in function took place. Maximal walking speed and muscle power examinations and face-to-face interview on mobility were performed at baseline. In addition, telephone interviews about mobility were carried out 3 times at 6-month intervals after the baseline and face-to-face interview again at 2-year follow-up point.
Statistical Analysis

Means and standard deviations (SDs) were used as descriptive statistics. Analyses of covariance were used to estimate the mean differences in muscle power and maximal walking speed between the groups based on hypothesized progression of mobility limitation. Age, sex, and number of long-term diseases and prescription medication were used as covariates. The relative differences between the study groups were determined using log transformation of the variables. When the 95% confidence intervals (CIs) did not include zero, the differences were regarded as statistically significant at α equal to .05. These analyses were performed using Mplus software.b

In the 2-year follow-up, we constructed a generalized estimating equations model24 on the dichotomized (no major manifest limitation, major manifest limitation) mobility variables to test the significance of subgroup differences in the risk for major manifest limitation over time. Subjects who had major manifest limitation with mobility task at baseline were excluded from the analyses of the given task. The analyses were performed in SAS, using the GENMOD procedure. To study factors that may underlie on the theoretic pathway to mobility limitation, 3 separate models were constructed for each mobility task using sex, age, presence of chronic diseases known to affect mobility (osteoarthritis, rheumatoid arthritis, diabetes, chronic obstructive pulmonary disease, ischemic heart disease, myocardial insufficiency, sciatica), depressive symptoms (CES-D score), weight, height, walking speed, and muscle power as covariates. For cases with missing values in a mobility task at some point of the 2-year follow-up, data were imputed with the multiple imputation procedure implemented in SAS by using information on the other mobility tasks and baseline information such as number of long-term diseases, and MMSE and CES-D scores. Sensitivity analyses performed suggested no significant differences in effects due to imputation. The number of missing observations at different measurement points ranged from 9 to 28. Subjects who died over the course of the study were censored at the date of their death and missing values were not imputed. During the 2-year follow-up, 8 participants died.

RESULTS

The mean age of our study population (N = 632) was 77.6 ± 1.9 years and 75% were women. At the baseline all the participants (N = 632) completed the face-to-face interview on mobility and 629 participants performed the maximal walking speed test and 614 participants the muscle power measurement. In our follow-up sample, attrition over 2 years was under 10%.

A substantial number of the participants who reported no difficulty in the 2-km walk, 0.5-km walk, or climbing up stairs reported task modification or increased tiredness in performing the task. Depending on the task being assessed, altogether 31% to 55% of the participants were categorized into the preclinical mobility limitation subgroup. The distribution of participants according to our subgroup division is given in detail in table 1.

Baseline characteristics according to self-reported mobility in the 2-km walk are shown in table 2. According to the number of long-term diseases and prescription medication, length of education, body mass index, depressive symptoms, muscle power, and walking speed, participants with preclinical mobility limitation were an intermediate group between the participants reporting no limitation and those reporting manifest limitation. Similar results were observed also when comparison was done based on the 0.5-km walk or stair climbing.

Validation Against Criterion Standard

We validated the self-report assessment tool against objectively measured maximal walking speed and muscle power. Adjusted mean percentage differences between the subgroups in maximal walking speed and muscle power compared with preclinical limitation subgroup are given in figure 2. The participants with preclinical mobility limitation had intermediate levels of maximal walking speed and muscle power between participants with no limitation and those with manifest limitation. This result was consistent in all 3 mobility tasks, being most evident in the 2-km walk and climbing up 1 flight of stairs (see fig 2). The participants reporting no limitation had significantly (P < .05) faster walking speed (11%–20%) and higher muscle power (14%–16%), compared with those with preclinical mobility limitation. In proportion, the participants reporting either minor or major manifest limitation had significantly (P < .05) slower walking speed (10%–28%), and lower muscle power (13%–26%), compared with participants with preclinical limitation.

Predictive Validity

The prevalence of major manifest limitation in the 2-km walk, 0.5-km walk, and climbing up 1 flight of stairs during the 24-month follow-up are shown in figure 3. The risk for the development of major manifest mobility limitation was intermediate among participants with preclinical mobility limitation compared with those with no limitation or minor manifest limitation. Table 3 shows the risk ratios for the onset of task-specific major manifest limitation in each mobility task compared with the subjects with no limitation. In the first model, adjusted for sex and age, preclinical limitation in the 2-km walk and 0.5-km walk increased the risk for major manifest limitation almost 3- to 6-fold compared with participants with no limitation. The trend was similar also in climbing up stairs, only with nonsignificant risk ratio. Subjects with minor manifest limitation had 14- to 18-fold risk for major manifest limitation in each mobility task compared with those with no limitation. In the second and third model, we adjusted the risk ratios with potential confounders together with lower-extremity muscle power and maximal walking speed. These procedures attenuated the risk ratios in all of the 3 tasks (table 3).

DISCUSSION

Our results indicate that self-reported preclinical mobility limitation is a valid measure to identify persons at high risk for future manifest mobility limitation. In our cross-sectional part of the study, objective measures of maximal walking speed and muscle power were associated in a stepwise relationship with the 4 categories of mobility limitation, ranging from no limitation to preclinical limitation and further to minor and major
manifest limitation. Participants reporting preclinical mobility limitation had intermediate walking speed and muscle power between those with no limitation and those with minor or major manifest limitation. In addition, our observational follow-up study confirmed that the self-reported preclinical mobility limitation predicted development of major manifest limitation in the near future.

Our findings are in accordance with the previous findings of Fried12,13 Wolinsky,14 and Avlund15,16,25 and colleagues providing criterion and predictive validity for the preclinical mobility limitation concept. In the earlier studies of self-reported preclinical mobility limitation, the target population has consisted of 70- to 80-year-old high-functioning American women12,13 or late-middle-aged African Americans.14 Our study population represented sedentary community-living older people. In addition, to our knowledge, muscle power or self-reported ability to walk 2km has not been used as outcome in the earlier studies of preclinical disability.

In the work of Fried12,13 and Wolinsky,14 preclinical mobility limitation was assessed by self-reported changes in the method or decreased frequency of task performance without perceived task difficulty. This approach suggests that people are able to compensate for underlying disease by modifying their task performance. This is in line with the theory of selective optimization with compensation by Baltes and Baltes,26 which has previously been mostly applied to studies on cognitive functioning. Baltes and Baltes26 described 3 adaptional processes: selection denotes a restriction of involvement in activities in response to lost capacity, optimization refers to optimization processes like pacing activities to enable one to continue performing activities, and compensation involves efforts to meet goals by new means (eg, modifying behaviors, using assistive devices). In the recent years, this theory has been applied to physical functioning, for example among older adults with osteoarthritis,27 showing variability and plasticity in older adults’ efforts to manage physical disability by selection, optimization, and compensation. This is highly relevant also in the perspective of preclinical mobility limitation concept.

In addition to self-reported changes in the method or decreased frequency of task performance, we included also increased tiredness introduced by Avlund15,16 into the determination of preclinical mobility limitation. Self-reported tiredness in daily activities is related to subsequent functional decline, hospitalization, and use of home help.15,16,25 Therefore it is reasonable to take tiredness...
into a definition of preclinical disability. More studies are needed to explore what aspects are relevant indicators of preclinical disability, and thus should be included in the measurements of preclinical disability, and whether the same determination applies to different groups of older people.

In our follow-up analysis, adjustment for long-term diseases and depressive symptoms attenuated the increased risk for manifest limitation somewhat among participants with preclinical mobility limitation or minor manifest limitation and a further reduction was observed when walking speed, muscle power, height, and weight were added into the models. This suggests that these covariates may lie on the theoretic pathway to mobility limitation. During our 2-year follow-up, participants developed major manifest limitation most often in the 2-km walk, indicating that it was the most demanding task among the 3 mobility tasks for our participants. In our cross-sectional data maximal walking speed was more strongly associated with self-reported mobility function compared with muscle power. This was expected, as self-reported mobility limitation and objectively measured walking speed represent the same category—functional limitation at the level of the organism as a whole—in the disablement process. Respectively, muscle power represents the impairment level of organs and body systems, being more distal from the disability category.

Study Limitations

Our participants represented a group of older people who would probably benefit the most from preventive actions, because we excluded both the physically very active and those who were not able to move independently even minimally. However, the use of this truncated distribution might cause some underestimation in our cross-sectional and follow-up results. Presumably, we would have seen stronger associations if we had included also very vigorous and more impaired older people in our study. Nevertheless, our large sample size, population-based sampling, and small dropout rate underline the reliability of our results.

The results of the present study have some implications to future prevention of disability, which are in line with earlier suggestions of Fried, Wolinsky, and Avlund and colleagues. Instead of continuing the disability prevention as secondary or tertiary treatment with people already disabled, the prevention should focus on the early stages of disability. It has been suggested that in terms of maximal effectiveness, interventions for reducing or postponing disability should be targeted for people who are not yet disabled but are at high risk. In our study the prevalence of manifest mobility limitation for the 2-km walk, 0.5-km walk, and climbing up 1 flight of stairs during 24-month follow-up. NOTE. At baseline, the number of participants with preclinical mobility limitation in 2km was 140; in 0.5-km walk, 100; and in climbing up stairs, 178. Respectively, the numbers for participants with no limitation was 74, 166, and 59, and for participants with minor manifest limitation 52, 36, and 58.

![Fig 3. Unadjusted prevalence (in percent) of major manifest limitation for the (A) 2-km walk, (B) 0.5-km walk, and (C) climbing up 1 flight of stairs during 24-month follow-up.](image)

### Fig 3. Unadjusted prevalence (in percent) of major manifest limitation for the (A) 2-km walk, (B) 0.5-km walk, and (C) climbing up 1 flight of stairs during 24-month follow-up. NOTE. At baseline, the number of participants with preclinical mobility limitation in 2km was 140; in 0.5-km walk, 100; and in climbing up stairs, 178. Respectively, the numbers for participants with no limitation was 74, 166, and 59, and for participants with minor manifest limitation 52, 36, and 58.

### Table 3: Risk Ratios and Their 95% CIs for the Onset of Major Manifest Limitation for the 2-km Walk, 0.5-km Walk, and Climbing Up 1 Flight of Stairs Among Participants With Preclinical or Minor Manifest Mobility Limitation, Compared With Participants With No Limitation at Baseline

<table>
<thead>
<tr>
<th>Activity</th>
<th>Model I* RR 95% CI</th>
<th>Model II† RR 95% CI</th>
<th>Model III‡ RR 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-km walk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preclinical limitation</td>
<td>5.8 2.6–12.9</td>
<td>5.0 2.2–11.2</td>
<td>2.9 1.2–6.6</td>
</tr>
<tr>
<td>Minor manifest limitation</td>
<td>17.8 7.6–41.9</td>
<td>17.1 7.0–41.5</td>
<td>8.9 3.6–21.6</td>
</tr>
<tr>
<td>0.5-km walk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preclinical limitation</td>
<td>2.5 1.2–5.1</td>
<td>2.3 1.1–4.6</td>
<td>1.4 0.7–2.9</td>
</tr>
<tr>
<td>Minor manifest limitation</td>
<td>13.2 6.1–28.4</td>
<td>10.3 4.8–22.0</td>
<td>5.4 2.3–12.2</td>
</tr>
<tr>
<td>Climb up 1 flight of stairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preclinical limitation</td>
<td>2.3 0.7–7.4</td>
<td>1.8 0.5–6.1</td>
<td>1.2 0.4–3.9</td>
</tr>
<tr>
<td>Minor manifest limitation</td>
<td>13.9 4.2–45.7</td>
<td>10.2 2.8–37.5</td>
<td>5.4 1.6–19.1</td>
</tr>
</tbody>
</table>

Abbreviation: RR, risk ratio.

*Model adjusted for sex and age.
†Model adjusted for sex and age and osteoarthritis, rheumatoid arthritis, diabetes, chronic obstructive pulmonary disease, ischemic heart disease, myocardial insufficiency, sciatica, and depressive symptoms.
‡Model adjusted for sex and age and osteoarthritis, rheumatoid arthritis, diabetes, chronic obstructive pulmonary disease, ischemic heart disease, myocardial insufficiency, sciatica, and depressive symptoms as well as weight, height, walking speed, and muscle power.
limitation in semiannual follow-up points during the 2-year follow-up was 4% to 23% among participants with preclinical mobility limitation and 28% to 52% among participants with minor manifest limitation. This indicates that people with preclinical mobility limitation are a potential target group for preventive interventions and respectively those with minor manifest limitations might already need some rehabilitative actions. This needs to be further ascertained with intervention studies focusing on preclinical mobility limitation.

CONCLUSIONS

The results of this study indicated that the self-report assessment tool was a valid measure to capture the early signs of disability, that is, preclinical mobility limitation. Characterizing those at preclinical stage of mobility limitation by self-report, may serve as a simple and inexpensive tool for identifying those at high risk for future disability and would probably help to find appropriate target groups for early interventions to prevent disability.

References


Suppliers

a. University of Nottingham, Medical Faculty Workshops, Queen’s Medical Centre, Nottingham, UK.
b. Version 4.2; Muthén & Muthén, 3463 Stoner Ave, Los Angeles, CA 90066.
c. Version 9.1; SAS Institute Inc, 100 SAS Campus Dr, Cary, NC 27513-2414.
Relationships Between Spasticity, Strength, Gait, and the GMFM-66 in Persons With Spastic Diplegia Cerebral Palsy

Sandy A. Ross, PT, DPT, MHS, PCS, Jack R. Engsberg, PhD


Objective: To determine the relationships between spasticity, strength, and the functional measures of gait and gross motor function in persons with spastic diplegia cerebral palsy (CP).

Design: Retrospective, cross-sectional study.

Setting: Hospital clinic.

Participants: Ninety-seven participants (49 boys, 48 girls; mean age ± standard deviation, 9.11 ± 4.8y) with spastic diplegia CP were tested once.

Interventions: Not applicable.

Main Outcome Measures: A KinCom dynamometer was used to objectively measure spasticity (ankle plantarflexors, knee flexors, hip adductors) and maximum strength (ankle dorsiflexors and plantarflexors, knee flexors and extensors, hip abductors and adductors). A gait analysis was conducted to evaluate linear variables (gait speed, stride length, cadence) and kinematic variables (ankle dorsiflexion, foot progression, knee and hip flexion, pelvic tilt at initial contact and ankle dorsiflexion, knee and hip flexion, pelvic tilt, trunk rotation angle of motion) during gait. Gross motor function was measured using the Gross Motor Function Measure (GMFM-66) and separately, the GMFM walking, running & jumping dimension. Multiple linear regression analysis was used to determine the relationships between spasticity, strength, gait, and the GMFM (P < .05).

Results: Spasticity did not account for a substantial amount of explained variance in gait and gross motor function (up to 8% for the GMFM walking, running & jumping dimension). Moderate to high correlations existed between strength and gait linear data and function, accounting for up to 69% of the explained variance (strength and GMFM-66, r² = .69).

Conclusions: For this cohort of participants with spastic diplegia CP who ambulated with or without an assistive device, strength was highly related to function and explained far more of the variance than spasticity. The results may not be generalized to those with more severe forms of CP.

Key Words: Cerebral palsy; Gait; Muscle spasticity; Rehabilitation.

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SPASTICITY AND A LACK of muscle strength (weakness) are primary impairments associated with people with cerebral palsy (CP). The main goal of most interventions is to improve function, but the relationships between spasticity and function or between strength and function, have rarely been reported in the same group of people with CP. Historically, spasticity was considered a primary limiting impairment in people with CP; therefore, if spasticity was reduced, function would automatically be improved.1 Strength, especially in spastic muscle groups, was not a therapeutic focus in people with CP because spastic muscles were thought to already be overly strong or active and there was an assumed risk of increasing spasticity or abnormal movement patterns if strength was increased.2 Interventions, such as botulinum toxin, tendon lengthening, and selective dorsal rhizotomy (SDR), have been based on assumptions about the relationships between spasticity, strength, and function without adequate research.

There are many assumptions about the relationship between spasticity, strength, and function in people with CP. Spasticity is thought to be inversely related to gross motor function and gait, so the greater the spasticity the lower the level of function. Spasticity of the hamstrings has been attributed to a knee-flexed gait pattern and spasticity of the plantarflexors has been attributed to a toe-walking gait pattern.3 However, because most researchers do not objectively quantify spasticity, there has been limited research on the correlation between the amount of spasticity, the associated gait deviation, and the level of gross motor function. Unlike spasticity, strength is thought to be directly related to gross motor function and gait: the greater the strength the higher the level of function. Increasingly, investigators have objectively documented strength in people with upper motoneuron damage but rarely did investigators objectively measure both strength and spasticity, so it remains unclear whether it is spasticity, weakness, or some combination of the 2 that could be the cause of the functional deficits seen in people with CP.

Spasticity related to function in a group of 18 participants with CP was reported by Tuazon et al.4 Tuazon determined a spastic threshold velocity, using electromyography during isokinetic testing, for the quadriceps and hamstrings and found it correlated with the Gross Motor Function Measure (GMFM) walk and run domain (r = .58) and walking velocity (r = .64), indicating the milder the spasticity the higher the function. They also reported that the Ashworth Scale score correlated significantly with the GMFM (r = .83). Damiano et al5 recently reported on a group of 25 children with CP, 9 of whom exhibited a spastic stretch response in both quadriceps and hamstrings with significantly slower knee angular velocities during the swing phase of gait compared with others with CP, but reported no significant correlations between spasticity measures (resistance to passive stretch) and gait parameters. Abel et al6 reported on a group of 129 ambulatory children with CP and found that the Ashworth scores for hip flexion and extension, abduction, and knee flexion and extension all correlated mildly negatively with the GMFM-66 (r range, −.22 to −.34). They found no significant correlation between ankle spasticity and gross motor function. Most recently, Østensjø et al7 re-
ported a significant correlation between the Modified Ashworth Scale (for hip, knee, and ankle) and the GMFM-66 ($r=0.64$) in a group of 95 children with CP. Most of the researchers used the Ashworth Scale to determine the amount of spasticity and the objectivity of this measure has been questioned. In addition, none of the above investigations also measured strength.

Strength related to function in a group of 17 adolescents with CP was reported by Kramer and MacPhail. They found that knee extensor strength (eccentric, concentric) related moderately (range, .57–.69) with the GMFM. Damiano and Abel found similar results in a group of 11 participants (6 with diplegia, 5 with hemiplegia): lower-extremity strength (hip, knee, ankle) correlated highly with gait speed ($r=.71$) and moderately with the GMFM ($r=.59$). In a later study of a group of 10 children with spastic CP, Damiano et al reported a moderate correlation between knee extensor strength and gait speed ($r=.68$) and knee extensor strength and the GMFM ($r=.57$). However, Damiano found no significant correlation between hamstring strength and function. None of the above investigations also measured spasticity.

The only group of investigators that has reported on spasticity and strength and how this relates to function in the same group of participants with CP is Damiano and colleagues. According to Damiano et al, increased knee flexor spasticity (only at the fastest speed 120°/s) was mildly related ($r=-.44$) to lower GMFM scores. Knee extensor spasticity at 30° and 60°/s related moderately with the GMFM ($r=-.57$, $r=-.52$, respectively). They reported that knee strength, both quadriceps and hamstrings, was highly related ($r$, range, .70–.83) to the GMFM. This study involved only the knee muscles of the lower extremity and did not examine gait.

To further explore the relationship among impairments and function in persons with CP, Abel et al performed a stepwise regression analysis to determine if any combination of variables could predict function to a substantial degree ($r>0.50$). The study included 129 children with spastic diplegia and hemiplegia CP and the variables analyzed included Ashworth scores, passive range of motion (ROM), and gait kinematics to predict motor function in the GMFM and Pediatric Outcomes Data Collection Instrument (PODCI). They found that the above variables explained 33% of the variance ($r^2=.33$) for the PODCI and a lower $r^2$ value for the GMFM (not reported). They concluded that strength, which was not measured, might have increased the predictability of the impairments because it has been shown to correlate moderately with gait velocity and the GMFM.

There is no single study addressing the relationship between hip, knee, and ankle impairments (spasticity, strength, gait, and gross motor function in the same group of participants with CP. The purpose of this investigation was to determine the relationships between lower-extremity spasticity, strength, and the functional measures of gait and gross motor function in subjects with spastic diplegia CP.

**METHODS**

A retrospective analysis was performed on the spasticity, strength, and function results from data collected on 97 participants with spastic diplegia CP (49 boys, 48 girls; mean age ± standard deviation [SD], 9.11 ± 4.8y; range, 4–23y). A neurosurgeon or neurologist had referred the participants to the Human Performance Laboratory for testing and they were participating in an SDR study. All participants were candidates for the SDR surgery and all measures were taken preintervention. The sample included participants from 23 states within the United States; 15 (16%) of 97 participants were from the St. Louis metropolitan area, and 71 (73%) of 97 were from out of state. The participants were at least 1 year post orthopedic surgery. 6 months post botulinum toxin type A (Botox) injections, and had no history of spasticity-altering surgeries (baclofen pump, SDR) prior to testing. The majority of the participants (66%) were independent ambulators with a relatively equal distribution between Gross Motor Function Classification System (GMFCS) levels I through III (table 1). Persons with GMFCS level I ambulate independently without limitations, but may have limitations in more advanced gross motor skills; persons with level II ambulate independently but have limitations walking outdoors and in the community; and persons with level III ambulate with an assistive device. All participants or parents (when appropriate) signed an informed consent approved by the Washington University Internal Review Board.

The general methods used in this investigation to measure spasticity and strength have been described elsewhere for the hip, knee, and the ankle. They will be briefly summarized here. Spasticity was tested for the hip adductors, knee flexors, and ankle plantarflexors. Strength was tested for the hip abductors and adductors, knee extensors and flexors, and ankle dorsiflexors and plantarflexors. For the sake of brevity, only the methods used at the ankle will be presented; similar methods were used at the knee and hip.

The participants were secured on the KinCom isokinetic dynamometer seat with a pelvic and thigh strap. The joint axis was aligned with the KinCom lever arm. Ankle dorsiflexion and plantarflexion ROM limits were established. For the spasticity tests, the participant was instructed to remain as relaxed as possible while the passive ankle joint was rotated from maximum plantarflexion to the participant’s maximum dorsiflexed position, thereby stretching the ankle plantarflexor muscles. Spasticity tests were conducted at speeds of 10°, 30°, 60°, 90°, and 120°/s (the 120°/s speed was only at the ankle). Only 1 trial at each speed was actually used in the analysis. The therapist saved the trial when variation between trials was minimal or nonexistent for a given speed.

Immediately following the passive spasticity test at a joint, the participant was asked to perform a maximum concentric contraction of either the ankle plantarflexors or dorsiflexors while the lever arm moved (passive mode) at 10°/s. The speed of 10°/s was chosen because some participants with CP did not have enough strength to initiate motion of the lever arm. In addition, testing strength throughout the passive ROM was possible using this method. Three to 5 trials were conducted to permit the participant to achieve his/her best performance. Only the trial indicating the greatest amount of torque was used in the analysis.

For the spasticity test, torque-angle data were processed to partial out the effects of gravity and minimize acceleration and

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**Table 1: Participant Demographics, GMFCS Level, and Gait Status**

<table>
<thead>
<tr>
<th>Parameter Demographics, GMFCS Level, and Gait Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (N)</td>
</tr>
<tr>
<td>Mean age ± SD (range), y</td>
</tr>
<tr>
<td>Sex (male/female)</td>
</tr>
<tr>
<td>GMFCS</td>
</tr>
<tr>
<td>Level I</td>
</tr>
<tr>
<td>Level II</td>
</tr>
<tr>
<td>Level III</td>
</tr>
<tr>
<td>Primary mobility device</td>
</tr>
<tr>
<td>Independent</td>
</tr>
<tr>
<td>Canes</td>
</tr>
<tr>
<td>Crutches</td>
</tr>
<tr>
<td>Walker</td>
</tr>
</tbody>
</table>

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machine dynamic responses. Areas within the torque-angle curves were calculated to yield work values. The work values were determined for each speed (ie, 10°, 30°, 60°, 90°, and 120°/s). Linear regression was used to determine the line of best fit for the work values as a function of speed. The slope of the linear regression line was the magnitude of the spasticity. A steeper slope indicated a greater amount of work was required to stretch that muscle group and a greater amount of spasticity. For the strength measures, maximum torque values were recorded. All values were normalized by dividing by participant mass to permit interparticipant comparison.16

The general methods for the gait analysis used in this investigation have been reported elsewhere and will briefly be described here.13,17,23 Three 9-mm diameter spherical reflective surface markers were placed on each of the trunk, thighs, legs, and feet of each participant. The participant walked barefoot at a self-selected pace along a 9-m walkway and video data were collected (6-camera HiRes) during the middle 3m. At least 6 trials of data were collected from each participant. Rest periods were provided as needed. Temporal gait variables including speed, stride length, and cadence were determined. The location-time data of the surface markers were tracked (digitized) and converted to 3-dimensional coordinates as a function of time. The tracked data were uploaded into KinTrak software for further processing. The software produced data describing the averaged joint angle as a function of the complete gait cycle for each of the 3 principal planes of the body. The variables calculated included in the sagittal plane: pelvic tilt, hip, and knee flexion and extension and ankle dorsiflexion and plantarflexion, and in the transverse plane: trunk rotation and foot progression angle.

GMFM data were collected. The GMFM is a standard criterion-referenced test designed to assess change in gross motor function in persons with CP.23 The 88 items of the test (GMFM-88) assess activities in 5 dimensions: (1) lying and rolling, (2) sitting, (3) crawling and kneeling, (4) standing, and (5) walking, running & jumping. Each item is scored using a 4-point Likert scale (0, does not initiate; 1, initiates; 2, partially completes; 3, completes). Totals from each category for a participant were divided by the total possible points to produce a category percentage score. These percentages were averaged to yield an overall score. The GMFM-66 uses 66 of the 88 items and was developed using Rasch analysis to improve the sensitivity and interpretability of the test.24 To account for a potential ceiling effect of the GMFM, we also evaluated the GMFM walking, running & jumping dimension.4 The GMFM walking, running & jumping is the fifth dimension and represents the highest gross motor function level in this test and thus is the most difficult for people to score 100% on, even those in GMFCS levels I and II.

The data analysis included 4 steps. First, spasticity and strength variables were tested for normality. The spasticity variables were found not to be normally distributed and were transformed using natural log to achieve a normal distribution. Second, multivariate linear regression analyses were used to examine the relationships between aggregate spasticity, aggregate strength, and the functional measures of gait (linear data and kinematics) and gross motor function (eg, all 6 lower-extremity strength variables were compared with the dependent variable GMFM-66 and GMFM walking, running & jumping dimension). Aggregate values that represent spasticity and strength (impairments) of the lower extremity were chosen to answer the clinical question “Which impairment (spasticity or strength) is most related to function in people with CP?” Aggregate values for spasticity included 3 variables: the individual hip adductor, knee flexor, and ankle plantarf lexor values right and left sides averaged for each variable. Aggregate values for strength included 6 variables: the individual hip abductor and adductor, knee flexor and extensor, and ankle dorsiflexor and plantarf lexor values with the right and left sides averaged for each variable. Colinearity statistics for the aggregate spasticity and strength values were within the acceptable range of tolerance with no variable less than .20. Third, partial correlations, controlling for age and the GMFCS, were performed for significant relationships between spasticity, strength, and function. Last, a forward stepwise linear multiple regression analysis, similar to that used in the Abel et al study on children with CP, was used to examine the relationships between the strength and spasticity variables and the 2 most clinically relevant function variables: gross motor function (GMFM-66) and gait speed. The stepwise analysis was chosen to attempt to answer the clinically significant question “Which impairment (spasticity or strength) at which joint explained the greatest amount of variance in function?” For correlations, an r of 0.90 to 1.00 was considered very high, 0.70 to 0.89 was considered high, 0.50 to 0.69 was considerable moderate, 0.26 to 0.49 was fair (mild), and 0.00 to 0.25 indicated little to no relationship.25 A significance level of P less than .05 was used in the analysis.

RESULTS

Spasticity and Strength Relationship With Gross Motor Function

Aggregate spasticity consisting of individual values for the ankle plantarf lexors, knee flexors, and hip adductors averaged across sides did not relate significantly to the GMFM-66 (r = .27) (fig 1) or GMFM walking, running & jumping dimension (r = .29) (table 2). Aggregate strength consisting of values for the ankle dorsiflexors and plantarf lexors, knee extensors and flexors, and hip adductors and adductors averaged across sides was highly related to the GMFM-66 (r = .83) (see fig 1) and GMFM walking, running & jumping dimension (r = .81).

Forward stepwise linear multiple regression showed that strength of the hip abductors followed by the ankle plantarf lexors and knee flexors explained 68% of the variance in the GMFM-66 and 64% of the variance in the GMFM walking, running & jumping dimension (table 3).

Spasticity and Strength Relationship With Gait Speed

Aggregate spasticity was not related to gait speed (r = .19) (fig 2) or cadence (r = .26) but was mildly related to stride length (r = .33) (see table 2). Aggregate strength was moderately related to gait speed (r = .61) (see fig 2), highly related to stride length (r = .71), and mildly related to cadence (r = .39).

Forward stepwise linear multiple regression showed that strength of the hip abductors followed by the ankle dorsiflexors, explained 36% of the variance in gait speed. For stride length, 47% of the variance was explained by strength of the ankle dorsiflexors followed by the knee extensors and hip adductors. Strength of the ankle plantarf lexors explained 32% of the variance in cadence (see table 3).

Spasticity and Strength Relationship With Gait Kinematics

Aggregate spasticity was not significantly related to any gait kinematic variables (table 4). Aggregate strength was moderately related to pelvic tilt ROM (r = −.55) and knee flexion at initial contact (r = −.50), mildly related to ankle dorsiflexion (r = .47) and internal foot progression angle (r = −.39) at initial contact, and mildly related to knee flexion (r = .46) and trunk
rotation \((r = -0.48)\) ROM during gait. Forward stepwise linear multiple regression was performed but data are omitted for brevity because explained variance for kinematic variables was very low. The largest variance (21%) was for knee flexion at initial contact explained by strength of the hip abductors and ankle plantarflexors.

**Age and GMFCS Relationships With Function: Controlling for Each Variable**

Age was not related to the GMFM-66 \((r = .03)\) or GMFM walking, running & jumping dimension \((r = .08)\) but was moderately related with stride length \((r = .64)\) and mildly related with gait speed \((r = .23)\) and cadence \((r = -.34)\). Given that age correlated significantly with stride length, partial correlations were performed controlling for age. The mild relationship between aggregate spasticity and stride length was no longer significant; thus age, not spasticity, accounted for most of the variance in stride length. When controlling for age, the significant relationships between strength and function did not change.

The GMFCS was highly related to the GMFM-66 \((r = -.77)\) and GMFM walking, running & jumping dimension \((r = -.82)\), and mildly related to gait speed \((r = -.49)\), stride length \((r = -.31)\), and cadence \((r = -.44)\). Partial correlations were performed controlling for GMFCS level to determine if a relationship existed between spasticity and function. When controlling for the GMFCS, stride length was significantly related to spasticity, however, only for the hip adductors. The relationship between spasticity and gait speed and cadence remained unchanged. When controlling for the GMFCS, the significant relationships between strength and function did not change.

**DISCUSSION**

The purpose of this investigation was to determine the relationship between the impairments of spasticity and strength and the functional measures of gait and gross motor function in persons with CP. Interpretation of a regression analysis that only captures a single time point of the relationship between variables should not infer causation. In other words, strength was highly related and spasticity was minimally related to gross motor function, but this does not imply that increasing strength or decreasing spasticity in a child with CP will automatically result in an improvement in function. In addition, the study was conducted with children in GMFCS levels I through III or independent ambulators with or without assistive devices to allow a gait analysis to be conducted. If children who were more limited in gross motor function or nonambulators (GMFCS levels IV and V) had been included, the results might have changed, especially with regard to spasticity. The relationship between spasticity and gross motor function in children with greater involvement was not a part of this investigation.

A limitation of the study was the lack of electromyography during spasticity testing. Electromyography would have added to the measure of spasticity (velocity-dependent resistance to passive stretch) by confirming a spastic response during stretch. This measure of spasticity (work values at increasing speeds) has been shown to be reliable in children with CP. All of the participants in this study were candidates for SDR and none of the individual impairment results were used to determine candidacy for the surgery. Although the results of
this study showed a minimal relationship between spasticity and function, it should not be inferred that a rhizotomy will be ineffective in improving function. Rhizotomy, in a meta-analysis of randomized clinical trials,\textsuperscript{27} has been shown to be effective in improving gross motor function. It may be that, as spasticity is reduced as a result of the rhizotomy, children have a window of opportunity during which they can more effectively work on muscle strength and expand their repertoire of movement patterns, which then may result in functional gains.

There tends to be a common assumption that impairments, especially spasticity, are strongly related to gait and gross motor development. Of the 15 variables measured, aggregate spasticity was mildly related only to 1 variable: stride length. When controlling for age, stride length was no longer significantly related to spasticity. When controlling for the GMFCS, stride length was only significantly related to hip adductor spasticity. Aggregate strength was significantly related to 11 of the 15 variables measured and moderately or highly related to 6 of these variables: the GMFM-66, GMFM walking, running & jumping dimension, gait speed, stride length, knee flexion at initial contact, and pelvic tilt ROM during gait. Controlling for age or GMFCS level did not change the significant relationships between strength and function. Based on the results, it appears that strength rather than spasticity accounted for a substantial degree of the variance in gait and gross motor function in persons with spastic diplegia CP. Strength accounted for up to 69% of the variance in the GMFM-66, whereas spasticity accounted for only up to 8% of the variance in the GMFM walking, running & jumping dimension.

The findings are in agreement with Damiano et al\textsuperscript{12} with regard to strength, which correlated highly with the GMFM, but they were not in agreement with regard to spasticity and the GMFM. According to Damiano, spasticity, in 1 of 3 speeds for the hamstrings and 2 of 3 speeds for the quadriceps, related moderately to the GMFM for the 23 participants tested. The results of our study indicated that spasticity was not significantly related to the GMFM ($N<.01$). One possible reason for the difference is that we measured individual spasticity values at the hip, knee, and ankle and combined the values in the analysis, whereas Damiano measured spasticity only at the knee and analyzed the muscles at individual speeds. The finding showed that only 1 of 3 speeds for the hamstrings spasticity was significantly related to the GMFM; thus if the speeds had been combined into a single value for spasticity for that muscle

### Table 3: Forward Stepwise Linear Multiple Regression Between Individual Impairment Variables and Gross Motor Function and Gait Linear Data

<table>
<thead>
<tr>
<th>Item</th>
<th>GMFM-66</th>
<th>GMFM Walking, Running &amp; Jumping Dimension</th>
<th>Gait Speed</th>
<th>Stride Length</th>
<th>Cadence</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAd spasticity</td>
<td>.54</td>
<td>.51</td>
<td>.32</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>KF spasticity</td>
<td>.03</td>
<td>.04</td>
<td>.04</td>
<td>.35</td>
<td></td>
</tr>
<tr>
<td>AP spasticity</td>
<td>.11</td>
<td>.09</td>
<td>.36*</td>
<td>.47*</td>
<td></td>
</tr>
<tr>
<td>HAd strength</td>
<td>.54</td>
<td>.51</td>
<td>.32</td>
<td>.04</td>
<td></td>
</tr>
<tr>
<td>KF strength</td>
<td>.03</td>
<td>.04</td>
<td>.04</td>
<td>.35</td>
<td></td>
</tr>
<tr>
<td>AD strength</td>
<td>.11</td>
<td>.09</td>
<td>.36*</td>
<td>.47*</td>
<td></td>
</tr>
<tr>
<td>AP strength</td>
<td>.54</td>
<td>.51</td>
<td>.32</td>
<td>.04</td>
<td></td>
</tr>
</tbody>
</table>

Explained variance ($r^2$)

- HAd spasticity: .68*
- KF spasticity: .64*
- AD strength: .36*
- AP strength: .47*
- Cadence: .32*

NOTE. The $r^2$ value indicates the total explained variance for each dependent measure.

Abbreviations: AD, ankle dorsiflexor; AP, ankle plantarflexor; HAd, hip abductor; HAd, hip adductor; KE, knee extensor; KF, knee flexor.

* $P<.01$.
The relationship between spasticity, strength, and function in the same group of subjects with CP has been unclear among clinicians and researchers. For this cohort of participants who ambulated with or without an assistive device, the results indicated that there was little to no significant relationship between spasticity and function. Unlike spasticity, strength correlated significantly with 11 of the 15 variables tested and correlated moderately or highly with 6 variables (GMFM-66, GMFM walking, running & jumping dimension, gait speed, stride length, knee flexion at initial contact, pelvic tilt ROM during gait). Forward stepwise linear multiple regression showed that the muscle groups that explained the largest variance in gait and gross motor function were the strength of the hip abductors followed by the ankle plantarflexors and ankle dorsiflexors. The results may not be generalized to those with more severe forms of CP.

Although it is difficult to draw clinical implications based on the results of a regression analysis, it is possible that strength may be very important in improving function in people with CP. Strength and spasticity should be objectively measured pre- and postintervention to continue to clarify the relationship between spasticity, strength, and function.

### Table 4: Multivariate Linear Regressions (r values) Between Spasticity, Strength, and Gait Kinematics

<table>
<thead>
<tr>
<th>Kinematics</th>
<th>Aggregate Spasticity</th>
<th>Aggregate Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF at initial contact</td>
<td>.20</td>
<td>.47*</td>
</tr>
<tr>
<td>DF ROM</td>
<td>-.15</td>
<td>.26</td>
</tr>
<tr>
<td>Flpro at initial contact</td>
<td>-.29</td>
<td>-.39*</td>
</tr>
<tr>
<td>KF at initial contact</td>
<td>-.18</td>
<td>-.50*</td>
</tr>
<tr>
<td>KF ROM</td>
<td>-.29</td>
<td>.46*</td>
</tr>
<tr>
<td>HF at initial contact</td>
<td>-.09</td>
<td>.30</td>
</tr>
<tr>
<td>HF ROM</td>
<td>-.29</td>
<td>.33</td>
</tr>
<tr>
<td>Pelvic tilt at initial contact</td>
<td>-.18</td>
<td>-.29</td>
</tr>
<tr>
<td>Pelvic tilt ROM</td>
<td>.16</td>
<td>-.55*</td>
</tr>
<tr>
<td>Trot ROM</td>
<td>.28</td>
<td>-.48</td>
</tr>
</tbody>
</table>

*P<.05; †P<.01.

NOTE. Aggregate Spasticity is spasticity of the hip adductors, knee flexors, and ankle plantarflexors; Aggregate Strength is strength of the hip adductors and adductors, knee extensors and flexors, and ankle dorsiflexors and plantarflexors. Abbreviations: DF, dorsiflexion; Flpro, foot internal progression; HF, hip flexion; KF, knee flexion; ROM, ROM excursion during gait; Trot, trunk rotation.

The results indicated that muscle strength was highly related to gross motor function and moderately related to gait. The results are in agreement with a preponderance of recent literature indicating a positive significant correlation between strength and gait and function in persons with CP. The results of this study indicated that the muscle groups that explained the largest variance in gait and gross motor function were the strength of the hip abductors, followed by the ankle plantarflexors and ankle dorsiflexors. We have found little to no literature about the relationship between spasticity and function in children with CP. Hip abduction strength in children with CP has been reported as significantly less than in their able-bodied peers. There is no literature about the relationship between hip abduction strength and function. Hip abductor strength may be important for tall kneel half kneel skills, single-limb balance, and gait. According to Perry, weak hip abductors (grade 3 or less on manual muscle testing) will result in a contralateral pelvic drop and excessive hip adduction during gait. For this cohort of participants, hip abductor strength appeared to be most closely related to function than any other lower-extremity muscle group. The second muscle group that most explained function was the strength of the ankle plantarflexors. There is no literature on the relationship between plantarflexor strength and function in cerebral palsy. Rodda and Graham referred to the ankle plantarflexion-knee extension force couple during gait as a critical biomechanic concept in studying gait patterns in children with CP. They described the role of a competent gastroc-soleus as controlling the progression of the tibia over the planted foot during stance. Dodd et al. strengthened the plantarflexors and knee extensors using a home-based strength training program for 6 weeks and found significant gains in strength and trends toward increased function, but no significant increase in the GMFM. Engsberg et al. strengthened the ankle dorsiflexors, plantarflexors, or both in a group of 12 children with spastic diplegia for 12 weeks and reported a significant improvement in the GMFM walking, running & jumping dimension. They also reported the correlation between change in ankle strength and change in the GMFM walking, running & jumping dimension was highly related (r=.84). The third muscle group to account for the explained variance in function was the ankle dorsiflexors. There is a great deal of research on ankle dorsiflexion strength and treatments to improve gait pattern, but no information on how this correlates to function. The dorsiflexors are critical for initial contact, loading response and swing during gait. It was no surprise that ankle dorsiflexor strength appeared to be the third most important muscle group with regard to function in persons with CP. Improving strength of the hip abductors and ankle plantarflexors and dorsiflexors and the effect on gait and gross motor function warrants further investigation.

Our results showed that for this cohort of participants with spastic diplegia CP, strength was highly related to function and explained far more of the variance than spasticity. Damiano et al. were the only group found to examine both spasticity and strength in the lower extremity, at the knee joint only, as they relate to gait and the GMFM in subjects with CP. This is the first study to examine the relationship between spasticity and strength at the hip, knee, and ankle and gait and gross motor function in subjects with spastic diplegia CP.

**CONCLUSIONS**

The relationship between spasticity, strength, and function in the same group of subjects with CP has been unclear among clinicians and researchers. For this cohort of participants who ambulated with or without an assistive device, the results indicated that there was little to no significant relationship between spasticity and function. Unlike spasticity, strength correlated significantly with 11 of the 15 variables tested and correlated moderately or highly with 6 variables (GMFM-66, GMFM walking, running & jumping dimension, gait speed, stride length, knee flexion at initial contact, pelvic tilt ROM during gait). Forward stepwise linear multiple regression showed that the muscle groups that explained the largest variance in gait and gross motor function were the strength of the hip abductors followed by the ankle plantarflexors and ankle dorsiflexors. The results may not be generalized to those with more severe forms of CP.
between impairment and function and how these change with regard to different interventions. Strength, rather than spasticity, might be given greater consideration when determining if a child with spastic diplegia may benefit from an intervention to improve functional outcomes. Future research is needed to see if functional outcomes, following any intervention, would be improved if rehabilitation focused on intensive strengthening exercises. The results support future work focusing on strengthening the hip abductors and ankle plantarflexors and dorsiflexors in people with spastic diplegia CP.

References

Suppliers
b. Motion Analysis Corp, 3617 Westwind Blvd, Santa Rosa, CA 95403.

Mark de Niet, MSc, Johannes B. Bussmann, PhD, Gerard M. Ribbers, MD, PhD, Henk J. Stam, MD, PhD


Objective: To test the Stroke Upper-Limb Activity Monitor (Stroke-ULAM), which uses electrogoniometry and accelerometry to measure the amount of upper-limb usage in stroke patients in daily life conditions, for its sensitivity to discriminate between moderately recovered and well-recovered stroke patients and control subjects.

Design: Cross-sectional study.

Setting: At home or a rehabilitation center.

Participants: Seventeen patients with stroke and 5 control subjects.

Interventions: Not applicable.

Main Outcome Measure: Level of usage of upper limb and the percentage of affected upper-limb activity compared with unaffected upper-limb activity (proportion).

Results: The level of usage of the affected upper limb of stroke patients was lower than that of the nondominant upper limb of control subjects (electrogoniometry, 97.8°±92.3°/min vs 286.2°±46.5°/min, P<0.01; accelerometry 1.0±0.5 g/min vs 2.4±0.5 g/min, P<0.01). Stroke had higher proportions than control subjects both in electrogoniometry (22.6%±18.0% vs 84.6%±9.8%, P<0.01) and accelerometry (39.2%±21.4% vs 93.3%±5.0%, P<0.01). Well-recovered stroke patients had significantly higher proportions compared with moderately recovered patients in both electrogoniometry and accelerometry.

Conclusions: The Stroke-ULAM sensitively measures actual performance, and therefore can be a valuable addition to the mostly capacity-oriented tools currently used to evaluate upper-limb function. Proportion is preferred to the level of usage.

Key Words: Cerebrovascular accident; Monitoring, ambulatory; Rehabilitation; Upper extremity.

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Stroke is the main cause of long-term disability in Western society.1 The majority of stroke cases involve infarctions in the middle cerebral artery region and about 40% of stroke survivors have partial or total loss of function of the hemiplegic upper limb.2 The International Classification of Functioning, Disability and Health3 distinguishes 3 levels of human functioning: body functions and structures, activity, and participation. The activity level is divided into capacity (a person’s ability to execute a task or an action) and performance (what a person actually does in his/her current environment).

Although rehabilitation interventions can focus on capacity and/or performance, the eventual aim is to improve performance. Nevertheless, studies related to upper-limb functioning after stroke focus more on measurement of capacity than on measurement of performance. Although related to each other, performance and capacity have to be regarded as different constructs.4,5 The concept of learned nonuse is a good illustration of the difference between capacity and performance: people with learned nonuse do not involve their hemiplegic upper limb in daily activities to the full extent of their capacity to do so.6,7

In evaluating the efficacy of subacute and chronic stroke rehabilitation, upper-limb function should be assessed at the level of performance as well as capacity. Many objective evaluation tools have been developed to test upper-limb capacity after stroke.9,10 In contrast, upper-limb performance in daily life has not received much attention due to the lack of validated measurement tools. Observations in daily life could be used but they are time consuming and may interfere with the patient’s natural behavior.11 Other possible methods include self-reports and questionnaires, but these kinds of instruments are inherently subjective, focus on other aspects of daily functioning (eg, experienced problems), and not all relevant aspects of upper-limb functioning in daily life can be measured this way. From our previous experience, we know that performance measured with an objective monitoring device is generally different from performance measurements obtained with interviews or self-reports.14 To evaluate the actual level of performance, there is a need to measure performance objectively, unobtrusively and in detail, especially with the concept of learned non-use in mind.

Several monitoring devices have been developed for the objective measurement of upper-limb activity. In general, these portable devices are based on sensors that are sensitive to movement of body segments, and their data are stored—possibly after some pre-processing—in that device. Uswatte et al15,16 presented an upper-limb activity-monitoring device based on accelerometers (sensors that measure acceleration in one plane) that detect movement and nonmovement of the upper limb. Vega-Gonzales and Granat17 also developed a device to measure upper-limb activities using pressure transducers on wrist and shoulder. The Upper Limb Activity Monitor (ULAM), as developed by Schasfoort et al,18 is a similar instrument, but it adds the capability to detect body postures and body motions,19 as well as upper-limb movements. Using a combination of sensors on the wrist, trunk, and legs, the ULAM relates upper-limb usage to different body postures (eg, walking, sitting).20 The ULAM has been validated and applied in patients with complex regional pain syndrome type I (CRPS I)21 and is able to discriminate upper-limb usage of patients from that of healthy subjects. Furthermore, the ULAM also
measures outcomes other than those based on questionnaires.\textsuperscript{20} The ULAM has recently been adapted for use in stroke patients, because the original ULAM was developed specifically for the CRPS I population. At that time, we assumed that CRPS I has consequences mainly affecting the amount of movement, and that accelerometers seemed to be adequate for purposes of measurement. In contrast to the CRPS I group, we assumed that—in stroke subjects—the intensity of upper-limb movement would be too low (ie, due to very slow movement of the arm) for valid measurement of upper-limb usage. Additionally, the range and quality of elbow movement is (part of) the focus of many clinical tests and movement analyses and could be measured with electrogoniometers.\textsuperscript{21-23} In personal discussions, experts have confirmed that elbow movement during daily life could be an indicator for upper-limb usage; these experts were rehabilitation specialists, physical therapists, and occupational therapists of our university medical center and of the rehabilitation center that we collaborate with. All are experienced people in the field of stroke treatment. Based on these findings, we extended the ULAM by 1 electrogoniometer on each elbow, which produced the Stroke Upper Limb Activity Monitor (Stroke-ULAM). The Stroke-ULAM registers both electrogoniometric data and accelerometric data.

The aim of the current study was to examine the sensitivity of the Stroke-ULAM, that is, the ability of the Stroke-ULAM to discriminate between groups. Measurements were performed in a stroke population and in a healthy control group. It was assumed that, on the group level, subjects with more capacity will have more upper-limb activity in daily life. Therefore, the Stroke-ULAM should be able to detect differences in upper-limb usage between moderately recovered stroke patients, well-recovered stroke patients, and healthy subjects. Furthermore, the differences in sensitivity between measurements based on electrogoniometry versus accelerometry was examined, primarily to investigate the possibility of reducing the number of sensors used.

**METHODS**

**Participants**

A total of 22 subjects volunteered to participate in the study; 17 stroke patients (of whom 5 patients were hospitalized at the Rijndam Rehabilitation Center and had a partly structured activity pattern during the day as a consequence of therapy) and 5 healthy control subjects (table 1). We divided the stroke population into moderately recovered and well-recovered subgroups, based on the score on the upper-extremity part of the Fugl-Meyer Assessment (FMA).\textsuperscript{24} Subjects with scores of 45 or higher were defined as well-recovered; scores below 45 defined those subjects as moderately recovered. We set the cutoff point at 45 because, with higher scores, patients have full wrist functioning, whereas with lower scores, patients generally lack full wrist functioning. The inclusion criteria were: knowledge of the Dutch language and the ability to walk inside the house or rehabilitation center. Control subjects were excluded if they reported any limitation in daily life activities. Patients were excluded if they suffered from any other medical condition besides stroke that might interfere with upper-limb function. Patients in the chronic phase had all been inpatients of the Rehabilitation Centre Rijndam. Control subjects were from the authors’ social circles. The study was approved by the Medical Ethics Committee of the Erasmus University Medical Centre Rotterdam and all participants gave informed consent.

### Table 1: Characteristics of All Study Subjects

<table>
<thead>
<tr>
<th>Group</th>
<th>FMA Score ≤45</th>
<th>FMA Score &gt;45</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>8 (2) 10 (3) 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>56.1 ± 13.0 52.1 ± 13.9 43.0 ± 13.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women (n)</td>
<td>2 6 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time after onset (mo)</td>
<td>32 ± 21 33 ± 23 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemorrhagic stroke</td>
<td>4 3 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paresis of right side</td>
<td>2 6 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paresis of dominant upper limb</td>
<td>6 5 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMA score</td>
<td>20.8 ± 16.2 56.7 ± 3.0 NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic activity (% of 12h)*</td>
<td>8.2 ± 4.2 5.6 ± 2.8 9.5 ± 4.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting or standing (% of 12h)</td>
<td>54.5 ± 17.6 55.5 ± 11.0 59.6 ± 8.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE: Values are mean ± standard deviation (SD) or as otherwise indicated. Stroke patients are divided into subgroups: those with an FMA score 45 or above, and those with FMA score below 45. Abbreviations: FMA, Fugl-Meyer Assessment; NA, not applicable; SD, standard deviation.

*Dynamic activity is the percentage of the measurement period in which the subject was active (ie, 5.6% means 5.6% of 12 hours thus around 40 minutes of activities; eg, walking).

**Device and Apparatus**

The Stroke-ULAM is the ULAM as described previously,\textsuperscript{25} with an additional electrogoniometer\textsuperscript{a} for each elbow. The ULAM consists of 5 piezoresistive acceleration sensors\textsuperscript{b} (4 uniaxial, 1 biaxial; size, 1.0 × 1.0 × 0.5 cm), placed on the lateral side of the left and right thigh (the sensitive axis in sagittal plane while standing), on the sternum (sensitive axes in sagittal and longitudinal plane while standing), and on the upper limbs, just proximal to the wrist joint (sensitive axis perpendicular to the upper limb in sagittal direction in anatomic position). Two electrogoniometers were added to the ULAM configuration on both the left and right elbow to measure elbow angles (fig 1). The electrogoniometer consists of 2 parts: a distal end block was attached to the forearm and a proximal end block to the upper arm, both with the center axis of the end block parallel to the segment axis. All sensors were fixed on Rolian Kushionflex using double-sided tape and subsequently attached to the skin. Raw signals of both accelerometers and electrogoniometers were stored on a Vitaport II digital recorder\textsuperscript{c} that was carried in a bag around the waist, with a sample frequency of 32 Hz. After the measurement the raw data were downloaded onto a personal computer.

**Protocol**

The monitoring period was 24 hours except for the patients who received inpatient rehabilitation. In this latter group, the monitoring period was 12 hours for practical reasons, such as nursing care. The 12-hour period for inpatients started at 9:00 AM and lasted until 9:00 PM. The FMA was performed at the earliest 1 day in advance of the monitoring period. Subjects were instructed to continue their ordinary life, although swimming and taking a bath or shower were prohibited during the monitoring period. The research questions were not revealed to the subjects prior to the monitoring period to prevent adaptations of daily activity patterns.

**Data Analysis and Transformation**

Based on feature signals derived from the measured accelerometer signals of the legs and trunk, and by using activity-
specific settings in the analysis software and a minimal distance-based detection method, each second of the measurement 1 body posture or motion (e.g., sitting, standing, lying, walking, cycling) from a set of body postures and motions was automatically detected. Additionally, from each accelerometer signal of the upper limb the intensity was calculated by calculating the root mean square of the signal after band-pass filtering (finite impulse response, 0.3–16Hz) and downscaling the sample frequency to 1Hz. Details on the data analysis can be found in Bussmann and Schasfoort and colleagues.

The elbow angle signals derived from the electrogoniometers were filtered using a recursive fourth-order Butterworth low-pass filter with a cutoff frequency of 2Hz. After filtering these data, the derivative of these signals was calculated. Subsequently, this derivative was summed over periods of 1 second, and finally the data were rectified. To eliminate measurement bias and to use only relevant elbow angular movement, a threshold was added at the end of the analysis of 6.4° per second. This threshold was based on standardized measurements in which the electrogoniometers were moved over known angles and several threshold values were tested. The actual outcome measure for the electrogoniometers was total elbow movement per minute (flexion, extension). The measurements with a 24-hour duration were trimmed to the period from 9:00 AM to 9:00 PM to allow comparison with the data of the control subjects (also measured from 9:00 AM to 9:00 PM). The percentage that subjects were sitting or standing was calculated. For descriptive purposes, the accelerometric proportion is expressed as the intensity per minute (in g/min). The intensity depends on the variability of the raw acceleration signal around the mean value, that is, the higher the variability, the higher the intensity. The accelerometric proportion is calculated in the same way as for electrogoniometry. For the control subject the proportion is the level of usage of the nondominant upper limb divided by the level of usage of the dominant upper limb. The outcome measures were calculated over the time periods during the 12-hour measurement period that subjects were sitting or standing. For descriptive purposes, also the percentage was calculated that subjects performed body motions (e.g., walking, cycling, general movement, climbing stairs), and the percentage that subjects were sitting or standing (see table 1).

Statistical Analysis

We used the Mann-Whitney U test to compare the proportions and levels of usage between the control and patient group, and between the patient subgroups. The level of usage of the affected upper limb was compared with the unaffected upper limb with the Wilcoxon test. Nonparametric tests were preferred to parametric tests because of the relatively small numbers in each group. The Pearson correlation coefficient was used to compare the outcome measures of electrogoniometry and accelerometry. The level of significance was set at .05 in all tests.

RESULTS

Because 5 patients were measured in the rehabilitation center instead of at their home, the data analysis for these subjects was performed twice: once over the total measurement period and once excluding the therapy periods. Because no differences were found between these two analyses, the total measurement period of these 5 patients was included in our analysis.

Sensitivity of Electrogoniometry

The electrogoniometric level of usage of the affected (nondominant for control group) upper limb was significantly lower in the stroke patients compared with the control subjects \( (P<.01) \) (table 2). Furthermore, a difference was found between the level of usage of the affected upper limb of the well-recovered and moderately recovered patients, in which the moderately recovered patients had lower levels of usage \( (P<.01) \). Contrary to the level of usage of the affected upper limb, the level of usage of the unaffected upper limb showed no differences between stroke patients and control subjects \( (P=.76) \) or between the 2 subgroups \( (P=.82) \). In all subjects (as well as in all subgroups) the level of usage of the affected upper limb was significantly lower than the level of usage of the unaffected upper limb \( (P<.01) \) (see table 2).

The goniometric proportion was lower in the stroke group compared with the control group \( (P<.01) \) (fig 2, see table 2). That means that stroke patients used their affected upper limb less compared with their unaffected upper limb, than control subjects used their nondominant upper limb compared with their dominant upper limb. The proportion for moderately

specific outcome measures in the analysis software and a minimal distance-based detection method, each second of the measurement 1 body posture or motion (e.g., sitting, standing, lying, walking, cycling) from a set of body postures and motions was automatically detected. Additionally, from each accelerometer signal of the upper limb the intensity was calculated by calculating the root mean square of the signal after band-pass filtering (finite impulse response, 0.3–16Hz) and downscaling the sample frequency to 1Hz. Details on the data analysis can be found in Bussmann and Schasfoort and colleagues.

The elbow angle signals derived from the electrogoniometers were filtered using a recursive fourth-order Butterworth low-pass filter with a cutoff frequency of 2Hz. After filtering these data, the derivative of these signals was calculated. Subsequently, this derivative was summed over periods of 1 second, and finally the data were rectified. To eliminate measurement bias and to use only relevant elbow angular movement, a threshold was added at the end of the analysis of 6.4° per second. This threshold was based on standardized measurements in which the electrogoniometers were moved over known angles and several threshold values were tested. The actual outcome measure for the electrogoniometers was total elbow movement per minute (flexion, extension). The measurements with a 24-hour duration were trimmed to the period from 9:00 AM to 9:00 PM to allow comparison with the data of the control subjects (also measured from 9:00 AM to 9:00 PM). The percentage that subjects were sitting or standing was calculated. For descriptive purposes, the accelerometric proportion is expressed as the intensity per minute (in g/min). The intensity depends on the variability of the raw acceleration signal around the mean value, that is, the higher the variability, the higher the intensity. The accelerometric proportion is calculated in the same way as for electrogoniometry. For the control subject the proportion is the level of usage of the nondominant upper limb divided by the level of usage of the dominant upper limb. The outcome measures were calculated over the time periods during the 12-hour measurement period that subjects were sitting or standing. For descriptive purposes, also the percentage was calculated that subjects performed body motions (e.g., walking, cycling, general movement, climbing stairs), and the percentage that subjects were sitting or standing (see table 1).

Statistical Analysis

We used the Mann-Whitney U test to compare the proportions and levels of usage between the control and patient group, and between the patient subgroups. The level of usage of the affected upper limb was compared with the unaffected upper limb with the Wilcoxon test. Nonparametric tests were preferred to parametric tests because of the relatively small numbers in each group. The Pearson correlation coefficient was used to compare the outcome measures of electrogoniometry and accelerometry. The level of significance was set at .05 in all tests.

RESULTS

Because 5 patients were measured in the rehabilitation center instead of at their home, the data analysis for these subjects was performed twice: once over the total measurement period and once excluding the therapy periods. Because no differences were found between these two analyses, the total measurement period of these 5 patients was included in our analysis.

Sensitivity of Electrogoniometry

The electrogoniometric level of usage of the affected (nondominant for control group) upper limb was significantly lower in the stroke patients compared with the control subjects \( (P<.01) \) (table 2). Furthermore, a difference was found between the level of usage of the affected upper limb of the well-recovered and moderately recovered patients, in which the moderately recovered patients had lower levels of usage \( (P<.01) \). Contrary to the level of usage of the affected upper limb, the level of usage of the unaffected upper limb showed no differences between stroke patients and control subjects \( (P=.76) \) or between the 2 subgroups \( (P=.82) \). In all subjects (as well as in all subgroups) the level of usage of the affected upper limb was significantly lower than the level of usage of the unaffected upper limb \( (P<.01) \) (see table 2).

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a relative measure indicating the level of usage of the affected upper limb compared with the unaffected upper limb (proportion). These outcome measures were determined by both electrogoniometric and accelerometric data. The electrogoniometry level of usage (for both affected and unaffected upper limb) is the elbow joint movement of the upper limb per minute (in degrees per minute), whereas the proportion is the level of usage of the affected upper limb divided by the level of usage of the unaffected upper limb. The level of usage for accelerometry is expressed as the intensity per minute (in g/min). The intensity depends on the variability of the raw acceleration signal around the mean value, that is, the higher the variability, the higher the intensity. The accelerometric proportion is calculated in the same way as for electrogoniometry. For the control subject the proportion is the level of usage of the nondominant upper limb divided by the level of usage of the dominant upper limb. The outcome measures were calculated over the time periods during the 12-hour measurement period that subjects were sitting or standing. For descriptive purposes, also the percentage was calculated that subjects performed body motions (e.g., walking, cycling, general movement, climbing stairs), and the percentage that subjects were sitting or standing (see table 1).

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recovered patients was lower than the proportion for well-recovered patients ($P < .01$). The individual data on the outcome measures of all subjects (per group) are shown in figure 2.

**Sensitivity of Accelerometry**

The results for the accelerometry were comparable with those of the electrogoniometry (see Table 2). The accelerometric level of usage of the affected upper limb was lower for stroke patients compared with the control subjects ($P < .01$). Moderately recovered patients also had lower levels of usage compared with the well-recovered patients ($P < .01$). The level of usage of the affected upper limb differed (ie, was lower) from that of the unaffected upper limb in all patient groups, but not for the control group (see Table 2).

The accelerometers were also discriminative for the proportion between stroke patients and control subjects, and between moderately recovered and well-recovered stroke patients ($P < .01$, $P < .01$, respectively). Thus, accelerometry is sensitive to differentiate between the level of usage of the affected upper limb and unaffected upper limb as well as between the level of usage of the patients and control subjects.

**Comparison of Electrogoniometry and Accelerometry**

The proportions of electrogoniometry and accelerometry were discriminative between the proportions for patients and for control subjects, and all proportions of electrogoniometry and accelerometry correlated very well ($r = .938$). The proportions for electrogoniometry were on average lower than for accelerometry (36.73% ± 31.14% vs 51.47% ± 29.77%, $P < .01$). Additionally, the range of individual proportion values was larger for electrogoniometry than for accelerometry (2.23% – 97.09% vs 12.48% – 100.01%). Figure 2 shows the individual levels of usage and proportions for both the affected and unaffected upper limb as well as the proportion values (upper row shows data derived from electrogoniometry).

The results of this study show that the Stroke-ULAM outcome measures, based on electrogoniometry or accelerometry, are sensitive to differences between patients and controls, and

<table>
<thead>
<tr>
<th>Group</th>
<th>Nonaffected Level of Usage (deg/min)</th>
<th>Affected Level of Usage (g/min)</th>
<th>Proportion (%)</th>
<th>Level of Usage (g/min)</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>338.8 ± 43.4</td>
<td>286.2 ± 46.5</td>
<td>.04</td>
<td>286.2 ± 46.5</td>
<td>.04</td>
</tr>
<tr>
<td>Stroke</td>
<td>432.9 ± 212.0</td>
<td>97.8 ± 92.3</td>
<td>&lt;.01</td>
<td>22.6 ± 18.0</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>$P$</td>
<td>7.6</td>
<td>&lt;.01</td>
<td></td>
<td>2.0 ± 1.3</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>FMA score &lt;45</td>
<td>426.8 ± 238.7</td>
<td>37.9 ± 30.1</td>
<td>&lt;.01</td>
<td>8.4 ± 4.7</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>FMA score ≥45</td>
<td>438.4 ± 199.9</td>
<td>151.1 ± 97.2</td>
<td>.01</td>
<td>35.3 ± 15.5</td>
<td>.01</td>
</tr>
<tr>
<td>$P$</td>
<td>.82</td>
<td>&lt;.01</td>
<td></td>
<td>2.5 ± 0.9</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

**Table 2: Data on Level of Usage and Proportion per Group and Subgroup**

**NOTE.** Values are mean ± SD.
to differences between well-recovered and moderately recovered stroke patients. The proportions based on electrogoniometry of moderately recovered patients are lower than when based on accelerometry (see fig 2).

**DISCUSSION**

The results of the healthy subjects show proportions close to 100%; although we measured only 5 healthy subjects, these data are very similar to the results of 10 healthy subjects that participated in a study by Schasfoort et al who also found proportions close to 100%. Because moderately recovered patients have little to no control over the affected upper limb, it is unlikely that the affected upper limb is actually involved in daily life activities. As a consequence, tasks are performed with the unaffected upper limb, resulting in lower proportions (and lower levels of upper-limb usage for the affected upper limb). The low proportions are best seen in the proportions of the electrogoniometry: the unaffected elbow joint movement is used up to 45 times as much as the affected elbow joint movement. A possible explanation for the difference in proportions between both methods is the effect of rigid upper-limb movements. Electrogoniometers will not detect activity during rigid upper-limb movements because the elbow joint is not moved. Accelerometers do detect rigid upper-limb movements because upper-limb usage will cause acceleration and deceleration profiles. Rigid upper-limb movements are assumed to represent involuntary movements, for example related to trunk activity rather than isolated actions of the affected upper limb. Rigid upper-limb movements are reflected to a lesser extent by electrogoniometry than by accelerometry; therefore, electrogoniometry probably reflects a more realistic proportion of intentional upper-limb usage.

In this study, 2 outcome measures were used to indicate upper-limb usage: (1) an absolute measure for each upper limb (level of usage), and (2) a relative measure between the level of usage of the affected and unaffected upper limb (proportion). The proportion is the result of the level of usage of both upper limbs and shows the relative use of the affected upper limb in comparison with the unaffected upper limb. The proportion is thus dictated by the relative use of both upper limbs and not by the factual or absolute use (these are represented by the level of usage). This has several advantages over the level of usage outcome measures. First, proportion depends less on the actual amount of activity of a subject, which is not only influenced by a patient’s capacity but also by external factors such as the social environment and aid tools. It measures the contribution of the affected upper limb to activities of daily life of the upper limbs compared with the unaffected side, that is, compensation strategies of the unaffected upper limb will result in a lower contribution of the affected side and therefore in lower proportions. One of the main targets of rehabilitation therapies (eg, the constraint-induced movement therapy) is that the affected upper limb will be involved more during activities of daily life. The Stroke-ULAM can measure the increase in this involvement. Also, it is an easy-to-use outcome measure because it allows one to compare upper-limb usage of several subjects or different periods of time without concerns about different activity patterns. Overall, the results suggest that, within a clinical context, the proportion is the most appropriate outcome measure of upper-limb usage in daily living conditions. As mentioned above, the electrogoniometer proportion is theoretically preferred to the accelerometric proportion as the outcome measure, but accelerometers are smaller, cheaper, less vulnerable, and are already frequently used in activity monitoring studies. The technical vulnerability of the electrogoniometers was the major cause of the incomplete measurements and is a major source of concern for future measurements. A decision as to which sensor is to be preferred could not be made on the basis of this study and should be explored in future research.

In this study, we investigated the sensitivity of the Stroke-ULAM to measure the upper-limb usage during sitting and standing, but not during the whole measurement period. We assumed that an upper-limb activity monitor that is able to discriminate between body motions and postures would increase the sensitivity of upper-limb usage outcome measures. Uswatte et al also studied the use of accelerometers to measure upper-limb usage and also used proportion based on accelerometry as the main outcome measure. They used accelerometers on the wrist and were not able to distinguish between body movements and postures and that has some potential limitations. The most important limitation is that movement of the whole human body (eg, during walking) will be reflected in the signals from the upper limbs. As a consequence, such activities will be regarded as being upper-limb usage, whereas this is not the case. To explore the effect of walking and other body movements, we analyzed our proportion data over the whole measurement period for the stroke patients. The proportion for accelerometry increased from 39.2% ± 21.4% to 44.3% ± 21.5% (P < .001) and for electrogoniometry from 22.3% ± 18.0% to 24.7% ± 18.5% (P = .015). This increase was expected, although the difference in increase between accelerometry and electrogoniometry was expected to be larger, because movements of the upper limbs caused by walking (and most other body movements) would be reflected more in accelerometers than in electrogoniometry. This analysis nevertheless shows that body movements do increase the proportion, and without measuring body postures and motions, an increase in proportion (eg, after an intervention) could be the effect either of increased upper-limb usage or of increased body motion. These data support our assumption that it is important to measure upper-limb usage only during sitting and standing.

**Study Limitations**

The relatively small number of patients who participated in this study could have influenced the results, although the results do reflect the expectations. A larger number of measurements would probably strengthen the results rather than weaken them. Furthermore, the proportion may be partly determined by the dominance of the affected upper limb (be it the dominant or nondominant upper limb prior to stroke). Although this is an interesting topic, we do not analyze this issue. In most cases, the unaffected upper limb becomes the dominant side after stroke because ultimately it becomes the most capable upper limb.

**CONCLUSIONS**

The Stroke-ULAM is sensitive enough to detect differences between upper-limb usage of moderately recovered stroke patients, well-recovered stroke patients, and control subjects. The Stroke-ULAM can be a valuable addition to the mostly capacity-oriented tools currently used to evaluate upper-limb function during the rehabilitation process. The outcome measure can give the physicians or therapists valuable information about the improvement (or lack thereof) of the performance of the upper limbs.

**References**


Suppliers

b. Analog Devices model ADXL201; adapted by TEMEC Instruments, Spekhostraat 2, PO Box 3011, NL-6460 HA Kerkrade, The Netherlands.
c. TEMEC Instruments, Spekhostraat 2, PO Box 3011, NL-6460 HA Kerkrade, The Netherlands.

Objective: To determine relationships between muscle activity and propulsive impulse in hemiparetic walking.

Design: Cross-sectional.

Setting: Gait analysis laboratory.

Participants: Forty-nine poststroke patients with chronic hemiparesis, stratified into hemiparetic severity subgroups based on Brunnstrom stages of motor recovery, walking at their self-selected speed.

Interventions: Not applicable.

Main Outcome Measures: Percent of muscle activity in the paretic and nonparetic legs and net anteroposterior (AP) ground reaction force impulse (ie, the time integral of the AP ground reaction force) within 4 regions of the stance phase (first double support, first and second halves of single support, and second double support).

Results: Medial gastrocnemius and soleus muscle activity correlated positively with paretic propulsion in the second half of single support and double support across all subjects and subjects grouped by hemiparetic severity. Tibialis anterior correlated negatively with paretic propulsion during preswing across all subjects and for subjects with moderate and severe hemiparesis. Rectus femoris activity also correlated negatively with preswing propulsion for the severe group. Uniaxial knee extensor activity correlated only with increased paretic braking in the first double-support phase for the severe hemiparesis group. Nonparetic leg muscle activity correlated with propulsive impulses across all subjects, but not within the severe group exclusively.

Conclusions: Paretic propulsion is strongly associated with increased plantarflexor activity and also negatively associated with increased leg flexor activity, especially in the severe hemiparesis group. These results suggest that exaggerated flexor muscle activity may counteract the effects of the plantarflexors by offloading the leg and interfering with the limb’s ability to generate appropriate AP ground reaction forces. There is also evidence for specific relationships between paretic braking and nonparetic propulsive forces and changes in timing of muscle activation.

Key Words: Electromyography; Hemiparesis; Rehabilitation; Walking.

STROKE IS THE LEADING cause of long-term disability, with less than 50% of surviving stroke patients walking in the community.1 Rehabilitation strategies often focus on improving walking.2,3 with emphasis on achieving faster speeds because walking speed is strongly correlated with functional status4,5 and whether a patient will be homebound or functional in the community.1 Generating the appropriate anteroposterior (AP) ground reaction forces is essential for achieving a given walking speed because they are responsible for advancing the body center of mass (COM).

The body COM is accelerated by the propulsive (positive, anteriorly directed) AP ground reaction force and decelerated by the braking (negative, posteriorly directed) AP ground reaction force. During steady-state walking, the net braking and propulsive impulses (ie, the time integral of the negative and positive AP ground reaction forces, respectively) must be approximately equal in order to maintain a given walking speed (ie, no net acceleration because the external resistance provided by air is practically negligible). The AP ground reaction force patterns of healthy walkers are bilaterally symmetric, with a reversal from braking to propulsion near midstance, while hemiparetic ground reaction forces demonstrate substantial asymmetries between the 2 limbs with markedly different propulsion and braking patterns.6 In general, paretic leg braking is increased with an accompanying decrease in propulsion. Thus, to maintain a given walking speed, the nonparetic leg must compensate and generate a greater propulsive impulse.6-8 Bowden et al9 determined that subjects with severe hemiparesis had the most profound deficits in generating paretic propulsion; some of their subjects, however, achieved community-walking status even with these deficits. This could be accomplished by compensatory generation of propulsion by the nonparetic leg or by increased hip flexor activity in the paretic leg to help advance the leg in pre- and early swing. Conversely, the subjects with mild hemiparesis in Bowden’s study showed little asymmetry in propulsion generation. Subjects with moderate hemiparesis generated varying levels of propulsion with their paretic leg. Our goal in this study was to relate specific changes in muscle activity to altered bilateral ground reaction forces.

Previous modeling and simulation work suggests that altered muscle activity will have a predictable effect on ground reaction forces. Such work has shown that the plantarflexors are the primary muscles contributing to the propulsive impulse in the last half of stance during normal, unimpaired walking.10,11 Therefore a reduction in paretic propulsion could be the result of decreased force production of these muscles because of inadequate muscle activation.10,12 Additionally, flexor muscles, such as the rectus femoris, reduce ground reaction force during late stance.8 Thus, flexor activity could negatively correlate with paretic propulsion in late stance, as increased leg flexor activity would act to offload the leg and decrease propulsion.

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In addition to the decreases in propulsion, altered muscle activity could also directly contribute to an increased braking impulse in early stance. Poststroke patients who take longer paretic steps relative to the nonparetic leg demonstrate increased paretic braking during early stance after paretic foot-strike. The unarticulated knee extensor muscles (vasti) are among the primary contributors to the braking impulse in early stance in normal walking. Therefore, excessive or prolonged force generation of these muscles during early stance could substantially increase paretic braking. In addition, premature activation of muscles not normally active during early stance, such as the plantarflexors, may also generate increased braking.

To further understand and delineate the possible neuromotor mechanisms responsible for the disrupted ground reaction force patterns in hemiparetic populations, we analyzed the relationships between muscle electromyographic and ground reaction force data collected from the same 49 subjects with poststroke hemiparesis reported by Bowden et al. Because deficits in paretic propulsion vary across hemiparetic severity and self-selected walking speed, we examined these relationships across the entire population of subjects, as well as within subgroups based on hemiparetic severity. We hypothesized that: (1) plantarflexor activity would positively correlate with paretic propulsion in late stance; (2) unarticulated knee extensor activity would positively correlate with paretic braking in early stance; (3) flexor activity would negatively correlate with paretic propulsion in late stance; and (4) there would be relationships between altered muscle activity and propulsive impulses in the nonparetic leg resulting from compensatory patterns.

METHODS

Forty-nine subjects with chronic hemiparesis (42 men, 7 women; age, 62.7 ± 10.2y; time since stroke, 4.25 ± 3.67y; affected side: left, 25; right, 24) were recruited at the Rehabilitation Research and Development Center at the Palo Alto Department of Veterans Affairs Medical Center. The data presented here were collected (but not reported) as part of a study that investigated the relationships between gait characteristics and bone density in chronic stroke survivors. Inclusion criteria were: ability to walk 10m in 50 seconds or less without contact assistance, at least 12 months poststroke, and unilateral weakness. Subjects were excluded if they had more than 1 previous cerebrovascular incident, had any orthopedic or neurologic conditions in addition to the stroke, or if they were unable to provide informed consent. Written informed consent was obtained from all participants and the Stanford University Administrative Panel on Human Subjects in Medical Research approved the protocol.

We used Brunnstrom’s stages of recovery to determine hemiparetic severity for each subject because the study participants differed in ability to perform movements outside of extensor and flexor synergy patterns. Subjects were classified as severely impaired with a Brunnstrom stage 3 score (n = 19), moderately impaired with a Brunnstrom stage 4 or 5 score (n = 20), and mildly impaired with a Brunnstrom stage 6 score (n = 10). While the reliability of Brunnstrom stages has not been established independently, Brunnstrom stage determination closely follows the scoring of the valid and reliable lower-extremity Fugl-Meyer Assessment (FMA), specifically the items that measure the ability to move in and out of synergy. We categorized subjects based on Brunnstrom’s stages because it was strongly related to the AP propulsive force generating ability reported in our previous study. Nevertheless, we also measured lower-extremity FMA. Subjects were permitted to use their usual mobility aids (canes or ankle-foot orthoses) during testing. Self-selected walking speed and spatiotemporal parameters were measured as subjects walked on a 4.3-m long GAITRite portable walkway system. Additionally, electromyographic and ground reaction force (GRF) data were acquired as subjects walked at their self-selected speed along a 10-m walkway. Surface electromyographic activity was recorded from the tibialis anterior, medial gastrocnemius, soleus, rectus femoris, vastus lateralis, biceps femoris, semimembranosus, and gluteus medius from both legs. Electromyographic data were sampled at 2000Hz. Three-dimensional ground reaction forces were collected from both legs using 3 embedded force platforms and were sampled at 200Hz.

We collected a minimum of 4 and a maximum of 15 trials for each subject to ensure adequate foot contact on the forceplate. Self-selected walking speeds, step lengths, electromyographic activity, and ground reaction forces were determined by averaging multiple trials. We computed a step-length ratio (SLR) to assess the relative asymmetry between the paretic and nonparetic leg by dividing the paretic step length by the nonparetic step length.

Electromyographic Data Collection Protocol

The subject’s skin was cleaned with alcohol before the electrodes were applied and, when necessary, hair was shaved to ensure good contact. Electromyography electrodes were placed over the muscle belly so that the electrode nodes were in parallel with the muscle fibers. Silver-silver chloride electrodes (interelectrode distance, 22mm; diameter, 8mm) were secured with prepaper and tape. The electrodes provided 35 times preamplification and their input impedance was greater than 150MΩ at 100Hz. The common mode rejection ratio was 87dB at 60Hz. Amplifier gain was selectable from 500 to 10,000 times, with a bandwidth of 20 to 4000Hz.

Forceplate and Electromyographic Data Processing

Electromyographic and force data were processed using customized Matlab programs. The force data were filtered with a fourth-order zero-phase shift low-pass Butterworth filter with a cutoff frequency of 20Hz, and then normalized by bodyweight. Electromyographic data were filtered with a fourth-order high pass Butterworth filter at 40Hz. The data were debiased, rectified, and smoothed with a fourth-order zero-phase shift low-pass Butterworth filter with a cutoff frequency of 20Hz.

Data for the stance phase were analyzed as average values within 4 bins defined by stance phase events (determined from the average spatiotemporal data when contralateral forefoot measures were unavailable). The stance phase (defined as heel-strike to toe-off) was subdivided into bins for each leg to roughly correspond with braking (bin 1, bin 2) and propulsive (bin 3, bin 4) phases that occur in normal, unimpaired walking (fig 1). Bin 1 corresponded to double-limb support following foot strike, bin 2 corresponded to the first 50% of single-limb stance, bin 3 corresponded to the second 50% of single-limb stance, and bin 4 corresponded to double-limb support preswing (see fig 1).

The horizontal component of the impulse was calculated to quantify the amount of braking and propulsion produced by each leg. The net impulse was determined for each bin by computing the time integral of the AP ground reaction force within that bin. Negative bin impulses indicated net braking for the corresponding bin and positive bin impulses indicated net propulsion for the corresponding bin. The rectified electromyographic signal was summed within each bin (ie, the integrated electromyographic activity within that bin), and then the sum in each bin was divided by the total sum of all bins (ie, the total integrated electromyographic activity for that muscle over the gait cycle) to give the percentage of the rectified electromyographic signal that occurred within
Fig 1. Bins associated with the AP ground reaction forces of the paretic leg are illustrated (solid line). The gray shaded regions represent double-support phases. Abbreviations: NHS, nonparetic heel-strike; NTO, nonparetic toe-off; PHS, paretic heel-strike; PTO, paretic toe-off.

Statistical Analysis

We performed correlation analyses to identify relationships between the electromyographic activity and net AP ground reaction force impulses within each bin by computing Pearson correlation coefficients between the variables. Analyses were performed for the paretic and nonparetic legs across the entire group, then for subgroups based on hemiparetic severity (ie, those classified with severe, moderate, and mild hemiparesis). We used Minitab® and SPSS® for statistical analysis and set statistical significance at P less than .05. We did not correct for multiple comparisons because not all measures were independent (see Discussion).

RESULTS

Average lower-extremity FMA scores for the groups with severe, moderate, and mild hemiparesis, respectively, were 18 of 34, 23 of 34, and 27 of 34 of the total possible points (note that complete lower-extremity FMA scores were not available for 6 subjects). Fifteen subjects used their usual unilateral mobility aid(s) (cane and/or ankle-foot orthosis) during testing.

We analyzed a total of 659 AP ground reaction force records. There was an associated contralateral forceplate record for 436 records (66%). To perform the bin analysis, 2 contralateral events must be identified for each step (ie, contralateral toe-off defines the end on bin 1 and contralateral heel-strike defines the beginning of bin 4). Thus, 436 (33%) of the 1318 contralateral events required for bin analysis were defined from the forceplate data. When a contralateral event was not available from the forceplate data, we used the average percentage of the stance phase in which that event occurred during the GAITRite trials to define that event. As a check on this methodology, we compared the spatiotemporally derived assumed value with the actual forceplate-determined value for the 218 events in which the contralateral events were available. The average error in the bin definition was 2.4% ± 1.9% of the paretic gait cycle.

Walking speeds for the hemiparetic subjects ranged from 0.11 to 1.34 m/s. Based on their Brunnstrom stage, 10 subjects were classified as mild, 20 were classified as moderate, and 19 were classified as severely hemiparetic. Analysis of the SLR showed that 22 subjects walked nearly symmetrically (SLR range, 0.9–1.1), while 23 took longer paretic step lengths (SLR >1.1) and 4 took longer nonparetic step lengths (SLR <0.9). Ratios between 0.9 and 1.1 were considered nearly symmetrical because these values indicate an SLR that is ±10% of perfect symmetry. Healthy adults walk with an SLR of 1.0 ± 5%, so bounds of ±10% were considered to be conservative. Outside of these bounds subjects were considered clearly asymmetric.

Figures 2, 3, and 4 illustrate the AP ground reaction force, net bin impulse, and net bin electromyographic data for representative subjects classified as mild, moderate, and severe, respectively, who generated different amounts of paretic and nonparetic leg propulsion and braking. Mildly impaired subjects usually generated fairly symmetrical AP ground reaction force patterns with equivalent paretic and nonparetic braking and propulsive impulses (see fig 2) (compare AP Imp between nonparetic and paretic bins). Compared with less impaired subjects, however, more impaired subjects primarily generated braking with the paretic leg, which was accompanied by a decrease in braking and an increase in propulsion in the nonparetic leg (see figs 3, 4) (compare AP Imp between paretic and nonparetic bins). Also, some subjects had appropriate paretic plantarflexor activity duration and timing (see fig 2) (paretic column, medial gastrocnemius, and soleus, bin 2 and bin 3), while others experienced prolonged (see fig 3) (paretic column, medial gastrocnemius, and soleus bins 1–3) or premature (see fig 4) (paretic column, medial gastrocnemius, and soleus bin 1) activity in these muscles.

The results in the individual data were confirmed in the group analyses (tables 1, 2). In the results below, we present all correlations related to our 4 stated hypotheses.

Correlations Between Plantarflexor Activity and Paretic Propulsion in Late Stance

When all subjects were included in the analysis, there were significant positive correlations for the paretic medial gastrocnemius (P = .000) and soleus (P = .001) with the bin 3 impulse (see table 1). Not all correlations were found, however, when subjects were analyzed by hemiparetic severity. Soleus activity correlated positively with the net bin 4 impulse (P = .007) in subjects with mild hemiparesis, while medial gastrocnemius activity correlated positively with the bin 3 impulse (P = .024) in subjects with moderate hemiparesis (see table 2). In subjects with severe hemiparesis, the net bin 3 impulse correlated positively with the medial gastrocnemius (P = .029) and soleus (P = .014) activity, while the net bin 4 impulse correlated positively with medial gastrocnemius activity (P = .038). Thus, our hypothesis that...
plantarflexor activity would positively correlate with paretic propulsion in late stance was supported.

Correlations Between Uniarticular Knee Extensor Activity and Paretic Braking in Early Stance

As a group, there was no correlation between vastus lateralis activity and paretic braking in bins 1 or 2, indicating the hypothesis that uniarticular knee extensor activity would positively correlate with paretic braking in early stance was not supported. There was, however, a significant, negative correlation between the vastus lateralis and the paretic net bin 1 impulse ($P = .048$) for the severe group (see table 2), indicating vastus lateralis activity increased braking. There were no correlations found in the mild or moderate groups.

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**Fig 2.** AP ground reaction force, impulse, and bin electromyographic data for a representative subject classified as mildly hemiparetic with a self-selected walking speed of 1.26m/s. Net bin impulses are similar, as is the duration of stance spent on each leg. Vertical lines in the ground reaction force plot indicate bin boundaries. Note that bins 1 through 4 correspond to the stance phase only. The units for the AP impulse (AP Imp) and bin electromyography are percentage of body weight (BW) × seconds and percentage of total integrated electromyography, respectively. Abbreviations: BF, biceps femoris; GM, gluteus medius; MG, medial gastrocnemius; RF, rectus femoris; SM, semimembranosus; SO, soleus; TA, tibialis anterior; VL, vastus lateralis.
Correlations Between Flexor Activity and Paretic Propulsion in Late Stance

As a group, tibialis anterior activity correlated negatively with the bin 4 impulse \((P = .000)\) (see Table 1). There was no correlation with rectus femoris or semimembranosus activity. In subjects with mild hemiparesis, tibialis anterior activity correlated positively with the net bin 3 impulse \((P = .034)\), while for those subjects with moderate hemiparesis, a significant, negative correlation was found for the bin 4 impulse with tibialis anterior activity \((P = .028)\) (see Table 2). For subjects with severe hemiparesis, significant, negative correlations were found for the net bin 4 impulse with tibialis anterior \((P = .001)\) and rectus femoris \((P = .006)\) activity. Thus, the hypothesis that flexor activity would...
Correlate negatively with paretic propulsion in late stance was partially supported, most strongly in the severe hemiparesis group.

Correlations Between Nonparetic Muscle Activity and Propulsion

As a group, nonparetic leg medial gastrocnemius \((P = .002)\) and soleus \((P = .007)\) activity correlated positively with the bin 1 impulse, while semimembranosus activity correlated negatively with the bin 2 impulse \((P = .034)\) (see table 1). In the nonparetic leg, gluteus medius \((P = .015)\) and tibialis anterior \((P = .040)\) activity correlated positively with the bin 3 impulse in subjects with mild hemiparesis, while net bin 4 impulse correlated positively with vastus lateralis \((P = .005)\) and gluteus medius \((P = .043)\) activity (see table 2). For the moderate group, net bin 4 impulse correlated negatively with medial gastrocnemius activity \((P = .041)\), while there were no significant correlations for the nonparetic leg in the severe group. Thus, there is support for the hypothesis that there would be relationships between altered muscle activity and propulsive impulses in the nonparetic leg as a result of compensatory patterns.

Fig 4. AP ground reaction force, bin impulse, and bin electromyographic data for a subject classified as severely hemiparetic with a self-selected walking speed of .44m/s. Net bin impulses are asymmetrical, with the paretic leg primarily generating braking and the nonparetic leg primarily generating propulsion. Vertical lines in the ground reaction force plot indicate bin boundaries. Note that bins 1 through 4 correspond to the stance phase only. The units for the AP impulse (AP Imp) and bin electromyography are percentage of body weight \(\times\) seconds and percentage of total integrated electromyography, respectively. Abbreviations: see fig 2 legend.
walking speed for this population. Analysis of the subjects as
ically, we sought to identify relationships between muscle
ground reaction force patterns in hemiparetic walking. Specif-
ing of the neuromotor mechanisms responsible for disrupted
(seetable 1) and within groups of subjects with moderate and
propulsion when the analysis was performed across all subjects
with severe hemiparesis (see table 1). The only signifi-
cant correlations in bin 4 were a positive correlation with
paretic propulsion for soleus activity in subjects with mild
hemiparesis and a negative correlation between propulsion and
medial gastrocnemius activity in the most severe group. The
negative correlation for the medial gastrocnemius likely relates
to subjects with very prolonged preswing phases11 that
usually indicate poor propulsion. In that case, medial gastro-
nemius activity may be either weak, ineffective at overcoming
additional flexor activity, or perhaps is abnormally associated
with increased limb flexor recruitment. These results agree
with those of previous studies showing that plantarflexor ac-
tivity is important for attaining faster walking speeds in post-
stroke hemiparetic populations.10,20

Reduced paretic propulsion during preswing may result from
several factors, including decreased neural drive, muscle atro-
phy, and/or the position of the leg (eg, if the nonparetic leg
takes a short step, the plantarflexors may be put at a biome-
chanical disadvantage). The reduced paretic propulsion may also
be the result of exaggerated flexion at the ankle, knee, or hip
joint acting to offload the leg. Flexor activity at this time would
counteract the effects of the plantarflexors, thus interfering with
the limb’s ability to generate appropriate ground reaction
forces. Our results, particularly those from the group with
severe hemiparesis, support this suggestion. Negative correla-
tions for the paretic tibialis anterior with the bin 4 impulse were

<table>
<thead>
<tr>
<th>Bin Impulse</th>
<th>Muscle</th>
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<tr>
<td>Paretic bin 2 impulse</td>
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<td>−.310</td>
<td>.034</td>
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NOTE. Braking impulses are negative and usually dominate bins 1
and 2 while propulsive impulses are positive and usually dominate
bins 3 and 4. Thus, a negative correlation in bins 1 and 2 tended to
indicate that as muscle activity increased, braking increased, whereas
a negative correlation in bins 3 and 4 tended to indicate that
as muscle activity increased, propulsion decreased. Similarly, a neg-
ative correlation in bins 1 and 2 occurred when muscle activity
decreased while braking decreased, whereas a negative correlation
in bins 3 and 4 indicated that as muscle activity decreased, propulsion
increased.

Abbreviations: GM, gluteus medius; MG, medial gastrocnemius;
SM, semimembranosus; SO, soleus; TA, tibialis anterior.

DISCUSSION

Our overall aim in this study was to further our understand-
ing of the neuromotor mechanisms responsible for disrupted
ground reaction force patterns in hemiparetic walking. Specif-
ically, we sought to identify relationships between muscle
activity and AP ground reaction forces, inasmuch as reduced
paretic propulsion is directly related to achieving a functional
walking speed for this population.5 Analysis of the subjects as
1 group and then across groups separated by hemiparetic se-
verity revealed that activity of the plantarflexor muscles was
consistently associated with the generation of propulsion by the
paretic leg. Conversely, activity of flexor muscles during
preswing appeared to counteract plantarflexor activity in sub-
jects with severe hemiparesis, thus contributing to a reduced
paretic propulsive impulse. Additionally, inappropriate nonpa-
retic (eg, soleus, medial gastrocnemius, semimembranosus)
and paretic (eg, tibialis anterior) muscle activity might indi-
rectly contribute to increased paretic braking in early stance
and reduced paretic propulsion in preswing, respectively, by
altering gait mechanics. Because all of the muscles, as well as
the particulars of the walking mechanics, influence the impulse,
it should not be expected that any single correlation would be
particularly high. Thus, we did not correct for multiple com-
parisons in our analyses, which has the potential for increased
type I errors. We believe that this was appropriate because our
data analysis resulted in several significant correlations that
were nearly all consistent with our a priori hypotheses based on
our previous work that impaired propulsion is related to both
decreased plantarflexor and increased limb flexor activations.
Thus, the data are sufficient to meet our purpose in this study,
which was to provide evidence that changes in muscle timing
can be related to the propulsive force generation.

Based on previous analyses of normal unimpaired walk-
ning,3,9 we predicted that plantarflexor activity would correlate
positively with paretic propulsion in late stance. There was
strong evidence that paretic propulsion was associated with
increased plantarflexor activity in late single-limb stance (bin 3)
and less evidence in preswing (bin 4), because bin 3
medial gastrocnemius activity correlated positively with paretic
propulsion when the analysis was performed across all subjects
(see table 1) and within groups of subjects with moderate and

<table>
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<th>Bin Impulse</th>
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<td>.01</td>
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Abbreviations: see fig 2.
found across all subjects and for subjects with moderate and severe hemiparesis. These results suggest that tibialis anterior activity is associated with decreased paretic propulsion in general and particularly with more impaired subjects. Interestingly, mildly impaired subjects do not exhibit this trend, which is consistent with patterns experienced by healthy walkers. Furthermore, there were negative correlations for the rectus femoris and tibialis anterior with paretic impulse during preswing in the severe group, indicating these subjects may be experiencing inappropriate flexor synergies in the paretic leg as the nonparetic leg begins its extension phase. The paretic leg has been shown to be strongly influenced by the sensorimotor state on the nonparetic leg during a pedaling paradigm. This confounding affect of hip and ankle flexion may overload the leg such that inadequate hip extension leads to insufficient posterior foot placement during push-off. These findings agree with de Quervain et al who found that patients who walked slower were unable to perform movements outside of a mass synergy pattern, such as dorsiflexion of the ankle with extension of the hip.

We hypothesized that prolonged or increased uniarticular knee (vastus lateralis) extensor activity may contribute to increased paretic braking in early stance because these muscles are the primary contributors to the braking impulse during normal unimpaired walking. These studies have also shown that the uniarticular hip extensors also contribute significantly to braking in early stance. We were, however, only able to collect electromyography from the vastus lateralis in this study. As a group, subjects did not exhibit abnormal vastus lateralis activity in early stance, suggesting additional factors may be responsible for increased paretic braking (although the severe group did demonstrate this relationship for vastus lateralis—see below). Altered gait mechanics associated with increased paretic step length, rather than active paretic leg muscle force generation, may contribute to excessive braking experienced by the paretic leg during early stance. In general, although step length asymmetry is very heterogeneous between subjects, many hemiparetic subjects take longer paretic step lengths relative to the nonparetic leg and spend more time in nonparetic stance. The increased paretic step results in increased paretic braking, most likely the result of a larger braking vector associated with exaggerated anterior placement of the paretic foot relative to the COM at foot-strike. Analysis of the subjects grouped by hemiparetic severity revealed relationships unique to the severe group. We found evidence that abnormal muscle activity in early stance contributed to excessive paretic braking, whereas decreased paretic propulsion in preswing may result from altered mechanics resulting from exaggerated hip flexion. The vastus lateralis and biceps femoris correlated positively with paretic braking in bin 1, suggesting that increased activity of these muscles was associated with increased braking in early stance. The vastus lateralis extends the knee while the biceps femoris acts to extend the hip and knee at this time, therefore inappropriate force production or prolonged activation of these muscles would cause the paretic leg to exert a greater braking force. With regard to decreased paretic propulsion, the gluteus medius, which contributes to hip extension in late stance, correlated negatively with paretic propulsion during preswing, suggesting that reduced propulsion is related to an inability to achieve adequate hip extension during push-off.

Study Limitations

A potential limitation of this study is that the method we used does not consider the mechanics of foot placement with respect to the pelvis. In normal walking, the pelvis crosses over the foot near midstance, with the pelvis spending an equivalent amount of time posterior (braking) and anterior (propulsion) relative to the foot. Nonparetic medial gastrocnemius and soleus activity correlated negatively with nonparetic braking in bin 1, which suggests that the medial gastrocnemius and soleus are associated with increased nonparetic propulsion during the increased paretic preswing phase. In general, nonparetic steps are shorter, and the nonparetic leg may spend more time posterior to the pelvis rather than anterior to it, which would explain the increased nonparetic propulsive impulse. Unfortunately, the method we used does not account for pelvis-foot interactions to elucidate how mechanics play a role. Future work will be directed toward investigating the relationship between foot-pelvis mechanics with the generation of propulsion and braking.

Another potential limitation of this study is the number of muscles for which electromyographic data were collected. While most major muscle groups were analyzed, a significant omission was collection of data for the uniarticular hip flexors. This was because of the inaccessibility of these muscles with surface electrodes. In healthy subjects, hip flexors provide the second largest amount of work in walking, and in poststroke populations slow gait velocity has been linked to an inability to achieve adequate hip extension, which could be the result of inappropriate hip flexor activity. Although there was rectus femoris activity, it is not known whether it was synergistic with the uniarticular hip flexors or adductor longus.

An additional limitation is that, in many instances, (eg, whenever consecutive foot strikes were not captured on individual forceplates) some of the bins were defined based on average values determined in separate trials collected immediately prior to forceplate data collection. Identifying the 4 bins required us to determine the timing of 4 events (ipsilateral and contralateral heel-strike and toe-off). The force records always determined the 2 ipsilateral events. As reported in the results, forceplate records determined 33% of all contralateral events. Thus, the timing of bins could be defined directly from the data for 1754 (67%) of the 2636 events that were determined for the 659 force records. In addition, we believe that the error introduced by using the spatiotemporal data was minimal because our check revealed that the average change in the bin boundary by using the spatiotemporally defined bins was only 2.4% of the gait cycle. The use of spatiotemporally defined bins would have been substantially more problematic if we had failed to find significant correlations between electromyographic data and propulsive impulses. Because we were able to find support for most of our a priori hypotheses within the data, however, we believe that we have shown persuasively that impaired propulsion is related to both decreased plantarflexor and increased limb flexor activity.

CONCLUSIONS

This study presents a first step toward understanding the neuromotor mechanisms responsible for the disrupted AP ground reaction forces in hemiparetic walking. Future studies will incorporate kinematic variables and spatiotemporal parameters so that the complex relationships between the pelvis, foot placement, and muscle function can be further elucidated. Even so, electromyography can only provide limited insight into specific muscle force deficits resulting from the stroke. Future work will also incorporate modeling and simulation techniques to analyze individual muscle force contributions to the disrupted AP ground reaction force patterns. This will provide additional insight into motor impairments and muscle coordination deficits that limit walking performance and for designing effective therapy for people with poststroke hemiparesis.
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Suppliers

a. CIR Systems Inc, 60 Garlor Dr, Havertown, PA 19083.
b. Advanced Mechanical Technology Inc, 176 Waltham St, Watertown, MA 02472.
c. Bertec Corp, 6171 Huntley Rd, Ste J, Columbus, OH 43229.
d. Therapeutics Unlimited Inc, 2835 Friendship St, Iowa City, IA 52245.
e. The MathWorks Inc, 3 Apple Hill Dr, Natick, MA 01760.
f. Version 11.0; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.

g. Version 14; Minitab, Quality Plaza, 1829 Pine Hall Rd, State College, PA 16801-3008.
The Impact of Previous Strokes on the Rehabilitation of Elderly Patients Sustaining a Hip Fracture

Eliyahu H. Mizrahi, MD, Yehudit Fleissig, MD, Marina Arad, MD, Abraham Adunsky, MD


Objective: To evaluate whether a previous stroke may affect the functional outcome gain of elderly patients undergoing rehabilitation for a hip fracture.

Setting: A retrospective cohort study.

Participants: Patients with hip fractures (N=460) undergoing a standard rehabilitation course.

Interventions: Not applicable.

Main Outcome Measures: The functional outcome of previous stroke- and nonprevious stroke (NPS)-affected patients assessed by the FIM instrument at admission and discharge from the rehabilitation facility. Data were analyzed by t-tests, Pearson correlation, chi-square tests, and linear regression analysis.

Results: Both admission and discharge total FIM scores were significantly higher in NPS compared with previous stroke patients (63.53±19.89 vs 52.19±19.37, P<.001) and (84.23±24.93 vs 71.37±25.03, P=.001), respectively. However, changes in total FIM (20.70±11.68 vs 19.17±13.32, P=.38) and in motor FIM (19.84±10.63 vs 17.96±11.21, P=.23) at discharge were not statistically significant between the 2 groups. A linear regression analysis showed that a previous stroke was not predictive of a worse total FIM gain at discharge (P=.58).

Conclusions: NPS hip fracture elderly patients show higher admission and discharge FIM scores compared with previous stroke patients. Nevertheless, both groups achieve similar FIM gains during rehabilitation period. A previous stroke should not be considered as adversely affecting the rehabilitation of such patients.

Key Words: Hip fractures; Prognosis; Rehabilitation; Stroke; Treatment outcome.

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HIP FRACTURE IS A MAJOR cause of disability and hospitalization among the elderly population.1-4 There are more than 250,000 hip fractures in the United States each year, with about 90% occurring in patients over the age of 50 years.5 The prognosis for older adults who sustain a hip fracture is unfavorable; about 20% die in the year after hip fracture, and 25% of the survivors require treatment in long-term care facilities.6

Previous studies4-8 have shown that fractures are a common and serious complication after stroke. Stroke patients have up to a 4-fold increased risk of hip fracture.9 Among patients with hip fracture, the prevalence of previous stroke ranges between 3% and 19%.10,11 The increased incidence of fractures after stroke is caused by factors such as the accelerated osteoporosis resulting from immobilization, which begins early after stroke,12,13 and the high incidence of accidental falls in stroke patients.13-15 Clearly, stroke-associated deficits such as perceptual disturbances and impaired balance are common and increase the risk of falls.14

The most frequent fracture encountered among stroke patients (compared with the corresponding rate from the reference general population) is a hip fracture, which usually occurs late after stroke (median time between the onset of stroke and fracture 24 mo) and most often affects the paretic side.9 There have been very few studies7,16-19 addressing the functional outcome after a hip fracture of patients with a history of stroke, which have concluded with controversial results. Therefore, the aim of the study was to evaluate whether and to what extent a history of a previous stroke impacts functional outcomes among hip fracture patients in a rehabilitation program as reflected by the FIM instrument, controlling for the presence of different clinical variables characteristic of this population. The proposed study would assist in evaluating rehabilitation potential and disability risk and in avoiding unrealistic expectations of rehabilitation professionals, patients, and caregivers.

METHODS

Setting

This retrospective chart survey comprised consecutive admissions between 1999 and 2004. The basic hypothesis was that a previous stroke could adversely affect the functional outcome of hip fracture patients compared with nonprevious stroke (NPS) patients. Therefore, the design of the study served to evaluate the functional outcome gain achieved by patients during the postacute care rehabilitation period. This study was performed in an orthogeriatric ward. The nature and characteristics of this orthogeriatric facility have already been described in detail.20 Briefly, the ward admits elderly hip fracture patients directly from the emergency department. The ward integrates a multidisciplinary staff, and care is taken of patients’ surgical, medical, and rehabilitation needs in a single setting, from admission to discharge. The standard rehabilitation course is based on an interdisciplinary rehabilitative team approach, and staff members meet twice a week to evaluate the status of each patient. A treatment plan is established and monitored with the purpose of coordinating and integrating the various aspects of the staff activities (medical, nursing, physical and occupational therapy, social work, geriatric psychologist). These patients usually undergo a mean of 6
hours a week of physical and occupational therapy. The study was approved by the local institutional review board.

Participants

The analyses included consecutive elderly patients with a primary diagnosis of hip fracture. Patients were admitted to the ward after percutaneous (extra capsular) or subcapital (intra capsular) hip fracture. There was no preselection of patients on clinical grounds. After surgery, patients were considered eligible for rehabilitation once they were in a stable medical condition enabling active rehabilitation treatment. Exclusion criteria included patients admitted for elective hip surgery because of osteoarthritis and a rehabilitation period shorter than 7 days (based on the assumption that the extent of rehabilitation in such a short period is limited and could distort results). Other exclusion criteria included the presence of other acute disabilities (eg, multiple trauma), postoperative unstable (non–weight-bearing) hip fractures, conservative hip fracture treatment, medical conditions preventing active rehabilitation (eg, cardiac failure with New York Heart Association functional capacity stage III or IV, severe chronic lung disease necessitating a constant use of oxygen), and transfer to acute care departments because of complications and/or death while being hospitalized in the ward. These exclusion criteria enabled us to exclude patients with either medical or functional conditions that would limit rehabilitation potential in advance. The presence of ischemic heart disease (manifested as stable or unstable coronary syndrome), diabetes mellitus, hypertension, hyperlipidemia, and atrial fibrillation had been established by a routine admission medical history obtained by an interview and a complete physical examination. All patients were evaluated for their cognitive level by the Mini-Mental State Examination (MMSE)\(^2\); however, the cognitive score was not used as an inclusion or exclusion parameter.

Validation of Previous Stroke Patients

The presence of a previous stroke and NPS was determined after searching the hospital records indicating a discharge diagnosis of stroke (reviewed by the study physicians). To validate the diagnosis of a previous stroke, we studied all 51 medical charts of patients with a hip fracture and previous stroke. The documentation of a stroke by a computed tomography scan or magnetic resonance imaging was recorded in 50 patients, corresponding to a verification rate of 99%. A patient was considered eligible for possible validation as a stroke case whenever a medical record contained a discharge diagnosis code indicative of cerebrovascular disease (codes 430–438 of the International Classification of Diseases, Ninth Revision). In addition, a case was eligible as a previous stroke case if a review of the medical records revealed diagnostic brain imaging with cerebrovascular findings compatible with a stroke.

Functional Assessment

The prefracture functional level was assessed as completely independent, minimally or partially dependent, or completely dependent in activities of daily living and functional movement activities. Each patient was evaluated twice (within 1 wk of hip fracture surgery and at discharge) for level of disability by the FIM instrument. This tool is widely used to rate patients' performances on 13 motor and 5 cognitive items. Total FIM scores range between 18 (reflecting complete functional dependency) and 126 (reflecting complete functional independence). In addition, we have separately calculated the motor FIM, which is highly sensitive to detect functional improvements.\(^2\)

### Table 1: Characteristics of Patients by Previous Stroke Status

<table>
<thead>
<tr>
<th>Variable</th>
<th>Previous Stroke</th>
<th>No Previous Stroke</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>51</td>
<td>409</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>81.8±6.27</td>
<td>82.23±6.96</td>
<td>.70*</td>
</tr>
<tr>
<td>Sex (% male)</td>
<td>54.5</td>
<td>51.9</td>
<td>.004*</td>
</tr>
<tr>
<td>LOS (d)</td>
<td>31.37±12.31</td>
<td>31.29±15.11</td>
<td>.34*</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>25.5</td>
<td>15.2</td>
<td>.12*</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>47.1</td>
<td>49.1</td>
<td>.77*</td>
</tr>
<tr>
<td>Hyperlipidemia (%)</td>
<td>13.7</td>
<td>13</td>
<td>.87*</td>
</tr>
<tr>
<td>Ischemic heart disease (%)</td>
<td>27.5</td>
<td>19.3</td>
<td>.17*</td>
</tr>
<tr>
<td>MMSE score</td>
<td>17.85±8.89</td>
<td>19.64±8.38</td>
<td>.16*</td>
</tr>
<tr>
<td>Prefracture function (%)</td>
<td></td>
<td></td>
<td>.003*</td>
</tr>
<tr>
<td>Independent</td>
<td>35.3</td>
<td>53.5</td>
<td></td>
</tr>
<tr>
<td>Partially dependent</td>
<td>35.3</td>
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</tr>
<tr>
<td>Totally dependent</td>
<td>29.4</td>
<td>16.9</td>
<td></td>
</tr>
</tbody>
</table>

NOTE. Values are mean ± standard deviation (SD) or as indicated. *Student t test (2 tailed). †Chi-square test (2 tailed).

The motor FIM is composed of 13 motor items with scores ranging between 13 (minimum) and 91 (maximum).

Data Analysis

Comparisons between previous stroke and NPS patients were performed on a list of clinical and functional measures by using \(t\) tests for continuous variables and chi-square tests for dichotomous variables. Linear regression analysis was performed to study simultaneously the independent relations among ages, sex, previous stroke, MMSE score, and prefracture function with the outcome of FIM gain (the difference between total FIM at discharge and at admission) and total FIM at discharge. A \(P\) value of .05 or less was considered to be statistically significant. All statistical analyses were performed by using SPSS\(^*\) for Windows.

### RESULTS

A total number of 591 medical charts were evaluated, 131 of which were excluded based on the exclusion criteria as described in the Methods section. Most of these patients were excluded because of the inability to participate in a rehabilitation course because of conservative treatment or postoperative non–weight-bearing fractures. The data of 460 consecutive hip fracture patients aged 63 and older admitted during a 5-year period were available. These patients met the aforementioned criteria and were included in the final analyses. The mean age was 82.18±6.88 years (range, 63–97y), and the patients were mostly women (80.0%). Fifty-one (11.1%) patients suffered from a previous stroke. Exactly 51.5% of the patients were classified as fully independent before fracture onset. There were no statistically significant differences between previous stroke patients (\(n=51\)) and the remaining NPS patients (\(n=409\)) regarding age, length of stay (LOS), diabetes mellitus, hypertension, hyperlipidemia, ischemic heart disease, or MMSE. Sex (\(P=.004\)) and prefracture function (\(P=.003\)) emerged as the only statistically significant parameters differing between those who sustained a previous stroke and those who did not (table 1).

NPS patients presented to rehabilitation with significantly higher total (\(P<.001\)) and motor (\(P<.001\)) FIM scores compared with previous stroke patients (table 2). These patients were also discharged from the ward with better total (\(P=.001\)) and motor (\(P<.001\)) FIM scores. There was no statistically
significantly different in total \((P=.38)\) and motor \((P=.23)\) FIM gain achieved by NPS compared with previous stroke patients (see Table 2).

We performed a linear regression analysis to test for predictors of total FIM gain at hospital discharge. This showed (Table 3) that total FIM gain was inversely and independently associated with prefraction function (prefraction was coded such that lower coding scores indicate better function) \((\beta = -.26, P < .001)\). A higher MMSE score \((\beta = .214, P < .001)\) and female sex \((\beta = .089, P = .046)\) emerged as significantly predictive of higher total FIM gain scores at discharge. NPS and female sex \((\beta = .089, P = .046)\) emerged as significantly predictive of higher total FIM gain scores at discharge. NPS did not predict a better FIM gain at discharge \((\beta = .025, P = .58)\) (see Table 3).

The mean total hospital LOS was almost identical for both groups (31 days, including medical, surgical, and rehabilitation phases), which is close to reported British and American data.23,24

**DISCUSSION**

In this study, the prevalence of previous stroke among those with a hip fracture was 11.1%. Patients who suffered a previous stroke had a lower functional status at presentation and discharge, yet, during the rehabilitation period, they achieved functional gains similar to those obtained by NPS patients. A linear regression analysis showed that a previous stroke is an independent predictor for total FIM outcome at discharge \((\beta = -.075, P = .016)\) but not for FIM gain \((\beta = .025, P = .58)\). This is somewhat surprising because a better gain would be expected by most clinicians in the case of NPS patients. Possible explanations for the similar functional gains may reflect the fact that the 2 groups were similar with regard to age and cognitive state, both being of major importance when concerning functional gain. Additionally, the similar functional gains may reflect the possible absence of interrelation of FIM gain and previous comorbidities25,26 in the hip-fractured elderly.

**Table 2: Patients’ Functional Characteristics by Previous Stroke Status**

<table>
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<th>Variable</th>
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<th>No Previous Stroke</th>
<th>(P^*)</th>
</tr>
</thead>
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<tr>
<td>Admission total FIM</td>
<td>52.19 ± 19.37</td>
<td>63.53 ± 19.89</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Discharge total FIM</td>
<td>71.37 ± 25.03</td>
<td>84.23 ± 24.93</td>
<td>.001</td>
</tr>
<tr>
<td>Change in total FIM</td>
<td>19.17 ± 13.32</td>
<td>20.70 ± 11.68</td>
<td>.38</td>
</tr>
<tr>
<td>Change in total FIM per day</td>
<td>0.60 ± 0.39</td>
<td>0.78 ± 0.72</td>
<td>.08</td>
</tr>
<tr>
<td>Admission motor FIM</td>
<td>30.80 ± 11.83</td>
<td>38.78 ± 11.97</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Discharge motor FIM</td>
<td>48.76 ± 16.89</td>
<td>58.62 ± 17.80</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Change in motor FIM</td>
<td>17.96 ± 11.21</td>
<td>19.84 ± 10.63</td>
<td>.23</td>
</tr>
<tr>
<td>Change in motor FIM per day</td>
<td>0.57 ± 0.36</td>
<td>0.76 ± 0.67</td>
<td>.059</td>
</tr>
</tbody>
</table>

NOTE. Values are mean ± SD.
*Student t test (2 tailed).

This is also in accordance with other results on stroke patients27 showing that significant inverse interrelations exist between the magnitude of FIM gain scores and the number of previous strokes but not with the overall number of associated comorbidities.

Previous studies revealed conflicting conclusions on the association of stroke and hip fracture rehabilitation outcome. Lieberman et al16 have shown that successful rehabilitation of hip fracture patients is not independently associated with previous stroke, whereas others17 showed that a previous stroke did correlate with unsuccessful rehabilitation among such patients. These 2 studies have examined factors related to rehabilitation outcome and did not focus on previous stroke hip fracture patients. Poplingher and Pillar7 addressed specifically this group of patients and found no difference in outcome of functional recovery between the 2 groups. However, this last study lacked a standardized assessment scale of functional outcome and comprised a relatively small number of patients. Only 1 study19 has directly investigated the functional outcome of hip fracture patients with previous stroke and has used the Barthel Index rather than the FIM instrument. Also, possibly affected by selection bias, the study showed that the presence of neurologic impairment was associated with lower Barthel Index scores, but it did not affect the increase (gain) in Barthel Index due to a course of rehabilitation, which is similar to our results.

Our results support the observation that rehabilitation provides a substantive clinical benefit among those previously affected by stroke, indicating that this parameter should not be used as a criterion for inclusion, or rejection, of potential patients for rehabilitation. Inclusion of such patients, who may be a priori in a greater risk for inadequate recovery when deprived of rehabilitation, should be encouraged. Our data also support and extend results from previous studies28-30 showing that in elderly hip fracture patients, male sex but, more important, low cognitive and low prefracture functions remain the most important factors predicting adverse functional outcome at discharge.

The excessive LOS of our patients is of interest and is because primarily of local health system nonmedical issues such as arrangements with health maintenance organization; psychosocial, educational, and economic background; and the need for access to alternate levels of care, such as waiting periods for nursing facilities.

**Study Limitations**

Possible limitations of our study result from its retrospective nature. This did not enable us to study the actual FIM score status (or, alternatively, the severity of neurologic disability) of the patients just before they had suffered their hip fractures. In addition, no data are available on the time interval between stroke onset and fracture, the laterality of stroke with regard to laterality of hip fracture, or whether the patient had a single or
several strokes. Clearly, the relatively low number of previous stroke may have resulted in clearly sizes too small to detect differences and could also affect the statistical analysis. Another limitation of our study results from the fact that stroke history was determined retrospectively by review of charts and brain imaging, and, thus, subjects might have been misclassified with regard to this predictor variable. However, our study is advantageous because it involved a substantial number of patients with a hip fracture and FIM-measured rehabilitation gains.

CONCLUSIONS

Our findings suggest that despite lower admission and discharge total and motor FIM scores, elderly hip fracture patients with a previous stroke achieve similar functional gains through rehabilitation, when compared with hip fracture patients without a history of a previous stroke. These findings suggest that patients should not be withheld from rehabilitation based on concerns regarding previous stroke.

References


Supplier

a. Version 10.0.1; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.
**ORIGINAL ARTICLE**

**Community-Dwelling Stroke Survivors: Function Is Not the Whole Story With Quality of Life**

Jennifer H. White, BAppSc, Megan K. Alston, BAppSc, Jodie L. Marquez, BAppSc, Anne L. Sweetapple, BAppSc, Michael R. Pollack, FAFRM (RACP), John Attia, PhD, Christopher R. Levi, FRACP, Jonathan Sturm, PhD, Scott Whyte, PhD


**Objective:** To compare function and quality of life in community-dwelling stroke survivors at 1, 3, and 5 years after stroke.

**Design:** A community-based, cross-sectional study of 3 retrospective cohorts.

**Setting:** Community-dwelling stroke survivors in Australia.

**Participants:** The 3 cohorts comprised 30 participants each at 1, 3, and 5 years poststroke discharge from a tertiary referral hospital.

**Interventions:** Not applicable.

**Main Outcome Measures:** Stroke severity, comorbidity, medications used, and demographic information were recorded. Poststroke function was assessed using the Modified Rankin Scale, Mini-Mental State Examination, Stroke Impact Scale, and Multidimensional Scale of Perceived Social Support.

**Results:** This cross-sectional study provides insights into trends in stroke survivors over time. A high proportion of stroke survivors use community services, even those who are independent with activities of daily living. Although there was little attrition in medication use over time except for warfarin, there was from a baseline of suboptimal compliance and adherence with stroke preventive therapies. Stroke survivors report high levels of perceived social support; however, emotional well-being was low overall. The data suggest that those who are independent at 1 year tend to remain independent, although this was an extrapolation from serial cross-sections and needs to be explored in a longitudinal study.

**Conclusions:** Stroke survivors’ function does not change significantly over time. A high proportion of survivors require community services. The development of needs-related effective long-term service delivery models is required.

**METHODS**

**Study Population**

Newcastle is a typical coastal city situated within the Hunter Region on the coast of New South Wales, Australia; the Hunter population is representative of the general Australian population except in the area of ethnicity. The Hunter has a population of 541,744 and hospital-based stroke services are provided by acute stroke units and stroke rehabilitation units in 2 tertiary referral centers.

**Sampling Frame and Case Ascertainment**

The study assembled 3 retrospective cohorts, each comprising 30 participants: (1) cohort 1: people who had had a stroke...
1 year ago; (2) cohort 3: people who had had a stroke 3 years ago; and (3) cohort 5: people who had had a stroke 5 years ago.

We identified stroke survivors from hospital records and discharges from the John Hunter Hospital (JHH), the largest tertiary referral hospital and the main hospital servicing Hunter residents. The cases were defined by: admission to JHH, alive at discharge, history, and examination consistent with stroke as determined by a stroke physician. Brain imaging was available in all cases. Patients with hemorrhagic stroke were included. Mortality status was determined by linkage of data with data from the New South Wales Registry of Births, Deaths and Marriages. Starting from health records in January, consecutive participants were contacted via mail-out, until 30 participants were recruited in each cohort. This number of participants was essentially selected to fit within the budget and time frame of existing resources, and was meant as a pilot study. Exclusion criteria consisted of severe cognitive impairment (Mini-Mental State Examination [MMSE] score \(\leq 16\)), inability to give informed consent, and current residence in a nursing home, that is, only community-dwelling stroke survivors (including hostels) were contacted. Consenting participants were subsequently phoned by the researchers to arrange an interview time with an experienced allied health clinician. All participants opted to be interviewed in their own homes. Interviews were undertaken within 3 months of consent. If dysphasia was present then the participant was interviewed by the speech pathologist on the research team, and proxy assessments were used where appropriate.

### Baseline Data

We collected baseline data from hospital records. This included date of stroke, comorbidities, and admission and discharge medications. Ischemic stroke subtype was classified using the Oxfordshire Community Stroke Project (OCSP) classification \(^17,18\) into the following syndromes: total anterior circulation infarction (TACI), partial anterior circulation infarction (PACI), posterior circulation infarction (POCI), and lacunar circulation infarction (LACI). This classification system identifies patients with potentially different outcomes (prognosis) as well as assisting with identification and prioritization of appropriate therapies. \(^18\)

### Instruments

The study team assessed consenting participants on physical and psychosocial functioning using a range of validated measures. The OCSP is a widely used system established to assist in defining ischemic stroke. Disability was assessed using the Modified Rankin Scale (MRS), which has been widely used within international stroke research to assess disability after stroke. \(^19,20\) Cognition was assessed using the MMSE, \(^10\) a widely used and well validated tool that can be used to systematically assess mental status. It involves an 11-question measure that tests 5 areas of cognitive function (orientation, registration, attention and calculation, recall, language) and is scored out of 30.

Health outcomes specific to a stroke population were assessed using the Stroke Impact Scale (SIS 3.0). \(^21\) The SIS provides a comprehensive measure of function and HRQOL based on self-report in the domains of strength, memory, emotion, communication, ADLs, mobility, and handicap. The SIS has undergone extensive psychometric testing \(^21\).

Social support was measured using the Multidimensional Scale of Perceived Social Support (MSPSS), \(^22\) which is a brief instrument used for assessing the hierarchical structure of perceived social support. It has been well validated in a range of populations, including cardiovascular disease populations and the elderly. \(^23,24\)

Patient medications at baseline were obtained from hospital records and medications at follow-up were obtained by self-report.

Participants were asked if and how often they had accessed support services for assistance over the past year. Assistance could be provided either formally by an established organization or informally by a member of the community.

### Statistical Analysis

We compared the characteristics of participants and nonrespondents by using the parametric \(t\) test for continuous variables and the Fisher exact test for categorical variables. Statistical analyses were undertaken using SPSS. \(^5\) The MRS was categorized as independent (MRS score \(\leq 2\)) or dependent (MRS score between \(\geq 3\) and \(\leq 5\)). The categorization of the MRS follows a similar method employed by Sulter et al. \(^20\) Descriptive analysis was undertaken for all other results.

Statistical analysis of the SIS 3.0 was limited by the small sample size and the fact that analysis typically involves a comparison of scores before and after any given intervention. \(^25\) Being a stroke-specific measure, it was difficult to judge whether the MSPSS score was high or low compared with other chronic diseases. To create this clinical context, the physical component of the SIS score was converted to Short-Form 36-Item Health Survey (SF-36) scores. This method of conversion was based on a previous study whereby the SIS 3.0 was converted to an SIS 16 score, \(^26\) and then to an SF-36 physical function score. \(^27\) The SF-36 \(^28\) is widely used as a generic HRQOL instrument assessing physical, psychologic, and social functions. \(^29\) Although this method has the drawback of only using the functional activity domain rather than the entire set of variables in the SIS, it was the only method of placing the SIS scores in some clinical context (appendix 1).

### Ethics

Ethics committee approval for this project was obtained from Hunter New England Human Ethics Research Committee and all patients enrolled in the study gave written, informed consent.

### RESULTS

A total of 336 stroke patients discharged from the JHH were assessed and 139 met the inclusion criteria. Forty-one declined to participate and a further 7 were nonrespondents. Informed consent was obtained for 91 cases (65% consent rate). An inclusion matrix is outlined in figure 1.

There was no statistical difference in sex, age, or stroke subtype between participants and nonrespondents (data not shown).

Table 1 compares the key demographics of participants between each cohort. There was no statistical difference for sex, presence of a caregiver, living situation, marital status, first ever stroke, ethnicity, and dysphasia. The statistical difference for employment status \((P=0.036)\) is significant but should be interpreted with caution in the setting of multiple comparisons. The majority of participants showed minimal cognitive impairments, scoring between 24 and 30 on the MMSE (83%, 90%, 93%, respectively).

### Comorbidities

Baseline comorbidity data were collected from the participants’ medical file and follow-up comorbidity data were based on self-report. At baseline, 90% of participants had 1 or more comorbidity.
risk factors for stroke (97%, 97%, and 87% for cohorts 1, 3, and 5, respectively) and 63% had 2 or more risk factors for stroke (73%, 58%, 57%, respectively). A comparison between cohorts 1, 3, and 5 indicated that hypertension (70%, 57%, 47%, respectively), cardiac conditions (57%, 33%, 37%, respectively), and hypercholesterolemia (33%, 20%, 33%, respectively) were the most common risk factor comorbidities at baseline.

**Medications**

Medication profile was similar across the cohorts with the most prevalent medications being antiplatelet medication (73%, 63%, 58%, respectively) and antihypertensive medication (80%, 80%, 61%, respectively) at discharge. There was a consistent proportion of participants being discharged on warfarin across the 3 cohorts (30%, 37%, 39%, respectively). Cohort 5 had the highest rate of attrition from warfarin following discharge (33%, 10%, 11%, respectively). More participants were discharged on antiplatelet medication than on warfarin.

At discharge the percentage of participants taking lipid-lowering medication was 50%, 27%, and 32% for each respective cohort. This had increased to 53%, 53%, and 61%, respectively, for each cohort at follow-up. Antidepressant usage across the cohorts at discharge was 10%, 7%, and 13%, respectively, and at follow-up 10%, 20%, and 10%, respectively.

**Service Utilization**

Sixty percent of cohort 1, who were 1 year poststroke, had accessed at least 1 service in the year since their stroke. Service utilization was marginally lower for cohorts 3 (45%) and 5 (50%).

The most frequently accessed services across all cohorts were housework (21%), gardening and mowing (24%), and meals on wheels (19%). Therapy services were less frequently accessed than maintenance type or respite services. Similar numbers of participants in cohorts 1, 3, and 5 were accessing allied health services (15%, 13%, 14%, respectively). The most frequently accessed therapy services across all cohorts were physiotherapy (15%) and podiatry (21%). In each cohort there were 1 to 2 participants using a surprisingly high number of community services (8 to 9) which may skew results (data not shown).

**Participant Function**

Dependency was determined by the MRS. Sixty-four of the 91 participants were independent at the time of interview (70%). This trend was consistent across the 3 cohorts (63%, 74%, 73%, respectively).

TACI participants were the least independent (40%) with LACI (92%) participants and PACI (63%) participants being the most independent.

Use of SIS 3.0 provided more detailed information regarding the functional levels of the participants. The combined functioning of the cohorts as determined by the SIS is outlined in figure 2. Results showed that the participants were scoring lowest in the emotion domain. In each cohort there was a subset of participants doing significantly worse than other participants (data not shown). The next lowest scoring domains were strength and mobility.
To obtain some clinical context for what the SIS scores meant, the SIS scores of physical function (SIS 16) results were “converted” to SF-36 scores, in order to compare these with normative data in the Australian population.29 The results showed that, at least from a physical function viewpoint, both men and women in our study sample were functioning at lower levels than the average Australian of the same age and sex and within the lowest 50th percentile (fig 3).29

Multidimensional Scale of Perceived Social Support

The MSPSS measured the perceived sources of social support received by the participants. High levels of perceived social support were maintained across the 3 cohorts (82%, 79%, 70%, respectively). Highest levels of perceived support were received from family (75%, 80%, 81%, respectively) and significant others (77%, 83%, 86%, respectively). This is shown in figure 4.

DISCUSSION

This study has generated unique data on the HRQOL outcome of Australian stroke survivors and provides baseline data for ongoing measurement of outcomes following stroke in this region.

A major strength of the study lies in the ability to obtain details of the participants’ current levels of stroke-specific functioning using a wide range of reliable outcome measures. The demographics of the 3 cohorts were similar, therefore, assisting comparison of poststroke functioning over time. Due to the study design, the cohorts are likely to be most representative of community-dwelling stroke survivors with relatively milder levels of impairment. An objective sampling frame was used which allowed for the inclusion of participants with dysphasia, who are often excluded from research studies. The proportion of dysphasic patients in this study was consistent with the prevalence of dysphasia in stroke survivors generally (between 21% and 38% in the broader population).30

The hypothesized decline in function over time between the 3 time cohorts was not seen. Instead, results suggest that those who are alive and managing in the community at 1 year poststroke are likely to remain so at 3 and 5 years, that is, the group of stroke survivors included in this study remain relatively stable following discharge. In favor of this interpretation is the fact that, although the proportion deceased at 1, 3, and 5 years increases, as expected in an aging population (20%, 31%, 34%, respectively), the proportion in nursing homes remains the same (14%, 15%, 12%, respectively). However, it is problematic to extrapolate across multiple cross-sectional measures, and given the number of stroke survivors who declined to participate, we also cannot exclude sampling bias; that is, the survivors with poorer function do not participate.

Table 1: Key Demographic Characteristics of Participants (N=91)

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<th>Cohort 5 (n=30)</th>
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<td></td>
</tr>
<tr>
<td>ICH</td>
<td>0 (0)</td>
<td>3 (10)</td>
<td>3 (10)</td>
<td></td>
</tr>
<tr>
<td>MMSE score between 24–30</td>
<td>83</td>
<td>90</td>
<td>93</td>
<td>.085</td>
</tr>
</tbody>
</table>

NOTE. Values are n (%) or n.
Abbreviations: ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage.
There was appropriate prescription of preventive medication during acute hospital admission; in each cohort there was almost 100% prescription of either warfarin or antiplatelet during the acute admission, which is integral in stroke prevention. Warfarin adherence showed the greatest range of attrition; however, rates at follow-up (33%, 10%, 11%, respectively) were still in keeping with the national figure of 10.3%. Statin adherence showed some gain following hospital discharge (50%, 27%, 32%, respectively), which is better than the national average of 21%. Increased use of lipid lowering medication at follow-up is consistent with recent, evidence-based trends regarding the use of cholesterol-lowering agents for protective benefits. This suggests that stroke survivors are not readily being pre-scribed antidepressants during acute admission or in the community. This is consistent with evidence suggesting that depression is under-recognized in the stroke population. It may also result from the lack of clear evidence supporting the benefit of prescribing antidepressants after stroke.

Due to the small sample size, it was difficult to identify trends with regard to stroke-specific function as measured by the SIS 3.0, because large standard deviations made it difficult to compare between cohorts. However, when numbers were combined, the emotion domain had the lowest score, suggesting that low mood was sustained over time. This result is supported by a qualitative study undertaken with a subgroup of participants from each cohort. We initially chose the SIS because it was a stroke specific scale; however, the disease specificity of this measure made it difficult to put the scores in the context of other chronic diseases. For this reason, the SIS score was “converted” to an SF-36 “equivalent.” Although it was only possible for the physical component of the score, this conversion enabled some comparison with the Australian norms and indicated that even on the physical function aspect, which was one of the highest scoring domains on the SIS, stroke survivors were on a par with the lowest half of the general population.

Information gained with regard to service utilization provides novel, descriptive local data. Service utilization across all cohorts was consistent; that is, service use did not appear to increase with time. More surprising was that, despite the high levels of independence in this community-dwelling sample, over 50% of stroke survivors still require support with instrumental ADLs. This was surprising given that one would expect that rationing of available services, lack of stroke survivor knowledge about available services, or refusal of some stroke survivors to accept services would underestimate this proportion. However, this is similar to data from the Australian Institute of Health and Welfare stating that approximately 50% of stroke survivors require assistance with health care, household chores, home maintenance, and mobility. A further 1 in 4 require assistance with self-care, cognitive and emotional tasks, and meal preparation. Ongoing therapy has the potential to address the difficulties highlighted by this study in the areas of emotion and physical functioning.

Future research would be of benefit to elucidate this issue by comparing available services, client knowledge of available services, clients’ perception of their service needs, and their willingness to engage with services and assistance. It would also be beneficial in future research to separate formal and informal service and assistance to help define gaps in formal services in the community.

The high levels of perceived social support, as measured by the MSPSS across all groups, was also surprising. From clin-
ical experience it was expected that stroke survivors would experience reduced social support over time. Future research would benefit from the use of an outcome measure that reflects both the quantity and the quality of social support. This may help to further define any changes that occur in social support over time. If one or a very limited number of people are providing support this may also contribute to increased carer burden and strain.

**Study Limitations**

There were several study limitations as indicated above. The use of a retrospective, cross-sectional cohort design limits the ability to make interpretations regarding changes in poststroke functioning over time. Sampling bias was present in that the study excluded people in residential care facilities; this may have not included more severe strokes with higher levels of impairment. People who have had another stroke or who died in the community have also not been captured in this study. Therefore this sample source will not entirely be representative of the wider stroke population. This limits knowledge about the true proportion of patients who improve or deteriorate.

**CONCLUSIONS**

Overall the results of this study suggest that the functioning of stroke survivors following discharge to the community does not change significantly over time. Data highlights that stroke survivors continue to use community services, even in a group that is community-dwelling and independent, and stroke survivors continue to use medications with little attrition, except for warfarin, although there is room to increase compliance and adherence. Importantly, stroke survivors report high levels of perceived social support although emotional well-being remains a significant concern.

These data support the need for a more extensive prospective study with a view to further exploration of changes in physical and psychosocial changes over time.

**APPENDIX 1: CONVERSION OF SIS 16 SCORES TO AN SF-36 PHYSICAL FUNCTIONING SCORE**

SF-36 physical functioning $= 1.01(\text{SIS 16}) - 29$.

**References**


Supplier
a. Version 13.0; SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.

Objective: To improve the reproducibility of testing hip abduction and adduction using an isokinetic dynamometer by a novel testing protocol.

Design: Test-retest design.

Setting: Biodynamics laboratory.

Participants: Fifteen healthy subjects (9 men, 6 women; age, 22.4±0.5y) were recruited.

Interventions: Two setups were compared: the first according to manufacturer’s guidelines (setup A) and the second a novel setup incorporating pelvic fixation (setup B). Setups A and B were performed in a random order. Both setups included the same battery of isokinetic (30°/s, 60°/s) and isometric tests, and were repeated 1 week later.

Main Outcome Measures: The peak torque for each abduction and adduction exercise was noted and pelvic motion during testing was recorded.

Results: Setup B significantly (P<.05) reduced transverse pelvic rotation by between 7.5° and 8.0° dependent on test speed. Mean differences for reproducibility of peak torque, ranged from 0.8 to 11.7Nm. The coefficients of repeatability of both setups were similar, ranging from 21.4 to 56.3Nm across isokinetic exercises. A similar observation was noted for isometric exercises, with the differences between the coefficients of repeatability ranging from 18.6 to 40.0Nm.

Conclusions: Reducing pelvic rotation does not enhance reproducibility of the system and is not related to torque production. Further research is required to determine the optimal test setup.

Key Words: Exercise test; Hip; Muscles; Pelvis; Rehabilitation.

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ORIGINAL ARTICLE

Assessing Hip Abduction and Adduction Strength: Can Greater Segmental Fixation Enhance the Reproducibility?

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doi:10.1016/j.apmr.2007.05.017

rotation of the pelvis away from the anatomic position may facilitate the recruitment of different muscle groups for the same action, which may contribute toward inaccurate readings.

The primary aim of this study was to develop a suitable methodology to decrease pelvic rotational movement during abduction and adduction testing on the isokinetic dynamometer. The secondary aim was to see whether the setup that reduced pelvic rotation enhanced the reproducibility and thus reliability of this form of testing. This would be done by comparisons with the setup suggested in the manufacturer’s instructions.

METHODS

Study Population

We recruited 15 volunteers into the study and obtained written informed consent. The age, height, weight, and sex of each subject was noted. Exclusion criteria included previous or current history of hip pain or injury or current engagement in a weight altering diet. All subjects were instructed not to undertake vigorous exercise in the hour preceding their testing, in an attempt to prevent any confounding of the data as a result of fatigue.

Apparatus Setup

We used the Cybex Norm Isokinetic Dynamometer System for all testing. It was driven by Human Assessment Computer (HUMAC) for Windows. Each subject was asked to wear loose fitting clothing. A belt was secured at the level of the anterior superior iliac spine (ASIS). In the midline, at the back of the belt, a plastic ruler was attached which projected vertically upward when the subject was lying on their side (adjusted when lying on their left or right side) (fig 1). During testing, once the subject was in place, a video camera was positioned at the level of their head, approximately 1m away, in line with the subject’s spine. The surface location of the head of the femur was found at the halfway point of a line joining the greater trochanter and the pubic tubercle. The height of the dynamometer, the length of the hip knee adapter, and the chair fore-aft distances were adjusted accordingly to ensure that the rotation of the head of the femur was at the same level as the dynamometer pivot and thus standardization was maintained. The full range of motion (ROM) of each limb was recorded. These dimensions were maintained for each side and each setup for both sessions.

Setup A: Cybex

Subjects were positioned in accordance with the manufacturer’s instructions. A hip and knee adapter was applied at the level of the quadriceps tendon, immediately superior to the patella on the testing side. A self-adhesive (Velcro) strap was applied over the resting thigh at the same level. This was fastened to the handle bars on each side of the Cybex seat (fig 2A). Testing was performed in this position with all subjects holding the handrail as shown.

Setup B: Modified Cybex

We developed this setup to minimize transverse pelvic rotation. A total of 4 straps were attached to the subject: ankle, thigh, abdomen, and chest (fig 2B). The hip and knee adapter was applied as detailed in setup A. The thigh strap was looped around the thigh and back onto the handle bar. A backboard of wood with sponge cushioning was attached to the backrest of the Cybex seat by the means of vises clamped to the side rails. The chest strap was looped around the subject, under the axillae and through slots in the wood piece, securing them to the backboard. The strap around the abdomen was fastened superior to the level of the ASIS, clear of the belt used for measuring pelvic rotation. This was looped around the subject and secured ventrally through the side rail. We found by visual observation that this setup reduced the range of transverse pelvic motion during testing.

Exercise Protocol

The exercises undertaken were identical for both setups (protocol details summarized in fig 3). Subjects were randomized to the setup they would undertake first. Both sides were tested sequentially with 1 setup and subjects were then allowed a 10-minute rest period while preparations were made for the other setup. We chose arbitrarily to test the right side first for each setup. The exercises involved both concentric isokinetic and isometric contractions. Isometric exercises were performed in the anatomic neutral position of the hip. Subjects were instructed to perform practice contractions at the start to familiarize themselves with what to expect. They were also given appropriate rest periods (up to 5min) after each set of contractions. The video recordings were made during the isokinetic exercises only. All subjects were given the same level of encouragement by the examiner. Each subject was instructed prior to the start that their maximal effort was required for each set of exercises, excluding the pretest contractions. Subjects returned 1 week later for repeat testing. The sequence of exercises and setups was identical to their first session. This was in part due to time constraints resulting from the inflexibility of the isokinetic system’s software.
Data Analysis

The maximum torque produced for each part of the exercise protocol was determined from the raw data files exported by the HUMAC software.

The measurements of pelvic rotation were determined from the videos of each exercise procedure using playback and snapshot features of Windows Movie Maker software. Measurements were made of the swing of the ruler in the transverse plane. The extremes of rotation on each side of the resting position were captured, collated, printed, and then measured manually to the nearest degree using a protractor. Data were compared using a Student t test (paired) to look for significant differences between the setups. Left and right sides were analyzed separately using the underlying assumption of independence of data points.

We used statistical methods described by Bland and Altman for assessing repeatability between 2 sets of measurements to assess the reliability of each setup configuration. The maximum torque values from weeks 1 and 2 were noted and the differences between them used to assess repeatability. This allowed an appraisal of the setups’ repeatability in terms of the real units of newton-meters.

RESULTS

All subjects completed all aspects of the study. A total of 15 subjects including 9 men and 6 women were recruited. The subject characteristics are presented in Table 1.

The results for isokinetic exercises at 30°/s show an overall mean reduction, from 24.2° to 16.2° (P < .01), in pelvic rotation in the transverse plane with setup B. The mean reduction of pelvic rotation at 60°/s was from 22.3° to 14.8°. However, this did not reach statistical significance (P = .07).

Table 1: Subject Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Mean mass (kg)</td>
<td>70.8 ± 9.4</td>
<td>56.0 ± 10.4</td>
</tr>
<tr>
<td>Mean height (cm)</td>
<td>176.4 ± 8.8</td>
<td>162.2 ± 6.6</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>22.4 ± 0.9</td>
<td>22.3 ± 0.3</td>
</tr>
</tbody>
</table>

NOTE. Values are mean ± standard deviation (SD) and range.

Fig 2. (A) A photograph showing a subject being secured as per the instructions provided by the manufacturer (setup A). (B) A photograph showing a subject secured in the novel setup described (setup B).

Fig 3. A schematic diagram detailing the protocol of exercises undertaken for hip abduction and adduction with the Cybex dynamometer. The diagram shows the exercise sequence per side of testing.
The group mean results and mean errors obtained during the isokinetic exercises at 30° and 60°/s are summarized in Table 2. As an example, a Bland-Altman plot is shown in Figure 4 for abduction (right side) at 30°/s showing the limits of repeatability of the 2 setups. Overall, there was no discernible pattern for which of the 2 setups consistently yielded more repeatable results. There was no consistent pattern for which of the 2 setups had a lower coefficient of repeatability. Consistently lower coefficients of repeatability would have implied smaller mean differences of the data and thus implied that it was more repeatable.

Table 3 includes a summary of the group mean results and the mean errors obtained for isometric abduction and adduction exercises. Again, there was no discernible pattern to distinguish which of the 2 was more repeatable.

To determine if maximal pelvic rotation was related to peak torque production, we performed correlations at each of the different speeds. The torque values were adjusted for body mass to achieve standardization and to remove any potential bias that body mass might have on peak torque. The coefficient of determination values ($r^2$) are presented in Table 4 and ranged from .04 to .22, indicating a very weak relationship between the 2. Figure 5 gives an example of the strength of the correlation in graphic form.

**DISCUSSION**

The burden of hip abduction and adduction morbidity has been highlighted\(^2,5,6,8\); however, isokinetic dynamometry testing of these muscle groups has been associated with low repeatability\(^11,15\). One causal factor that has been implicated with this low repeatability is excess pelvic mobility, although this has never been quantified or evaluated.\(^16-19\) The novel setup described in this study was noted to reduce pelvic rotation in the transverse plane, particularly at the slower speed of 30°/s. Despite this, the results indicate that there is no great difference in repeatability between a conventional setup and the setup described in this study was noted to reduce pelvic rotation in the transverse plane, particularly at the slower speed of 30°/s. Despite this, the results indicate that there is no great difference in repeatability between a conventional setup and this novel setup. Movement of other body segments may influence the repeatability; for example, the degree of femoral rotation may also be important. During ambulation, the abductors on the stance side cause medial femoral rotation moving the pelvis toward it.
When testing in the lateral position, the situation is variable; based on our observations, there is a tendency to laterally rotate the femur when attempting to produce maximal force and this may lead to more inconsistent results between readings. However, there is mixed evidence on this topic.\textsuperscript{17,20-22} It is not clear how this movement could be controlled during isokinetic testing.

Figure 5 suggests that pelvic rotation has a weak relationship with peak torque production; this would indicate that the movement of the pelvis will have minimal if any impact on the maximum torque output. This is corroborated by the limited differences observed in mean group peak torque between each setup (2.8–15.1Nm during isokinetic testing; 6.7–7.8Nm during isometric testing). This factor is further supported when considering normal pelvic motions during gait. The pelvis does not move greatly (>10°) in gait.\textsuperscript{23} A reason may be that training of this muscle in the vast majority of the nonathletic population may only be limited to ambulation—and as such the peak torque produced would be within this narrow (anatomic position) range.

The implications of the findings lie in the clinical significance of the absolute values and their respective coefficients of repeatability. The degree of accuracy and change that is sought outside the limits of repeatability, remain the key benefactors of this type of testing. Such increases would show trends that would be easily discernible from artifact. Rowing coaches have been known to increase training from 0- to 4-kg weights—a difference of 39N for the subject (P. Thompson, head coach, UK British women and lightweights, personal communication, May 18, 2006)—a value well within the coefficient of repeatability of the isometric contractions performed in this study. Real change would not then be distinguishable from repeatability error.

**Study Limitations**

Limitations of the study methodology might have contributed to reduced accuracy of the findings. In setup B, variances between sessions of the anchoring strap tension may have influenced the pelvic ROM. Subjects recruited were all university attendees, with a narrow age range, and had a mixed repertoire of sporting talent, exercise habits, and motivation.\textsuperscript{25} Further investigation is necessary on subjects of a more aged or diseased disposition to assess feasibility of the setup. Athletes might have been more motivated to perform to their maximum potential, outside the limits of repeatability, remain the key benefactors of this type of testing. Such increases would show trends that would be easily discernible from artifact. Rowing coaches have been known to increase training from 0- to 4-kg weights—a difference of 39N for the subject (P. Thompson, head coach, UK British women and lightweights, personal communication, May 18, 2006)—a value well within the coefficient of repeatability of the isometric contractions performed in this study. Real change would not then be distinguishable from repeatability error.

### Table 3: Results of the Isometric Exercises

<table>
<thead>
<tr>
<th>Apparatus Setup</th>
<th>Isometric Abduction</th>
<th>Isometric Adduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Tested</td>
<td>Setup A (Nm)</td>
<td>Setup B (Nm)</td>
</tr>
<tr>
<td>Left</td>
<td>60.9±23.1</td>
<td>64.3±22.2</td>
</tr>
<tr>
<td>Right</td>
<td>−9.0±18.8</td>
<td>−2.0±11.6</td>
</tr>
<tr>
<td>Mean diff ± SD</td>
<td>2.9±10.4</td>
<td>3.3±11.7</td>
</tr>
<tr>
<td>Coefficient of</td>
<td>0.21</td>
<td>0.22</td>
</tr>
<tr>
<td>repeatability*</td>
<td>0.21</td>
<td>0.22</td>
</tr>
<tr>
<td>Limits of repeatability†</td>
<td>46.6 to 28.6</td>
<td>25.2 to 21.1</td>
</tr>
<tr>
<td>SE</td>
<td>4.9</td>
<td>3.0</td>
</tr>
</tbody>
</table>

**NOTE.** Peak torque values per repetition were used to calculate the mean and the subsequent interweek torque mean differences. (Negative numbers represent a fall in the values recorded in week 2 versus week 1.)

Abbreviations: see table 2.

*Equals 2 SDs.

†Represents 1 coefficient of repeatability above and below the mean difference. These are the 95% confidence intervals.

### Table 4: Coefficient of Determination Values of the Correlation Between the Maximum Angle of Pelvic Rotation and the Peak Torque Produced (adjusted for mass)

<table>
<thead>
<tr>
<th>Exercise Protocol</th>
<th>Coefficient of Determination Values (r^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Setup A</td>
</tr>
<tr>
<td>Abduction</td>
<td></td>
</tr>
<tr>
<td>30°/s</td>
<td>0.04</td>
</tr>
<tr>
<td>60°/s</td>
<td>0.15</td>
</tr>
<tr>
<td>Adduction</td>
<td></td>
</tr>
<tr>
<td>30°/s</td>
<td>0.14</td>
</tr>
<tr>
<td>60°/s</td>
<td>0.13</td>
</tr>
</tbody>
</table>

**NOTE.** All correlations significant at \(P<.001\).
commonly used in medical clinics; however, it is not sensitive enough to detect small improvements. Another study design factor that might have influenced the results was the lack of randomization of the test protocol itself, and the inevitable fatigue in the muscles that the protocol will have induced.

The encouragement offered in the study might have played a pivotal role in the reproducibility. Subjects’ motivational status, along with physical fatigue, might have varied both intrasession and intersession. Offering everyone the same level of encouragement might have resulted in some strictly adhering to the instructions provided at the start and others less so. Furthermore, the testing process took approximately 1 hour per session. Much of the time was engaged in setting up the necessary equipment and not in the subject being actively exercised. Mental fatigue might have further played an interactive role with motivation. Additionally, a learning effect might have contributed to mental and physical preparedness (e.g., having a snack beforehand or training between sessions) and thus produced torque values differing from those of the previous session.

Cheaper and simpler alternatives to isokinetic dynamometry are widely in use. Subjective MMT grading is quick and is commonly used in medical clinics; however, it is not sensitive enough to detect small improvements. The HHD is a more accurate way of manually measuring muscle strength, but it carries the disadvantage of examiner error and cannot be used to acquire isokinetic data. Evidence suggests that the use of HHDs in lower-limb testing is unreliable because of differences in strength between the examiner and patient and of the unexpected movements that may occur. This hurdle has been overcome with the introduction of a specially designed HHD anchoring station as described by Nadler et al. These portable hip dynamometer anchoring stations have been shown to be reliable and provide a cheaper and quicker alternative to the Cybex dynamometer, but at the cost of accuracy.

CONCLUSIONS

Reduction of transverse pelvic rotation had little effect on enhancing repeatability for measuring peak torque during hip adduction and abduction, in health young controls. Furthermore, maximum pelvic rotation angle has a weak correlation with peak torque production. Directions for future work should include further analysis to look at the torque pattern produced throughout the whole ROM as well as isolating both femoral and pelvic rotation. In addition testing in different positions (i.e., sitting, lying) with different groups of athletes/subjects and to examine the feasibility of the interventions among diseased patients and the elderly are also further avenues worth exploring.

References


Suppliers
a. Cybex International Inc, 10 Trotter Dr, Medway, MA 02053.
b. Version 4.5.3; CSMi, 101 Tosca Dr, Stoughton, MA 02072.
Six Weeks of Intensive Treadmill Training Improves Gait and Quality of Life in Patients With Parkinson’s Disease: A Pilot Study

Talia Herman, MSc, Nir Giladi, MD, Leor Gruendlinger, MSc, Jeffrey M. Hausdorff, PhD


Objective: To evaluate the effects of 6 weeks of intensive treadmill training on gait rhythmicity, functional mobility, and quality of life (QOL) in patients with Parkinson’s disease (PD).

Design: An open-label, before-after pilot study.

Setting: Outpatient movement disorders clinic.

Participants: Nine patients with PD who were able to ambulate independently and were not demented. Mean age was 70±6.8 years. Patients had mild to moderate PD (Hoehn and Yahr stage range, 1.5–3).

Interventions: Patients walked on a treadmill for 30 minutes during each training session, 4 training sessions a week, for 6 weeks. Once a week, usual overground walking speed was re-evaluated and the treadmill speed was adjusted accordingly.

Main Outcome Measures: The 39-item Parkinson’s Disease Questionnaire (PDQ-39), motor part of the Unified Parkinson’s Disease Rating Scale (UPDRS), gait speed, stride time variability, swing time variability, and the Short Physical Performance Battery (SPPB).

Results: A comparison of the measures taken before and after the treadmill intervention indicates general improvement. QOL, as measured by the PDQ-39, was reduced (improved) from 32 to 22 (P<.014). Parkinsonian symptoms, as measured by the UPDRS, decreased (improved) from 29 to 22 (P<.043). Usual gait speed increased from 1.11 to 1.26 m/s (P<.014). Swing time variability was lower (better) in all but one patient, changing from 3.0% to 2.3% (P<.06). Scores on the SPPB also improved (P<.008). Interestingly, many of the improvements persisted even 4 months later.

Conclusions: These results show the potential to enhance gait rhythmicity in patients with PD and suggest that a progressive and intensive treadmill training program can be used to minimize impairments in gait, reduce fall risk, and increase QOL in these patients.

Key Words: Cues; Gait; Parkinson’s disease; Quality of life; Rehabilitation; Treadmill test.

GAIT DISTURBANCES AND instability are common among patients with Parkinson’s disease (PD). The most significant consequences of the dysrhythmic and disturbed gait include falls,1,9 often leading to functional dependence and markedly impinging on quality of life (QOL).10,11 The therapeutic options for treating these gait disturbances and reducing fall risk in PD are quite limited. Despite advances in pharmacologic therapy and surgical procedures, impairment in gait and balance remain common in PD patients.12 Development of adjunct therapy and rehabilitation-like approaches is important for the management and the welfare of these patients.

Treadmill training is widely used to enhance the gait of poststroke patients and patients with spinal cord injury, in part because it enables walking while allowing for partial body-weight support. Only a few studies have examined the effects of treadmill training on gait on motor performance in PD. In 2000, Miyai et al15 investigated the effects of body-weight supported treadmill training (BWSTT) on gait and parkinsonian symptoms of PD patients. In this 4-week crossover study, BWSTT produced greater improvement in motor performance compared with conventional physical therapy (PT), increasing stride length and gait speed and reducing parkinsonian symptoms. A follow-up randomized controlled trial showed a long-term effect of BWSTT on gait, beyond that of conventional PT, which lasted for about 4 months.14 Similarly, Toole et al16 studied the effects of 6 weeks of treadmill walking in 23 subjects with PD, who were divided into 3 intervention groups who trained with different amounts of weight bearing. Muscle strength did not change, but significant improvement in the motor portion of the Unified Parkinson’s Disease Rating Scale (UPDRS), balance and gait were seen in all 3 groups, regardless of the degree of weight bearing. These findings suggest that treadmill training is effective in PD, but that unlike in the stroke patient, body-weight support is apparently not critical for training patients with PD.

Three works have studied how the treadmill can be used to improve PD gait without body-weight support. Pohl et al16 examined the immediate effects of a single treadmill session in a crossover, 4-consecutive-day trial in 17 patients with early PD. Their results suggest that gait speed and stride length can be improved through a single intervention of treadmill training (even without body-weight support), but not through conventional gait training. Using a paradigm that focused on stepping rather than routine walking, Protas et al17 assessed the benefits of gait and step training in PD. They found that walking on a treadmill at a speed greater than overground walking speed while walking in 4 directions (back and forth and sideways) and step training (practicing starting and stopping) resulted in a reduction in falls and improvement in gait and dynamic balance in a small group of patients. Whereas these investiga-
tions examined gait parameters such as speed, cadence, and stride length. Frenkel-Toledo et al. assessed the influence of treadmill training on stride-to-stride variability. This aspect of gait reflects the consistency of the gait pattern and has been associated with fall risk and has been shown to be independent of stride length in PD. Frenkel-Toledo showed that when walking on a treadmill, patients with PD improve their gait and walk with reduced gait variability, even when walking at the same speed as on overground walking. These findings indicate that treadmill walking can promote a more stable walking pattern in patients with PD, and suggest that perhaps an intervention program that includes long-term treadmill walking—without using body-weight support—will be able to restore rhythm, reduce gait variability, and perhaps succeed at lowering fall risk. The objective of the present study, therefore, was to examine the effects of 6 weeks of intensive treadmill training on gait rhythmicity. In addition, we assessed the effects of this treadmill training program on functional mobility, gait, and QOL in patients with PD. To this end, patients were assessed before they participated in the training program, after, and 4 weeks later to evaluate post-training effects.

**METHODS**

**Participants**

In this study, we included 9 patients with idiopathic PD who were able to ambulate independently. Subjects who met the inclusion criteria were recruited from the Movement Disorders Unit at the Tel Aviv Sourasky Medical Center, using a convenience sample of mild to moderate PD patients. All patients were free of serious comorbidities, other than PD (eg, dementia, unstable cardiovascular disease [CVD], rheumatologic disease, orthopedic disturbances, or pain while walking) or acute illness that would make training inappropriate. Patients who had used a treadmill more than once a week, or were unwilling to commit to the training program and to the follow-up period, were excluded. Patients with any signs of CVD were asked to provide written medical clearance from their cardiologist. The study was approved by the Human Studies Committee of Tel-Aviv Sourasky Medical Center and all patients signed a consent form.

**Pre- and Post-Assessments**

After providing informed written consent, the patients underwent a comprehensive physical and neurologic assessment. Patients were studied 3 times: (1) before the treadmill training program started; (2) 2 to 3 days after they completed the 6 weeks program; and (3) about 4 to 5 weeks after they completed the training program. The pre- and postassessments included a full medical history, history of falls, Mini-Mental Status Examination (MMSE), and the motor part (part III) of the UPDRS. The 39-item Parkinson’s Disease Questionnaire (PDQ-39) was used to assess QOL. The Short Physical Performance Battery (SPPB) was used to assess balance and lower-extremity capabilities. We also administered the Activities-specific Balance Confidence (ABC) scale and the Geriatric Depression Scale (GDS) to assess fear of falling and mental well-being, respectively. To measure and quantify stride-to-stride variability, we placed force-sensitive insoles in the subject’s shoe while the subject walked on a level surface for 2 minutes at comfortable walking speed. Overground comfortable walking speed was measured using a stop watch, and average stride length was calculated. In addition, we used a modified visual analog scale (VAS) to quantify the subject’s subjective perceptions of his/her gait performance.

**Treadmill Training Protocol**

Patients walked on a motorized medical treadmill, under the close supervision of a physical therapist. The patients walked in all sessions while wearing a safety harness to prevent falls, but no patient used the weight-support option. The training program consisted of sessions of 30 minutes each, 4 sessions a week, for 6 weeks (a total of 24 sessions). Once a week, overground walking speed was re-evaluated and the treadmill speed was adjusted accordingly, in order to enable a progressive increase in gait speed as detailed below.

A unique aspect of this study was the application of an intensive and progressive gait training program. Because walking on the treadmill is different than overground walking, we started the program of each patient by setting the treadmill speed to 80% of his/her overground comfortable walking speed, increasing to 90% of the comfortable walking speed after a week. Thus, by the third week of training, all patients reached the overground measured comfortable walking speed (on the treadmill). From the third week, the treadmill speed was gradually increased to reach a goal of 5% to 10% above that week’s overground comfortable walking speed. Because the overground comfortable walking speed improved each week, patients ended up walking on the treadmill at speeds higher than those measured at baseline. Each session of the training program was designed to be a rehabilitation-like treatment with positive feedback and re-enforcement of the patient’s performance by the physical therapist who conducted the treatment. During the sessions, the physical therapist encouraged the patients to devote effort to their gait by walking with large strides and correct posture.

**Statistical Analysis**

Descriptive statistics are reported as mean ± SD. The Mann-Whitney U test (nonparametric equivalent of the paired t test) was used to compare the pre- and postmeasurements. All statistical analyses were performed using SPSS. A P value of .05 or less was considered statistically significant.

**RESULTS**

**Patient Characteristics**

Demographic and clinical characteristics of the 9 patients at baseline are summarized in table 1. Disease severity of the patients was mild to moderate, and the Hoehn and Yahr stages ranged from 1.5 to 3. Two patients experienced motor response fluctuations. Eight patients were on levodopa or dopamine

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>PD Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>70 ± 6.8</td>
</tr>
<tr>
<td>Sex (men)</td>
<td>6 (66.7)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>168.5 ± 6.7</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>72.1 ± 9.6</td>
</tr>
<tr>
<td>Disease duration (y)</td>
<td>5.0 ± 2.6</td>
</tr>
<tr>
<td>MMSE score</td>
<td>28.9 ± 0.6</td>
</tr>
</tbody>
</table>

**NOTE.** Values are mean ± SD or n (%). We determined average stride time, swing time (in percent), stride time variability, and swing time variability from the force record using previously described methods. Variability measures were quantified using the coefficient of variation (CV); for example, stride time variability equals 100 × (average stride time/standard deviation [SD]).
Table 2: Measures of Pre- and Post-Treadmill Training

<table>
<thead>
<tr>
<th>Measures</th>
<th>Pre-Treadmill Training</th>
<th>Post-Treadmill Training</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPDRS motor score</td>
<td>29.0±9.3</td>
<td>22.0±11.1</td>
<td>.043</td>
</tr>
<tr>
<td>(part III)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDQ-39 score</td>
<td>32.2±23.1</td>
<td>22.4±14.3</td>
<td>.014</td>
</tr>
<tr>
<td>SPPB score</td>
<td>9.9±1.4</td>
<td>11.1±0.8</td>
<td>.008</td>
</tr>
<tr>
<td>GDS score</td>
<td>7.1±5.7</td>
<td>5.4±3.6</td>
<td>NS</td>
</tr>
<tr>
<td>ABC scale score</td>
<td>84.9±13.8</td>
<td>84.1±15.8</td>
<td>NS</td>
</tr>
<tr>
<td>VAS gait rating</td>
<td>6.3±1.3</td>
<td>7.5±1.9</td>
<td>.026</td>
</tr>
<tr>
<td>Gait speed (m/s)</td>
<td>1.11±0.17</td>
<td>1.26±0.16</td>
<td>.014</td>
</tr>
<tr>
<td>Stride length (m)</td>
<td>1.17±0.22</td>
<td>1.25±0.22</td>
<td>.012</td>
</tr>
<tr>
<td>Stride time variability (%)</td>
<td>2.6±1.2</td>
<td>2.6±2.2</td>
<td>NS</td>
</tr>
<tr>
<td>Average swing time (%)</td>
<td>36.0±3.9</td>
<td>36.2±3.8</td>
<td>NS</td>
</tr>
<tr>
<td>Swing time variability (%)</td>
<td>3.5±1.9</td>
<td>5.3±3.8</td>
<td>.066</td>
</tr>
</tbody>
</table>

NOTE. Values are mean ± SD. Abbreviation: NS, not significant.

agonsit therapy, and 1 patient was treated with amantadine and selegiline.

Short-Term Effects

Table 2 compares baseline values with those measured a few days after completion of 6 weeks of intensive treadmill training. There was no significant change in the level of fear of falling (as measured by the ABC score) or mental well-being (as measured by the GDS). There was a tendency for reduced swing time variability, as can be seen in the change of swing percentage CV. Mobility, as measured by gait speed, stride length, VAS, and the SPPB, significantly improved in response to the training. Scores on the PDQ-39 also significantly improved. Consistent with the observed improvements in many of the objective measures, all participants expressed enthusiasm for the protocol and a desire to continue with it.

Longer-Term Effects

Seven patients were retested 4 to 5 weeks after they completed the 6 weeks of treadmill training. Many variables remained significantly improved compared with baseline values (pretreatment). Gait speed (longer-term speed, 1.16±0.24m/s; P=.028), VAS gait (longer-term score, 8.14±2.3; P=.043) and stride length (longer term stride length, 1.26±0.21; P=.043) were significantly increased compared with baseline values 4 weeks after the training was stopped. Parkinsonian motor signs, as measured by part III of the UPDRS, remained significantly lower (19.7±6.4, P=.027) 4 weeks later compared with the value seen at baseline. Compared with baseline values, even functional performance, as measured by the SPPB, tended to be improved 4 weeks after the intervention was completed (11.0±1.2, P=.06). Other measures were more new similar to baseline values.

DISCUSSION

This study examined the possibility that a treadmill may be used as an adjunct treatment to complement PT, to improve QOL, physical performance, and enhance gait stability in PD patients. We focused on these issues because PD is a classic example of a motor disorder that impacts on QOL. With this intervention, not only were positive effects seen immediately, but a carryover effect was observed 4 weeks later for many measures. Furthermore, positive effects beyond gait were seen in the patients’ perspective of their general well-being and QOL.

In this pilot study, the rationale to choose an intensive and progressive training derived from studies using progressive resistance strength training and high-intensity voice treatment. For example, Fiatarone et al showed that high-intensity, progressive resistance training is highly efficacious, even among frail adults. Additional justification that a progressive and intensive training program may improve gait rhythmicity in PD, despite the presence of neurodegeneration, comes from work on voice treatment in PD. There are at least 3 features that underlie the voice disorders common in PD: (1) reduction in amplitude; (2) a problem with the sensory perception of effort; and (3) deficient internal cueing causes difficulty in generation of appropriate effort. To some extent, parallel deficiencies can be found in gait (eg, shortened stride length as an expression of small amplitude; impaired rhythmicity as a deficient internal cueing). Ramig et al have shown that patients with PD can be trained to work around these deficits in speech, and that the training effects can last at least 2 years after cessation of an initial intensive training period. The parallels between voice and gait suggest that retraining of gait (rhythmicity) may also be achievable. Increasing the walking demand and challenging the patient by setting gait speed is one way to adapt progressive training. With the treadmill, there is no getting around it, the patient must match his/her pace to the treadmill.

The mechanism whereby treadmill training works in PD remains to be fully determined. One possibility is that the treadmill acts as an external cue by setting the walking pattern, reinforcing neuronal circuits that contribute to gait pacing. This explanation is supported by earlier findings which showed that external cues improve gait in PD. Perhaps a treadmill provides an external rhythm that compensates for the defective internal rhythm of the basal ganglia in the same way that rhythmic auditory stimulation or visual cues work in PD. Another possibility is that treadmill training works as a form of motor learning. Recently van Hedel et al evaluated the acquisition and performance of a high-precision locomotor task in patients with PD compared with healthy subjects. Initially, PD patients performed poorer and improved foot clearance more slowly. However, after task repetition, the groups performed similarly, indicating that adequate training can improve locomotor behavior in PD patients. The treadmill protocol described here may achieve its short-term and longer-term, carryover effects by inducing gradual implicit motor learning of rhythmic walking. Like voice training, the treadmill training used here was intensive, repetitive, and involved ongoing feedback. The patient learns to adapt to progressively increasing demands—a process that may enhance the automatization of motor control. Motor learning may explain the carryover effect, because the treadmill trains a steady gait speed and paces gait on a more subconscious level, but the pacing cannot be ignored. In this respect, it is important to note that in our group of patients, treadmill walking began as a novel task because subjects did not have a history of using a treadmill.

In reviews of the literature, we find calls for additional study of rhythmic stimulation and training and for outcome measures with particular relevance to patients, caregivers, physical therapists, and physicians. Here, in the present intervention, we tried to meet these needs, and enhance the main and secondary outcomes from motor performance (eg, speed, stride length) to QOL and mental well-being.
Study Limitations

The study has a number of limitations. This was an open trial with a relatively small number of participants. Nonetheless, the results of this pilot study are quite promising. After only 6 weeks, improvements were seen in a number of key areas including stride length, parkinsonian symptoms (as measured by the UPDRS), and QOL (as measured by the PDQ-39, probably the most widely used measure of QOL in patients with PD). It is possible that all of these gains are merely the result of a placebo effect. It is, however, somewhat surprising that such an effect would last even 5 weeks after the intervention was stopped. We suggest, instead, that these preliminary findings support the idea that treadmill training has an effect greater than a placebo and that some of its influence continues even weeks after completion of the intervention. Consistent with the work of Toole et al., the present findings suggest that body-weight support is apparently not critical in achieving positive treadmill effects in PD. Nonetheless, larger scale, randomized controlled studies are needed to definitively establish efficacy and long-term carryover effects, to explain why certain aspects of gait and mobility appear to be more sensitive to the intervention, and to directly measure the effects of treadmill training on fall risk. The present findings should be useful in guiding the design of such studies.

Potential Clinical Implications

The present findings indicate that walking on a treadmill improves gait, mobility, and QOL of patients with PD. Treadmill training may promote a more stable walking pattern in patients with PD and an intervention program that includes long-term treadmill walking apparently is able to restore rhythmicity and impact fall risk, even when the patient is off the treadmill. In the presence of PD, many see the goal as maintenance care, but do not see the feasibility or opportunity for rehabilitation. This pilot study contributes to a growing body of evidence that shows that “rehabilitation” may be achievable even in the presence of a neurogenerative disease like PD.

Recent studies suggest that treadmill training is more effective than conventional approaches to improve gait characteristics associated with PD. We suggest combining conventional PT with intensive treadmill training using a protocol of at least 3 sessions a week, 20 to 30 minutes each. It is probably important that the physical therapist ensures a “normal” gait pattern while the patient walks on the treadmill. However, if any gait deviations occur or if there are signs of pain or fatigue complaints, treadmill speed should be adjusted accordingly.

CONCLUSIONS

In PD, there appears to be no need to unload the patient, unless specific safety issues arise. Based on our experience, we also suggest conducting all training sessions when the PD patient is in the “on” state. Still, one has to remember that due to the relatively high cost of this apparatus, the need for a relatively large facility and increased time commitment, a treadmill training program based on a medical treadmill (with a safety harness) may not be practical for everyone or for everyday use in the clinic. Important safety issues arise when treadmill training might be prescribed in the home setting for patients with PD.

Acknowledgment: We thank Shelli Ehrlich for her invaluable assistance in data collection.


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Mechanics of Ambulation With Standard and Spring-Loaded Crutches

Adriana Segura, BS, Stephen J. Piazza, PhD


Objective: To compare kinetic measures and spatiotemporal variables assessed during walking with standard axillary crutches and spring-loaded crutches.

Design: A repeated-measures design in which healthy subjects walked with both standard and spring-loaded crutches.

Setting: Biomechanics research laboratory.

Participants: Ten healthy young adult volunteers participated. Only female volunteers between 154.9 and 175.3 cm in stature were selected to fit the size of the crutches used.

Interventions: Not applicable.

Main Outcome Measures: The main outcome measures were kinetic variables such as ground reaction force, rate of force rise, and impulse and spatiotemporal variables such as stride length, stride time, and percentage of stride spent in stance.

Results: The rate of ground reaction force rise and impulse of the ground reaction force (both \( P < .001 \)) were reduced by 33% and 13% to 26%, respectively, but the peak ground reaction force was slightly greater (\( P = .001 \)) with spring-loaded crutches. The stride time was increased with spring-loaded crutches (\( P = .005 \)), but the stride length did not differ significantly (\( P = .465 \)).

Conclusions: The use of spring-loaded crutches altered the mechanics of crutch gait in ways that are likely to reduce overuse injury in crutch users. Further study of spring-loaded crutches is warranted, especially with respect to their energetic efficiency.

Key Words: Biomechanics; Crutches; Gait; Rehabilitation. © 2007 by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation

It is important for people with disabilities to be able to use crutches comfortably and effectively. Many long-term crutch users prefer axillary (underarm) crutches to elbow crutches because axillary crutches may offer increased control during gait as well as the ability to stand stably while performing tasks with the arms. However, walking with axillary crutches can be problematic because of complications known to be associated with their long-term use.1,2 Large forces may be applied to the tips of axillary crutches at initial contact, and these forces may be transmitted to the elbow and shoulder joints, causing irritation and injury.3,4 Such forces may lead to crutch palsy, aneurysms, and thromboses, causing pain, discomfort, and other serious conditions in some axillary crutch users.2,5,6

Spring-loaded crutches are a potentially more comfortable alternative to standard crutches because they may alter the way in which loads are transmitted to the body during crutch gait. Parziale and Daniels7 found a 24% decrease in peak handle load applied and a 22% decrease in the average amplitude of the initial handle force when using spring-loaded axillary crutches in comparison to standard axillary crutches. Shoup8 found that subjects using spring-loaded crutches used a stride length greater than that observed during standard crutch use. The use of spring-like tendons for energy conservation is known to occur in human and animal locomotion,9,10 and it may be the case that such benefits will also apply to users of spring-loaded crutches. Shoup8 hypothesized that the energy storage and return expected from spring-loaded crutches might represent an energy savings of about 25% of the metabolic energy typically consumed during standard crutch gait, although this hypothesis was not tested.

Previous investigations of the mechanics of spring-loaded crutch gait have been limited in their scope. Parziale and Daniels2 did not measure ground reaction forces during ambulation with the spring-loaded crutches, and Shoup8 evaluated the ground reaction forces in only a single subject and only during the interval just after the initial crutch contact. A recent innovation in spring-loaded crutches was described by Shortell et al.,11 who designed a forearm crutch with compliant shafts in S-shapes, but the authors did not measure the ground reaction forces during ambulation with the modified design.

The purpose of this study was to determine if there are differences in ground reaction force, rate of force rise, impulse, and spatiotemporal gait variables between ambulation with spring-loaded axillary crutches and ambulation with standard axillary crutches. A video-based motion analysis system and forceplate were used to record crutch kinematics and ground reaction forces in healthy young adult subjects who were not habitual crutch users as they walked with both types of crutches. It was hypothesized that introducing springs into crutches would reduce peak ground reaction force, rate of force rise, and impulse while increasing stride length.

METHODS

Ten healthy women (age range, 21–28y; mean height, 169.4 cm; mean body mass, 63.9 kg) free of musculoskeletal problems and nonusers of crutches in the previous 6 months volunteered as subjects. Subjects were selected on the basis of their bodily dimensions, such that the stature of each was suited to the size of the modified and standard crutches (167.6–175.3 cm) and the body mass of each was suited to the stiffness of the spring introduced into the modified crutches (54.5–86.4 kg). This body mass limitation was in accordance with the recommendations of Shortell11 that a spring constant of...
21.9kN/m (125lb/in) was suitable for subjects within this range of body masses. All procedures were approved by the Institutional Review Board of The Pennsylvania State University.

Two pairs of standard aluminum axillary crutches,a designed for persons between 154.9cm (61in) and 175.3cm (69in) in height, were used in this study. One of the pairs of crutches was not modified in any way and was used as the standard axillary crutch. The other pair of crutches was modified by the addition of a sliding mechanism and a helical compression spring to the bottom of the shaft just above the crutch tip. The springs were 8.9cm long and 1.9cm in diameter, with a stiffness of 22.4kN/m and a small preload of approximately 10N.

A forceplateb was used to measure the ground reaction forces under the crutch tips at a sampling rate of 1000Hz. Subject and crutch kinematics were recorded by using a 6-camera digital video-based motion analysis system.c Five spherical reflective markers, each 12mm in diameter, were placed on the left crutch (fig 1) with 2 of the markers located above and below the spring to monitor spring deflection. Markers were also placed at several locations on the body of the subject, but coordinates of these markers were not used in the present study.

Each subject was fitted for both pairs of crutches according to standard guidelines, and subjects were instructed in proper axillary crutch walking technique. Each subject practiced with each pair of crutches for 15 minutes to become accustomed to crutch gait before data collection. The ordering of the crutch type (springy or standard) was alternated for each subject. For each crutch type, the subject was asked to perform 10 “good” trials by walking over the forceplate with a right-leg-support, swing-through crutch gait. A trial was considered “good” if the left crutch tip struck the forceplate and the subject cleared the plate without striking it again with the crutch tip or with either foot. Each trial was performed at the subject’s self-selected walking speed, with subjects instructed to walk in the way that was most comfortable.

Force and marker coordinate data were low-pass filtered with a cutoff frequency of 45Hz by using a fourth-order Butterworth filter implemented in Matlabd to remove 60Hz noise. Crutch tip strike was identified as occurring at the first frame for which ground reaction force rose above a 10-N threshold. The impulse of the ground reaction force was calculated as the area under force versus time curves. Vertical, anteroposterior (AP), and mediolateral components of impulse as well as total impulse were calculated for the first 50, 100, and 200ms after crutch tip strike. In addition, the following variables were computed for each trial: time of crutch stance (crutch tip strike to tip liftoff), time for 1 stride (crutch tip strike to subsequent tip strike), percentage of stride in crutch stance, stride length (AP distance traveled by the bottom crutch marker during a stride), velocity, and maximum ground reaction force. The average rate of force rise over every 10-ms interval during crutch stance was also calculated, and the largest rate of force rise was noted for each trial.

A 2-way analysis of covariance (ANCOVA) with repeated measures with factors of crutch type (spring-loaded, standard) and trial number (1–10) using velocity (stride length divided by stride time) as a covariant was performed for each variable by using Minitab.e Velocity was chosen as a covariant because it was expected to influence ground reaction force, but it was not controlled to allow the subjects to walk with the most natural gait possible. Tukey post hoc tests were performed to determine if there were significant differences between the standard and springy crutch means only when ANCOVA results were significant. In addition, velocities were compared by using a paired t test. The level of statistical significance was set at α equal to .05 for all tests.

RESULTS

The maximum resultant ground reaction force was slightly but significantly higher (P=.001) when subjects ambulated with spring crutches than when they walked with standard crutches (fig 2). The maximum rate of force rise over any 10-ms interval of crutch stance phase was significantly lower (P<.001) when subjects ambulated with the spring crutches as opposed to when subjects walked with the standard crutches (fig 3).

The average impulse over the first 50ms of crutch stance phase was significantly lower (P<.001) with spring-loaded crutches than with standard crutches. This was true for the total impulse magnitude and for each component of the impulse vector (fig 4). Similarly, total impulses were also significantly lower for spring-loaded crutches when time periods of 100 and 200ms were considered (both P<.001).

There were some small but significant differences in spatiotemporal parameters between the 2 types of crutches (table 1). The stride time and the time that the subjects spent in crutch stance phase were significantly higher (P=.005, P=.002, re-
and the walking velocity was significantly lower (P = .025) when they walked with spring-loaded crutches than when they walked with standard crutches. No significant differences were seen, however, between spring crutches and standard crutches in the duty factor, the percentage of the gait cycle spent in crutch stance (P = .463), or in the stride length (P = .465).

Crutch ground reaction force versus time plots were highly variable between subjects and across trials of the same subject. Trials collected minutes apart for the same subject did not show a consistent ground reaction force profile; it was often the case that some trials exhibited 2 distinct force peaks, some had only a single peak, and still others featured a force plateau (fig 5). Furthermore, there was substantial variability in peak force magnitude seen across trials. ANCOVA revealed no significant effect of trial number on any of the spatiotemporal or kinetic measures.

**DISCUSSION**

Of the spatiotemporal measures considered in this study, significant differences were found between the spring-loaded and standard crutches only with respect to the period in crutch stance phase, the stride time, and the velocity. Our hypothesis that the stride length would be increased when using the spring crutches, as suggested by Shoup,8 was not supported. Also contrary to our expectation, the maximum ground reaction force was higher when subjects walked with the spring-loaded crutches than when they used standard crutches. In line with our hypotheses, however, were the findings that the maximum rate of force rise and the impulse of the ground reaction force in early crutch stance were lower for spring-loaded crutches.

Shoup8 reported increases in stride length accompanying the use of spring-loaded crutches that were not reproduced in the present study. The reduction of the initial force transient reported by Shoup for a single subject, however, was similar to the reduced rate of force rise and reduced impulse found in 10 subjects in the present study.

Parziale and Daniels7 also added springs to the shafts of standard crutches but measured uniaxial forces at the crutch handles rather than the ground reaction force. The authors reported handle forces that were 24% lower for spring-loaded crutches than for standard crutches, but in the present study a small but significant increase in ground reaction force was noted for spring-loaded crutches. The difference in methodology (forces measured at the handle vs the crutch tip) and transmission of torque at the crutch handle may be the causes of this discrepancy, and future studies should consider simultaneous measurement of these forces because both are likely to have implications for injury.

The unexpected larger maximum ground reaction forces seen when subjects walked with spring-loaded crutches could have been caused by “bottoming out” that might have occurred if the spring became fully compressed during crutch stance. The measurement of crutch deflection from the crutch marker coordinates, however, indicated that this was not the case, and none of the subjects described experiencing this sensation during spring-loaded crutch trials. Alternative explanations are that subjects may have used different techniques for each crutch type and that the increased force was caused by subjects

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Spring-Loaded</th>
<th>Standard</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stride time (s)</td>
<td>1.471 ± 0.174</td>
<td>1.433 ± 0.186</td>
<td>.005</td>
</tr>
<tr>
<td>Stance time (s)</td>
<td>0.793 ± 0.110</td>
<td>0.766 ± 0.099</td>
<td>.002</td>
</tr>
<tr>
<td>Duty factor (%)*</td>
<td>53.9 ± 2.7</td>
<td>53.5 ± 3.0</td>
<td>.463</td>
</tr>
<tr>
<td>Stride length (m)</td>
<td>1.582 ± 0.175</td>
<td>1.607 ± 0.165</td>
<td>.465</td>
</tr>
<tr>
<td>Velocity (m/s)</td>
<td>1.096 ± 0.212</td>
<td>1.146 ± 0.225</td>
<td>.025</td>
</tr>
</tbody>
</table>

NOTE: Values are mean ± 1 SD. *The percentage of the stride time spent in crutch stance.
Fig 5. Vertical ground reaction force (vGRF) traces for the 10 spring-loaded crutch trials of subject 1. The considerable intertrial variability in loading patterns shown here was evident for all subjects and for both the spring-loaded and standard crutch types.
falling through a greater distance before the springs arrested their falls.

The decrease in the rate of force rise when subjects used the spring-loaded crutches indicates that more jarring and quickly changing forces are applied to the crutch user when using standard crutches. Similarly, the findings that the impulses were lower when using the spring-loaded crutches are important because of the implications for overuse injuries. Because injuries, such as aneurysm formation, that occur as a result of axillary crutch use are often caused by repetitive trauma to the upper extremities, it is likely that walking with spring-loaded crutches lessens the risk of injury to the crutch user. Repetitive impulsive loading of joints leads to articular stiffness and has been found to lead to injury and osteoarthritis. Lower impulses and rates of force rise when using the spring crutches, such as those found in the present study, may indicate that the spring-loaded crutches may decrease skeletal impact loading during crutch stance phase, thus decreasing the likelihood of crutch palsy, aneurysm, and thrombosis that are associated with axillary crutch use. Although it is true that the subjects walked more slowly with spring-loaded crutches, velocity differences cannot explain the differences in impulse and rate of force rise because ANCOVA should have removed the variance accounted for by velocity. When the 10 subjects in this study were asked which crutches they preferred after having used both, 4 chose the spring-loaded crutches, 4 chose standard, and 2 had no preference. One comment made by 2 subjects was that the spring-loaded crutches felt “more comfortable but less stable.” If spring-loaded crutches offer such a trade of stability for comfort, it raises the question whether they are suitable for use by patients with neuromuscular disorders.

Study Limitations

There were a number of limitations to the present study. One of the most obvious was that young, healthy subjects were tested rather than habitual crutch users. The reason these subjects were used was that they were easy to recruit, healthy, and therefore likely to be able to adequately use crutches with minimal risk of falling or injury. However, subjects practiced for only 15 minutes with each crutch type before data collection. This practice was enough for subjects to become accustomed to using the crutches but probably not enough for subjects to master crutch walking with each crutch type at the level of a habitual crutch user. The lack of extended practice was likely to have been a major determinant of the variability within subjects that was seen in the ground reaction force traces, but more studies of habitual crutch users’ gait are required to confirm this. Testing of the crutches with habitual crutch users would most likely reduce the within-subject variability because subjects would be more comfortable using crutches but, because people with a variety of medical conditions and varying degrees of disability use crutches regularly, the between-subject variability may be greater than that seen in this study. The spring constant used in this study was based on the qualitative rather than quantitative recommendations of Shortell et al., and unfortunately only 1 spring constant was tested. It would have been helpful to evaluate walking with spring crutches with a variety of spring constants to detect differences between spring constants in subjects with different body weights.

CONCLUSIONS

The results of this study have important implications for the design of axillary crutches and suggest avenues for future research. The reduced impulses and rates of force rise imply that spring-loaded crutches may allow crutch users to ambulate more comfortably with axillary crutches and with fewer complications. Further work is needed to quantify how loads applied to the body (as opposed to ground reaction forces) are altered and what loading differences exist for habitual crutch users and for varied spring constants. Although oxygen consumption during crutch ambulation has been measured previously, there have not been studies of the oxygen consumption while walking with spring-loaded crutches compared with standard crutches. LeBlanc et al., however, failed to find differences between spring-loaded and standard crutches in a heart rate–based energy expenditure index. If using spring crutches could substantially reduce the high-energy demands of crutch walking, many people with disabilities might opt to use crutches rather than wheelchairs.

Acknowledgment: We thank Laura Nigro, BSc, for assistance with the data collection.

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Suppliers

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Reliability of a New Instrument for Measuring Plantarflexor Muscle Strength

Maria Örtqvist, PT, MSc, Elena M. Gutierrez-Farewik, PhD, Markus Farewik, BSc, Anna Jansson, PT, PhD, Åsa Bartonek, PT, PhD, Eva Broström, PT, PhD


Objectives: To test the reliability of a new muscle strength testing instrument (the Strength Measuring Chair [SMC]) designed to quantify isometric strength in the lower extremities, and to determine the agreement between the SMC and an isokinetic dynamometer (Biodex).

Design: Isometric strength tests were performed in plantarflexors with 2 different knee positions (60°, 30°). Measurements were taken at 3 different sessions.

Setting: Strength testing laboratory.

Participants: Twenty-three able-bodied adults and 15 able-bodied children.

Interventions: Not applicable.

Main Outcome Measure: Isometric plantarflexor strength.

Results: The reliability of isometric measurements of plantarflexors taken in the SMC was excellent for both the adult and children groups (intraclass correlation coefficient range, .84-.87). A Bland-Altman 95% limit of agreement test showed no systematic variation in 3 of the 4 SMC test observations; systematic variation was only observed in the adult group at a knee position of 30°. There was no systematic difference in the adult group between the SMC and the isokinetic dynamometer, but there was a systematic variation in the children’s group.

Conclusions: The SMC reliably measured isometric plantarflexor strength in the tested populations.

Key Words: Gastrocnemius muscle; Isometric contraction; Rehabilitation; Reproducibility of results; Soleus muscle.

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Measuring muscle strength is a routine procedure in the assessment of children and adults with pathology that affects muscle strength or motion. Traditionally in clinical practice, manual muscle testing (MMT) is the most commonly used method of evaluating muscle strength. The disadvantages of this method, namely, the subjective nature of assessing the amount of resistance applied during the test and the noninterval data scale—which complicates and rules out many statistical analyses—have led to more frequent use of quantitative instruments such as hand-held dynamometers and computerized isokinetic dynamometers. Hand-held dynamometers are used to assess isometric strength at isolated joint positions. Studies with hand-held dynamometers have found that they have good reliability in various populations.

Even so, this method has some important limitations, such as difficulties in stabilizing the patient, accurately assessing the joint position, and using the examiner’s strength as the estimated resistance, particularly when testing large muscle groups. A more sensitive and valid testing technique may be achieved by using a computerized strength-testing isokinetic dynamometer. Such dynamometers reliably measure strength in the calf and knee muscles in different populations.

Several studies have shown that one commonly used isokinetic dynamometer, the Biodex System 3, is a reliable device that has a negligible learning effect. Isokinetic dynamometers are more commonly used in larger physiotherapy clinics than in smaller clinics or gait laboratories.

The reliability of any new instrument must be tested before it can be used clinically. Reliability refers to the consistency of repeatability of a measurement. It is difficult to find a clinical measurement that is totally reliable because all instruments and raters have some inconsistencies. Any observed value may, therefore, be considered a function of one true value and one error component. The difference between the true value and the observed value is called “measurement error.” “Agreement” refers to how well results from 2 different methods or instruments agree.

Testing muscle strength in the lower extremities is not an easy task because strength is dependent on posture and joint position. This is particularly true for the plantarflexors, which are normally capable of lifting several times body weight and which are important for ankle and knee stability and for propelling the body forward in gait. To our knowledge, relatively few studies have measured isometric plantarflexor strength in healthy adults and children. Because of their strength, plantarflexors of adolescents and adults are impossible to measure reliably with MMT and hand-held dynamometers. The demands on an instrument for testing this muscle group while controlling the joint position are many.

In this project, a new muscle strength testing instrument, the Strength Measuring Chair (SMC), was designed to restrict joint motion during testing.

Our purpose in this study was to test the SMC’s intrasubject, intrasession, and intersession reliability and to determine the agreement between this new instrument and a commonly used isokinetic dynamometer, the Biodex System 3.
METHODS

Participants

An adult group consisted of 23 able-bodied subjects (13 women, 10 men) between 23 and 60 years of age. A second group consisted of 15 able-bodied children (8 girls, 7 boys) ranging in age from 5 to 10 years (table 1). None of the subjects had current or recent injuries in the lower extremities at time of testing. Subjects were recruited from among colleagues, friends, and acquaintances. Participation was voluntary and written and verbal information was given to all subjects. The Karolinska University Hospital ethics committee approved the study.

Instrumentation

The SMC. This new instrument is designed for seated subjects undergoing testing with hip and ankle joints in the 90° positions and the knee joint adjustable from 90° to 30° positions (0° is extended leg). The chair is adjustable in size so as to accommodate subjects from approximately 5 years of age to adulthood. Four force sensors, which measure force generation in both tension and compression, are placed at adjustable distances from joint centers (fig 1). The same sensors can be used to test opposing muscle groups; for example, by pushing on a sensor, plantarflexor strength can be tested, and dorsiflexor strength can be tested by pulling up on a strap attached to the same sensor. The instrument is therefore able to measure force generation in 4 different muscle groups: plantarflexors, ankle dorsiflexors, knee flexors, and knee extensors on both sides simultaneously. This study was focused only on plantarflexors.

To restrict motion during plantarflexor strength testing, 5 straps were attached to the subjects: one around the waist, one over the thigh, and one around the lower shank. The foot was fixed by 2 straps to restrict movement at the ankle, to prevent harmful loading to the equipment, and to ensure against obtaining inaccurate data because of a nonaxial movement. Plantarflexor strength was tested when force was applied to the sensor by pushing the sensor plate under the foot.

The moment arm was measured from the lateral malleolus to the sensor’s middle along the sensor plate axis. The voltage signal from the force sensors is converted to a digital signal and sent to a personal computer (PC). The instrument measures plantarflexor strength as the product of the compression force (in newtons) of the sensor and the moment arm (in meters). A user-friendly PC interface was designed in LabView. The user interface implements moment arms and displays the generated torque in newton-meters. The data are then collected and exported to Microsoft Excel. Taring for each sensor was implemented to offset the limb weight on the sensor. Data were sampled at 1000Hz and analyzed as a mean over a 10-second interval. The mean of the collected data were then considered the tare value of the limb weight. Sensors were calibrated shortly before this study began.

Isokinetic dynamometer. The Biodex System 3 can be used for both muscle strength testing and rehabilitation. It accommodates several positions and exercises. Five different modes are available for muscular testing or rehabilitation: isokinetic resistance, eccentric resistance, passive motion, isotonic, and isometric mode. The manufacturer has provided recommendations for testing isometric plantarflexor strength. The leg is attached via straps and strength is measured by a central torque-measuring device.

Testing Procedure and Data Collection

Subjects attended 3 trial sessions that lasted about 1 hour each. Isometric torque was measured with both devices. Subjects were tested first in the SMC and then with the isokinetic dynamometer by the same examiner to evaluate agreement, and then again in the SMC. In the SMC the plantarflexors were tested with both 60° and 30° angles in the knee. Because of the instrument setup conditions for the isokinetic dynamometer, the plantarflexors were only tested with a 60° angle in the knee. During all tests, subjects were seated with their backs supported, hips at right angles, and arms across their chests. The right leg only was tested, with 3 repetitions per testing position and a minimum resting period of 2 minutes between each trial to avoid muscle fatigue. Before each trial, subjects were told to push as hard as they could for 5 seconds. The lateral malleolus of the fibula was used as the reference landmark and aligned with the axis of rotation of the machine. There was a 1-week

<table>
<thead>
<tr>
<th>Table 1: Characteristics of the Adult and Children Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group</strong></td>
</tr>
<tr>
<td><strong>Adult group</strong></td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td><strong>Children group</strong></td>
</tr>
<tr>
<td>Girls</td>
</tr>
<tr>
<td>Boys</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

NOTE. Values are n, average ± standard deviation (SD), or median (range).
interval between trials with the different devices to avoid muscle fatigue and prevent a learning effect (fig 2). Subjects were given similar verbal encouragement during all tests. Visual feedback on the computer monitor during the tests was not provided. The same examiner (MO) conducted all tests.

**Statistical Analysis**

Descriptive statistics of muscle strength are presented as torque (in newton-meters). The differences in peak torque measured in the 2 testing positions (60°, 30°) were calculated with repeated-measures analysis of variance (ANOVA).

The degree of correlation between the 3 repetitions during session 2 in the isokinetic dynamometer and the 3 repetitions during session 3 in the SMC (intrasubject reliability) was calculated with an intraclass correlation coefficient, model 1,1 (ICC1,1).28 We used a Bland-Altman 95% limit of agreement29 and an ICC2,1 to test the intersession reliability and evaluate systematic variations between session 1 and 3. The Bland-Altman test is an approach to assessing agreement between 2 different methods of clinical measurements. This test involves calculating the mean result from each method and using it in a series of agreement tests. The results are presented in a Bland-Altman plot. The measurement error was calculated with a standard error of measurement and a coefficient of variation (CV).20 ICC was interpreted according to recommendations by Fleiss.30 An ICC greater than .75 represents excellent reliability; 0.4 to .75 represents fair to good reliability.30 In the adult group, reliability was additionally calculated separately for men and women but sex was not considered individually in children.31

One child could not be tested with the knee at 30° during the first session because of technical problems. That subject’s data were not included in the calculation of statistics for plantarflexor strength in the 30° knee position in both groups, as well as with a 60° knee position in the adult group (table 3). The ICC was lower for plantarflexor strength in the 60° knee position (.46) in the children’s group. The intersession reliability of measurements in the SMC was also calculated separately for women and men (tables 3, 4). SMC intersession reliability was somewhat lower when sex was considered separately. Table 5 presents the ICC between 3 repetitions during session 3 in the SMC. There was an excellent intrasubject, intrasession reliability coefficient (.85–.97) in the 2 testing positions in both the children and adult groups.

There were no systematic variations in the SMC test sessions 1 and 3 in 3 of the 4 observations (children in a 30° knee position, children in a 60° knee position, adults in a 60° knee position), but there was a systematic variation in the adult group. Both groups showed higher plantarflexor strength with the knee in the 30° position than in the 60° position (adults in session 3, 117.0Nm, P<.001; children in session 3, 30.3Nm, P<.05) (fig 3).

**Instrument Reliability**

The ICC values indicate excellent intersession reliability (.84–.87) of the plantarflexor strength measurements with the 30° knee position in both groups, as well as with a 60° knee position in the adult group (table 3). The ICC was lower for plantarflexor strength in the 60° knee position (.46) in the children’s group. The intersession reliability of measurements in the SMC was also calculated separately for women and men (tables 3, 4). SMC intersession reliability was somewhat lower when sex was considered separately. Table 5 presents the ICC between 3 repetitions during session 3 in the SMC. There was an excellent intrasubject, intrasession reliability coefficient (.85–.97) in the 2 testing positions in both the children and adult groups.

There were no systematic variations in the SMC test sessions 1 and 3 in 3 of the 4 observations (children in a 30° knee position, children in a 60° knee position, adults in a 60° knee position), but there was a systematic variation in the adult group.

**RESULTS**

**Muscle Strength**

Table 2 shows that with the knee in the 30° position while seated in the SMC, the mean plantarflexor peak torque was 137.1Nm in the adult group and 37.3Nm in the children’s group. Both groups showed higher plantarflexor strength with the knee in the 30° position than in the 60° position (adults in session 3, 117.0Nm, P<.001; children in session 3, 30.3Nm, P<.05) (fig 3).

**Table 2: Mean Values of 3 Peak Torque Measurements (in Nm) in Plantarflexion at the 3 Different Sessions, in the SMC, and in the Isokinetic Dynamometer, With 60° and 30° Knee Angles**

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Session 1 SMC</th>
<th>Session 2 Biodex</th>
<th>Session 3 SMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee 60° all</td>
<td>23</td>
<td>120.0±40.0</td>
<td>112.5±39.0</td>
<td>117.0±40.4</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>92.3±28.5</td>
<td>87.5±23.3</td>
<td>98.3±33.6</td>
</tr>
<tr>
<td>Men</td>
<td>10</td>
<td>135.7±31.9</td>
<td>144.9±30.4</td>
<td>141.4±36.3</td>
</tr>
<tr>
<td>Knee 30° all</td>
<td>23</td>
<td>131.6±43.4</td>
<td>ND</td>
<td>137.1±42.2</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>99.6±32.6</td>
<td>ND</td>
<td>111.0±35.6</td>
</tr>
<tr>
<td>Men</td>
<td>10</td>
<td>154.7±30.7</td>
<td>ND</td>
<td>156.7±39.0</td>
</tr>
<tr>
<td>Children group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee 60°</td>
<td>15</td>
<td>30.7±12.5</td>
<td>39.3±17.3</td>
<td>30.3±13.6</td>
</tr>
<tr>
<td>Knee 30°</td>
<td>14</td>
<td>35.6±12.4</td>
<td>ND</td>
<td>37.3±15.3</td>
</tr>
</tbody>
</table>

NOTE. Values are n and mean ± SD. Abbreviation: ND, no data.
MEASURING PLANTARFLEXOR MUSCLE STRENGTH, Örtqvist

The ICC values between the SMC and the isokinetic dynamometer indicate excellent agreement (ICC = .82) for plantarflexor strength measurement with a 60° knee position in the adult group, but only fair to good agreement (ICC = .55) in the children’s group. The ICC values calculated separately for women and men indicated good to excellent agreement (.65 and .76, respectively).

There was no systematic variation between the SMC and the isokinetic dynamometer in the adult group (P = .37), but in the children’s group, strength was measured approximately 10Nm lower in the SMC (P < .05) (figs 5A, 5B).

### DISCUSSION

We have shown that the SMC reliably measured isometric strength in the plantarflexors. The examiner (MÖ) perceived it to be easier to operate than the isokinetic dynamometer; also, its size is such as to make it feasible for use in, for example, a clinical gait laboratory. When testing the children with the isokinetic dynamometer, the examiner had difficulty finding a stable position with no joint motion and found the SMC easier to adjust for smaller children. Because subject positioning and technical settings were easier with the SMC, its testing time took approximately 15 fewer minutes than with the dynamometer.

### Strength Measurements

Subjects who had difficulty in isolating the muscle groups performed a repetition trial. The test order may influence reproducibility and therefore, the test order and the examiner were the same for each subject each time. Verbal encouragement during the test may influence the ability to produce maximum strength. The encouraging words spoken during the tests were standardized and strictly followed. Seger and Thorstensson have shown that there is a significant difference in muscle strength between sexes in adults, but no such difference has been found in prepubertal children. As such, the reliability was calculated only for each sex individually in the adult group.

### Reliability Statistics

Statistical methods for assessing reliability and agreement between repeated quantitative measurements and between different apparatuses have been discussed often in the literature. Several statistical tests are appropriate for analysis of reliability, but no individual test alone provides sufficient information. Earlier studies have recommended that several tests be used complementarily.

The ICC analysis was specifically designed to evaluate reliability and provide a reliability index with which to indicate the measurement of error. The single index ICC is calculated using variance estimates obtained through the partitioning of total variance into between- and within-subject components. It is dependent on the heterogeneity of the group and will be high if the variance of measurements between subjects is higher than that within subjects. There is no standard acceptable level of reliability using the ICC. It will range from 0 to 1, with values closer to 1 representing a higher reliability.

Fleiss recommends that an ICC greater than .75 be interpreted to represent excellent reliability and ICCs from 0.4 to .75 to be considered to be fair to good reliability, but whether a value is truly excellent can depend on the specific application. According to these recommendations, our results indicate excellent reliability in plantarflexor strength measurement with a 30° knee position in both groups and a 60° knee position in the adult group in the SMC, and a fair to good reliability with a 60° knee position in the children’s group. Because the ICC gives no indication of the size of disagreement between measurements, either a standard error of measurement or a Bland-Altman 95% limit of agreement test, or both, should be used to complement it.

### Table 3: ICC<sub>2,1</sub> Between Session 1 and Session 3 in the SMC

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>ICC 1–3 SMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee 60° all</td>
<td>23</td>
<td>.87</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>.87</td>
</tr>
<tr>
<td>Men</td>
<td>10</td>
<td>.75</td>
</tr>
<tr>
<td>Knee 30° all</td>
<td>23</td>
<td>.84</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>.80</td>
</tr>
<tr>
<td>Men</td>
<td>10</td>
<td>.70</td>
</tr>
<tr>
<td>All children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee 60°</td>
<td>15</td>
<td>.46</td>
</tr>
<tr>
<td>Knee 30°</td>
<td>14</td>
<td>.86</td>
</tr>
</tbody>
</table>

NOTE. Data analyzed from trials with 60° and 30° knee angles. Plantarflexor peak torque was used in all cases. Abbreviation: SE, standard error of measurement.

### Table 4: Standard Error of Measurement and CV Between Measured Plantarflexor Strength During Session 1 and Session 3 in the SMC

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>SE (Nm)</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee 60° all</td>
<td>23</td>
<td>14.7</td>
<td>12</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>11.4</td>
<td>12</td>
</tr>
<tr>
<td>Men</td>
<td>10</td>
<td>18.0</td>
<td>13</td>
</tr>
<tr>
<td>Knee 30° all</td>
<td>23</td>
<td>17.3</td>
<td>13</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>15.6</td>
<td>14</td>
</tr>
<tr>
<td>Men</td>
<td>10</td>
<td>19.4</td>
<td>12</td>
</tr>
<tr>
<td>All children</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee 60°</td>
<td>15</td>
<td>9.7</td>
<td>32</td>
</tr>
<tr>
<td>Knee 30°</td>
<td>14</td>
<td>5.2</td>
<td>14</td>
</tr>
</tbody>
</table>

NOTE. Data analyzed from trials with 60° and 30° knee angles.

### Table 5: ICC<sub>1,1</sub> Between 3 Repetitions in Plantarflexor Strength During Session 3 in the SMC

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>ICC 1–3 SMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee 60° all</td>
<td>23</td>
<td>.96</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>.97</td>
</tr>
<tr>
<td>Men</td>
<td>10</td>
<td>.91</td>
</tr>
<tr>
<td>Knee 30° all</td>
<td>23</td>
<td>.97</td>
</tr>
<tr>
<td>Women</td>
<td>13</td>
<td>.96</td>
</tr>
<tr>
<td>Men</td>
<td>10</td>
<td>.96</td>
</tr>
<tr>
<td>All children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee 60°</td>
<td>15</td>
<td>.87</td>
</tr>
<tr>
<td>Knee 30°</td>
<td>14</td>
<td>.85</td>
</tr>
</tbody>
</table>

NOTE. Data analyzed from trials with 60° and 30° knee angles.
A Bland-Altman 95% limit of agreement test assesses agreement between 2 different methods of clinical measurements and involves calculating the mean for each method and using it in a series of agreement tests. If there is a systematic variation, for example, when one of the measurements is larger than the other, the values are not distributed equally around the zero line, and a Bland-Altman plot is useful. From the graph, systematic variation and trends can be detected. The interpretation of the results depends on the clinical circumstances, and it is not possible to use statistics to define acceptable agreement.

Reliability and Agreement Results

The excellent reliability for repeated measurements of plantarflexor strength in the adult group with 60° and 30° knee positions and in the children’s group with a 30° knee position in the SMC is promising. There was no apparent systematic variation during the 2 test sessions in the SMC in the children’s group, although some systematic variation was observed in the adult group. A learning effect wherein the adults became more accustomed to the protocol by the second and third session may explain this.

The results also indicate that there is a systematic variation between the 2 measuring devices in children but not in adults. This variation may be attributable to several factors, for example, greater sources of testing errors in the isokinetic dynamometer and differences in testing environments. The examiner experienced difficulty in stabilizing subjects in the isokinetic dynamometer; its modules for stabilizing the foot and the sitting surface are often too large for the children.

To apply our results in a clinical setting, the targeted population must be considered. For example, to conclude that strength has substantially improved, the magnitude of the patients’ original strength and functional improvement must be known. A reasonable goal for strength improvement must be set. Small differences in strength should be interpreted with caution because of the wide range in the within-subject torque.

Studies of lower-extremity strength in adults have reported a wide range of peak isometric strength values. Studies of plantarflexor isometric strength have reported values ranging from

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**Fig 4.** Bland-Altman plots showing the differences between session 1 in the SMC and session 3 (SMC) for plantarflexor peak torque plotted against their mean for each subject, to check for any systematic variations between the 2 test sessions. (A) Adult group (n=23); (B) children group (n=15); (C) adult group (n=23); and (D) children group (n=14).
Fig 5. Bland-Altman plots showing the differences between session 2 (isokinetic dynamometer) and session 3 in the SMC for plantarflexor peak torque plotted against their mean for each subject, to check for any systematic variations between the 2 different strength measuring devices. (A) Adult group (n=23) and (B) children group (n=15).

CONCLUSIONS

The new SMC instrument reliably measured isometric plantarflexor strength in able-bodied children and adults. This is clinically important because there are many demands placed on an instrument for testing plantarflexor strength while controlling the position of the joint. Small statistical differences in strength measured in the SMC, however, should be interpreted with caution and discussed with regard to clinical relevance. We believe that the SMC is a useful device with which to measure plantarflexor muscle strength objectively in children and adults in clinical practice, for example, in a clinical gait laboratory.

Acknowledgments: We thank Mikael Persson and Marie Eriksson, CPO, at Olmed Ortopediska AB for their help in designing and constructing the Strength Measuring Chair.

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Neurologic Injury Associated With Pelvic Trauma: Radiology and Electrodiagnosis Evaluation and Their Relationships to Pain and Gait Outcome

Anthony Chiodo, MD


Objectives: To study the electrodiagnosis presentation of patients with lower-extremity nerve injury related to pelvic trauma, to assess gait outcome and correlation to injury type and electrodiagnosis, and to study the incidence of pain postinjury and the relationships between injury type and electrodiagnosis and pain type.

Design: Retrospective review.

Setting: Tertiary care university hospital.

Participants: Seventy-eight patients who present with lower-extremity nerve injury associated with pelvic trauma.

Interventions: Not applicable.

Main Outcome Measures: Electrodiagnostic results, the relationship between electrodiagnosis and fracture or injury type, and gait and pain outcomes.

Results: The characteristic neurologic injury in patients with pelvic trauma was a lumbosacral plexus injury (71% of cases). Sciatic nerve injuries were more common in patients with isolated acetabular fractures (9/10 cases). Gait outcome was related to electrodiagnostic abnormality and severity. Long-term assisted gait was best predicted by absent peroneal conduction to the extensor digitorum brevis (P<.001) and absent motor unit potentials on anterior tibialis needle examination (P<.001). Neuropathic pain was seen in patients with any degree of gait abnormality. Orthopedic pain was more common in patients with an acetabular fracture (P<.025).

Conclusions: Lumbosacral plexus injury after pelvic trauma is a characteristic disorder with severe long-term implications regarding both pain and gait outcome.

Key Words: Electromyography; Lumbosacral plexus; Pelvis; Rehabilitation; Trauma.

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The lumbosacral and lumbosacral plexuses are vulnerable to injury when their bony protection, the pelvis, is compromised. Injury to the lumbar plexus is less common because it is not as proximate to the locations of the most common pelvis fractures, namely, the sacroiliac joint (SIJ) and the acetabulum. Retroperitoneal hemorrhage, superior ramus fractures, and traction do cause injury to the lumbar plexus.1 Penetrating injuries more commonly affect the lumbar rather than the lumbosacral plexus due to its more superficial location.1 The lumbar plexus proximal branches to the iliohypogastric are the most susceptible to traction injury (C. Goodmurphy, personal communication, Grenada, May 2003).

The lumbosacral plexopathy accounts for 80% of all nerve injuries after pelvic trauma.1 Nerve traction sites for the lumbosacral plexus include the dura attachments, connective tissue attachments to the sacral ala and anterior SIJ, and connective tissue attachments to the piriformis and sacrotuberous ligament.2 Compression due to SIJ fracture-dislocation with concomitant anterior joint hematoma is common.2,3 Compression is also seen after acetabulum fracture. The reported incidence of lumbosacral plexopathy after acetabular fracture is .38% to 24%.4,5 The discrepancy in these numbers depends on whether patients were included if they were recognized by observation (smaller number) or if all patients in the cohort were evaluated neurologically and by electrodiagnosis. Root avulsion is less common and seen with more severe pelvic and sacral fractures.6-8 SIJ fracture and/or dislocation associated with an L5 transverse process fracture (“far out” fracture) is likely to result in an L5 nerve root injury. Sacral fractures result in nerve root injury if the fracture passes through a nerve foramen or if the fracture is transverse across the spinal canal.9

Spinal cord, conus medullaris, and cauda equina injuries should be considered, especially if neurologic bladder or bowel dysfunction is reported. Sciatic neuropathy with stretch at the piriformis attachment sites is a possible mechanism of injury, with the peroneal branch of the sciatic nerve most susceptible to damage. Sciatic neuropathy should also be considered in femur fracture due to direct injury. Direct injury of the obturator nerve could occur due to pubic rami fractures, whereas femoral nerve injury is common after anterior acetabulum and superior rami fractures. The differential diagnosis should include peroneal neuropathy at the fibular head in any patient with increased likelihood of compression due to bedrest.

Electrodiagnosis completed at least 21 days after injury is helpful in evaluating this lesion. Sensory nerve conduction studies of the superficial peroneal and sural nerves bilaterally allow for the confirmation of damage distal to the dorsal root ganglion. Amplitude drops of 50% or more on the affected side are consistent with an injury to the plexus. In a case series, 72% of patients with a lumbosacral plexus showed abnormalities on sural nerve testing and 41% showed abnormalities of other sensory nerves tested. Abnormalities in motor nerve conduction study evoked amplitude were seen in 55% in this same series.5 Saphenous sensory studies are not reliable enough to use to identify damage but may be helpful to confirm that the lumbar plexus is not affected.10 Needle examination of proximal and distal muscles clarifies the distribution of the nerves involved.
Needle examination findings are the criterion standard by which the diagnosis of plexopathy is made in most studies. This study is the largest group of patients evaluated retrospectively with known neurologic injury after pelvic trauma. A preliminary assessment will allow us to see if the types of injury seen are similar to other studies. This study evaluates the electrodiagnostic findings in plexus and nerve injuries due to pelvic trauma. Prior studies had large numbers of patients with incomplete nerve conduction studies and needle examinations, making study interpretation difficult. It is expected that the sample size will allow the relationship between injury type and nerve injury type to be studied, which was not done in other studies. Electrodiagnostic and radiologic findings as they relate to gait outcome and pain will be correlated, because they have not been examined in similar studies.

METHODS

We identified 335 cases of lower-extremity plexus injury in the University of Michigan EMG Pro database from 1991 to 2005. Query was made of injuries to the lumbosacral plexus, lumbar plexus, sciatic nerve, femoral nerve, obturator nerve, or other nerve and then reviewed in the computerized medical record system to capture only those associated with pelvic trauma. These accounted for cases that were referred to the electromyography laboratory for clinical evaluation. Of these, 78 cases were identified as being related to pelvic trauma. Demographic information was recorded including age, sex, and mechanism of injury.

The nerve conduction studies were reviewed. Sural sensory and superficial peroneal sensory responses were abnormal if the amplitude was less than half of the unaffected side or if the amplitude was less than 6μV. The peroneal motor response was abnormal if the amplitude was less than 2mV or less than half the amplitude of the opposite side. The peroneal motor response with recording over the anterior tibialis was abnormal if the amplitude was less than 3mV. The tibial motor response was abnormal if the amplitude was less than 3mV or less than half of the other side. The tibial F response was abnormal if the distal latency was greater than 55ms or 5ms longer than the other nonaffected side.

On the needle examination, we noted an abnormality if abnormal spontaneous activity was noted or if recruitment was more than mildly decreased. The absence of recruitment was specifically noted. The gluteal muscles were grouped together in the analysis, as were the hamstring muscles.

Needle examination pattern, together with nerve conduction studies, allowed characterization of the nerve injury as being at the root level, plexus level, nerve level, or a combination. Root level injury was diagnosed with a neurogenic muscle abnormality in the context of a normal sural response and/or abnormal paraspinal examination. A plexus level injury was diagnosed with abnormal sensory evoked amplitudes with denervation in a characteristic pattern distal to the paraspinal muscles. A specific nerve injury was diagnosed with abnormal just in the distribution of a specific nerve on nerve conduction and needle studies. Sciatic neuropathy was distinguished from a lumbosacral plexopathy by the presence of a normal needle examination of the gluteal muscles. A lumbar plexus was distinguished from a femoral neuropathy by the presence of obturator and femoral nerve distribution abnormalities on needle examination.

We then reviewed medical records to identify fracture or injury type, neurologic presentation, and orthopedic complication. Radiologic studies and operative reports were used to identify the fractures or injuries sustained. Injury types included proximal femur fracture, femur fracture with ramus fracture, acetabular fracture, SIJ disruption, SIJ disruption with acetabular fracture, and other (isolated ischial wing and avulsion fractures). Acetabular fracture type was ascertained as well. Clinical records were reviewed to obtain results of neurologic examination and clinical outcome in regard to both gait outcome and pain. Gait outcome was obtained from clinical observation and the recorded need for ankle-foot orthosis (AFO) or other orthotic, assistive device, or alternative mobility equipment. Significant pain was recorded if pain required pain medication intervention. Orthopedic pain was defined as pain located proximal to the site of fracture on palpation or with motion testing of the hip and pelvis. Neuropathic pain was defined as pain located distal to the hip with characteristics including allodynia, dysesthesia, burning, electrical sensation, and numbness and tingling. Gait and pain outcomes were only recorded at least 1 year postinjury. Follow-up radiologic studies were reviewed to evaluate for any late orthopedic complications, as can be seen in proximal femur and acetabular fractures.

All analyses were conducted comparing incidences between groups. Therefore, the chi-square test was used to evaluate for statistical significance.

RESULTS

The 78 patients identified had a mean age of 38.9 years (range, 11–86y). Mean follow-up time was 4 years. Eleven patients were women and 67 were men. Motor vehicle collisions (MVCs) accounted for 48 patients. Eight patients sustained crush injuries, 7 had falls, and 6 each had a motorcycle collision or pedestrian MVC. Two patients had a snowmobile collision and 1 had a horse-related injury. The total number of female injuries was too small to allow an analysis of differences between male and female injury causes. However, it was interesting to note that motorcycle injuries and crush injuries were only seen in men. This may reflect a difference in the amount of motorcycle use and exposure to heavy equipment that could result in an injury in these 2 groups.

Table 1 displays female and male MVC-related injuries as they relate to fracture or injury type and gait outcome. As noted, the injury types were highly variable in men and women and do not show a characteristic pattern. No difference in the rate of acetabular fracture was noted between the

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Normal Gait</th>
<th>Unassisted</th>
<th>Uses AFO</th>
<th>Uses Assistive Device</th>
<th>Uses AFO and Device</th>
<th>Cannot Walk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men*</td>
<td>7</td>
<td>9</td>
<td>10</td>
<td>0</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Women*</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Femur Fracture</th>
<th>SIJ Fracture</th>
<th>Acetabulum Fracture</th>
<th>SIJ Plus Acetabulum</th>
<th>Other Pelvic Fracture</th>
<th>Femur Plus Pelvis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men*</td>
<td>3</td>
<td>4</td>
<td>18</td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Women*</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

*P>-.05 in evaluating the relationship between sex and both gait outcome and injury type.
groups ($\chi^2 = 1.10, P > .05$). No difference in gait outcome was noted ($\chi^2 = 0.59, P > .05$).

The nerve abnormalities on electrodiagnosis are delineated in table 2. Of the 78 patients studied, 55 had lumbosacral plexus injuries and 11 had sciatic nerve injuries. No patient had a lumbar plexus injury alone. However, 29 of the lumbosacral plexus injury patients had involvement of the lumbar plexus and femoral nerve. Only 19 of the lumbosacral plexus injuries occurred without other neurologic injury but 10 of 11 sciatic nerve injuries occurred in isolation.

Nerve conduction characteristics are noted in table 3. Sixty-five of the 78 patients had an abnormal sural sensory response. For 60% of patients, the sural sensory response was absent. Of the 11 patients with a normal sural sensory response, 10 did not have the opposite side evaluated for comparison. In one, the superficial peroneal sensory response was abnormal. In 8 of the others, the paraspinal examination was normal. In the remaining 2, the paraspinal examination was not completed.

The peroneal motor response recorded at the extensor digitorum brevis was similarly abnormal in 68 with 68% of all patients having no peroneal motor-evoked amplitude. In comparison, 48 patients had an abnormal tibial motor response with 32% of all patients having no tibial motor-evoked amplitude.

On needle examination, seen in table 3, all but 4 patients had an abnormal peroneal innervated muscle. In the 4 that were normal, needle examination showed that 2 had abnormal tibial muscles and 2 had an abnormal gluteal muscle. In all, 56% had absent recruitment in a peroneal innervated muscle. In comparison, although 69 had an abnormal tibial muscle on needle examination, only 19% had no recruitment of a tibial innervated muscle. An abnormality of the gluteal, hamstring, and quadriceps each were present in half of the patients in this study. These muscles were not tested in 15, 29, and 5 of the subjects, respectively. The iliopsoas and adductors were abnormal in 12 and 14 patients, respectively, and were not evaluated in over two thirds of the patients in this series.

The fracture or injury type and associated neurologic injury is noted in table 4. Sciatic nerve injuries were unlikely to be present in relationship with SIJ fractures or disruptions compared with lumbosacral plexus injuries ($\chi^2 = 6.8, P < .01$). This was not surprising given the more distal location of the sciatic nerve with respect to the SIJ and the relative proximity of the acetabulum to the sciatic nerve. No significant difference was noted relating sciatic nerve and lumbosacral plexus injuries in the presence or absence of acetabular fractures ($\chi^2 = 1.66, P > .05$). Most SIJ injuries associated with lumbar plexus or femoral nerve injuries were associated with pubic rami fractures.

Gait outcome was related to type of injury in the 71 of 78 patients where gait outcome data were available for at least 1 year postinjury. As noted in table 5, two thirds of patients required an AFO, an assistive device, or both. This was true in

<table>
<thead>
<tr>
<th>Injury Location</th>
<th>Total</th>
<th>No Gluteal Muscle Tested</th>
<th>Alone</th>
<th>With Lumbar Plexopathy</th>
<th>With Iliopsoas Only</th>
<th>With Femoral Neuropathy</th>
<th>With Obturator Neuropathy</th>
<th>With Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbosacral</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>plexus</td>
<td>55</td>
<td>9</td>
<td>19</td>
<td>14</td>
<td>2</td>
<td>15 (14)*</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Sciatic</td>
<td>11</td>
<td>10</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distal tibial and peroneal</td>
<td>10</td>
<td>6†</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluteal and femoral</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gluteal, obturator, and iliopsoas</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE. Values are n. Values in parentheses are where the adductor muscle was not tested.

*No iliopsoas examined.
†No muscles proximal to the knee were examined.
‡Normal sural sensory response.
§No patients fulfilled the criteria.

<table>
<thead>
<tr>
<th>Table 3: Distribution of Nerve Injury Associated With Pelvic Trauma</th>
<th>Table 4: Electrodiagnostic Findings After Pelvic Trauma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrodiagnostic Findings</td>
<td>% Abnormal (% No Response)</td>
</tr>
<tr>
<td>Sural sensory</td>
<td>83 (58)</td>
</tr>
<tr>
<td>Superficial peroneal sensory</td>
<td>14 (99)</td>
</tr>
<tr>
<td>Peroneal motor at the extensor digitorum brevis</td>
<td>87 (72)</td>
</tr>
<tr>
<td>Peroneal motor at the anterior tibia</td>
<td>58 (76)</td>
</tr>
<tr>
<td>Tibial motor</td>
<td>62 (52)</td>
</tr>
<tr>
<td>Tibial F wave</td>
<td>28 (32)</td>
</tr>
<tr>
<td>Anterior tibia</td>
<td>95 (59)</td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>88 (22)</td>
</tr>
<tr>
<td>Vastus</td>
<td>50 (18)</td>
</tr>
<tr>
<td>Internal hamstring</td>
<td>25 (8)</td>
</tr>
<tr>
<td>External hamstring</td>
<td>38 (8)</td>
</tr>
<tr>
<td>Either hamstring</td>
<td>50 (8)</td>
</tr>
<tr>
<td>Superior gluteal</td>
<td>55 (28)</td>
</tr>
<tr>
<td>Inferior gluteal</td>
<td>22 (38)</td>
</tr>
<tr>
<td>Either gluteal</td>
<td>62 (8)</td>
</tr>
<tr>
<td>Iliopsoas</td>
<td>15 (8)</td>
</tr>
<tr>
<td>Adductor longus</td>
<td>18 (8)</td>
</tr>
<tr>
<td>Paraspinal</td>
<td>6 (8)</td>
</tr>
</tbody>
</table>

NOTE. Of 7 normal peroneal motor, 6 had normal tibial motor and 4 had a normal sural sensory response. Of 3 not done peroneal motor, 2 tibial motor not done and the other is borderline normal without opposite comparison. Two have a normal sural sensory response.

*Of these sural responses, one was associated with an abnormal superficial peroneal sensory, the other the paraspinal exam was not done.
†Of the normal sural sensory responses, 9 of 11 had a normal paraspinal exam and 2 were not done.
‡Two with abnormal tibial muscle, one with gluteal and lumbar plexus involvement and the other with gluteal involvement only.

Percentage not provided because needle examination on other side not conducted.
90% of patients with sciatic nerve injury compared with about 50% of patients with lumbosacral plexus injuries, although the difference did not reach statistical significance ($\chi^2$ test = 3.5, $P > .05$). Seven percent of patients were unable to walk, although none of them had a sciatic nerve injury. This was due to severe gluteal nerve involvement or bilateral nerve injury. In patients with a lumbosacral plexus injury, additional lumbar plexus injury did not result in a significant difference in gait outcome ($\chi^2$ test = 0.84, $P > .05$).

Pain was related to type of injury. As seen in table 6, neuropathic pain was seen in 29 (37%) of 78 patients. Neuropathic pain was seen in 25% to 40% of patients in all injury groups. No significant difference was seen between injury type and the incidence of neuropathic pain ($\chi^2$ test = 2.05, $P > .05$). No statistically significant relationship was seen between type of neurologic injury and neuropathic pain ($\chi^2$ test = 0.02, $P > .05$). In contrast, orthopedic pain was seen in 26 (33%) of 78 patients. However, the incidence of orthopedic pain was skewed to patients with acetabular fracture, with 44% of these patients unable to walk. No statistically significant relationship was noted between gait outcome and orthopedic pain ($\chi^2$ test = 0.07, $P > .05$).

The relationship between nerve conduction study and gait outcome is noted in table 8. Sural sensory response was related to gait outcome ($\chi^2$ test = 6.1, $P < .025$), but not severity of sural sensory abnormality ($\chi^2$ test = 3.35, $P > .05$). Tibial motor response ($\chi^2$ test = 5.25, $P < .025$) and absence ($\chi^2$ test = 7.19, $P < .01$) were related to gait outcome. Peroneal motor response ($\chi^2$ test = 13.7, $P < .001$) and absence ($\chi^2$ test = 20.36, $P < .001$) were the best predictors of gait dysfunction. There was no statistical relationship between type of neurologic injury and nerve conduction abnormality, needle examination abnormality, or severity of abnormality. However, patients with sciatic neuropathy were more likely to have abnormal sural sensory responses and absent sural sensory, peroneal motor, and tibial motor responses than patients with lumbosacral plexopathy in this series. This may account for the difference in the gait outcome in these 2 groups. The relationship between needle examination and functional outcome is seen in table 9. The motor recruitment that best predicted functional outcome included any anterior tibialis abnormality ($\chi^2$ test = 9.67, $P < .005$) and the severity of abnormality of both the anterior tibialis ($\chi^2$ test = 27.6, $P < .001$) and vastus medialis ($\chi^2$ test = 4.47, $P < .05$). The poorer gait outcome of patients with sciatic neuropathy is shown by the fact that patients with normal gluteal muscles

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Femur</th>
<th>Femur*</th>
<th>Anterior† Acetabulum</th>
<th>Posterior Acetabulum</th>
<th>Both</th>
<th>SIJ</th>
<th>SIJ Plus Acetabulum</th>
<th>Other Pelvic</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbosacral plexus†</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No gluteal muscle tested</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>With lumbar plexus</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With femoral</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With iliopsoas</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With obturator</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>With root</td>
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<td>1</td>
<td>(3)</td>
<td>(3)</td>
<td>(3)</td>
<td>(3)</td>
<td>(3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sciatic</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>With femoral</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Distal tibial and peroneal</td>
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<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No proximal knee study</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With femoral</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolated proximal nerve§</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>12</td>
<td>16</td>
<td>15</td>
<td>5</td>
<td>78/78</td>
<td></td>
</tr>
</tbody>
</table>

*Additional pelvic fractures are present in the form of pubic rami fractures.
†Comparing the incidence of acetabular fracture in lumbosacral plexus versus sciatic nerve injury gives a $P > .05$.
‡Comparing the relationship between fracture type and the presence or absence of lumbosacral plexopathy gives a $P > .01$.
§One gluteal and femoral, the other gluteal and obturator.

Table 5: Neurologic Injury Type Versus Gait Outcome (Gait Outcome Data Available in 71/78 Patients)

<table>
<thead>
<tr>
<th>Injury Type</th>
<th>Normal</th>
<th>Unassisted</th>
<th>With AFO</th>
<th>With Assistive Device</th>
<th>AFO and Device</th>
<th>Unable to Walk</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbosacral plexus*†</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Lumbosacral and lumbar*</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Lumbosacral and femoral*</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Sciatic*†</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Distal tibial and peroneal</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Isolated</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>15</td>
<td>18</td>
<td>2</td>
<td>20</td>
<td>6</td>
<td>71</td>
</tr>
</tbody>
</table>

*Comparing functional outcome of all lumbosacral plexus patients versus sciatic nerve injuries gives a $P > .05$.
†Comparing functional outcome between isolated lumbosacral plexus injury versus sciatic nerve injuries gives a $P > .05$. 

Table 4: Injury Type Versus Neurologic Injury Type
on needle examination had a worse gait outcome than those with abnormal gluteals ($\chi^2$ test = 3.82, $P = .05$).

**DISCUSSION**

The characteristic neurologic injury related to pelvic trauma is a lumbosacral plexus injury. This is especially true of patients with sacroiliac joint or complex fracture and/or dislocations. In patients with acetabular fractures, sciatic and lumbosacral plexus injuries are nearly equal in prevalence. With open book and unstable pelvic ring fractures, it is not uncommon in these patients for combined lumbosacral plexus and lumbar plexus injuries to occur. We did not see patients with isolated lumbar plexus injuries, which is different from prior studies.1 Differentiation between lumbosacral plexus injuries and sciatic nerve injuries was conducted in this study and is a difference from prior studies. This is important, because sciatic neuropathies did not occur in the presence of sacroiliac fracture and/or dislocations, only in the presence of acetabular fractures. The data reflect the characteristic loss of sural evoked amplitude and/or normal paraspinal needle exam in patients with these neurologic injuries with more detailed and complete electromyography evaluations than seen in other studies.

Pain outcome has not previously been described in this population. Neuropathic pain after nerve injury related to pelvic trauma occurs in all gait outcome groups, regardless of the severity. Statistical analysis did not find a statistical difference in nerve pain in either normal or higher functioning ambulatory groups compared with those with more severe nerve and functional injury. Orthopedic pain was not more common in patients with more severe gait limitation. However, orthopedic pain was most commonly seen in patients with acetabular fractures. This is not surprising because there exists in these patients the risk of osteoarthritis after injury.

Although electrodiagnostic data has been reported in this patient population, the severity of abnormality, pattern of abnormality, and impact of these abnormalities on gait outcome have not been described. Patients in this series were much more likely to have peroneal abnormality and those abnormalities were more severe than in other nerve distributions. This is not surprising because the peroneal branches are posterior at the level of the SIJ, in proximity to hemorrhage that compresses the nerve at that site. In addition, peroneal motor evoked response and anterior tibialis abnormalities best predicted gait outcome. This is explained by the severity of these abnormalities and the importance of ankle dorsiflexion in gait outcome. Although gluteal muscle strength is important for gait dynamics, the involvement of these muscles in this series was not severe and did not affect gait outcome appreciably.

This study indicates that both gait outcome and pain are significant issues in patients who sustain nerve injury associated with pelvic trauma. This had not been previously described. More than half of patients with lumbosacral plexus and sciatic nerve injuries sustained long-term impact on gait. The

**Table 7: Gait Outcome Versus Pain**

<table>
<thead>
<tr>
<th>Gait</th>
<th>Total</th>
<th>% Orthopedic Pain</th>
<th>% Neuropathic Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Unassisted</td>
<td>15</td>
<td>67</td>
<td>40</td>
</tr>
<tr>
<td>With AFO</td>
<td>18</td>
<td>11</td>
<td>44</td>
</tr>
<tr>
<td>With device</td>
<td>2</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>AFO plus device</td>
<td>20</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Cannot walk</td>
<td>6</td>
<td>67</td>
<td>50</td>
</tr>
<tr>
<td>Total for each group</td>
<td></td>
<td>25</td>
<td>29</td>
</tr>
</tbody>
</table>

**Table 8: Nerve Conduction Studies Versus Gait Outcome**

<table>
<thead>
<tr>
<th>Nerve Study Findings</th>
<th>Unassisted Gait</th>
<th>Assisted Gait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sural sensory response: normal*</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Sural sensory response: abnormal</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Sural sensory response: absent</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>Peroneal motor at the extensor digitorum brevis: normal†</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Peroneal motor at the extensor digitorum brevis: abnormal</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Tibial motor at the abductor hallucis: normal*</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Tibial motor at the abductor hallucis: abnormal</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Tibial motor at the abductor hallucis: absent†</td>
<td>3</td>
<td>21</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Needle Examination Findings</th>
<th>Unassisted Gait</th>
<th>Assisted Gait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior tibialis: normal*</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Anterior tibialis: abnormal</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Anterior tibialis: absent†</td>
<td>5</td>
<td>37</td>
</tr>
<tr>
<td>Medial gastrocnemius: normal</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Medial gastrocnemius: abnormal</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Medial gastrocnemius: absent</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Vastus medialis: normal</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Vastus medialis: abnormal</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Vastus medialis: absent*</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Hamstrings: normal</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Hamstrings: abnormal</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>Hamstrings: absent</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Gluteals: normal*</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Gluteals: abnormal</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>Gluteals: absent</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

* $P < .05$; † $P < .005$; ‡ $P < .001$.
impact on vocational and recreational pursuits would be expected to be at least this significant.

**Study Limitations**

There are many limitations to this study as a retrospective analysis. Incomplete examinations, incomplete electrodiagnostic studies, and limited evaluation of pain and functional outcome are some of the problems that haunt this study. Incomplete physical examinations made it impossible to complete any statistical analysis of the relationship between physical examination findings and gait outcome. Incomplete electrodiagnostic studies resulted in some difficulty with categorizing injuries, especially with the fact that gluteal muscles were not consistently evaluated. Pain and functional outcome would have been more completely evaluated prospectively using widely available validated measures. In addition, more detailed gait analysis would allow for a quantitative assessment of each electromyography evaluation on gait and gait mechanics. Evaluating all patients with injury would also allow an accurate assessment of the frequency of neurologic disorder in these injuries and, thereby, an estimation of the scope of this problem. It would also allow the identification of patients with more subtle abnormalities and improve the ability to assess if functional outcome is affected in those patients as well.

Improving this study would involve evaluating all pelvic trauma patients with a codified neurologic and orthopedic evaluation, electrodiagnosis, and both functional and pain measures out to 1 year postinjury. Two years postinjury would allow for reaching the endpoint of neurologic outcome and to allow ample time to pass for the manifestation of late orthopedic complications, such as hip osteoarthritis. The electrodiagnostic evaluation should include bilateral sensory (peroneal and sural) and motor (tibial and peroneal) evoked responses, needle exam in anterior and posterior divisions of the lumbar and lumbosacral plexus, and needle examination in superior and inferior gluteal and paraspinal muscles. The role of a sacral plexus muscle (piriformis, quadratus femoris, obturator inter- nus) evaluation in this disorder has not been clarified. A complete study would also look in detail at accident mechanisms as predictors of injury to identify strategies for prevention.

**CONCLUSIONS**

Lumbosacral plexopathy after pelvic trauma is a characteristic lesion. It is commonly associated with lumbar plexus injuries that rarely occur in isolation. Sciatic neuropathy is seen in acetabular fractures but not in sacroiliac disruptions or pelvic ring fractures. Gait outcome is predicted by electrodiagnostic data. Gait outcome is worse in patients with sciatic neuropathy than lumbosacral plexus injuries. Neuropathic pain is common in patients with residual nerve injury, regardless of the severity. Orthopedic pain is seen in patients with acetabular fractures.

**References**

Quantitative Histology and Ultrastructure Fail to Explain Weakness of Immobilized Rabbit Achilles’ Tendons

Jian Zhou, Yoichi Koike, MD, Hans K. Uthhoff, MD, Guy Trudel, MD


Objective: To test the hypothesis that mechanical weakness caused by immobilization is the result of characteristic histologic and ultrastructural changes in rabbit Achilles’ tendons.

Design: Single-blind, randomized controlled trial.

Setting: University animal care facility.

Animals: Twenty-three New Zealand rabbits.

Intervention: Twenty weight-matched rabbits underwent unilateral hind leg immobilization. The Achilles’ tendons of immobilized and contralateral legs were harvested after 4 or 8 weeks. For ultrastructural outcomes, 6 normal Achilles’ tendons of 3 rabbits served as controls.

Main Outcome Measures: Light microscopic assessments were made on the tendons for cross-sectional area of the tendon, number of tenocytes, adipocytes and blood vessels, roundness of nuclei, area of intense metachromasia, and area of spatially aligned collagen fibers. Transmission electron microscopy (TEM) measured mean collagen fibril diameter and density.

Results: Light microscopic assessment failed to reveal a statistical difference in any of the outcome measures between immobilized and contralateral tendons. TEM did not show a statistical difference in mean fibril diameter between the immobilized groups (4wk, 113.8 ± 1.6nm; 8wk, 113.5 ± 1.4nm) compared with their respective contralateral tendons (4wk, 111.4 ± 1.4nm; 8wk, 116.2 ± 1.8nm) and normal controls (111.8 ± 2.0nm). Eight-week contralateral fibrils were statistically larger than 4-week contralateral fibrils, which was attributed to a training effect of the leg opposite of the casted leg.

Conclusions: Our results add to the recent literature about collagen fibril organization and diameter.13-19 Other investigators, however, found neither histologic nor ultrastructural changes in the tendons after immobilization. In ligaments, microscopic alterations such as hypercellularity, the presence of adipocytes, and disorganized matrix have been associated with a decrease in the tensile load-bearing capabilities of the tissue. Given that many previous studies were qualitative and that their results were often contradictory, we undertook a quantitative study of histologic and ultrastructural changes in rabbits Achilles’ tendons after 4 and 8 weeks of immobilization.

Our objectives in this study were (1) to quantify key histologic markers: the number of tenocytes, adipocytes, and blood vessels, the roundness of tenocyte nuclei, the area of metachromasia, and the alignment of collagen fibers; and (2) to quantify collagen fibril size distributions using transmission electron microscopy (TEM) in immobilized and contralateral tendons.

Our hypothesis was that 1 and 2 months of cast immobilization of the rabbit Achilles’ tendons would lead to tenocyte alterations, extracellular degradation, and altered size of the collagen fibrils.

Key Words: Achilles tendon; Collagen; Histology; Immobilization; Rehabilitation; Transmission electron microscopy.

A CHILLES’ TENDON RUPTURES are serious injuries that are most prevalent between 40 to 60 years of age,1 with an incidence of between 1 in 1000 to 1 in 5600, and the incidence is increasing.1,2,3 Immobilization may contribute to the increasing number of Achilles’ tendon ruptures. Cast immobilization, used to treat lower-limb fractures and injuries to ligament, tendon, and other soft tissues, accentuates the disuse resulting from the initial injury. Also, the reduced activity of people bedridden for systemic conditions leads to tendon disuse. Stress deprivation has been shown to impair the mechanical properties of tendons.7,8,11 This weakness puts the tendon at risk of injury when mobility and physical activity are resumed.10 The mechanisms that cause the tendon weakness have not been elucidated. Finding key markers and pathways for tendon weakness would not only benefit the rehabilitation, but also the secondary prevention, of tendon injuries.

In previous work,12 we assessed qualitatively the structural, cellular, and matrix alterations of immobilized rabbit Achilles’ tendons to find a marker for this decrease in strength. We could not detect differences between the immobilized and contralateral tendons. This was surprising because several histologic and ultrastructural outcomes have been reported to change after immobilization, including tenocyte number and morphology and collagen fibril organization and diameter.13,14 Other investigators, however, found neither histologic nor ultrastructural changes in the tendons after immobilization. In ligaments, microscopic alterations such as hypercellularity, the presence of adipocytes, and disorganized matrix have been associated with a decrease in the tensile load-bearing capabilities of the tissue. Given that many previous studies were qualitative and that their results were often contradictory, we undertook a quantitative study of histologic and ultrastructural changes in rabbits Achilles’ tendons after 4 and 8 weeks of immobilization.

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METHODS

The University Animal Care Committee approved the protocol for these experiments. We used 23 adult female New Zealand white rabbits, in 20 of which 1 lower limb was immobilized in a fiberglass cast, as previously described.12
Briefly, the cast extended from mid-thigh to the toes, spanning the 135° flexed knee and ankle held fully plantarflexed so that the gastrocnemius and soleus muscles were in a shortened position. Savolainen et al20 found that passive stretching of these muscles in a position of dorsiflexion minimized tendon alterations during immobilization in their rat Achilles’ tendon model. Our cast immobilization technique prevented such a passive stretching in dorsiflexion.12 The rabbits were allowed unrestricted activity in group housing after casting. The casts were changed every 2 weeks to correct for loosening resulting from muscular atrophy.

Ten rabbits were sacrificed at 4 weeks and the other 10 at 8 weeks. The Achilles’ tendons were processed for histology and a sample was obtained for TEM. In addition, 3 rabbits (6 tendons) served as normal controls for TEM. All assessments were made at or distal to the tendon mid-portion because human Achilles’ tendon ruptures occur most frequently at that level.21

Light Microscopic Assessment

Achilles’ tendons and calcanei were fixed in 4% neutralized formalin for 24 hours. Seven micrometer-thick sagittal serial sections were stained with hematoxylin and eosin, hematoxylin, toluidine blue, and picrosirius red stains to be measured microscopically. A transverse section of the Achilles’ tendon was harvested at 25nm from the insertion and paraffin was embedded to measure the cross-sectional area (CSA).

All slides were examined by 1 investigator (YK) who was blind to the status of the specimen (control or immobilized, 4wk or 8wk). The slides were coded using randomly generated numbers. The original identification of each slide was revealed only after all slides had been assessed. The following 7 outcome measures were quantified.

CSA of the Achilles’ tendon. The transverse sections were viewed with a video camera mounted on an Olympus microscope at 5 times magnification. Images were captured with a video digitizer system. The CSA was measured with a scientific image analysis software.

Number of tenocytes, adipocytes, and blood vessels. Each sagittal section slide was digitized at 33 times magnification. The site of measurement was 15nm proximal to the insertion, the mid-portion of the rabbit’s Achilles’ tendon. At this site we counted all spindle-like cells, deemed tenocytes, in a standardized field (1.46×2mm²) on hematoxylin and eosin stained slides. Signet-ring cells with a nucleus compressed against the cell wall and an unstained vacuolar space were deemed as adipocytes and reported separately. In addition, all blood vessels were counted in the same field. Tubular structures internally bordered by endothelial cells, or with smooth muscles media or with erythrocytes in the lumen, were defined as blood vessels.

Roundness of nuclei. Tenocyte nuclear morphology was quantitatively analyzed by measuring the “roundness coefficient,”22 which is defined by the formula: \( r = \frac{4 \pi A}{P^2} \), where \( A \) is the area of the object, and \( P \) is the perimeter of the object. A perfect circle has a roundness coefficient of 1.0, whereas an irregular shape has a value less than 1. On the same slides and standardized field used for the measurement of numbers of cells or vessels, the roundness coefficient of all tenocyte nuclei was measured automatically with the Image Tool software. On digitized images, nuclei staining positively with hematoxylin were dark on a gray scale, whereas black is 0 and white is 255. All nuclei with an intensity of 0 to 55 were selected and summed and the roundness of each nucleus was measured.

Area of intense metachromasia. Proteoglycan binds basic blue dyes, such as toluidine blue changing its color to reddish blue.23 This property is known as metachromasia. Intense metachromatic staining with toluidine blue has been used as an indicator of proteoglycan content.24,25 We measured the area of intense metachromasia using the same image-analysis system we used to measure nuclear roundness. On the toluidine blue stained slides at a magnification of 6.6 times, we captured a standardized field (3×2mm²) starting 1mm proximal to the calcaneal insertion. Intense metachromatic areas within the standardized field were measured automatically. On digitized images, intense metachromatic areas were the darkest on a gray scale where black is 0 and white is 255. All areas with an intensity of 0 to 180 were selected and summed.24

Area of spatially aligned collagen fibers. Quantitative analysis of spatially aligned collagen fibers was done on picrosirius-red stained paraffin sections with a polarizing microscope.9,24,26,27 Polarizing light directed at oriented collagen fibers in tissue sections is diffracted and shines brightly against a dark background. In this study, we measured areas of brightly diffracted light. Each slide was rotated 90° on the microscope tray to find the position of maximum brightness. Then, at a magnification of 6.6 times, we captured the same standardized field used for the measurement of the metachromatic area. Areas of brightly diffracted light within the standardized field were measured automatically using the Image Tool software. On digitized images, areas of brightly diffracted light were white on a gray scale. All areas with an intensity of 200 to 255 were selected and summed.24

TEM Assessment

Tendon specimens were rinsed in 0.1M sodium cacodylate buffer (pH, 7.2) and post-fixed in 1% osmium tetroxide in 0.1M sodium cacodylate buffer (pH, 7.2) and Kornovsky fixative. Immobilized and contralateral tendons were dehydrated in a graded series of ethanol, transferred to propylene oxide, and embedded in Epon according to standard procedures. The normal group’s specimens were processed by Karnovsky fixative and embedded in Epon. All samples were sliced into ultra-thin sections with a microtome and the sections were stained with toluidine blue. Sections produced at the correct orientation were collected on 1-hole copper grids with Formvar supporting membranes and stained with uranyl acetate and lead citrate. We examined the sections using a JEOL 1010 transmission electron microscope equipped with a built-in camera and operated at an accelerating voltage of 80kV. Digital images were obtained with Adobe Photoshop Elements.

For every sample, 1 high-contrast digitized cross-sectional electron microscopic image was obtained on a standardized field (2384×1759.4mm). All measurements were done with the ImageJ software by the same person, who was blinded to the status of the specimen (immobilized, contralateral, or normal, 4wk or 8wk). The number of collagen fibrils per field was counted to determine fibril density at a magnification of 40,000 times, and the cross-sectional diameter of each collagen fibril was measured.

Statistical Analysis

We used the software program SPSS for Windows to build the database and for statistical analysis. Light microscopy histologic outcome measures for the 4-week and 8-week immobilized groups were compared with their respective contralateral groups using analysis of variance. Post hoc analysis of statistically significant comparisons was conducted with multiple paired t tests. A P value of .05 or less was regarded as statistically significant.
NOTE: No significant difference was detected in any histologic measure.

For TEM outcome measures, the diameters of the collagen fibrils in all groups (4- and 8-week immobilized, 4- and 8-week contralateral, normal) were expressed as mean ± standard error of the mean (SEM). Because of unequal numbers of fibrils in the paired samples, we used independent t tests to compare the mean fibril diameters among the 5 groups. Mean collagen fibril diameter was compared because it was the collagen fibril parameter most commonly considered in previous studies.8,28,29

We also displayed collagen fibril diameters using frequency histograms. The mean number of collagen fibrils falling in each of twenty, 20-nm diameter intervals from 0 to 400 nm was graphed. For each of the 4- and 8-week time points, we used independent t tests to compare the means of the 3 groups (immobilized, contralateral, normal) at each 20-nm-diameter interval. A P value of .05 or less after Bonferroni adjustment was regarded as statistically significant. The frequency histograms indicate whether there was an increase or a decline in the number of fibrils within each diameter range.15,16

The above analysis allows for comparison with previous reports in the literature. The chi-square test, however, better analyzed the fibril frequency distribution data. We performed a global chi-square analysis on all 5 groups, followed by individual posthoc chi-square analyses between the immobilized and contralateral groups at 4 and 8 weeks, as well as between the 3 control groups.

For visual comparisons between groups, we also graphed fibrils, ordered from the smallest to the largest, to report their percentile rank (0–100 percentile). This made it possible to compare specimens independent of fibril density. The average collagen fibril diameter for each of twenty, 5-percentile ranges was plotted against the percentile rank. Twenty intervals were chosen to correspond with the 20 intervals used in the frequency distribution graph.

RESULTS

Light Microscopy

**CSA of the Achilles’ tendon.** The mean CSA of immobilized tendons was the same at 4 weeks (10.4±0.5mm²) compared with the contralateral tendons (10.1±0.7mm²; P>.05). Findings were similar after 8 weeks of immobilization (immobilized: 9.5±0.3mm² vs contralateral: 9.8±0.5mm²) (table 1).

**Number of tenocytes, adipocytes, and blood vessels.** There was no statistical difference between the number of tenocytes of immobilized (445±27) and contralateral tendons (480±29) at 4 weeks. After 8 weeks of immobilization, the tendons contained fewer tenocytes (378±23 vs 466±40 contralateral) but the difference was not statistically significant (P>.05). There were few adipocytes found in the Achilles’ tendons. The number of adipocytes did not differ statistically between immobilized (0.0±0.0) and contralateral tendons (0.3±0.2) at 4 weeks or at 8 weeks (immobilized, 0.2±0.13 vs contralateral, 0.0±0.0; both P>.05). No significant difference was detected between the number of blood vessels of immobilized (0.6±0.3) and contralateral tendons (0.9±0.4) at 4 weeks or at 8 weeks (immobilized, 0.4±0.2 vs contralateral, 0.8±0.4; both P>.05) (see table 1).

**Roundness of tenocyte nuclei.** Tenocyte nuclei preserved their elongated shape30 after immobilization. There was no statistical difference between the roundness of tenocyte nuclei of immobilized (0.33±0.10) and contralateral tendons (0.34±0.03) at 4 weeks or at 8 weeks (immobilized, 0.35±0.04 vs contralateral, 0.34±0.04; all P>.05) (table 2).

**Area of intense metachromasia.** The rabbit Achilles’ tendon area of intense metachromasia was lower in immobilized (1.70±1.22mm²) compared with the contralateral (2.61±1.22mm²), but the large variability between specimens prevented this comparison from reaching statistical significance (P>.05). There were similar results at 8 weeks (immobilized, 1.70±0.76mm² vs contralateral, 2.16±0.96mm²; P>.05) (see table 2).

**Area of spatially aligned collagen fibers.** There was no statistical difference between the area of spatially aligned collagen fibers of immobilized (4.99±0.35mm²) and contralateral tendons (4.70±0.36mm²) at 4 weeks or at 8 weeks (immobilized, 5.59±0.08mm² vs contralateral, 5.17±0.24mm²; both P>.05) (see table 2).

Ultrastucture (TEM)

Five tendons were excluded from final analysis because the fibrils could not be positioned to cover the entire TEM field, or

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>CSA ± SEM (mm²)</th>
<th>No. of Tenocytes ± SEM*</th>
<th>No. of Adipocytes ± SEM*</th>
<th>No. of Blood Vessels ± SEM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-wk immobilized</td>
<td>10</td>
<td>10.4±0.5</td>
<td>445±27</td>
<td>0.0±0.0</td>
<td>0.6±0.3</td>
</tr>
<tr>
<td>4-wk contralateral</td>
<td>10</td>
<td>10.1±0.7</td>
<td>480±29</td>
<td>0.3±0.2</td>
<td>0.9±0.4</td>
</tr>
<tr>
<td>8-wk immobilized</td>
<td>10</td>
<td>9.5±0.3</td>
<td>378±23</td>
<td>0.2±0.1</td>
<td>0.4±0.2</td>
</tr>
<tr>
<td>8-wk contralateral</td>
<td>10</td>
<td>9.8±0.5</td>
<td>466±40</td>
<td>0.0±0.0</td>
<td>0.8±0.4</td>
</tr>
</tbody>
</table>

Table 1: Histologic Outcome Measures of the Rabbit Achilles’ Tendon by Light Microscopy—Part I

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>Shape of Tenocytes Nuclei ± SEM</th>
<th>Area of Metachromasia ± SEM (mm²)*</th>
<th>Area of Spatially Aligned Collagen Fibers ± SEM (mm²)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-wk immobilized</td>
<td>10</td>
<td>0.3±0.10</td>
<td>1.25±0.48</td>
<td>4.99±0.35</td>
</tr>
<tr>
<td>4-wk contralateral</td>
<td>10</td>
<td>0.3±0.03</td>
<td>2.61±1.22</td>
<td>4.70±0.36</td>
</tr>
<tr>
<td>8-wk immobilized</td>
<td>10</td>
<td>0.4±0.04</td>
<td>1.70±0.76</td>
<td>5.59±0.08</td>
</tr>
<tr>
<td>8-wk contralateral</td>
<td>10</td>
<td>0.3±0.04</td>
<td>2.16±0.96</td>
<td>5.17±0.24</td>
</tr>
</tbody>
</table>

Table 2: Histologic Outcome Measures of the Rabbit Achilles’ Tendon by Light Microscopy—Part II

NOTE: No significant difference was detected in any histologic measure. *Per field of 1.46×2.00mm.
because the fibril orientation was not perpendicular to the main axis of the tendon (producing elliptical rather than circular fibrils). The final numbers of samples in each group are comparable (table 3, fig 1).

Four or 8 weeks of immobilization did not change the mean fibril diameter of tendons when compared with their respective contralateral tendons (4-wk immobilized, 113.8±1.6nm vs contralateral, 111.4±1.4nm; 8-wk immobilized, 113.5±1.4nm vs contralateral, 116.2±1.8nm) or to normal tendons (111.8±2.0nm, all P>.05) (see table 3).

The mean diameter of collagen fibrils, however, was significantly increased in the contralateral leg after 8 weeks compared with 4-week tendons (P<.05), but not when compared with normal tendons (P>.05) (see table 3).

The mean number of collagen fibrils in the same diameter interval did not differ statistically between 4-week immobilized, 4-week contralateral, and normal controls at any of the 20 intervals studied (all P>.05) (fig 2A). Similar results were obtained when the 8-week immobilized, contralateral, and normal controls (all P>.05) (fig 2B) were compared.

The chi-square analysis detected a global difference when all groups were compared. Individual posthoc chi-square tests detected no difference in fibril distribution between 4-week immobilized and either of the 4-week contralateral or normal tendons (both P>.05) (fig 3A). There was also no significant difference in fibril distribution between the 4-week contralat-

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>Total No. of Fibrils</th>
<th>Mean Fibril Diameter ± SEM (nm)</th>
<th>Mean Fibril Density ± SEM*</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-wk immobilized</td>
<td>7</td>
<td>1079</td>
<td>113.8±1.6</td>
<td>154.1±21.9</td>
</tr>
<tr>
<td>4-wk contralateral</td>
<td>10</td>
<td>1459</td>
<td>111.4±1.4†</td>
<td>145.9±20.7</td>
</tr>
<tr>
<td>8-wk immobilized</td>
<td>10</td>
<td>1439</td>
<td>113.5±1.4</td>
<td>143.9±16.9</td>
</tr>
<tr>
<td>8-wk contralateral</td>
<td>9</td>
<td>1127</td>
<td>116.2±1.8†</td>
<td>125.2±22.9</td>
</tr>
<tr>
<td>Normal</td>
<td>5</td>
<td>801</td>
<td>111.8±2.0</td>
<td>160.2±10.2</td>
</tr>
</tbody>
</table>

*Per field of 2384.4×1759.4nm.
†Significant difference between 4-week and 8-week contralateral (P<.05).

Fig 1. TEM of rabbit Achilles’ tendon cross-sections of 4-week immobilized and contralateral legs (original magnification, ×40,000). The circular structures are collagen fibril cross-sections. Abbreviations: CON, contralateral; IMM, immobilized.

Fig 2. Mean number of collagen fibrils in 20nm-diameter intervals in immobilized, contralateral, and normal Achilles’ tendons after (A) 4 and (B) 8 weeks of immobilization. There was no significant difference between the 3 groups at all 20-nm intervals (P>.05). Abbreviations: 4C, 4-week contralateral; 4I, 4-week immobilized; 8C, 8-week contralateral; 8I, 8-week immobilized.
Immobilized Tendons Are Weaker

The Achilles’ tendon, as are other tendons and ligaments when they are stress deprived, are weaker and consequently are more prone to rupture.5,9,10,12,31-33 Immobilized rabbit Achilles’ tendons had a 48% loss in stiffness after 4 weeks and a 57% loss after 8 weeks.12 In this study, we looked for microscopic alterations that would explain the weakness in rabbit Achilles’ tendons after 1 or 2 months of immobilization.

Quantitative Histology Results Are Negative

Immobilization of the Achilles’ tendon did not identify a significant change in several previously used outcome measures—the number of tenocytes, adipocytes, and blood vessels, the metachromasia (reflecting proteoglycan content), and the spatially aligned collagen fibers (reflecting collagen orientation). This quantitative investigation confirms the results of a previous qualitative histologic study of the Achilles’ tendon.12

Results of previous studies are conflicting, therefore our findings confirm some of the results, but also contradict other results. Different results may be attributed to the use of different models, methods, and durations of stress deprivation on tendons and ligaments.8,9,11,12,14,16,18,20,33-38

Tenocytes, Adipocytes, and Blood Vessels

A viable tenocyte population maintains the functionality of the tensile-resisting extracellular matrix (ECM).19 It has been proposed that either a decrease in tenocytes or an increase in tenocytes, adipocytes, and blood vessels might introduce microscopic mechanical flaws and compromise the tendon strength.19 In addition, hypotheses have been put forward that weakening in immobilized tendons to tenocyte death37 or proliferation,9,39 to increased or decreased angiogenesis,19,39 or to adipocyte proliferation.19 In this study, immobilization did not significantly change the tenocyte, adipocyte, or blood vessel numbers in the Achilles’ tendon. Despite stated limitations, these negative results are important considering that many studies have attributed tendon weakness after immobility to 1 or more of these factors.

Shape of Nucleus, Proteoglycan Content, and Arrangement of Collagen

Mechanical stress keeps tenocytes elongated37 and compressive forces correlate with cell shape at the ligament insertion.22 Matyas et al22 showed that nuclear shape was a good predictor of cell shape. Proteoglycans transfer stress between discontinuous collagen fibrils using their glycosaminoglycan (GAG) moieties, thus maintaining fibril regularity.30-42 Collagen alignment optimizes tensile stress transfer and force loading across all fibrils, possibly by promoting larger and tighter proteoglycan-collagen surface contacts; new fibrils are not aligned.7,37 Previous immobilization studies showed more spindle-shaped cells than oval cells in ligaments14 whereas tenocytes became rounder37; a loss of proteoglycan and GAG content in the periarticular tissue,18,43 and either no changes in collagen fibril arrangement,14 or disorientation.9,13,43 In this study, markers of cellular and ECM health did not differ significantly from controls after 4 or 8 weeks of immobilization. Although these results are limited by sample size, they suggest that these microscopic markers do not explain the weakness of immobilized tendons.

TEM Results

Fibril diameter and density. We could not measure any effect of immobilization after 4 or 8 weeks on the mean diameter of the collagen fibrils in the rabbit Achilles’ tendon. These results are important because the mechanical weakness of immobilized tendons has been attributed to ultrastructural alterations, based on studies showing increased16,34,37 decreased13,15,16, or unchanged8 fibril density, diameter, or area.16,31 Initially, Finsterbush and Friedman34 reported more collagen fibrils in immobilized rabbit knees after 4 weeks of immobilization. In 1986, Binkley and Pea16 observed an increase in the proportion of thick fibrils in the immobilized medial collateral ligament. In 1989, Nakagawa et al13 showed a decrease in the thick fibrils in the rat
Study Limitations and Future Direction

Microscopic alterations such as tenocyte proliferation or death may become evident after periods of immobilization of the Achilles’ tendon of more than 2 months. Alterations after longer periods, however, would not account for the initial tendon weakening.

Despite being quantitative, with more subjects, and using more time points than many previous studies, our study might not have been sufficiently powered to identify changes specifically regarding the histologic outcomes of tendon CSA, tenocyte number, or proteoglycan content.

Outcomes other than the ones we selected may correlate with tendon strength after immobility. These include: (1) fibril length, where longer fibers allow for more longitudinal cross-linking; and (2) type of proteoglycan, where high molecular weight proteoglycans increase tissue stiffness by transferring stress between the discontinuous collagen fibrils, or where small leucine-rich proteoglycans such as lumican and fibromodulin increase the tensile strength by regulating the maturation of collagen fibrils. In addition to fibril length and proteoglycan type, the type, degree, and maturity of collagen cross-links may correlate with tendon strength. Cross-link formation between adjacent tropocollagen molecules is a necessary precursor to collagen maturation. These covalent links are fundamental units holding tendons together. Cross-link deficiency, an increase in reducible cross-links, or preferential degradation of mature collagen pyridinoline cross-links can weaken the tendon during immobilization.

CONCLUSIONS

We found no characteristic quantitative microscopic or ultrastructural alterations in rabbit Achilles’ tendons immobilized for 4 or 8 weeks. The cause of tendon weakness after immobilization remains unclear. Our study adds to the recent literature that suggests that such alterations are found neither histologically nor ultrastructurally. Biochemical, gene expression, or functional imaging markers need to be explored and mechanisms for the mechanical weakness of immobilized tendons further researched. Finding such alterations and mechanisms would constitute major breakthroughs for the detection, clinical management, and rehabilitation of tendon weakness after immobilization.

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The Spinal Cord Injury Spasticity Evaluation Tool: Development and Evaluation

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Objective: To develop and assess the reliability and validity of a new scale designed to measure the impact of spasticity on daily life in people with spinal cord injury (SCI).

Design: Scale development and assessment.

Setting: General community.

Participants: Community-dwelling persons with chronic SCI and spasticity participated in study 1 (n = 9), study 2 (n = 19), and study 3 (n = 61).

Interventions: Not applicable.

Main Outcome Measures: Study 1: participant definitions of spasticity and list of scale items. Study 2: scale refinement, face validity, and time to complete. Study 3: internal consistency, test-retest reliability, and construct validity.

Results: The Spinal Cord Injury Spasticity Evaluation Tool (SCI-SET) is a 7-day recall self-report questionnaire that takes into account both the problematic and useful effects of spasticity on daily life in people with SCI. The scale exhibited good face validity and required 6.8 ± 2.6 minutes to complete. The internal consistency (α) and intraclass correlation coefficient of the SCI-SET were .90 and .91, respectively. Construct validity was supported by correlations (r range, −.48 to .68; P < .01) between SCI-SET scores and theoretically meaningful constructs.

Conclusions: The SCI-SET fills a need for a reliable and valid self-report measure of the impact of spasticity on daily life in people with SCI, taking into account both the problematic and useful effects of spasticity.

Key Words: Muscle spasticity; Rehabilitation; Reliability and validity; Spinal cord injuries.

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A spinal cord injury (SCI) is most commonly sustained by people who are relatively young in age, and, over the last 3 decades, there has been a 40% decline in mortality during the critical 2-year period post-SCI. Therefore, it has become increasingly important to focus on the long-term effective management of the secondary consequences of SCI that can impact quality of life (QOL). Spasticity has been reported in 65% to 78% of samples of persons with chronic SCI. The SPASM group has recently suggested that spasticity be defined as “disordered sensori-motor control, resulting from an upper motor neuron lesion, presenting as intermittent or sustained involuntary contraction of muscles.” Therefore, the term spasticity is no longer limited to only “muscle hypertonicity” (as was initially suggested by Lance) but, rather, is acknowledged to include numerous positive features of the upper motoneuron syndrome (ie, clonus, spasms).

It is generally accepted that the effects of spasticity can be perceived as both problematic and beneficial by persons with SCI. Spasticity can contribute to pain, falls, fatigue, and poor self-esteem and body image, and can interfere with mobility, transfers, self-care, activities of daily living (ADLs), social participation, caregiving, sleep, and sexual functioning. However, it also has been reported that spasticity can have beneficial effects on sitting, standing, transfers, walking, lower-body dressing, and performance of ADLs. Although there is widespread agreement in the literature that decisions regarding the treatment of spasticity must be based on the goal of achieving balance between the useful and problematic effects of these symptoms on a person’s QOL.

To make decisions about spasticity management and to evaluate the effects of treatment in people with SCI, it is necessary to apply measurement instruments shown to be valid and reliable in this population. There are a number of measures of spasticity (clinical, biomechanic, electrophysiologic) described within the literature that are performed and evaluated by the examiner. Although some of these measures have limitations, the careful selection of a combination of measures can provide an appropriate overall examiner-based assessment of spasticity. There are many indications, however, that spasticity should also be assessed by the person with SCI. For example, examiner-based physical examination does not necessarily elicit spasticity in people who report the symptom, and people with SCI may experience spasticity in body segments that are not tested by an examiner. Research has also indicated that examiner-based assessments of 1 or more symptoms of spasticity do not correlate well with self-assessments of spasticity, with improved function, or with each other. Self-assessments have also been found to be more sensitive to changes in aspects relevant to daily life after the implementation of a spasticity-management intervention. These findings support the suggestion that the best judge of spasticity severity is the person with SCI, who can assess the impact of spasticity on daily life.

Routine clinical work often includes self-evaluation or self-descriptions of the extent and impact of spasticity. Although limited, there are also examples of research studies that have begun to include self-ratings among the outcome measures of spasticity in the SCI population. Examples of these self-ratings include measures of both spasticity severity (eg, by using visual analog scales or single-item ratings) or spasticity impact (on daily pain and function or daily life). It is interesting to note that not all people with SCI who report...
having spasticity indicate that spasticity has an impact on their daily life. It is encouraging that the importance of participant-rated spasticity is being recognized. None of the methods of measurement implemented to date, however, have been appropriately validated or are broad enough in scope to capture both the detrimental and potentially beneficial impact of spasticity on daily life in people with SCI. It is noteworthy that an 88-item self-report spasticity scale has been recently designed for the multiple sclerosis (MS) population. This scale, however, is inadequate for the SCI population because it only measures the problematic effects of spasticity, and it was specifically designed for the MS population. As a result, the scale includes items that would not be relevant to many people with SCI. Therefore, the purpose of the present article is to describe the development and preliminary assessment of the Spinal Cord Injury Spasticity Evaluation Tool (SCI-SET), a self-report measure of the impact of spasticity on daily life in people with SCI.

METHODS

Overview of Studies and Participants
The development and evaluation of the SCI-SET were performed in 3 studies. In study 1, a definition of spasticity was developed, and a list of possible aspects of daily life that may be affected by spasticity was generated through a detailed search of the spasticity literature and interviews with people with SCI. In study 2, the SCI-SET underwent pilot testing and refinement based on participant suggestions. Finally, in study 3, test-retest reliability and construct validity of the SCI-SET were assessed through administration of the scale to a sample of people with SCI. Community-dwelling people with SCI were recruited for these studies from 3 sources: physiatrist referral, a community exercise program for people with SCI, and at local events targeting the SCI population. Because the SCI population is very heterogeneous, participants for this study represented a wide range of characteristics; people with neurologic levels from C2 to T12, American Spinal Injury Association (ASIA) impairment grades from A to D, and number of years postinjury from 1 to 34 years were included (table 1). Participants also varied in terms of age, highest education level completed, and current employment status (see table 1). All individuals provided verbal informed consent before participating, and the study was approved by the McMaster Research Ethics Board.

General Statistical Analyses
All statistical analyses were conducted by using SPSS for Windows. Data are presented as mean ± standard deviation (SD). For all analyses, the level of statistical significance was set at P less than .05.

Study 1: Development of the SCI-SET

Semistructured individual interviews and a comprehensive search of the literature were conducted to generate the following: (1) an operational definition of spasticity and (2) a comprehensive list of aspects of daily life that can be affected (benefited or hindered) by spasticity. Additional participants were interviewed until no new themes emerged, resulting in a final sample of 9 people with SCI and self-reported spasticity (see table 1). Information collected during the interviews was used to develop scale items and design a preliminary questionnaire.
Study 2: Pilot Testing the SCI-SET

The preliminary version of the SCI-SET underwent 2 phases of pilot testing in 19 people with SCI and self-reported spasticity (see table 1); minor changes were made based on comments of the first 14 participants, and the revised SCI-SET was then pilot tested in an additional 5 participants. The SCI-SET instructions (including the operational definition of spasticity) and all scale items were administered to participants by telephone or in person. Immediately on completion of the questionnaire, participants were asked to provide feedback about the scale items and the questionnaire as a whole through 4 open-ended questions addressing (1) the clarity and ease of understanding, (2) the ease of completion, (3) the appropriateness of the items (redundancy, clarity, sense), and (4) whether the questionnaire captured how they felt about the impact of spasticity on daily life and, if not, what was missing. Participant feedback was used to refine the SCI-SET. Overall face validity of the SCI-SET was assessed on a 5-point scale (1, very irrelevant; 5, very suitable), and the time to complete the questionnaire was recorded.

Study 3: Assessing the Test-Retest Reliability and Construct Validity of the SCI-SET

Sixty-one participants with SCI and self-reported “stable” spasticity (ie, consistent medication routine and absence of conditions known to affect spasticity intensity, frequency, or impact) completed all of the study measures. The reliability of the SCI-SET was assessed by the administration of the SCI-SET in person or by telephone, 3 times, 3 weeks in a row, on the same day of the week. The same administration format was used across all 3 time points for each participant. Before the first scheduled questionnaire administration, participants received the SCI-SET instructions and rating scale (appendix 1) and an example question. If participants could not be reached on a scheduled questionnaire administration date, efforts to reach them continued, with the goal of minimizing alterations to the planned schedule. For 37 participants, the questionnaire administration proceeded as planned. For 24 participants, the second or third administration was greater than 7 days (8–14d) after the first or second administration, respectively. At the time of his second scheduled telephone interview, 1 participant revealed the recent onset of a urinary tract infection. Because of previous experience with this complication, the participant assured us he would be well within 1 week and would be ready to perform his second interview 2 weeks from the scheduled interview date. This was the case, and, therefore, the second and third interviews were performed 14 and 21 days after the first interview. Removing this participant from the analyses did not alter the results; therefore, his data were included. Self-assessments of spasticity have been shown repeatedly to have poor correlations with examiner-based measures of spasticity,32,33 and there is no accepted criterion standard measure of spasticity. Therefore, rather than criterion validity, the construct validity of the SCI-SET was assessed. Construct validity reflects the correlation between the SCI-SET and other theoretically related constructs for which current measures exist.33 Because spasticity is thought to be related to functional performance and QOL,34 SCI-SET scores (third administration) were correlated with: (1) self-assessment of spasticity severity, (2) self-assessment of spasticity impact, (3) the Penn Spasm Frequency Scale (PSFS), (4) the FIM motor subscale, and (5) the Quality of Life Index (QLI) SCI Version–III health and functioning subscale (satisfaction). Before the first administration of the SCI-SET, participants were asked to rate the overall severity of their spasticity on a 6-point scale (0, no spasticity; 5, extreme spasticity) and the overall impact of spasticity on their daily life on a 6-point scale (0, no impact; 5, extreme impact). The FIM motor subscale, the QLI health and functioning subscale, and the PSFS were administered in a random order immediately after the third administration of the SCI-SET.

The FIM is an 18-item subjective scale that assesses burden of care.32 It has been suggested that some, although not all, of the FIM items are relevant for assessing the effects of spasticity intervention.32 A self-assessment version of the FIM has been shown to be a reliable and valid measure of perceived functional independence in the SCI population.35 Most likely to be relevant to spasticity, is the motor subscale of the FIM (13 items assessing self-care, sphincter control, transfers, and locomotion).34 Participants in the present study were asked to rate their levels of ability for the independent performance of the motor tasks during the previous 7 days on a 7-point Likert-type scale (1, low ability; 7, high ability). The individual item ratings were summed to produce a total score that could range from 13 to 91. The QLI36 SCI Version–III is a 35-item questionnaire designed to assess several components of QOL relevant specifically to the SCI population.33 The health and functioning subscale of the QLI was selected as most likely to be related to spasticity. This subscale has 15 items and has been shown to have adequate internal consistency ($\alpha = 0.80$).36 Although the QLI was designed to assess importance-based weighted satisfaction, the weighting component of this scale was omitted for the present study because of the known limitations when scales use multiplicative composite scores.33 Participants were asked to rate how satisfied they have been with each item over the past 7 days on a 6-point Likert-type scale (1, very dissatisfied; 6, very satisfied). Individual item ratings were summed to produce a total score that could range from 15 to 90. The PSFS38 is a measure of self-assessed spasm frequency commonly applied in studies involving the SCI population.25 Participants were asked to rate their spasms during the past 7 days on a 5-point scale (0, no spasms; 4, spasms occurring more than 10 times per hour). This scale has been used recently for the examination of the validity of a new clinical measure of spasms and clonus.39 Means, SDs, and internal consistency ($\alpha$) were calculated from the third administration of the SCI-SET. For the purposes of calculating $\alpha$ nonapplicable items were coded as “−4”; this was necessary because a code of “N/A” would have falsely resulted in items having missing data. The intraclass correlation coefficient (ICC) was calculated as an index of test-retest reliability; 2-way random effects models and an absolute agreement definition of reliability were used. The estimate for single-trial reliability was reported. Two-tailed, Pearson product-moment correlations ($r$) were computed between the average SCI-SET score (third administration) and self-assessed spasticity severity, self-assessed impact of spasticity, FIM motor subscale, QLI SCI Version–III health and functioning subscale, and PSFS.

RESULTS

Study 1

The first version of the SCI-SET was a 38-item, 7-day recall questionnaire that took into account the potential problematic and helpful effects of spasticity on daily life in people with SCI. Responses could range from −3 (extremely problematic) to +3 (extremely helpful), with the option of choosing “0” if spasticity had no effect on that aspect of life. The instructions
developed for the SCI-SET included a statement asking participants to recall the previous week: “For each of the following, please choose the answer that best describes how your spasticity symptoms have affected that area of your life during the past 7 days.” The following operational definition of spasticity was also developed and included in the instructions: “When I talk about ‘spasticity symptoms’, I mean: a) uncontrolled, involuntary muscle contraction or movement (slow or rapid; short or prolonged), b) involuntary, repetitive, quick muscle movement (up and down; side to side), c) muscle tightness, and d) what you might describe as ‘spasms’.”

**Study 2**

Pilot testing of the preliminary version of the SCI-SET identified the need for a statement at the end of the instructions allowing participants to rate items as nonapplicable when appropriate: “Please let me know when a question is not applicable to you.” The original 38 SCI-SET items were pared down to 35; of the original items, 2 were combined because of similarity (indicated by a high correlation between the items; r = .89) and 2 were removed from the questionnaire because further scrutiny by the investigators identified them as being unsuitable. During final pilot testing of the SCI-SET, no items were considered redundant, unclear, or nonsensical, and no additional items were suggested. Rating of the relevance and suitability of the SCI-SET by the participants resulted in a mean score of 4.4±0.6 out of 5, indicating good face validity. The SCI-SET required 6.8±2.6 minutes to complete. The final version of the SCI-SET (see appendix 1) is scored by summing the responses from all applicable items and dividing the sum by the number of applicable items. Therefore, scores on the SCI-SET can range from −3.00 to +3.00.

**Study 3**

The completion of the SCI-SET by 61 participants with chronic SCI and “stable” spasticity (n = 35 in-person; n = 53 by telephone) produced a range of scores from −2.35 to 0.00 (−6.5±5.6). From the sample, the group of participants with paraplegia (n = 24) had a score of −6.2±5.7, and the group of participants with tetraplegia (n = 37) had a mean score of −6.7±5.7. Men (n = 45) and women (n = 16) had mean scores of −6.0±5.5 and −8.0±5.7, respectively. Individual scores of 0.00 were because of tabulation of either all items rated as “0” or an equal positive and negative rating. Internal consistency (α = .90) and test-retest reliability (ICC = .91) were both adequate.

Although the correlation between the SCI-SET and the FIM motor subscale was weak (r = .21, P = .12), the SCI-SET showed statistically significant (P < .001) moderate to strong correlations with all other measures including (1) self-assessed spasticity severity (r = −.48), (2) self-assessed spasticity impact (r = −.61), (3) the QLI SCI Version—III health and functioning subscale (r = .68), and (4) the PSFS (r = −.66) (table 2).

**DISCUSSION**

The overall purpose of these studies was to develop and conduct a preliminary psychometric evaluation of a new self-assessment measure of the impact of spasticity on daily life in people with chronic SCI. The resulting scale is a 35-item, 7-day recall questionnaire that targets aspects of daily life relevant to the SCI population and allows respondents to rate the impact of their spasticity from extremely problematic to extremely helpful. Our analyses provide support for the reliability and validity of the SCI-SET for this population.

As a self-report questionnaire, the SCI-SET addresses the need for a measure that considers the person’s perception of the impact of spasticity on his/her daily life. Compared with many current measures that consider spasticity to be a physical impairment, the SCI-SET allows spasticity to be considered as it relates to activity and participation restrictions. Therefore, the SCI-SET offers a method to acknowledge the often-overlooked aspects of the International Classification of Functioning, Disability and Health. The questionnaire was designed to be comprehensive but easy to understand by respondents and potentially useful in both research and clinical settings. Self-ratings of spasticity at any given moment have been shown to correlate poorly with self-ratings of general spasticity, and the presence of spasticity can fluctuate hourly and with different days of the week (as was also noted in our interviews). Therefore, a 7-day recall self-report format was chosen as a time period most likely to be representative of perceived impact of spasticity on daily life, despite hourly and daily fluctuations. The high internal consistency of the SCI-SET (α = .90) was within the suggested range of .70 to .90, supporting this combination of items as a cohesive measure. Participants also felt that the questionnaire was easy to complete. With repeated administration of the SCI-SET, the investigators developed an understanding of the importance, in some cases, of reminding participants to consider the impact of spasticity (and not other SCI-related impairments) when responding to questionnaire items. Future users of the SCI-SET may want to implement a standardized statement to this effect.

The bidirectional response scale (−3 to +3) is new to spasticity assessment instruments. Numerous reports in the literature have emphasized the importance of considering both the problematic and the potentially beneficial effects of spasticity on aspects of daily life. Some participants in the present study identified spasticity as being helpful (positive rating) on items such as “your ability to change positions in bed” (n = 5) and “your ability to stand/weight-bear” (n = 3). During the third administration of the SCI-SET (reliability assessment), 21 of the 35 items were given a positive rating by
at least 1 study participant. The mean SCI-SET score was negative, however, indicating an overall negative impact of spasticity on daily life in this population despite perceptions of some benefits. Items receiving the most ratings of “−3” (spasticity extremely problematic) were “your pain” (n = 7), “your hobbies/recreational activities” (n = 6), and “the quality of your sleep” (n = 6). Therefore, the SCI-SET should prove useful as an instrument to aid in decision making regarding spasticity management and as a measure to assess the effectiveness of management strategies designed to minimize the detrimental impact of spasticity. In particular, the SCI-SET may help people with SCI to consider and communicate their thoughts about the impact of spasticity on their daily life, facilitating their involvement in spasticity-related management decisions.

With regard to test-retest reliability, the ICC for the SCI-SET (.91) was above the recommended minimum reliability values of .70 and .90 for the use of a scale in research and SET (.91) was above the recommended minimum reliability for all 3 subscales. Therefore, the SCI-SET can be considered as a basis of comparison with our findings. Nevertheless, it is clear that the ICC has good reliability.

Investigators have typically considered validity coefficients between .30 to .50 to be satisfactory. Therefore, the validity of the SCI-SET as a self-report measure of the impact of spasticity on daily life in people with SCI was supported by the moderate to strong and statistically significant correlations between average SCI-SET scores and (1) self-ratings of spasticity severity, (2) self-ratings of spasticity impact, (3) the QLI SCI Version—III health and functioning subscale, and (4) the PSFS. Because the SCI-SET was designed to assess the impact of spasticity on daily life, it is particularly noteworthy that the correlation between the SCI-SET and the QLI SCI Version—III health and functioning subscale scores was larger than the correlation between the SCI-SET and self-ratings of spasticity severity. The negative correlations suggest that participants who reported the most problematic spasticity (i.e., the most negative scores) also tended to report greater severity, impact, and frequency (PSFS, r = −.66) of spasticity. Conversely, the positive correlation between the SCI-SET scores and QLI SCI Version—III health and functioning subscale scores (r = .68) suggests that participants who reported the highest QOL were those who experienced the smallest impact of spasticity (i.e., scores near or at “0” on the SCI-SET). These results are encouraging when compared with previous studies assessing correlations among measures of spasticity in the SCI population. In particular, self-assessed spasm frequency (single item; 5 possible responses) by 85 participants with SCI had a correlation of .41 with self-assessed rating of interference of spasticity with function (single item; 3 possible responses). In this same group, correlations between the Ashworth Scale score and various other clinical measures of spasticity ranged from .20 to .55. In a more recent study of 47 persons with SCI, the Ashworth score had correlations of .36 and .70 with self-ratings of spasticity during the Ashworth Scale (4-point scale) and with self-rating of spasticity in general (4-point scale), respectively.

The SCI-SET had a poor correlation with the FIM motor subscale (r = −.1). Although it might be suggested that the impact of spasticity on daily life should be reflected in a measure of functional performance such as the FIM, this result is not surprising in hindsight. Inspection of the individual FIM motor subscale items identifies items that might be affected by spasticity; however, these items are also likely to be affected by various other deficits or complications resulting from SCI. For example, differences in impairment ratings (ASIA score), neurologic levels, and other characteristics likely mask relations between spasticity and functional independence. In particular, partial or complete paralysis of skeletal muscle caused by SCI is likely to have a much greater effect on function than spasticity in most people. Therefore, unless there are also changes in muscle strength or function, a change in spasticity severity or frequency may not be reflected by FIM scores. A recent study observing reductions in spasticity measured clinically and through self-assessment did not find an improvement in ADLs as assessed by the FIM. In response to reports of poor correlations between observed reductions in spasticity and improvements in function, Priester has questioned, “Does change in spasticity not affect function because no effect actually occurs, because the patient was inappropriately selected for spasticity reduction, or because the functional measures used are insensitive or unreliable?” Our findings of poor correlations between the SCI-SET and the FIM motor subscale suggest that general measures of function may be insensitive as indicators of change in spasticity. It is anticipated that, as a valid and reliable measure of the impact of spasticity on daily life, the SCI-SET will provide a more appropriate indication of change after spasticity intervention in people with SCI.

Study Limitations

There are 3 possible limitations of our series of studies that deserve mention. First, as with any study performed by using a convenience sample, there is the potential to misrepresent the population of interest. We are confident, however, that our samples were representative of the general SCI population; a range of education levels and a variety of employment statuses were included, and the proportions of injury levels, injury severities, and sex were similar to that of the general SCI population (see table 1). Second, the selection of a 7-day recall period for the SCI-SET may lead to an inability to accurately capture short-term changes in spasticity (if any) that might occur with an intervention. So long as any short-term benefits are perceived by participants, however, the 7-day recall period of the SCI-SET should allow for the person to report the perceived change. Furthermore, because spasticity has been shown to vary depending on the day of the week, there are 2 additional benefits of a 7-day recall period: (1) arguably, inclusion of each day of the week is most appropriate to obtain an accurate assessment of the effects of spasticity on overall daily life; and (2) a questionnaire with a shorter recall period (eg, 3d) would only be useful for the measurement of changes over time if administered on the same days of the week with successive administrations. Of course, any questionnaire designed with a 7-day recall may not be appropriate for use in studies designed to assess only the acute effects of an intervention. Last, it is possible that individual participants in the present study applied different assessments when considering the impact of spasticity during the previous 7 days. If questioned, the interviewer instructed the participant to consider the “overall” impact. The high test-retest reliability of the SCI-SET suggests that participants were consistent in their assessment methods over time. Although not included within the SCI-SET instructions, future users may wish to clarify, “For each of the following, please choose the answer that best describes how your spasticity symptoms have affected that area of your life [overall or on average] during the past 7 days.”
CONCLUSIONS
The importance of the inclusion of self-assessment of spasticity by participants with SCI has been recognized, but no appropriate measure has been available. The SCI-SET fills a need for a reliable and valid self-report measure of the impact of spasticity on daily life in people with SCI, taking into account both the problematic and useful effects of spasticity. As an adjunct to conventional spasticity assessment, the SCI-SET could be used in clinical and research settings and, in particular, as a tool to facilitate the role of the person with SCI as an active contributor to his/her medical management decisions. Because scale validation is an ongoing process and cannot be “proven” by any single study, we recommend continued validation studies of the SCI-SET by using broader samples and other validation techniques. In particular, it would be valuable to examine the responsiveness to change of the SCI-SET during an intervention known to have a significant impact on spasticity.

Acknowledgments: We thank Joanne Bugaresti, MD, FRCPC, for her assistance with recruitment and Fahreen Ladak for her assistance with data collection.

APPENDIX 1: THE SPINAL CORD INJURY SPASTICITY EVALUATION TOOL (SCI-SET)

For each of the following, please choose the answer that best describes how your spasticity symptoms have affected that area of your life during the past 7 days. When I talk about “spasticity symptoms”, I mean:

a) uncontrolled, involuntary muscle contraction or movement (slow or rapid; short or prolonged),

b) involuntary, repetitive, quick muscle movement (up and down; side to side),

c) muscle tightness, and

d) what you might describe as “spasms”. Please let me know when a question is not applicable to you.

<table>
<thead>
<tr>
<th>Extremity problematic</th>
<th>Moderately problematic</th>
<th>Somewhat problematic</th>
<th>No effect</th>
<th>Somewhat helpful</th>
<th>Moderately helpful</th>
<th>Extremely helpful</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
<td>+2</td>
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<td>+2</td>
<td>+3</td>
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<tr>
<td>-3</td>
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<td>-1</td>
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<td>+1</td>
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<td>+3</td>
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<td>+1</td>
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<tr>
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<td>-1</td>
<td>0</td>
<td>+1</td>
<td>+2</td>
<td>+3</td>
</tr>
</tbody>
</table>

DURING THE PAST 7 DAYS, HOW HAVE YOUR SPASTICITY SYMPTOMS AFFECTED:

1. your showering?
2. your dressing/undressing?
3. your transfers (to and from bed, chair, vehicle, etc.)?
4. your sitting positioning (in your chair, etc.)?
5. the preparation of meals?
6. eating?
7. drinking?
8. your small hand movements (writing, use of computer, etc.)?
9. your ability to perform household chores?
10. your hobbies/recreational activities?
11. your enjoyment of social outings?
12. your ability to stand/weight-bear?
13. your walking ability?
14. your stability/balance?
15. your muscle fatigue?
16. the flexibility of your joints?
17. your therapy/exercise routine?
18. your manual wheelchair use?
## APPENDIX 1 (cont’d): THE SPINAL CORD INJURY SPASTICITY EVALUATION TOOL (SCI-SET)

![Evaluation Tool Table]

DURING THE PAST 7 DAYS, HOW HAVE YOUR SPASTICITY SYMPTOMS AFFECTED:

<table>
<thead>
<tr>
<th>Item</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. your power wheelchair use?</td>
<td>-3</td>
</tr>
<tr>
<td>20. your lying positioning (in bed, etc.?)</td>
<td>-3</td>
</tr>
<tr>
<td>21. your ability to change positions in bed?</td>
<td>-3</td>
</tr>
<tr>
<td>22. your ability to get to sleep?</td>
<td>-3</td>
</tr>
<tr>
<td>23. the quality of your sleep?</td>
<td>-3</td>
</tr>
<tr>
<td>24. your sex life?</td>
<td>-3</td>
</tr>
<tr>
<td>25. the feeling of being annoyed?</td>
<td>-3</td>
</tr>
<tr>
<td>26. the feeling of being embarrassed?</td>
<td>-3</td>
</tr>
<tr>
<td>27. your feeling of comfort socially?</td>
<td>-3</td>
</tr>
<tr>
<td>28. your feeling of comfort physically?</td>
<td>-3</td>
</tr>
<tr>
<td>29. your pain?</td>
<td>-3</td>
</tr>
<tr>
<td>30. your concern with falling?</td>
<td>-3</td>
</tr>
<tr>
<td>31. your concern with getting injured?</td>
<td>-3</td>
</tr>
<tr>
<td>32. your concern with accidentally injuring someone else?</td>
<td>-3</td>
</tr>
<tr>
<td>33. your ability to concentrate?</td>
<td>-3</td>
</tr>
<tr>
<td>34. your feelings of control over your body?</td>
<td>-3</td>
</tr>
<tr>
<td>35. your need to ask for help?</td>
<td>-3</td>
</tr>
</tbody>
</table>

Number of (+) items: _______  Negative score: _______
Number of (-) items: _______  Positive score: _______
Number of (0) items: _______

**Total score:** _______
Applicable items (#): _______
Average score: _______

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References

Asymptomatic Median Mononeuropathy Among Men With Chronic Paraplegia

Huey-Wen Liang, MD, Yen-Ho Wang, MD, Shin-Liang Pan, MD, Tyng-Guey Wang, MD, Tien-Shang Huang, MD


Objectives: To compare electrophysiologic abnormalities of the median nerve in asymptomatic paraplegic subjects and able-bodied controls and to examine the influence of personal factors on these parameters.

Design: Cross-sectional survey.

Setting: University hospital.

Participants: Forty-seven men with paraplegia and 36 able-bodied controls underwent nerve conduction studies on both upper limbs. All were free of hand numbness in the past month, diabetic mellitus, or neuromusculoskeletal injuries to the upper limbs.

Interventions: Not applicable.

Main Outcome Measure: Nerve conduction studies of the bilateral median and ulnar nerves.

Results: Although the 2 groups were of comparable age and had a similar body mass index (BMI), the subjects with paraplegia had a significantly higher proportion of asymptomatic median mononeuropathy than the controls (25.5% vs 5.6%, P = .02). The spinal cord injury (SCI) group had a prolonged median distal latency and a slowed digit-wrist sensory nerve conduction velocity. Multivariate general linear model analysis showed that prolonged motor and sensory latencies of the median nerve were associated with the SCI group and with greater BMI.

Conclusions: The asymptomatic subjects with paraplegia had a significantly higher frequency of median mononeuropathy than the able-bodied controls. There was also an association between BMI and distal latency of the median nerve.

Key Words: Carpal tunnel syndrome; Electrodiagnosis; Rehabilitation; Spinal cord injuries.

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LIFE EXPECTANCY OF PEOPLE with spinal cord injury (SCI) has increased in the past 30 years,1 but secondary impairments in chronic cases cannot be overlooked.2 Subjects with paraplegia are obliged to use their upper extremities extensively in everyday activities. Consequently, they are considered to be at high risk for overuse injuries to the upper limbs, especially the shoulders, hands, and wrists.3 Furthermore, associated pain, limitation of range of movement, and numbness are common and cause secondary disabilities.4,5 It is important to know the characteristics and mechanism of these upper-limb disorders when developing therapeutic and preventive strategies.

Carpal tunnel syndrome (CTS) is a frequent cause of hand pain in SCI subjects; several small-sample surveys have shown its prevalence in such subjects to range from 23% to 63%.6-9 The prevalence of cases determined by electrodiagnosis is even higher than the number of self-reported symptoms.10 Common risk factors for CTS include old age, pregnancy, obesity, rheumatoid arthritis, diabetes mellitus, gout, wrist squaring, hypothyroidism, occupational exposure to forceful and repetitive hand and/or wrist motions, and operating vibrating equipment.11-14 People with paraplegia use their upper extremities in daily activities that likely require repetitive and forceful wrist and hand movements. Studies have shown that paraplegic patients with CTS have a higher carpal tunnel pressure.7,15 Furthermore, Gellman et al7 found that paraplegic subjects had a higher carpal tunnel pressure on wrist extension than did nonparaplegic patients, whether or not they had CTS. Therefore, we wanted to know whether such a combination of repetitive trauma and a repeated increase in carpal canal pressure increases the risk of electrophysiologic abnormalities that might be independent of symptoms.

We hypothesized that subjects with chronic paraplegia are more likely to have electrophysiologic abnormalities of the median nerves, regardless of symptoms. We therefore evaluated the prevalence of abnormal nerve conduction in the median and ulnar nerves in asymptomatic subjects with paraplegia and in able-bodied controls. We also examined whether there is a correlation between the electrodiagnostic parameters and other personal factors, for example, body mass index (BMI), age, and duration of injury.

METHODS

We performed this cross-sectional study with a convenience sample in a special SCI clinic of a university hospital. A physiatrist specialized in the care of the SCI was in charge for the clinic, but no prerequisite was required for the patients to make appointments. Patients who met the following criteria were invited to participate in the study, which was a part of a joint program of surveillance of chronic SCI. The criteria were: traumatic paraplegia (neurologic level lower than T2) with significant motor deficits (defined as A, B, or C by the American Spinal Injury Association16), age between 18 and 60 years, injured for more than 1 year, no associated traumatic brain injuries, no peripheral nerve injuries of the upper limbs, no previous fracture of the upper limbs, and no diabetes mellitus, uremia, or other endocrine disorders. We recruited men only. None of the patients were taking drugs regularly, but a few were taking stool softeners (magnesium oxide) or low-dose...
antispastic agents (baclofen). All subjects volunteered to participate in the study and gave their written informed consent. The Research Ethics Committee of the National Taiwan University Hospital approved the study.

Every subject completed a questionnaire that was designed to collect information related to the injury history (cause, date), demographic data (age, years of education, employment), mobility condition (wheelchair or walking device type, hours a day spent in a wheelchair), and hand symptoms (hand diagram\(^1\)). Body height and weight were recorded. BMI was defined as the weight divided by the height squared (in kg/m\(^2\)).

Only subjects reporting no hand numbness in the previous month underwent nerve conduction studies. Out of 54 volunteers, 7 subjects reported hand numbness in the preceding month and were therefore excluded from analysis. A total of 47 men (45 with complete paraplegia; mean age, 36.9 y) were eligible. Their mean age at time of injury was 24.7 ± 6.3 years and the mean injury duration was 12.2 ± 7.0 years. The main causes of injury were traffic collisions (66.0%), falls from a height (17.0%), being struck by an object (10.6%), and penetrating injuries (6.4%). Forty-two subjects (89%) used a manual wheelchair and the other 5 used either an electric wheelchair or a walking device. Thirty-six male employees of the National Taiwan University Hospital comprised the control group. They, too, were asked to complete a screening questionnaire to elicit information about their medical history and hand symptoms. None had a previous history of endocrine disease or was engaged in a highly repetitively manual job, and none reported any hand numbness in the previous month. They were tested after they signed the informed consent form.

Nerve conduction studies were performed by 2 of the authors (H-WL, S-LP) on the bilateral median and ulnar nerves. They used a Medelec Synergy\(^2\) and followed the same measurement protocol. The bandwidth of the filter setting for motor conduction studies was 3 to 3kHz, and for sensory conduction studies it was 20 to 2kHz. The compound motor action potential, obtained by supramaximal stimulation, was recorded on the abductor pollicis brevis for the median nerve and on the abductor digiti quinti for the ulnar nerve. Distal stimulation was applied 7cm from the recording site and proximal stimulation was applied at the elbow. The sensory nerve action potential was recorded by an orthodromic method, with the recording electrodes placed over the wrists at a distance 14cm from stimulation for the finger-to-wrist segments and at 8cm for the mid palm-to-wrist segments. The peak latency was recorded for sensory nerve studies. The median-ulnar sensory latency difference was calculated by subtracting the ulnar sensory latency from the ipsilateral median nerve sensory latency in the digit-to-wrist segments. Median mononeuropathy was defined as a median-ulnar sensory latency difference equal to, or greater than, 0.5ms in either hand. The skin temperature of all subjects was maintained above 31°C.

All descriptive data were expressed as either a mean or a frequency and the statistical analysis was performed using SPSS.\(^3\) We compared the results of the demographic characteristics and the nerve conduction studies in both groups with a nonpaired \(t\) test or the chi-square test. Correlations between demographic data (age and BMI in both groups and injury years in the SCI group) and the results of the nerve conduction studies (distal motor latency, sensory conduction velocity) were analyzed using the Pearson product-moment correlation coefficient. We used a multivariate general linear model to analyze the relation between certain demographic characters and electrophysiologic measurements of the median nerve. Dependent variables included distal motor latency and sensory latency (4th finger-to-wrist and mid palm-to-wrist segments) of the bilateral median nerves. The fixed factor was whether subjects were or were not in the SCI group and age and BMI were the covariates. Covariates were selected by stepwise regression. \(P\) value less than .05 was considered statistically significant.

## RESULTS

Our 2 groups were similar in age, body weight, body height, and BMI, but the control group had more years of education, fewer smokers, and a higher rate of employment (table 1). Although the means of the BMI in the groups were similar, the variance was not equal (Levene test for equality of variance, \(P<.001\)). The SCI group had a wider BMI range than the control group (15.4–31.3kg/m\(^2\) vs 18.5–29.1kg/m\(^2\)). Seven in the paraplegic group and 1 in the control group had a BMI greater than 28kg/m\(^2\), 2 in the paraplegic group had a BMI of 30kg/m\(^2\) or higher.

Most of the results for the median nerves in the 2 groups differed (table 2). In the paraplegic group, the bilateral median distal motor latency was relatively prolonged and the motor nerve conduction velocity was slowed on the right side. These subjects also had a significantly slowed sensory nerve conduction velocity in the bilateral digit-wrist segments and right palm-wrist segment of the median nerves, and a lower sensory amplitude in the palm-wrist segments in the bilateral median nerves. In the ulnar nerve studies (see table 2), most parameters were similar in the 2 groups except that the SCI group had a slightly longer distal motor latency and slightly reduced digit-wrist sensory amplitude in the left ulnar nerve. Twelve (25.5%) subjects in the paraplegic group and 2 (5.6%) in the control group had median-ulnar sensory latencies of 0.5ms or higher (Fisher exact test, \(P=.02\)) and were defined as having a median mononeuropathy.

We used the Pearson correlation coefficient to analyze the association between personal factors (age, BMI, duration of injury) and selective electrophysiologic parameters (distal motor latency of the median nerve, sensory latency of the median and ulnar nerves). In the control group, almost all nerve conduction study measurements correlated with age. As age in-

<table>
<thead>
<tr>
<th>Variable</th>
<th>Paraplegia ((n=47))</th>
<th>Controls ((n=38))</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>36.9±8.6</td>
<td>35.6±9.1</td>
<td>0.51</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>65.4±13.9</td>
<td>69.3±8.7</td>
<td>0.13</td>
</tr>
<tr>
<td>Body height (cm)</td>
<td>170.8±5.6</td>
<td>171.9±5.4</td>
<td>0.25</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>22.4±4.8</td>
<td>25.4±2.4</td>
<td>0.20</td>
</tr>
<tr>
<td>Education (y)*</td>
<td>≤9</td>
<td>19 (41.3)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td></td>
<td>9–12</td>
<td>17 (37.0)</td>
<td>4 (11.1)</td>
</tr>
<tr>
<td></td>
<td>≥12</td>
<td>10 (21.7)</td>
<td>32 (88.9)</td>
</tr>
<tr>
<td>Smoker*</td>
<td>No</td>
<td>7 (15.6)</td>
<td>27 (75.0)</td>
</tr>
<tr>
<td></td>
<td>Past smoker</td>
<td>9 (20.0)</td>
<td>1 (2.8)</td>
</tr>
<tr>
<td></td>
<td>Present smoker</td>
<td>29 (64.4)</td>
<td>8 (22.2)</td>
</tr>
<tr>
<td>Handedness</td>
<td>Right</td>
<td>43 (91.5)</td>
<td>34 (94.4)</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>3 (6.4)</td>
<td>2 (5.6)</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>1 (2.1)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Current employment</td>
<td>30 (63.8)</td>
<td>32 (88.9)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**NOTE. Values are mean ± standard deviation (SD) or n (%). Differences between the 2 groups were compared using a nonpaired \(t\) test or a chi-square test, as applicable.**

*Values for paraplegia do not equal 47 because of missing data.
Table 2: Comparison of Nerve Conduction Study Results in the Median and Ulnar Nerves of Paraplegia Subjects and Controls

<table>
<thead>
<tr>
<th>Variables</th>
<th>Paraplegia (n=47)</th>
<th>Controls (n=36)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right, distal motor latency (ms)</td>
<td>3.7±0.5</td>
<td>3.3±0.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Right, MNCV (m/s)</td>
<td>58.6±4.2</td>
<td>62.0±6.7</td>
<td>.01</td>
</tr>
<tr>
<td>Left, distal motor latency (ms)</td>
<td>3.7±0.6</td>
<td>3.3±0.4</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Left, MNCV (m/s)</td>
<td>60.3±5.5</td>
<td>60.7±4.7</td>
<td>.71</td>
</tr>
<tr>
<td>Right, digit 4-wrist SNCV (m/s)</td>
<td>44.1±5.3</td>
<td>46.5±4.1</td>
<td>.03</td>
</tr>
<tr>
<td>Right, palm-wrist SNCV (m/s)</td>
<td>40.5±5.0</td>
<td>44.5±4.3</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Left, digit 4-wrist SNCV (m/s)</td>
<td>44.5±5.0</td>
<td>46.9±4.0</td>
<td>.02</td>
</tr>
<tr>
<td>Left, palm-wrist SNCV (m/s)</td>
<td>40.5±5.0</td>
<td>43.6±5.7</td>
<td>.12</td>
</tr>
<tr>
<td>Right, digit 4-wrist sensory amplitude (µV)</td>
<td>12.0±7.2</td>
<td>12.5±4.1</td>
<td>.69</td>
</tr>
<tr>
<td>Right, palm-wrist sensory amplitude (µV)</td>
<td>51.2±28.7</td>
<td>113.2±47.1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Left, digit 4-wrist sensory amplitude (µV)</td>
<td>12.6±5.0</td>
<td>11.5±3.5</td>
<td>.24</td>
</tr>
<tr>
<td>Left, palm-wrist sensory amplitude (µV)</td>
<td>53.5±28.7</td>
<td>110.3±35.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Median-union sensory latency difference ≥0.5ms</td>
<td>12 (25.5)</td>
<td>2 (5.6)</td>
<td>.02</td>
</tr>
</tbody>
</table>

NOTE. Values are mean ± SD or n (%). Abbreviations: MNCV, motor nerve conduction velocity; SNCV, sensory nerve conduction velocity.

creased, the distal motor and sensory latencies became prolonged. In the paraplegic group, the only correlation was between the BMI and left median distal motor latency (Pearson r = .35, P = .02). In contrast, multivariate general linear model analysis showed that having or not having SCI was the most important factor associated with prolonged distal motor and sensory latencies of the median nerve (table 3). The SCI group had a longer distal motor latency by 0.4ms and a longer digit-wrist sensory latency by 0.2ms than the control group. BMI, and not age, was a significant covariate for parts of the parameters, including left distal median motor latency and sensory latency of the bilateral palm-to-wrist segments.

**DISCUSSION**

Several studies have reported a high prevalence of signs or symptoms of CTS in patients with paraplegia,6-7,9 but our report is unique in that it focuses on electrophysiologic abnormalities of the median nerves in asymptomatic people. Compared with the able-bodied control group, the paraplegic group had a significantly higher frequency of median mononeuropathy (25.5% vs 5.6%). Furthermore, multivariate analysis showed an association between the electrophysiologic parameters and BMI.

Different frequencies of asymptomatic median mononeuropathy have been reported in different occupational groups18; this may be explained by the different populations, test methods, and criteria. The median mononeuropathy detected by electrodiagnosis is usually defined on a relative basis.19 We set a median-ulnar sensory latency difference of 0.5ms or more as the cutpoint, the same as in a previous study that applied an antidromic method.20 Because the populations we tested were asymptomatic, we chose a highly sensitive, but probably not as specific, criterion. Asymptomatic median mononeuropathy is not uncommon among subjects with SCI. A survey of 47 paraplegic subjects found that 40.4% had clinical symptoms of CTS and 63.8% had electrophysiologic evidence of CTS, defined as a distal motor latency greater than 4.4ms, or a sensory latency greater than 3.4ms in the median nerve.5 Also, a study involving wheelchair athletes21 showed the frequency of clinical symptoms and electrophysiologic abnormalities to be 23% and 64%, respectively. Gellman et al6 showed that carpal tunnel pressure is high in paraplegic subjects, even in those without CTS symptoms. The pressure during extension or ischial pressure-releasing maneuvers can be as high as 160 to 220mmHg, which greatly exceeds the critical pressure of 40 to 50mmHg that induced morphologic changes in nerves in animal studies.22,23 The higher incidence of median mononeuropathy in SCI subjects, in the absence of corresponding symptoms, is likely multifactorial but is exacerbated by a long-lasting high carpal tunnel pressure resulting from repetitive and forceful movements of the wrists, as is seen in asymptomatic workers with similar occupational exposure.18,24

Asymptomatic workers with electrodiagnosed median mononeuropathy had a similar risk of developing symptoms compared with a control group (10% vs 12%, respectively) when the follow-up was only 2 years.25 Two studies,26,27 however, did show a correlation between the severity of electrodiagnosed median mononeuropathy and the development of CTS symptoms after a 6- to 11-year follow-up. Our study, limited by its cross-sectional design, did not allow us to determine whether the SCI subjects with asymptomatic median mononeuropathy had a higher risk of developing CTS symptoms or more severe median mononeuropathy in the future; longitudinal research is needed to clarify the clinical significance of these abnormal findings in the SCI population. Moreover, we agree with the recommendation of Rempel et al28 to not rely on electrodiagnostic findings alone in epidemiologic studies. The high frequency of abnormal median

---

Table 3: The Parameter Estimates of Multivariate General Linear Model Analysis

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Parameters</th>
<th>β</th>
<th>SE</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right distal motor latency</td>
<td>Intercept</td>
<td>2.97</td>
<td>.33</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SCI group</td>
<td>0.41</td>
<td>.10</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
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<td>.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left distal motor latency</td>
<td>Intercept</td>
<td>2.36</td>
<td>.33</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SCI group</td>
<td>0.43</td>
<td>.10</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>0.04</td>
<td>.01</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Right median sensory latency, digit 4-wrist</td>
<td>Intercept</td>
<td>3.00</td>
<td>.26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SCI group</td>
<td>0.19</td>
<td>.08</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>0.00</td>
<td>.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right median sensory latency, mid palm-wrist</td>
<td>Intercept</td>
<td>1.50</td>
<td>.17</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SCI group</td>
<td>0.20</td>
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<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
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<td>.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left median sensory latency, digit 4-wrist</td>
<td>Intercept</td>
<td>2.98</td>
<td>.26</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SCI group</td>
<td>0.20</td>
<td>.08</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>0.00</td>
<td>.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left median sensory latency, mid palm-wrist</td>
<td>Intercept</td>
<td>0.39</td>
<td>.25</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>SCI group</td>
<td>0.14</td>
<td>.08</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>0.02</td>
<td>.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: SE, standard error.
nerves in asymptomatic SCI subjects will result in an overestimation of its prevalence if not used in combination with symptoms characteristics of CTS.

Reported predictors of CTS in SCI subjects have been inconsistent in previous studies. Longer duration of the injury seems to be an important risk factor, but some studies made no adjustments for other personal confounding factors such as age, sex, and BMI. We examined the association between some personal factors and median and ulnar nerve function with the Pearson correlation coefficient and multivariate general linear model analysis. Age was associated with a prolonged distal motor latency and slower sensory conduction velocity only in the control group, in accordance with prior reports. There was no correlation, however, between age or injury duration and CTS in the SCI subjects. Age was not a significant covariate in multivariate general linear model analysis and we attributed that to either the small sample size or confounding by other risk factors. The multivariate analysis also showed that BMI, an important risk factor for CTS, was associated with prolonged motor and sensory latency of the median nerve. Boninger et al showed an association between median nerve function and body weight in subjects with SCI. They hypothesized that a higher weight led to higher pushrim forces and moments during wheelchair propulsion and, therefore, to median nerve injuries. We found a higher proportion of obesity in the SCI group and only 1 subject in the control group had a BMI of 28 kg/m² or more, compared with 7 in the SCI group. Note that the means of the BMI were similar but were of unequal variance in these 2 groups, despite the differences in the number of subjects with high BMI.

Study Limitations

Our study has several limitations. First, the cross-sectional design did not allow us to interpret the clinical significance of abnormal measurements or to examine their predictive value. Follow-up studies are warranted. Second, our study population was a convenience sample, which limits generalization of the results. We did not think there would be a selection bias related to the outcome (eg, electrophysiologic measurements). It cannot be ruled out that subjects with symptoms are more willing to be examined, but we did not observe such an inclination between the 2 groups. Third, we did not evaluate the physical activities or ergonomic exposure of the hands and wrists in these 2 groups, and it was difficult to tell whether the higher frequency of electrophysiologic abnormalities was related to chronic SCI or to the mechanical stress resulting from overuse of the upper limbs.

CONCLUSIONS

The asymptomatic subjects with paraplegia had a significantly higher frequency of abnormal nerve conduction in the bilateral median nerves than the able-bodied controls. This is possibly because of a high carpal tunnel pressure resulting from overuse of the hands and wrists. The clinical significance of abnormal median nerve function should be tested in longitudinal studies.

References


 Suppliers
b. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.
Different Risk Factor Patterns for Metabolic Syndrome in Men With Spinal Cord Injury Compared With Able-Bodied Men Despite Similar Prevalence Rates

Huijiang Liang, MD, PhD, David Chen, MD, Youfa Wang, MD, PhD, James H. Rimmer, PhD, Carol L. Braunschweig, PhD, RD


Objective: To determine if the prevalence of metabolic syndrome and risk factors differs between age- and race-matched men with spinal cord injury (SCI) and able-bodied men.

Design: Cross-sectional.

Setting: Urban university.

Participants: Men with SCI (n=185), ages 20 to 59 years, were matched 1 to 1 with able-bodied men from the 1999–2002 National Health and Nutrition Examination Surveys.

Interventions: Not applicable.

Main Outcome Measures: Waist circumference, blood pressure, glucose, triglyceride (TG), total (TC), and low-density lipoprotein (HDL) cholesterol.

Results: Despite similar prevalence for metabolic syndrome, different risk factor patterns were found between groups. Men with SCI had a significantly lower mean HDL, TG, and glucose in addition to lower TC and LDL. After adjusting for smoking, education, and household income by using conditional logistic regression, men with SCI had a higher risk for abdominal obesity (odd ratio [OR]=1.78; 95% confidence interval [CI], 1.07–2.96) and reduced HDL (OR=1.76; 95% CI, 1.06–2.94) but lower risks for elevated glucose (OR=0.55; 95% CI, 0.33–0.94) than their able-bodied counterparts. By using linear regression and controlling for waist circumference, men with SCI had lower TC, LDL, TG, and glucose concentrations but lower HDL. Racial differences in risks were found in both SCI and able-bodied men; however, among the SCI men, prevalence for low HDL and elevated glucose was similar between whites and African Americans.

Conclusions: Men with SCI do not appear to have an increased prevalence of metabolic syndrome compared with able-bodied counterparts, suggesting that other nontraditional risks may contribute to their increased mortality from cardiovascular disease and diabetes.

Key Words: Metabolic syndrome X; Obesity; Rehabilitation; Risk factors; Spinal cord injuries.

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METABOLIC SYNDROME predicts insulin resistance, type 2 diabetes, and cardiovascular disease (CVD). People with spinal cord injury (SCI) have increased morbidity and mortality from both of these diseases compared with able-bodied populations; however, whether their prevalence for metabolic syndrome is higher than able-bodied populations has not been determined. Abdominal obesity is a component of metabolic syndrome, which is thought to be more prevalent in SCI than able-bodied populations and may contribute to elevated disease rates; however, no studies have documented its prevalence in SCI or its relation with these diseases. Additionally, reports of heightened risks in SCI compared with able-bodied men for total cholesterol (TC), low-density lipoprotein (LDL) cholesterol, and other components of metabolic syndrome including elevated glucose, high blood pressure, and elevated triglyceride (TG) have been inconsistent. These varied results are at least partially caused by a failure to include an able-bodied control group or because comparison groups not similar in factors known to influence these measurements (eg, age, adiposity, sex, race) were used.

The purpose of this study was to determine if the overall prevalence and patterns of the component risk factors for metabolic syndrome (abdominal obesity, low high-density lipoprotein [HDL] cholesterol, elevated glucose, blood pressure, TG) and TC and LDL differ between SCI and able-bodied men matched for age and race. We hypothesize that men with SCI have a higher prevalence of metabolic syndrome and risk factors than their able-bodied counterparts. Identification of heightened risks enables health care providers to design interventions that are specifically tailored to them and intervene prior to development of overt disease, potentially reducing morbidity, mortality, and overall medical costs in this underserved population.

METHODS

Participants

Men with SCI. Men with SCI were recruited for this cross-sectional study by using flyers and word of mouth from clinic waiting areas at the Rehabilitation Institute of Chicago (RIC). Eligible men had SCI, were between 20 and 59 years of age, and at least 1 year postinjury. This research was approved by the institutional review boards of RIC and the University of Illinois at Chicago.
Able-bodied men. A dataset of able-bodied men was created from the 1999–2002 National Health and Nutrition Examination Surveys (NHANES)\(^1\) for comparison by using 1 to 1 matching on age and race with SCI participants.

Eligibility and Subject Matching

Men in the 1999–2002 NHANES datasets without paralysis or amputation and having complete data on age, height, weight, waist circumference, blood pressure, plasma glucose, and serum lipid profiles (fasting time, >9h) and information on disease history, smoking status, education, and marriage were identified. Matching criteria included age (within 5y), sex, and ethnicity and race. All records that met the matching criteria were selected. The record having the same race and sex and minimum age difference with the SCI case was selected as the control. To guarantee no duplication of able-bodied controls, an able-bodied record was deleted after being selected from the NHANES dataset and no longer available for further matching. The dataset with able-bodied controls was vertically merged with the SCI dataset before analysis.

Study Variables

Demographics. Demographic parameters included age, sex, race and ethnicity (self-reported), level of education (di-chotomized as high school and above or below), marital status (single or married/living with partner), and smoking status (yes, no). Household income at poverty level (yes, no), was defined based on the poverty income ratio and the ratio of household income to the annually updated poverty threshold for a household of the same size.\(^1\) A poverty income ratio value below 1 indicates a below poverty level income.

Additionally, SCI subjects were assessed for “time since injury” (in years) and neurologic injury level. Injury level was defined as the first spinal vertebral level consistent with abnormal neurologic loss (ie, C2-8, T1-12, L5, S1-5) and also as complete or incomplete. Complete injury was defined as no motor or sensory function in the anal and perineal region representing the lowest sacral (S4-5) cord; incomplete injury was defined as otherwise.\(^1\)

Anthropometric measurements and blood pressure. Because standing heights were not feasible and supine measurements are difficult and inaccurate because of spasm,\(^1\) self-reported heights were used in the SCI participants. These self-reported measures have been found to be the best indicator of height for people with SCI, although they tend to be over-estimated by 1.5cm in complete paraplegics and 3.1cm in complete paraplegics.\(^15\) To increase comparability between the groups, self-reported height was also used for the able-bodied controls. However, measured height was also used to examine the difference with self-reported height because self-reported height in able-bodied has been found to be .76cm (95% confidence interval [CI], .64 – .88cm) greater than measured height among adults in the U.S. general population.\(^16\) Weight in SCI men was obtained by using a wheelchair scale\(^6\) calibrated for accuracy daily to within 0.1kg for the SCI men; the able-bodied men were weighed on a beam scale calibrated for minimal clothing when weighed.

Waist circumference measurement varied between the groups. The supine waist was obtained for the SCI men because standing waist circumference is not feasible among wheelchair users.\(^17\) However, men in NHANES were standing while their waist circumference was assessed. Recumbent and standing measures of waist circumference are highly comparable.\(^18\) Both groups had 3 measurements taken at the high point of the iliac crest to the nearest 0.1cm with minimal expiration, and the average was used for data analysis. Blood pressure in SCI men was taken in the morning on the right arm in a sitting position.\(^19\) Measurements of blood pressure in able-bodied men also followed these standard procedures.

Biochemical indices. Blood samples were obtained from all participants after a minimum of 9 hours of fasting. Although TC and LDL are not included in metabolic syndrome, these measures have been understudied in the SCI population and therefore were included. Measures for serum TG, TC, HDL, and LDL in NHANES have been described.\(^20\) The serum lipid and lipoprotein assays in SCI men followed similar standard procedures. Specifically, glycerokinase assay was used for TG; cholesterol oxidase assay was used for TC and HDL, and the Friedewald equation was used for LDL calculation in those with serum TG levels of 400mg/dL or less.\(^21\) Plasma glucose was measured by the modified hexokinase enzymatic assay in the able-bodied men\(^2\) and the glucose oxidase assay in men with SCI.

Secondary outcome variables. Metabolic syndrome was defined as the presence of at least 3 of the following 5 risk factors as described by the American Heart Association and the National Heart, Lung, and Blood Institute:\(^22\) central obesity (waist >102cm), elevated TG (TG ≥1.69mmol/L [150mg/dL] or medication use for elevated TG), reduced HDL (HDL <1.04mmol/L [40mg/dL] or medication use for reduced HDL), elevated blood pressure (systolic blood pressure [SBP]/diastolic blood pressure [DBP] ≥130/85mmHg or hypertension history and medication use), and elevated glucose (fasting plasma glucose ≥5.6mmol/L [100mg/dL] or diabetes history and medication use). High TC and high LDL were defined as 6.22mmol/L (240mg/dL) or higher and 4.14mmol/L (160mg/dL) or higher, respectively, as well as having history of hypercholesterolemia and taking medication for it.

Statistical Analysis

Means and standard deviations (SDs) were used to describe normally (eg, age, height, weight, body mass index [BMI], waist, blood pressure, TC, LDL) as well as nonnormally (HDL, TG, glucose) distributed variables for consistency and to facilitate interpretation. Those nonnormally distributed variables were log transformed and then converted back to original scale for the presentation of results. To eliminate the effect of medication use on blood pressure, glucose, and lipid profiles, participants taking medications for diabetes, hyperlipidemia, or hypertension were excluded (131 pairs used for analyses). To examine the difference between self-reported versus measured height in able-bodied men, the median of the difference was calculated. Frequencies were used as descriptors for categorical variables (eg, diabetes, hypertension, high TC, LDL, metabolic syndrome). The dependent t test, Wilcoxon signed-rank test, and the McNemar test were conducted for comparisons between matched able-bodied and SCI pairs; the McNemar test was used for dichotomous variables. The independent t test, Wilcoxon rank-sum test, and chi-square test were used for comparisons between complete versus incomplete injury and high (T6 and above) versus low (below T6) injury level within SCI men and comparisons between white and African Americans within SCI or able-bodied groups. Hispanic (n=40 pairs) or other races (n=6 pairs) were not included in race comparisons because of a small sample size.

Conditional logistic regression models were used to calculate odds ratios (ORs) and 95% CIs for high TC, LDL, metabolic syndrome, and its component risk factors (central obesity, elevated TG, blood pressure, glucose, reduced HDL) for SCI men compared with age- and race-matched able-bodied con-
Table 1: Demographic Characteristics of Age- and Race-Matched SCI and Able-Bodied Men*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>SCI (n=185)</th>
<th>Able-Bodied (n=185)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age ± SD (y)</td>
<td>39.2±10.4</td>
<td>39.1±10.4</td>
<td>NA</td>
</tr>
<tr>
<td>Race (frequency, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>60 (32.4)</td>
<td>60 (32.4)</td>
<td>NA</td>
</tr>
<tr>
<td>African American</td>
<td>79 (42.7)</td>
<td>79 (42.7)</td>
<td>NA</td>
</tr>
<tr>
<td>Hispanic</td>
<td>40 (21.6)</td>
<td>40 (21.6)</td>
<td>NA</td>
</tr>
<tr>
<td>Other race</td>
<td>6 (3.2)</td>
<td>6 (3.2)</td>
<td></td>
</tr>
<tr>
<td>Education (% &gt;high school)</td>
<td>103 (55.7)</td>
<td>90 (48.6)</td>
<td>.193</td>
</tr>
<tr>
<td>Income (% at poverty level)</td>
<td>85 (45.9)</td>
<td>43 (23.2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Smoking (% yes)†</td>
<td>88 (47.6)</td>
<td>91 (49.2)</td>
<td>.842</td>
</tr>
<tr>
<td>Married (% yes)†</td>
<td>47 (25.4)</td>
<td>125 (67.6)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviation: NA, not applicable.
*Able-bodied data from NHANES 1999–2002 survey.† McNemar test was used to examine differences in dichotomous variables between SCI and able-bodied men.

Data were managed and analyzed by using SAS. Because the goal of this study was to compare the prevalence of CVD risk factors between matched SCI and able-bodied men, the complex survey design and the sample weights in NHANES were not used in the matching or analysis.

RESULTS

Demographic characteristics of the study population are presented in table 1. A total of 185 men with SCI were recruited. Their mean age at injury was 27.6 years, and on average they were 11.7 years postinjury (range, 1–40.4y). Their injury levels ranged from C6 to S5; overall 56% (n=103) had a complete injury. Men with SCI were more likely to be single (75% vs 32%, P<.001) and live at poverty level (46% vs 23%, P<.001). African-American men with SCI were more likely to have complete injury (65.8% vs 41.7%, P=.004), smoke (58.2% vs 38.0%, P=.007), live in poverty (63.3% vs 16.7%, P<.001), and be unmarried (84.8% vs 61.7%, P=.002) compared with white men with SCI. Fewer SCI men reported a history of hyperlipidemia (SCI vs able-bodied: 10.8% vs 21.1%, P=.005); however, no differences for history of hypertension (SCI vs able-bodied: 18.4% vs 17.8%, P=.884) or diabetes (SCI vs able-bodied: 5.4% vs 2.7%, P=.196) or medication use for these disorders occurred between the groups.

Overall and race-stratified comparison for anthropometrics, blood pressure, and biochemical risk factors in age- and race-matched SCI and able-bodied men are provided in table 2. Risk factors among SCI men did not vary by level of injury, except for DBP, which was lower in those with injury levels at or above T6 (72mmHg vs 78mmHg, P=.04).

All anthropometric measures were similar between the groups, except for height, which was 2cm greater in the SCI compared with the able-bodied men. Self-reported height in able-bodied men was on average 0.5cm taller than their measured height. Although overall weight, BMI, and waist circumference were similar between the groups, the SCI men had lower TC, LDL, glucose, and TG than their able-bodied counterparts.

Table 2: Overall and Race-Stratified Comparison of Anthropometrics, Blood Pressure, and Biochemical Risk Factors in Age- and Race-Matched SCI and Able-Bodied Men*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Overall (Pairs=185)</th>
<th>White (Pairs=60)</th>
<th>African American (Pairs=79)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>83.5±20.3</td>
<td>83±18.0</td>
<td>80.3±17.7</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.79±0.08</td>
<td>1.77±0.08</td>
<td>1.80±0.08</td>
</tr>
<tr>
<td>BMI (kg/m2)</td>
<td>26.1±6.0</td>
<td>27.1±5.1</td>
<td>26.2±6.3</td>
</tr>
<tr>
<td>WC (m)</td>
<td>0.97±0.17</td>
<td>0.95±0.14</td>
<td>0.99±0.15</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>122±14</td>
<td>120±13</td>
<td>119±11</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>77±11</td>
<td>75±11</td>
<td>76±10</td>
</tr>
<tr>
<td>TC (mmol/L)</td>
<td>4.71±1.16</td>
<td>5.26±1.13</td>
<td>4.71±1.09</td>
</tr>
<tr>
<td>HDL (mmol/L)</td>
<td>1.11±0.32</td>
<td>1.21±0.33</td>
<td>1.07±0.30</td>
</tr>
<tr>
<td>LDL (mmol/L)†</td>
<td>2.95±0.91</td>
<td>3.35±1.00</td>
<td>3.01±0.87</td>
</tr>
<tr>
<td>TG (mmol/L)</td>
<td>1.36±1.07</td>
<td>1.52±1.04</td>
<td>1.50±0.94</td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td>5.11±1.29</td>
<td>5.41±0.65</td>
<td>5.03±0.61</td>
</tr>
</tbody>
</table>

NOTE. Values are mean ± SD. To convert TC, HDL, and LDL from mmol/L to mg/dL, multiply by 38.67; to convert TG from mmol/L to mg/dL, multiply by 88.57; to convert glucose from mmol/L to mg/dL, multiply by 18.02. Medication users for hypertension, diabetes, and hyperlipidemia were excluded for blood pressure and biochemical risk factors. The dependent t test and Wilcoxon signed-rank test were used for comparisons between SCI and able-bodied men. Abbreviations: AB, able-bodied; WC, waist circumference.

*Able-bodied data from NHANES 1999–2002 survey.† The independent t test and Wilcoxon rank-sum test were used for comparisons between white and African-American men within SCI or able-bodied groups.

P<.05 for comparisons between white and African-American men within SCI or able-bodied groups.

P<.01 for comparisons between white and African-American men within SCI or able-bodied groups.

Records without available LDL and their matched counterparts were deleted before analysis to guarantee equal numbers between SCI and able-bodied men.

terparts; HDL was the only risk factor that was undesirable in the SCI than able-bodied men. Risk factor profiles were more favorable for African-American compared with white men. Overall African-American men tended to have lower mean waist circumference, glucose, TC, and TG and higher HDL levels than white men.

When disease risks were dichotomized (table 3), higher risks for central obesity and low HDL but lower risks for elevated glucose and trends for lower risks for elevated TC and TG occurred in SCI compared with able-bodied men. African-American able-bodied men had a significantly lower prevalence for elevated glucose, TG, TC, and low HDL and a lower prevalence for metabolic syndrome than white able-bodied men. However, among the SCI men, the significance for difference in the prevalence for low HDL and elevated glucose disappeared between whites and African Americans.

Adjusting for education, smoking, and household income by using conditional logistic regression, a trend of lower risk for elevated glucose, TC, LDL, and TG and higher HDL remained in SCI versus able-bodied men. African-American able-bodied men had significantly higher DBP and depressed HDL concentrations compared with race- and age-matched able-bodied controls (table 5). After medication users were excluded, the significantly lower TC, LDL, and glucose concentrations but lower HDL remained in SCI versus able-bodied men.

**DISCUSSION**

In the general population, TC, LDL, and parameters included in metabolic syndrome (abdominal obesity, TG, glucose, blood pressure, HDL) explain the majority of total CVD events and are recommended for routine monitoring of risks for CVD. Prospective population studies show that the presence of metabolic syndrome confers a 2-fold increase in relative risk for atherosclerotic CVD events and, in people without established type 2 diabetes, an estimated 5-fold increase in risk for established type 2 diabetes, an estimated 5-fold increase in risk for atherosclerotic CVD events and, in people without established type 2 diabetes, an estimated 5-fold increase in risk for

### Table 3: Overall and Race-Stratified Comparison of Categorical Risk Factors in Age- and Race-Matched SCI and Able-Bodied Men*

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Overall (Pairs=185)</th>
<th>White (Pairs=60)</th>
<th>African American (Pairs=79)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SCI</td>
<td>AB</td>
<td>P</td>
</tr>
<tr>
<td>High TC</td>
<td>14.6</td>
<td>21.6</td>
<td>.074</td>
</tr>
<tr>
<td>High LDL†</td>
<td>14.3</td>
<td>21.1</td>
<td>.102</td>
</tr>
<tr>
<td>Metabolic syndrome</td>
<td>30.8</td>
<td>28.6</td>
<td>.605</td>
</tr>
<tr>
<td>Central obesity</td>
<td>35.1</td>
<td>23.2</td>
<td>.011</td>
</tr>
<tr>
<td>Elevated TG</td>
<td>28.1</td>
<td>36.2</td>
<td>.066</td>
</tr>
<tr>
<td>Low HDL</td>
<td>44.3</td>
<td>32.4</td>
<td>.011</td>
</tr>
<tr>
<td>Elevated blood pressure</td>
<td>44.9</td>
<td>37.8</td>
<td>.173</td>
</tr>
<tr>
<td>Elevated glucose</td>
<td>23.8</td>
<td>36.2</td>
<td>.010</td>
</tr>
</tbody>
</table>

NOTE. The McNemar test was used for comparisons between SCI and able-bodied men.

*Able-bodied data from NHANES 1999–2002 survey.†Records without available LDL and their matched counterparts were deleted before analysis to guarantee equal numbers between SCI and able-bodied men.

### Table 4: Adjusted ORs and 95% CIs for Risk Factors in Men With SCI Compared With Age- and Race-Matched Able-Bodied Controls (Pairs=185)*

<table>
<thead>
<tr>
<th>Risk Factors</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High TC</td>
<td>0.68 (0.36–1.27)</td>
</tr>
<tr>
<td>High LDL†</td>
<td>0.58 (0.31–1.09)</td>
</tr>
<tr>
<td>Metabolic syndrome</td>
<td>1.17 (0.68–2.01)</td>
</tr>
<tr>
<td>Central obesity</td>
<td>1.78 (1.07–2.96)</td>
</tr>
<tr>
<td>Elevated TG</td>
<td>0.66 (0.38–1.14)</td>
</tr>
<tr>
<td>Low HDL</td>
<td>1.76 (1.06–2.94)</td>
</tr>
<tr>
<td>Elevated blood pressure</td>
<td>1.46 (0.90–2.32)</td>
</tr>
<tr>
<td>Elevated glucose</td>
<td>0.55 (0.33–0.94)</td>
</tr>
</tbody>
</table>

NOTE. Conditional logistic regressions were used for analysis while adjusting for education, smoking, and household income.

*Able-bodied data from NHANES 1999–2002 survey.†Records without available LDL and their matched counterparts were deleted before analysis to guarantee equal numbers between SCI and able-bodied men.
developing diabetes compared with people without metabolic syndrome.22 We found similar prevalence rates for metabolic syndrome in men with SCI compared with their age- and race-matched able-bodied counterparts. No previous studies have compared prevalence for metabolic syndrome in SCI and able-bodied men. Lee et al24 reported that 22% (n=93) of adults with SCI had metabolic syndrome; however, their study included women (14%) and more tetraplegic (42%) people and did not include an able-bodied comparison group. Despite these differences, their findings are very similar to ours if same definition is applied. The prevalence of individual risk factors for metabolic syndrome was not reported. The similarity in prevalence for metabolic syndrome between the SCI and able-bodied men supports the need to investigate other nontraditional risk factors to help explain increased CVD in persons with SCI.24,25

We found that men with SCI had higher prevalence for central obesity than their age- and race-matched able-bodied controls. Centrally located adipose tissue has been associated with heightened risk for CVD and type 2 diabetes.26,28 Despite limited data in SCI populations,27 the conventional wisdom has been that they have higher prevalence for abdominal obesity, which predisposes them to increased risks for diabetes and CVD compared with the general population.2,4,30 Frisbie and Brown29 found an increased waist change in tetraplegic (analysis of all 4 limbs and caused by an SCI at a level from C1 to T1) patients whose duration of injury varied from 2 to 49 years (n=20) compared with able-bodied men; however, they did not report the mean waist circumference. Two other studies31,32 have reported the mean waist circumference in an SCI population. Both of these studies had small sample sizes (n=46, n=69, respectively); one included inpatients and outpatients, and the other included women but failed to report sex-specific results. Despite these differences, the mean waist circumference reported by Maki et al12 was very similar to ours (waist circumference, 97.7cm vs. 97.8cm). The mean reported by Demirel et al51 was much lower (waist circumference, 84.8cm) than ours, which probably reflects their inclusion of women. Unfortunately, neither of these studies reported the prevalence of central obesity or its association with obesity-related risk factors. Although our findings for abdominal obesity need to be confirmed in a population-based study, because clinic visits among people with SCI are fairly common, it is likely that our sample is more reflective of the general SCI population than a clinic-based sample of the general able-bodied population. The greater prevalence for abdominal obesity and the similar prevalence for metabolic syndrome in SCI strongly suggest that different risk factor patterns exist for SCI compared with able-bodied men.

Our data also showed that subjects with SCI had significantly lower glucose concentrations and lower prevalence for elevated glucose compared with able-bodied men, which was consistent with the literature.5,34 Bauman and Spungen4 reported lower fasting glucose concentrations in SCI men compared with age- and BMI-matched controls. Jones et al14 found a trend of lower mean fasting glucose (5.20mmol/L vs. 5.46mmol/L, P<.05) despite significantly higher trunk fat mass from dual-energy x-ray absorptiometry (DXA) (11.2kg vs. 7.1kg, P<.05) among the SCI men compared with the age-, weight-, and height-matched able-bodied controls (pairs n=20). Neither of these studies specified race, measured waist circumference, or examined the prevalence for elevated glucose. However, after administration of the oral glucose tolerance test (OGTT), which measures the body’s ability to appropriately handle an excess glucose load, both studies showed higher glucose levels in SCI than able-bodied controls. This test has been recommended by the American Diabetes Association for use in healthy, ambulatory persons because physical inactivity can produce abnormal glucose tolerance.25 These concerns have been substantiated by several investigators. Szczypaczewska et al36 found blood glucose and insulin concentrations during the OGTT were lowest in body builders, medium in similar lean body mass controls, and highest in obese men, suggesting physical activity and greater lean body mass improve glucose tolerance. Furthermore, Elder et al37 found that 2-hour plasma glucose after a standard OGTT was negatively associated with the percent of skeletal muscle and positively correlated with magnetic resonance imaging scans of intramuscular fat. They concluded that the abnormal glucose tolerance in this population reflected their decreased skeletal muscle mass and more intramuscular fat. The abnormal glucose tolerance reported in previous studies of people with SCI1,34 may have been a reflection of their physical inactivity and greatly diminished muscle mass in addition to their increased adiposity and thus have different implications than findings in an able-bodied population. Collectively, our data and those of Jones and Bauman suggest that SCI men have lower fasting glucose concentrations. The mechanism for this finding requires further study.

Increased prevalence and mortality from hypertension have been reported in SCI populations.1,16 Imai et al38 found mortality was 2.5 to 3 times greater in SCI than that in an age- and sex-matched able-bodied population. Yekutiel et al11 also reported increased hypertension in adult SCI subjects (mean age, 40.4y; range, 27–62y). Injury level, type (complete or incomplete), and race were not described in either of these studies. High spinal level and complete injuries cause less sympathetic input and are characterized by lower blood pressure. We found similar overall rates for elevated blood pressure between our SCI and able-bodied men and lower blood pressure in those with injuries above T6 compared with those with lower injuries. The similarities in hypertension prevalence between able-bodied and SCI is not unexpected because a substantial proportion of our SCI men had conditions that lower blood pressure (eg, 37% of the SCI men had an injury level at or above T6, 46% of these with high injury levels had complete injury).

Reports about lipid levels in SCI men compared with able-bodied men have been varied.7,31,39-41 We found significantly lower mean TC and LDL in addition to lower HDL and TG in SCI compared with able-bodied men. Bauman et al42 also found lower TC in SCI men compared with age- and BMI-matched men. In a later study,7 they reported significantly lower LDL and TC compared with controls matched for race and sex; however, the mean BMI in the SCI participants was approximately 5 BMI units lower than controls. Very few investigators have reported prevalence rates for elevated LDL and TC.43 Demirel15 showed both higher prevalence of unfavorable TC and LDL and higher means for TC and LDL in a small SCI sample (n=69) compared with young healthy controls; however, those with a duration of injury less than 6 months were included. Additional studies reported no difference in TC and LDL in SCI40,41 compared with controls; however, none of these studies controlled for age, sex, and race. Conditions characterized by elevated inflammation are characterized by decreases in TC, LDL, HDL, and moderate stress/inflammation increases TG clearance and lowers TG levels.43 Several investigators44,45,47 have reported elevated inflammation as measured by C-reactive protein in SCI populations, which may explain the lipid profiles we observed; however, the heightened inflammatory state needs to be confirmed because none of these studies included appropriate
comparison groups or controlled for other known influences of C-reactive protein (eg, waist, race, age, smoking). As anticipated, racial differences in risk factors occurred between our SCI and able-bodied men. Consistent with the literature, overall African-American men had lower mean waist circumference, glucose, TC, and TG and higher HDL concentrations than white men. Compared with able-bodied, when risks were dichotomized, the African-American SCI men did not have statistically lower prevalence for low HDL than their white SCI counterparts, despite their smaller waist and lower TG. Low HDL concentrations have been consistently reported for over 2 decades in SCI populations and are thought to be at least partially caused by lower physical activity postinjury. Our findings extend these prior studies by showing that the lower HDL tends to be more pronounced among the African-American men with SCI. In the general population, a higher prevalence for leisure time inactivity has been reported in African-American compared with white men. We did not examine physical activity; however, a greater percentage of the African-American SCI men had complete injuries (65.8% vs 41.7%, \( P = .004 \)), which may have resulted in lower physical activity levels. African Americans have the highest rate for overall cardiovascular mortality of any ethnic group. Our findings highlight the need for further studies for CVD prevention in this traditionally underserved, high-risk population.

### Study Limitations

There are several limitations to our findings. First, we did not have a direct measure of fat mass (eg, DXA); thus, absolute differences in adiposity between groups can only be inferred from the anthropometric measures. Second, methodologic differences in some of the measurements of risk factors occurred between the SCI and able-bodied men. Specifically, different glucose determination methods were used; however, these methods provide comparable glucose concentration. Self-reported heights were used for both SCI and able-bodied men; however, median difference (0.5cm) between self-reported and reported heights were used for both SCI and able-bodied men; thus, median difference (0.5 cm) between self-reported and measured height in the able-bodied men is smaller than what has been reported for SCI populations, which was speculated to be because of interindividual differences in bone mineralization. If the self-reported heights were less overstated in the SCI men, their BMIs would have been larger and the differences observed between the groups for BMI would be eliminated. Recumbent waist circumference was used in SCI and standing waist circumference in able-bodied; however, they were highly comparable. Last, although considerably larger than most studies reported on SCI populations, our sample was still fairly small and limited our power to detect small differences between the 2 groups.

### CONCLUSIONS

We found a similar prevalence rate for metabolic syndrome in the SCI group compared with able-bodied men. These findings suggest that other nontraditional risks may contribute to their increased CVD and diabetes risks. Given different risk factor patterns between SCI and able-bodied men, future interventions should target abdominal obesity, low HDL, and other nontraditional risk factors.

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Suppliers
b. YSI 2300 STAT Plus glucose and lactate analyzer; YSI Inc, PO Box 279, Yellow Springs, OH 45387.
c. Version 9.1.3; SAS Institute Inc, 100 SAS Campus Dr, Cary, NC 27513.
The Relationship Between Perceived Exertion and Physiologic Indicators of Stress During Graded Arm Exercise in Persons With Spinal Cord Injuries

John E. Lewis, PhD, Mark S. Nash, PhD, Larry F. Hamm, PhD, Shannon C. Martins, MS, Suzanne L. Groah, MD, MPH


Objective: To examine the relationship between psychologic cues of somatic stress and physiologic responses to exercise in persons with paraplegia and tetraplegia. Design: Repeated measures with 2 comparison groups. Setting: Academic medical center. Participants: Forty-two subjects between 18 and 69 years of age with motor-complete spinal cord injury (SCI) resulting in paraplegia or tetraplegia (American Spinal Injury Association grades A and B). Interventions: Not applicable. Main Outcome Measures: Subjects underwent peak graded arm ergometry during which heart rate, oxygen consumption (VO2), minute ventilation (VE), and ratings of perceived exertion (RPE) (Borg Categorical 6–20 Scale) were measured at successive work rate increments from baseline to fatigue. Results: There were inconsistent associations among the outcomes. For subjects with tetraplegia, RPE related positively to heart rate at the initial work rate, but there were no other significant correlations. For subjects with paraplegia, RPE did not correlate significantly with heart rate, VO2, or VE. VO2 and VE related positively at the first and last work rates. In general, heart rate, VO2, and VE increased as the exercise intensity increased, and were more pronounced in subjects with paraplegia. While RPE values increased with increasing work rates for each group, we found no differences between groups. Conclusions: Our findings contradict the well-accepted relationships between RPE and both heart rate and VO2 during exercise by people without disabilities, and challenge the use of RPE as a valid psychophysologic index of perceived exertion in persons with SCI.

Key Words: Aerobic exercise; Perception; Rehabilitation; Spinal cord injuries.

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Psychophysologic rating of perceived exertion (RPE) is a commonly used clinical tool with which to assess intensity of effort during acute exercise.1-5 RPE also forms a basis for prescribing an intensity of work paralleling that measured by physiologic standards of heart rate, respiratory metabolic functions, and lactate production.4,6 Measures that rate perceived exertion allow people who are exercising to estimate their work intensity based on an array of peripheral and central cues whose input is generated by muscle kinesthetic proprioceptors and chemoreceptors and cardiopulmonary responses to exercise.5,7,8 While peripheral cues dominate the locus of reference for RPE during low to moderate levels of exertion, central factors mediate the perception of higher intensity efforts.4,7,9-11

The instrument designed and validated by Borg2 has been the primary tool for assessing perceived exertion for nearly 3 decades.12 The scale’s design is based on Borg’s range model,3 which posits a relationship between human sensory responses and external physical stimuli. Thus, the scale serves as a psychophysiologic index of somatic stress based on a model that integrates objective and subjective properties of exertion.8 The earliest version of the Borg scale used an open-ended numeric range from 6 to 20, in which an exercising individual would match odd numbers with written descriptors of somatic sensations of stress. The creation of the 6- to 20-item instrument was based on Borg’s earliest findings that RPE is highly correlated with heart rate at r equal to .85, and that the value selected on the scale, times 10, approximates the heart rate.8 Not all studies have confirmed this relationship,13 but the association is quite consistent.14 Factors such as age, type of exercise, and temperature may, however, make the heart rate and RPE relationship tenuous and compromise the instrument’s validity.15,14

Notwithstanding its limitations, the Borg Categorical Scale is widely used as a valid and reliable indicator of perceived exertion during exercise by healthy people.6,8,15-17 Various studies18-23 also used the Borg Scale as an index of physiologic response to exercise by persons with spinal cord injury (SCI), but scant work has been done to determine whether the RPE scale is valid for use in the SCI population. A small study of persons with SCI at T6-8 injury level, who were trained in arm-crank ergometry, showed that RPE was a valid indicator of workload and power output.24 Because of the small sample size and the limited range of injury level, however, these findings by Capodaglio and Bazzini may not generalize to people with other SCI levels. Thus, further research is necessary to deter-
mine whether the RPE scale is useful for examining the exercise response of persons with SCI.

People with SCI may experience varying degrees of chronotropic incompetence when responding to exercise, and may have higher heart rate and oxygen consumption (VO₂) than do people without SCI when exercising at the same work intensities. Therefore, the unique physiologic responses to activity of SCI subjects may challenge the use of the Borg Scale as a valid tool for assessing their integrated exertional responses. Adaptation of the upper extremities in the performance of daily activities may also influence their perception of daily work, a factor not usually considered when examining subjects without disability who are generally naive to upper-extremity exercise. Other factors such as loss of sensation, physical imbalance during exercise, and level of conditioning might also disrupt the interaction between somatic cues and physiologic responses to physical exertion that form the foundation of the Borg range model.

In addition, level of SCI injury influences cardiopulmonary responses during exercise. For example, persons with cervical and superior thoracic injury have lower peak work output and higher average heart rate and diastolic blood pressure than people with lower thoracic injuries (T6-12). During arm exercise, subjects with the highest VO₂ and heart rate had SCI injuries below T6, while those with the lowest heart rate, VO₂, and minute ventilation (VE) had SCI injury above T7.

Our purpose in this study was to examine the relationship between perceptual and physiologic responses to graded arm exercise in people with C5-8 tetraplegia compared with subjects with T1-12 paraplegia, all of whom were previously habituated to upper-extremity conditioning. While research has intimated that RPE is determined by many factors, we wanted to determine if RPE was related to heart rate, VO₂, and VE in this sample of SCI subjects. We hypothesized that heart rate, VO₂, and VE would be more related to RPE in subjects with paraplegia than in those with tetraplegia because of the latter’s atypical physiologic responses to acute bouts of exercise.

METHODS

Participants

Forty-two subjects (33 men, 9 women) with motor-complete SCI (American Spinal Injury Association grades A and B) participated in the study. In 10 subjects the level of injury was C5-8 (n=10) and in 32 subjects it was T1-12. Twenty-eight subjects were from the University of Miami Miller School of Medicine and 14 were from the National Rehabilitation Hospital, Washington, DC. The average age of the sample ± standard deviation was 37.3±12.5 years (range, 18–69y). Age, level of injury, and sex did not differ significantly between subjects at the 2 study sites, according to t test and chi-square analysis. All subjects were in good health, operationally defined as asymptomatic for acute treatable illness, and were without a history of known cardiac disease (including resting or exertional chest discomfort). A brief medical history was obtained from all subjects. The institutional review boards of the 2 institutions approved the study. Before participating in the study, subjects were advised of the risks of the research and gave their informed consent to participate.

Materials and Procedure

All subjects were evaluated by graded peak arm exercise testing on a calibrated arm ergometer. The multistage discontinuous exercise test was performed in 3-minute stages beginning at a workload of 300kpm, with subsequent stages increasing in 100kpm increments. Data were collected at rest and during the last 10 seconds of each stage. Heart rate (in beats per minute [bpm]) was measured using 12-lead electrocardiography with standard electrode placement. VO₂ (in mL·kg⁻¹·min⁻¹) and VE (in L/min) were measured by open-circuit spirometry. Physiologic and electrocardiographic exercise termination points were consistent with published guidelines. Peak work was operationally defined as the highest VO₂ achieved during maximal effort, volitional fatigue, limiting symptoms, or the point at which increasing the workload failed to provoke further increased VO₂. Once the test was terminated, subjects underwent a passive-minute recovery during which electrocardiogram and VO₂ monitoring continued.

RPE was collected at rest and at the end of each work stage using recommended language. The possible scores for the Borg Scale ranged from 6 (no exertion) to 20 (very strong exertion).

Data Analyses

Data were analyzed using SPSS® for Windows. Frequency and descriptive statistics were calculated. We analyzed relationships among heart rate, VO₂, VE, and RPE using Pearson product-moment correlations. We used repeated-measures model analysis of variance to examine the main effects of group (level of injury) and time for heart rate, VO₂, VE, and RPE. We used the Huynh-Feldt correction factor to adjust the degrees of freedom (df) for the averaged tests of significance when the Mauchly test of sphericity was significant. Significant main effects were further examined using simple effects tests. The criterion for significance in all tests was α equal to .01, which was adopted to control for any type I error rate that might result from a small sample size.

RESULTS

Table 1 shows the descriptives for heart rate, VO₂, VE, and RPE at baseline, the first work rate, the mid-point work rate, and the peak work rate for the entire sample. Correlations were calculated among heart rate, VO₂, VE, and RPE at each of the 3 work rates for the total sample, for the persons with tetraplegia, and for the subjects with paraplegia.

Correlation Analyses for Total Sample

Table 2 shows the Pearson product-moment correlations for the entire sample. VO₂ related linearly to VE (r=.39, P=.01; 95% confidence interval [CI], .10–.62) at the first work rate. At the mid-point work rate, VO₂ related positively to VE (r=.46, P<.001; 95% CI, .42–.79) and VO₂ (r=.79, P<.001; 95% CI, .64–.88), and VO₂ was associated with heart rate (r=.56, P<.001; 95% CI, .31–.74).

Subjects With Tetraplegia

RPE related positively to heart rate (r=.78, P<.01; 95% CI, .30–.95) at the first work rate; no significant correlations were found at the mid-point work rate, while at the peak work rate VO₂ related positively to VE (r=.86, P<.01; 95% CI, .50–.97).

Subjects With Paraplegia

VO₂ related linearly to VE (r=.56, P<.01; 95% CI, .26–.76) at the first work rate; there were no significant correlations at the mid-point work rate or at the peak work rate; VE related positively to heart rate (r=.52, P<.01; 95% CI, .21–.74) and VO₂ (r=.73, P<.001; 95% CI, .51–.86).
Figure 1 shows the heart rate values by time point for each work rate from the first work rate to the mid-point work rate, but not thereafter. Similarly, there were significant \( V_{O2} \) effects for group (\( F_{1,40}=10.7, P<.01 \)), time (\( F_{1,5,60.7}=44.0, P<.001 \)), and the group by time interaction (\( F_{1,3,52.2}=11.4, P<.01 \)). The \( \phi df \) Huynh-Feldt correction factor for the within-subjects effects was .65. There were no significant differences between groups at the first work rate (mean difference \( \pm \) standard error SE, 28.7 \pm 70; \( P=.69; 95\% \) CI, -1.14 to 1.70), but at the mid-point work rate (mean difference \( \pm \) SE, 2.63 \pm 90; \( P=.005; 95\% \) CI, 0.82 to 4.45), and peak work rate (mean difference \( \pm \) SE, 6.00 \pm 1.62; \( P=.001; 95\% \) CI, 2.73 to 9.26), the paraplegia group had higher values than the tetraplegia group. Although the \( V_{O2} \) values for the group with tetraplegia did not increase significantly over time, the paraplegia group had statistically significant increases at each successive time point. Figure 2 shows the \( V_{O2} \) values by time point for each group. There was no \( V_{E} \) effect for group, but there were significant effects for time (\( F_{1,2,46.1}=39.0, P<.001 \)) and the group by time interaction (\( F_{1,6,46.3}=13.8, P<.001 \)).

### Table 1: Resting Value, First Work Rate, Mid-Point Work Rate, and Peak Work Rate for Heart Rate, \( V_{O2} \), \( V_{E} \), and RPE

<table>
<thead>
<tr>
<th>Measures</th>
<th>Total Sample</th>
<th>Subjects With Tetraplegia</th>
<th>Subjects With Paraplegia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (bpm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>75.36±13.82 (52, 107)</td>
<td>68.6±11.87 (58, 91)</td>
<td>77.4±13.87 (52, 107)</td>
</tr>
<tr>
<td>First work rate</td>
<td>85.48±15.07 (57, 124)</td>
<td>77.7±11.47 (67, 96)</td>
<td>87.9±15.38 (60, 124)</td>
</tr>
<tr>
<td>Mid-point work rate</td>
<td>109.62±20.17 (80, 172)</td>
<td>90.2±7.57 (80, 103)</td>
<td>115.6±19.0 (84, 172)</td>
</tr>
<tr>
<td>Peak work rate</td>
<td>133.10±32.10 (80, 195)</td>
<td>95.8±8.97 (80, 107)</td>
<td>144.7±27.4 (84, 195)</td>
</tr>
<tr>
<td>( V_{O2} ) (mL·kg(^{-1})·min(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>2.70±1.59 (5, 6.6)</td>
<td>2.62±1.92 (5, 6.6)</td>
<td>2.73±1.50 (5, 6.3)</td>
</tr>
<tr>
<td>First work rate</td>
<td>4.09±1.92 (1.4, 10.4)</td>
<td>3.88±1.71 (1.6, 7.2)</td>
<td>4.16±2.01 (1.4, 10.4)</td>
</tr>
<tr>
<td>Mid-point work rate</td>
<td>7.01±2.69 (2.2, 12.2)</td>
<td>5.0±2.24 (2.2, 8.1)</td>
<td>7.63±2.54 (4.4, 12.2)</td>
</tr>
<tr>
<td>Peak work rate</td>
<td>11.20±5.11 (2.2, 21.50)</td>
<td>6.63±3.27 (2.2, 10.7)</td>
<td>12.6±4.76 (4.5, 21.5)</td>
</tr>
<tr>
<td>( V_{E} ) (L/min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>9.47±3.50 (3.2, 19.6)</td>
<td>10.48±3.94 (5.0, 16.6)</td>
<td>9.16±3.36 (3.2, 19.6)</td>
</tr>
<tr>
<td>First work rate</td>
<td>12.87±3.94 (6.2, 23.0)</td>
<td>15.1±4.49 (9.1, 22.8)</td>
<td>12.17±3.54 (6.2, 23.0)</td>
</tr>
<tr>
<td>Mid-point work rate</td>
<td>19.12±5.22 (9.2, 32.3)</td>
<td>17.8±3.57 (12.1, 22.8)</td>
<td>19.5±5.62 (9.2, 32.3)</td>
</tr>
<tr>
<td>Peak work rate</td>
<td>36.26±16.45 (12.1, 80.2)</td>
<td>22.6±5.97 (12.1, 29.0)</td>
<td>40.5±16.37 (15.1, 80.2)</td>
</tr>
<tr>
<td>RPE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>6.00±0.00 (6, 6)</td>
<td>6.00±0.00 (6, 60)</td>
<td>6.00±0.00 (6, 6)</td>
</tr>
<tr>
<td>First work rate</td>
<td>8.95±2.11 (6, 13)</td>
<td>10.8±1.55 (9, 130)</td>
<td>8.38±1.93 (6, 13)</td>
</tr>
<tr>
<td>Mid-point work rate</td>
<td>12.93±2.63 (6, 17)</td>
<td>13.2±2.25 (10, 170)</td>
<td>12.84±2.77 (6, 170)</td>
</tr>
<tr>
<td>Peak work rate</td>
<td>17.17±2.97 (6, 20)</td>
<td>16.7±2.95 (12, 20)</td>
<td>17.3±3.01 (6, 20)</td>
</tr>
</tbody>
</table>

**Note.** Values are mean ± standard deviation (minimum, maximum).

### Table 2: Pearson Correlation Coefficients Among Heart Rate, \( V_{O2} \), \( V_{E} \), and RPE at 3 Work Rates for the Total Sample, Those Persons With Tetraplegia, and Those Persons With Paraplegia

<table>
<thead>
<tr>
<th>Measures</th>
<th>Total Sample (N=42)</th>
<th>Participants With Tetraplegia (n=10)</th>
<th>Participants Those Persons With Paraplegia (n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (bpm)</td>
<td>HR&lt;.11 (.51)</td>
<td>-.07 (.68)</td>
<td>-.02 (.91)</td>
</tr>
<tr>
<td></td>
<td>( V_{O2} )</td>
<td>.39 (.010)</td>
<td>.13 (.41)</td>
</tr>
<tr>
<td></td>
<td>( V_{E} )</td>
<td>.30 (.056)</td>
<td>.15 (.088)</td>
</tr>
<tr>
<td>Mid-point work rate</td>
<td>HR .25 (.11)</td>
<td>-.09 (.58)</td>
<td>-.28 (.44)</td>
</tr>
<tr>
<td></td>
<td>( V_{O2} )</td>
<td>.46 (.002)</td>
<td>-.35 (.024)</td>
</tr>
<tr>
<td></td>
<td>( V_{E} )</td>
<td>-.06 (.70)</td>
<td>-.15 (.26)</td>
</tr>
<tr>
<td>Peak work rate</td>
<td>HR .56 (.001)</td>
<td>.64 (.001)</td>
<td>.11 (.49)</td>
</tr>
<tr>
<td></td>
<td>( V_{O2} )</td>
<td>.79 (.001)</td>
<td>-.06 (.70)</td>
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<tr>
<td></td>
<td>( V_{E} )</td>
<td>.14 (.37)</td>
<td>.53 (.12)</td>
</tr>
</tbody>
</table>

**Note.** Bold face coefficients are statistically significant at \( \alpha=.01 \). \( P \) values are in parentheses.

Abbreviation: HR, heart rate.
correction factor equal to .58. At the first work rate, the tetraplegia group had a nonsignificantly higher V˙E (mean difference \(\pm SE\), 2.93 \(\pm\) 1.37; \(P = .04\); 95% CI, 0.17 to 5.70), while the paraplegia group had higher V˙E values at the mid-point work rate (mean difference \(\pm SE\), 1.77 \(\pm\) 1.90; \(P = .36\); 95% CI, 2.07 to 5.60) and the peak work rate (mean difference \(\pm SE\), 18.0 \(\pm\) 5.32; \(P = .002\); 95% CI, 7.23 to 28.74), but the difference at the mid-point was not significant. Although the V˙E values did not change for the tetraplegia group over time, the paraplegia group had statistically significant increases at each successive time point. Figure 3 shows the V˙E values by time point for each group.

There was no RPE effect for group or the group by time interaction, but there was a significant effect for time (\(F_{1.6,65.3} = 88.5, P < .001\)) with the \(\Delta df\) Huynh-Feldt correction factor equal to .84. For both groups, RPE significantly increased over each successive time point. Figure 4 shows the RPE values by time.

**DISCUSSION**

Our findings in this study support previous reports of an inconsistent relationship between heart rate and RPE in healthy subjects. In our study, RPE was only related to heart rate at the first work stage for persons with tetraplegia. Interestingly, while there were group differences between subjects with tetraplegia and paraplegia for heart rate, VO\(_2\), and V˙E, we found no group difference for RPE. Although not different between groups, RPE increased with higher work rates for subjects with tetraplegia and paraplegia. The higher values for heart rate, VO\(_2\), and V˙E reported in subjects with paraplegia might be explained by their greater body stability during exercise, larger muscle mass involved in the exercise, and an impaired circulatory response to exercise that is reportedly lacking in subjects with tetraplegia. While these factors might explain the differences between groups, it is unlikely that they alone can explain the significant difference in VO\(_2\) between groups, especially since both subject groups had been habituated to arm ergometry.

While significant linear associations between heart rate and VO\(_2\) normally occur throughout subpeak exercise range in persons without disabilities and among subjects with paraplegia below the T6 level, we found a positive relationship only at the maximal work rate but not at the first or mid-point work rates for the total sample; we found no group effect for injury level. V˙E correlated positively with VO\(_2\) at each exercise stage. V˙E correlated with heart rate and VO\(_2\) for the total sample and for subjects with paraplegia at the peak work stage. VO\(_2\) was positively associated with V˙E at the peak exercise stage for persons with tetraplegia and at the first work rate for the subjects with paraplegia.

Otherwise, the most intriguing findings of the study were the significant interactions between level of injury and stages of exercise for heart rate, VO\(_2\), and V˙E, but not for RPE. Thus, although RPE continued to increase with each successive work rate for both groups, the differences in heart rate, VO\(_2\), and V˙E did not correspond to a disparity in the perceived level of the exercise. These findings raise again the questions of whether some unique physiologic response to exercise alters RPE in subjects with SCI and/or whether or not the RPE scale is a truly valid tool for perceptually estimating work rate in this population.

The validity of the perceptual-physiologic relationship during exercise and the relationship between heart rate and RPE for people with certain medical conditions are questionable. For example, patients with cardiac disease reported higher RPE during group therapy than during a graded exercise test at the same heart rate. Psychologic factors can also affect perceived exertion inasmuch as it has been determined that people who...
are anxious, depressed, or neurotic do not thoroughly discriminate workload level; also, personality type (extroverts underestimate work intensity compared with introverts) may cause variations. In addition, ambient conditions may also disrupt the heart rate and RPE relationship. For example, Noble found that changes in the temperature produced variations in heart rate during extended exercise. He suggested that perceived exertion is due to externalization of $V˙E$ and skin temperature, which can be directly perceived, and not on physiologic functions such as heart rate.

In our view, the altered chronotropic response to exercise in the SCI population is an obvious exception to the range model proposed by Borg. It is commonly reported that SCI subjects have a unique circulatory response to upper-extremity exercise. Subjects with paraplegia experience exaggerated heart rate responses when challenged by increasing work intensities, which sustains cardiac output in the face of decompensated stroke volume resulting from venous insufficiency. This circulatory "hypokinesis" has been widely reported, and explains exaggerated heart rate responses experienced by people with paraplegia when exercising. Subjects with tetraplegia experience similar dysregulation of venous return from their paralyzed lower extremities, although they have an exercise heart rate attenuated by adrenergic dysfunction that accompanies injury above the level of sympathetic outflow at the T1 spinal cord level. In these instances, heart rate response fails to linearly match increasing work intensities, which is predictable in people without disability but was not seen in our subjects with tetraplegia.

The absence of consistent significant associations between RPE and either heart rate or $V_o_2$ in subjects with either paraplegia or tetraplegia during arm exercise poses an interesting dilemma for researchers examining exercise responses of persons with SCI because many studies have already used RPE as an index of work response in subjects with paraplegia. We are unaware of any study that has validated the use of RPE with SCI subjects. A study commonly cited as establishing the validity of using the Borg RPE with people with SCI used subjects with either spinal bifida or cerebral palsy. Another study found a strong linear association between heart rate and $V_o_2$ in subjects with paraplegia, but not between RPE and heart rate; consequently, the authors concluded that RPE is an invalid indicator of exercise intensity in subjects with paraplegia, which is consistent with our results.

In response to increasing workloads, subjects with paraplegia experienced significantly higher heart rates than subjects with tetraplegia, yet their perception of exertion was similar at the same work stages. Subjects with paraplegia may become habituated to a chronically higher heart rate resulting from their persistent state of circulatory hypokinesis and thus may not rate their exertion as being as intense as it actually is. Although the heart rate, $V_e$, and $V_o_2$ responses to exercise were more dramatic for subjects with paraplegia than with tetraplegia, it is not known whether these responses alone explain the loss of their RPE and heart rate continuity at the first and mid-point work points. Perhaps additional data collected under similar testing conditions that show an improved strength of association would likely identify circulatory dysregulation as the cause for altered RPE and heart rate relationship in subjects with paraplegia and tetraplegia.

We have noted that peripheral cues dominate one’s perception of exertion at low to moderate effort. At work intensities eliciting approximately 75% to 80% of peak heart rate and $V_o_2$, people begin to better perceive central cues as indicators of their level of exertion. In our sample, subjects with paraplegia underestimated their level of exertion at moderate levels of exertion, during which time peripheral cues are the predominant source of kinesthetic and proprioceptive input. As they approached maximal effort, however, their perception of exertion was not associated with heart rate, $V_o_2$, or $V_e$. Our
inconsistent results may indicate a need to test RPE responses that can differentiate input from peripheral and central sources.

**Study Limitations**

The findings of this study are limited by a small sample size. Typically, associations between RPE and either heart rate, \( V\dot{O}_2 \), or \( V\dot{E} \) failed to approach significance. The lack of significant findings could be attributed to the conditioning state of subjects, although we did not select subjects based on state of conditioning. Even so, RPE has been found to be identical for groups of low and highly active men despite differences in relative intensity.\(^8,14\) In addition, others suggest that the RPE response to acute exercise is largely unaffected by level of conditioning, in which case, differences in fitness among study participants, and between groups might have limited influence on the study findings.\(^8,9\)

**CONCLUSIONS**

People with tetraplegia and paraplegia experience linear responses to heart rate, \( V\dot{O}_2 \), \( V\dot{E} \), and RPE, although the responses were more pronounced for subjects with paraplegia at increasing exercise intensities. Unlike previous studies examining RPE relationships with both heart rate and \( V\dot{O}_2 \), inconsistent associations were observed between these variables. The absence of a consistent association among these variables may be attributed to unique circulatory responses to exercise in persons with SCI or the absence of lower-extremity stabilization during arm work in subjects with either paraplegia or tetraplegia. Varying relationships between the outcome measures across work intensities suggest that different, or unknown, cues may be used by people with SCI to rate their exertion. Discriminating peripheral from central cues to establish a method for using RPE as a valid and reliable indicator of somatic exertion in persons with SCI is warranted.

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Supplier

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CLINICAL NOTE

Diffusely Increased Insertional Activity: “EMG Disease” or Asymptomatic Myotonia Congenita? A Report of 2 Cases

Christopher W. Mitchell, MD, Tulio E. Bertorini, MD


The term “EMG disease” is used by some to describe the unexpected finding of diffusely increased insertional activity on needle electromyography in an otherwise asymptomatic person. The cause is unknown, but it has been hypothesized that these patients actually have a subclinical myotonic disorder. We describe 2 patients with diffusely increased insertional activity on electromyography who had mutations of the CLCN1 gene associated with myotonia congenita. Neither patient had symptoms or reproducible signs of this disorder. We propose that asymptomatic patients with CLCN1 mutations may at least partially account for the EMG disease phenotype.

Key Words: Case report; Chloride channels; Electromyography; Myotonia congenita; Rehabilitation.

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The evaluation of insertional and spontaneous activity when needle electromyography is performed is an important step in electrodiagnosis. Some abnormal patterns, such as myotonia or myokymia, help to limit the differential diagnosis considerably, while other patterns such as fibrillation potentials and positive sharp waves (PSWs) are less specific. The latter potentials are believed to be recordings of single fiber potentials and may be seen whenever there is a destabilization of the resting membrane potential. Insertional activity, believed to result from local tissue damage caused by passage of the needle, could also presumably be altered (ie, prolonged) when the resting muscle membrane potential is unstable.

Wiechers and Johnson first reported the rare occurrence of diffusely increased insertional activity on electromyography in asymptomatic patients. Because the etiology of these findings is unknown, the term “EMG disease” has been used by some; however, the diffuse distribution of the abnormal insertional activity suggests that there is an abnormality of skeletal muscle membrane stability. The CLCN1 gene encodes the major human skeletal muscle chloride channel that contributes to and stabilizes the resting membrane potential; mutations of CLCN1 that decrease chloride conductance are associated with myotonia congenita, a nondystrophic myotonic disorder with a highly variable clinical phenotype. We report 2 patients with EMG disease who had CLCN1 mutations associated with myotonia congenita.

Case 1

A 47-year-old man was evaluated for elevated creatine kinase (CK). He had been placed on a combination of ezetimibe and rosuvastatin for several weeks. Routine laboratory evaluation thereafter revealed a serum CK of 528 IU/L (normative, <200 IU/L). A baseline CK was not available. The patient complained of mild aching in his shoulders during vigorous exercise but had no other complaints. He denied muscle weakness or stiffness. A repeat CK 6 months after the above medications were discontinued was 353 IU/L. Clinical examination showed normal strength, tendon reflexes, and sensation.

Nerve conduction studies showed evidence of mild carpal tunnel syndrome bilaterally. Concentric needle electromyography showed increased insertional activity in every muscle sampled, including proximal and distal muscles of the right upper extremity and the right quadriceps. The activity consisted of brief runs (duration, 300–800 ms) of PSWs that were often decrescendo in frequency without an abrupt cessation (fig 1). Amplitudes were 50 to 400 μV with minimal decrescendo changes. Classical waxing and waning was not seen. The motor unit action potentials (MUAP) were of normal size and configuration, with a normal recruitment pattern.

Further clinical examination revealed no myotonia for grip, eyelid closure, or percussion over the thenar eminence or wrist extensors. We did not test for warm-up phenomenon. There was no muscle hypertrophy.

Deoxynucleobinucleic acid (DNA) sequencing of the CLCN1 gene revealed a C to T transition at nucleotide position 2680, a nonsense mutation resulting in a premature termination at codon 894. There were no repeat expansions in the DMPK and ZNF9 genes causing myotonic dystrophy types 1 (DM1) and 2 (DM2), respectively.

Case 2

A 41-year-old woman with no medical history was referred to the electromyography laboratory for evaluation of right shoulder pain. She denied neck pain as well as weakness, sensory loss, or paresthesias. She also denied muscle stiffness. Physical examination was remarkable only for some tenderness to palpation about the shoulder joint. Other examination findings—including muscle strength, reflex, and sensory testing—were normal. Laboratory studies, including serum CK, were within normative limits. Routine nerve conduction studies of the right upper extremity were normal. Electromyography revealed abnormal insertional activity identical to that seen in case 1 in all muscles sampled, including distal and proximal muscles of the right upper extremity and the right lower extremity and paraspinals. Analysis of MUAPs was unremarkable.

Further clinical examination revealed brief myotonia on percussion of the wrist extensors but not on grip, forced eye closure, or percussion of the thenar eminence. There was no warm-up phenomenon or muscle hypertrophy.

DNA sequencing of the CLCN1 gene revealed a C to T transition at position 1649 resulting in a threonine to methio-

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nine substitution at codon 550. Repeat expansions in DMPK and ZNF9 were not detected. Magnetic resonance imaging of the patient’s shoulder showed changes suggestive of subacromial bursitis. When she returned to our clinic several weeks later, her pain had spontaneously resolved and clinical myotonia could not be elicited by any maneuver.

DISCUSSION

We report 2 cases of EMG disease in which the patients appeared to have asymptomatic myotonia congenita as the cause of the diffusely increased insertional activity. In the case of patient 1, it is impossible to say what the inheritance was because there was no additional family information and the R894X mutation has been reported in both autosomal dominant and recessive pedigrees. Although myotonia has been observed in statin myopathy, in vitro studies suggest that the reduction of chloride conductance caused by these agents occurs via a reversible interaction with the muscle membrane, making it unlikely that myotonia resulting solely from statins would persist for more than 6 months after they are discontinued. It is possible, however, that the statins may have precipitated or worsened electrical myotonia in this patient, who had an otherwise asymptomatic channelopathy. The T550M mutation in the second patient has been reported in a single family with apparent autosomal dominant inheritance.

Myotonia congenita displays significant phenotypic variability, and some people in affected families may be asymptomatic but have abnormal insertional activity or spontaneous discharges, sometimes called “latent myotonia,” on electromyography. In the case series reported by Wiechers and Johnson, the abnormality on electromyography was the presence of diffuse PSWs provoked by needle insertion or movement in almost all muscles. Although some of their patients had symptoms suggestive of myotonia, it could not be demonstrated on physical examination. They concluded: “Possibly it is a form of myotonic [sic] congenita...” Our findings support this hypothesis as an explanation for at least some patients with so-called “EMG disease.” We propose that patients with CLCN1 mutations who are asymptomatic or very mildly affected may display abnormal discharges on electromyography that are too brief to be easily recognized as myotonia.

Furthermore, although both of our patients had mutations associated with myotonia congenita, other myotonic disorders such as DM1, DM2, and hyperkalemic periodic paralysis could theoretically present as EMG disease because some such patients may be asymptomatic or very mildly affected. This theory is supported by Barkhaus and Nandedkar, who studied a patient with DM1 and observed “slow” myotonic discharges that could be mistaken for simple fibrillations or PSWs at faster sweep speeds. Also, testing for undiagnosed DM1 or DM2 in patients with EMG disease could be more important than testing for myotonia congenita inasmuch as the former diagnoses can be more severe and may necessitate screening for systemic complications.

CONCLUSIONS

Asymptomatic patients with mutations of the CLCN1 gene may present in the neurophysiology laboratory as EMG disease. Additional testing of patients with EMG disease to detect myotonic disorders should be considered.

References

Supplier
BRIEF REPORT

Stroke-Related Knowledge and Health Behaviors Among Poststroke Patients in Inpatient Rehabilitation

Kris L. Koenig, MBA, Ellen M. Whyte, MD, Michael C. Munin, MD, Lynn O’Donnell, RN, CRNP, Elizabeth R. Skidmore, PhD, Louis E. Penrod, MD, Eric J. Lenze, MD


Objective: To measure stroke knowledge and prestroke personal health behaviors of stroke patients undergoing inpatient rehabilitation and their caregivers.

Design: Prospective cohort.

Setting: Academic rehabilitation hospital.

Participants: A total of 130 stroke patients and 85 caregivers interviewed after ischemic stroke.

Interventions: Not applicable.

Main Outcome Measure: The Stroke Education Assessment measured stroke knowledge and prestroke personal health behaviors.

Results: Large deficiencies in patient and caregiver stroke knowledge were found. Fifty-two percent of patients could not name any stroke risk factors, 52% were unable to name a stroke warning sign, and 35% were unable to identify appropriate actions to take in a stroke emergency. Older patients were less knowledgeable than younger patients. Caregivers were more knowledgeable than patients. Regarding prestroke personal health behaviors, 28% of patients reported medication nonadherence, 26% did not see their primary care physician in the preceding year, and less than 40% of patients with diabetes or hypertension reported diets consistent with these diagnoses.

Conclusions: Stroke patients participating in inpatient rehabilitation and their caregivers have large gaps in stroke knowledge and have suboptimal personal health behaviors, thereby putting patients at high risk for recurrent stroke. Our findings highlight the need to develop stroke-education programs for rehabilitating patients that are effective in closing these gaps in knowledge and personal health behaviors.

Key Words: Cerebrovascular accident; Education; Rehabilitation; Stroke.

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STROKE SURVIVORS ARE at risk for recurrent stroke. However, over one half of stroke survivors are unaware of their increased risk1 and many cannot identify any risk factors.2 Furthermore, many people do not know the signs or symptoms of stroke or what to do if stroke is suspected3-5 and therefore present to a hospital too late to receive time-sensitive medications that would improve clinical outcome.6

We conducted this study to examine stroke knowledge in poststroke patients participating in rehabilitation as well as to assess patients’ prestroke personal health behaviors. We hypothesized that we would find significant stroke-knowledge deficiencies consistent with those described previously. Furthermore, we used this study to explore patient and caregiver characteristics that correlated with stroke knowledge.

METHODS

We prospectively interviewed stroke patients consecutively admitted to an inpatient rehabilitation facility and their caregivers. All patients had experienced an ischemic stroke (first-ever or recurrent) within the preceding 30 days. Patients who were unable to reliably answer interview questions were excluded.

We assessed patients admitted to the acute hospital setting during the previous year. Some patients had received stroke education in the acute hospital setting; however, this education was limited to the provision of written materials. We measured knowledge of stroke risk factors and warning signs, as well as the most appropriate response to a suspected stroke by using open-ended questions from the Michigan Behavior Risk Factor Survey7 and by using information approved by the American Heart Association. We measured medication adherence in the week before the index stroke by using a validated self-report questionnaire.8 We also assessed diet; smoking status; frequency of appointments with a primary care physician; and knowledge and treatment of hypertension, hyperlipidemia, and diabetes. Stroke location was derived from either the radiologist’s interpretation of any brain-imaging study or the attending neurologist’s clinical determination of lesion location.

Statistical analysis used SPSS.4 We used 1-way analysis of variance tests and chi-square tests for continuous and categorical variables, respectively. The study was approved by the institutional review board.

RESULTS

From October 2003 through March 2005, 295 patients were admitted for acute inpatient rehabilitation. One hundred thirty patients and 85 caregivers participated in this study (characteristics presented in table 1). Reasons for exclusion included primary hemorrhagic stroke (n=83); stroke more than 30 days before admission (n=23); administrative reason (n=23); subject unable to reliably answer questions because of medical instability (n=10), aphasia (n=7), severe cognitive impairment (n=3), deafness or blindness (n=4), or inability to speak English (n=3); and refusal of study participation (n=5). Fewer caregivers were interviewed as they were difficult to contact.
Knowledge of Risk Factors

Fifty-two percent of patients were unable to name any stroke risk factors. Age (but not race, sex, education, or type of medical insurance) was significantly associated with number of risk factors named ($F_{1,126}=6.966, P<.001$). Older patients were more likely to name zero (Tukey honestly significant difference [HSD] post hoc, $P<.001$) or 1 (Tukey HSD post hoc, $P=.002$) stroke risk factors versus 2 or more risk factors. Among caregivers, 17% were unable to name at least 1 risk factor for stroke. No demographic or clinical characteristics correlated with caregiver knowledge (data not shown).

Knowledge of Warning Signs and Emergent Treatment

Although 99% of patients acknowledged the importance of seeking medical attention, only 65% stated they would call 911 or go to an emergency department if they thought they were having a stroke. Furthermore, 52% were unable to name any warning signs other than symptoms of their index stroke. Twenty percent of caregivers were unable to name at least 1 warning sign for stroke. There was no significant effect of age, race, sex, education, or type of insurance on knowledge of warning signs or of need for emergent treatment for either patients or caregivers (data not shown).

Health Behaviors

Among patients with hypertension ($n=94$) or type 2 diabetes mellitus ($n=44$), less than 40% reported following any dietary recommendations before their stroke.

Regarding medication adherence, 14% of patients were not taking any prescribed medications before the stroke, and an additional 8% could not remember if they had missed any doses. Of the remaining 102 patients, 28% reported missing at least 1 pill in the week before their stroke. Eighteen percent of caregivers were unable to comment on the patients’ medication adherence. Of the remaining 70 caregivers, 21% endorsed patient nonadherence in the week before their stroke. Twenty-six percent of patients reported not seeing their PCP in the previous year. Age, race, sex, and type of insurance were not significantly associated with medication adherence or annual PCP visit.

DISCUSSION

We found significant deficiencies in stroke-related knowledge and prestroke health behaviors in patients undergoing inpatient rehabilitation after ischemic stroke. These patients are at risk for poor long-term outcomes because of a lack of knowledge regarding modifiable stroke risk factors and the need to obtain prompt medical attention for subsequent strokes.

Study Limitations

Study limitations include the exclusion of patients with severe cognitive impairment as well as the lack of cognitive assessment; therefore, we cannot comment on the relation of milder cognitive impairment with stroke knowledge and personal health behaviors. We acknowledge that patients’ knowledge could have been greater than what they reported and that recall bias may have affected patients’ descriptions of prestroke personal health behaviors. This study was carried out in a single site, thereby limiting the results’ generalizability. Finally, we do not know which subjects received stroke education during their acute inpatient hospitalization; therefore, we cannot comment on the impact of this education on stroke knowledge.

Our findings show the need for establishing effective patient-education programs. Inpatient rehabilitation offers an opportunity to provide education to stroke patients and families; however, given decreasing length of stay, the best ways to conduct this education, including when, where, and by whom, requires further study.

CONCLUSIONS

Patients undergoing inpatient rehabilitation after ischemic stroke show large gaps in stroke-related knowledge and shortcomings in prestroke health behaviors. Patients’ primary caregivers also show poor stroke-related knowledge. Patient and caregiver education programs are needed as a means of promoting patients’ health.

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Supplier

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Compensatory Strategies Used by Older Adults Facing Mobility Disability

Carlos O. Weiss, MD, MHS, Helen M. Hoenig, MD, MPH, Linda P. Fried, MD, MPH


Preclinical disability in mobility tasks can be recognized by asking people without overt mobility disability whether they have changed the way, either the manner or the frequency, of doing a mobility task because of a health or physical condition. Like other compensatory strategies, preclinical mobility disability has a dual nature as both a risk marker associated with impairment or limitation and a mediating factor affecting the natural history of disability. The method of ascertaining preclinical disability through self-report has been shown to have construct validity, to be reliable, and to identify people at an elevated risk of developing overt mobility disability over 1 to 2 years. Many worthy research questions in this field remain to be addressed, especially regarding qualitative heterogeneity (doing more vs doing less) and interactions among compensatory strategies. Nonetheless, there is sufficient evidence to apply what is known about preclinical disability to screening in clinical settings. This area of research and practice constitutes an opportunity for physical medicine and rehabilitation and geriatric medicine to jointly make a large beneficial impact on population health through strategies to prevent disability because rapidly growing numbers of older adults will experience this early and potentially malleable stage.

Key Words: Aged; Disability evaluation; Mass screening; Rehabilitation.

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THE SCIENCE IS DEVELOPED and the opportunities are large for physical medicine and rehabilitation (PM&R) and geriatric medicine to join productively in the prevention of mobility disabilities, now also called restricted participation in daily life.4-6 In this issue, Mänty et al7 provide findings from a European sample of women (75%) and men aged 75 to 81 years. They found that preclinical disability was associated with an intermediate level of leg extensor muscle power and maximal walking speed at baseline compared with robust and disabled groups and an elevated risk of new disability at 2 years compared with robust older adults. We propose that the study of preclinical mobility disability has reached a late adolescence full of promise. Taken together, these findings motivate us to ask whether we know enough to move forward clinically, screening for preclinical disability in older adults, and who should respond to this challenge.

DO WE KNOW ENOUGH ABOUT PRECLINICAL DISABILITY?

As developed and implemented, preclinical disability is a method for identifying precursors to disability through ascertainment of compensatory strategies when disability is not yet present. Thus, the approach offers a preventative framework and the opportunity for early intervention. For many daily tasks, there are alternative ways of getting things done. A compensatory strategy can be defined as a way of achieving a result that is adopted frequently in the face of a
physical impairment or limitation and under usual conditions. Compensatory strategies are also usually recognizable as something healthy people do not “normally” do. As an example, most people do not use a cane to walk. At one time, canes were used often as a fashion statement. Now, they are used to compensate for an activity limitation related to walking. Under demanding conditions, such as climbing across jagged boulders, even the healthiest person would appreciate a cane; in contrast, on a flat, nonslippery surface, a cane be recognized as a compensatory strategy. General categories of compensation for mobility include behavioral adaptations, using technology or environmental supports, and receiving human help.18,19 Gignac et al20 applied the Baltes’s theory of selective optimization with compensation to mobility disability, classifying a wide range of adaptations. By using their scheme, preclinical disability encompasses a range of adaptations, including “selection” by performing the activity less often, “optimization” by planning activities to avoid problems, “compensation” by using assistive devices, and “receiving help.”

Approaching preclinical disability at this conceptual level leads to consideration of the complexity of the issue; preclinical disability has a dual nature with compensation as both a risk marker associated with impairment or limitation and a mediating risk factor affecting the natural history of disability. A large amount of potential heterogeneity among such compensations remains to be understood. Most importantly, perhaps, are the qualitative differences between strategies that leverage abilities to overcome threats to activity and participation in life and strategies that consist of decreasing task demands. Does a compensatory strategy lead to less or more activity? Some gerontologists believe that people on the chronic pathway to disability should “use it or lose it!” Is relying on someone’s arm for support when walking fearful walking, and does it lead to using one’s own physiologic systems for balance less and walking less? Or, does it lead to overcoming barriers and walking more? Thus, there are many worthy future research questions regarding mobility compensations, some of which will require advanced methods because of compensations’ complex, nonindependent, nature. Why does someone start to compensate? What are the downstream effects of spontaneous compensations? What are the tradeoffs between different compensatory strategies? Can distinct contributions from diseases, changes in energy utilization and metabolism, psychologic factors, and environmental and social variables as causes of compensation and disability be identified? How do these factors affect the gradual transition from preclinical disability to overt disability? The interaction between the individual and his/her environment is an emphasis of the new World Health Organization conceptual model of disability1 and a research area that will surely lead to theoretical and practical insights into how to apply more potent therapeutic strategies. Nonetheless, we propose that enough is known already about preclinical disability to move forward to translational research and clinical application.

SHOULD WE BE SCREENING?

To chart directions about the way forward in applying knowledge about preclinical disabilities in clinical settings to improve the health of older adults, a review of the 4 criteria for screening provides a useful structure.

IS THE OUTCOME A SIGNIFICANT (PREVALENT AND POTENT) PUBLIC HEALTH BURDEN?

Should the outcome be rare enough, even a near-perfect screening test can be more likely to lead to a false-positive than a true-positive. In this case, mobility disability is a huge public health burden, with a prevalence on the order of 30% to 50% in adults 65 years and older.21 Furthermore, the prevalence of preclinical disabilities in mobility tasks is considerable, ranging from approximately 20% to 40% in prior studies and 31% to 55% in the sample of adults age over 75 reported by Mänty et al1 in this issue.

IS THERE AN ACCEPTABLE LEVEL OF POTENTIAL HARM?

Some screening tests lead to dangerous procedures or treatments and serious psychologic burden. These concerns are mitigated if the consequence of screening is tailored recommendations for physical activity, as in this case. Low risk from resulting interventions lowers the bar for screening. Although we should not minimize the need to carefully monitor for adverse effects in trials of physical activity in older adults, the level of concern about potential harm is arguably acceptable in this case.

IS THERE AN ACCEPTABLE LEVEL OF POTENTIAL HARM?

This screening criterion is poorly suited to preclinical disability because mobility disability is a latent construct with no criterion standard. However, the epidemiologic studies of predictive validity mentioned previously form a reasonable basis for moving forward. In addition, nomograms are available, providing screening accuracy data for clinical use.17 Perhaps ironically, a challenge to establishing the accuracy of measures of preclinical disability lies in the fact that many older adults experience fluctuations in health status. For example, the risk of disability among women with preclinical disability has been found to be 26% to 31% at 18 months, depending on the item measured. The likelihood of improvement or recovery to reporting no preclinical disability was 31% to 34%.13 Similarly, substantial rates of recovery have been found for disability. If some would get better on their own, should we be intervening? Several considerations are relevant. Periods of transient disability followed by recovery form one of the strongest risk factors for recurrent and persistent disability.22,23 We do not yet know who will spontaneously recover or if such recovery will be optimal. Furthermore, increasing physical activity as an intervention leads to multiple benefits across a range of physiologic systems and dimensions of health, beyond benefits in mobility, forming the basis of a strong argument for tailored activity interventions in the presence of preclinical disability.

IS EARLY INTERVENTION MORE EFFECTIVE THAN WAITING FOR OVERT PRESENTATION?

There may be sufficient data to move toward effectiveness trials targeting preclinical disability. In a trial of prehabilitation, a home-based intervention was found to benefit older adults who were able to perform an out-and-back 10-foot walk test in less than 10 seconds or able to rise from a chair with arms folded. Notably, the intervention was not effective in those who were unable to do both.24 In a study by Mann et al,25 home visits by an occupational therapist providing assistive technology and environmental modifications to increase function and safety reduced the rate of functional decline. There are other examples, both from epidemiologic studies and interventions, suggesting that restorative therapy alone may miss opportunities to prevent disability. Preclinical disability aims to identify people in a transitional zone, functionally, who are not
already near the benefit ceiling from an intervention, yet not so sick that recovery to a previous state of functioning is much less likely to occur.

**THE BENEFIT WILL BE LARGE**

In the Women's Health and Aging Study II, the probability of becoming disabled in women with preclinical disability was 26% to 31% at 18 months versus 7% to 12% in those with no preclinical disability. The risk difference between these groups was therefore 14% to 24%. An intervention with the modest expectation of altering this outcome in 1 in 4 people would be associated with an absolute risk reduction of one fourth of 14% to 24% or 3.5% to 6%. The corresponding number needed to treat (NNT) is 17 to 29. By comparison, the NNT with a statin to prevent a generous composite measure of death or a nonfatal stroke or heart attack is estimated to be 35.

These rough calculations provide some perspective on the potential for clinical benefit from treating preclinical disability. However, these figures do not consider that only small proportions of the population are either very active or very physically disabled, and the vast majority fall closer to the middle and are more likely to benefit from an intervention than those at the extremes. As is the case in treating blood pressure, focusing public health efforts on middle values (blood pressures in the low-abnormal or even high-normal range) would lead to massive population benefits because that is where most of the population lies. Similarly, effective efforts to treat preclinical disability in older adults will have a large impact on the health of our aging population.

**WHO CAN RESPOND TO THIS CHALLENGE?**

PM&R and geriatric medicine offer complementary and overlapping expertise important to the treatment of physical disability in later life. Physiatrists are trained in the mechanistic treatment of impairments and limitations, focused primarily on restorative therapy or tertiary prevention, especially after an acute illness or injury, and are comfortable with the empirical nature of prescribing and adjusting therapeutic regimens to maximize activity for a patient. Geriatricians bring knowledge gained from identifying and intervening on multifactorial syndromes and age-related diseases that interact to create nonspecific clinical presentations, such as fatigue, and lead to aggregate outcomes such as disability, experience in the prevention of disability and in prioritizing among many possible medical treatments, and skill minimizing adverse reactions to medical treatment. The geriatricians’ focus is often on primary and secondary prevention. Collaboration between rehabilitation and geriatrics experts now tends to occur only during acute rehabilitation. Extending this collaboration to other settings is needed to make even larger gains in population health. More than ever, collaborative clinical and research efforts joining PM&R and geriatric medicine are likely to make contributions that, in the context of a demographic imperative to ameliorate health in later life, will lead to large public benefit.

**References**

New Books

Brain Injuries

Cognition Disorders


Communication Disorders

Exercise


General PM&R


Geriatrics

Medical Ethics

Medical Terminology

Musculoskeletal Disorders

Neurologic Disorders


Neuropsychology

Neurosurgery

Occupational Therapy

Pediatrics


Physiology

Sports Medicine

Stroke


American Board of Physical Medicine and Rehabilitation 2007 Part II (Oral) Certification Examination

On May 19–20, 2007, the American Board of Physical Medicine and Rehabilitation held the Part II (oral) certification examination. Effective July 1, 2007, the following individuals are certified.

A

Abreu-Ramos, Antonio M, San Juan, PR; Adams, Marc, Portsmouth, MA; Agarwal, Sanjeev, West Chester, OH; Ahmad, Arsal, Copley, OH; Altman, Jeff, Huntington Beach, CA; Anderson, William A, Philadelphia, PA; Aronson, Rebecca S, North Potomac, MD; Asanza, Juan, Brookline, MA; Atienza, Jason Tia, Berkeley, CA; Attaman, Jason Gene, Ann Arbor, MI; Augustine, Reggie Matthew, Fort Worth, FL.

B

Bahigumira, Edward, Metairie, LA; Baddigam, Latha, Malcomb, MI; Baiina, Jennifer Anne, Cambridge, MA; Baker, Karin W, Chicago, IL; Balbas, Edward Albert Gurain, Santa Rosa, CA; Bandemer, Dennis Allan, Howell, MI; Banh, Co V, Reseda, CA; Bapineedu, Radhika K, Boston, MA; Barker, Andrew Jason, Grand Rapids, MI; Barroga, Deno B, Dallas, TX; Barton, Kerrey Lin, Brookfield, WI; Bast, Brian Alan, New York, NY; Bastien, Maria Altagrace, Hainesport, NJ; Bathla, Baljinder Singh, Chicago, IL; Baucage, Kathia S, Aguadilla, PR; Bayazitoglu, Matt Y, Birmingham, AL; Beckworth, William Jeremy, Ashland, VA; Belcher, Brooke A, Dublin, OH; Bennett, Lisa Marie, Seattle, WA; Bergfeld, Deborah Ann, Buffalo, NY; Bernaiche, Maurice R, Holyoke, MA; Binder, David Saul, Brookline, MA; Blackburn, Heather, North Richland Hills, TX; Blackinton, Dilshad D, Waterville, ME; Bouffard, Mark Henry, Indio, CA; Boulet, Melanie, Cleveland Heights, OH; Boysel, Lynn Casey, Tucson, AZ; Brierne, Tristan C, Owensboro, KY; Brown, Robert, Hermitage, PA; Bruei, Brian M, Houston, TX; Buljina, Amir Ismet, Peoria, AZ; Bunch, Kenneth, Macungie, PA; Burack, Steven A, boca Raton, FL; Buttau, Charles Joseph, Red Lion, PA; Button, Jeanne Helen, Salt Lake City, UT.

C

Calder, Frankin Evaristo, Honolulu, HI; Calima, Milton, Capetown, NJ; Canlas, Judith R, Louisville, KY; Cao, Wenhui, McMurray, PA; Carayannopolous, Alexios George, Lebanon, NH; Carpenter, Michael Dean, Richland, VA; Carter, Jerome O, Houston, TX; Carvalho, Claudio, Urmia, CT; Chang, John William, Los Angeles, CA; Chang, Michael Yao-Jen, Redlands, CA; Chasnis, Benjamin Charles, Winston-Salem, NC; Chen, Alan, Los Angeles, CA; Cheng, Ernest Yudao, Oakland, CA; Chimes, Gary Phillip, Chicago, IL; Chin, Warren Bruce, Santa Rosa, CA; Christensen, Sara Ann, Madison, WI; Cohen, Stephen Jonathan, Voorhees, NJ; Correa, Colleen Marie, Appleton, WI; Cottrell, Roderick, Lithonia, GA; Crowe, Scott Carl, Minneapolis, MN; Crump, Monica E, Charlotte, NC; Cunniff, Joseph Gerard, Worchester, MA.

D

Dalton-Bethea, Shawn Michelle, Collegeville, PA; David, Glen, Seattle, WA; Davidson, Loren, Denver, CO; DeFeix-Davila, Roberto A, Rio Piedras, PR; Desai, Mehlul Jagdish, Washington, DC; Dholakia, Madhurt, Philadelphia, PA; Dockery, John Dee, Memphis, TN; Domroese, Mark, La Crosse, WI; Dooley, Radana, Middletown, CT; Doward, David A, Atlantic Beach, FL; Downey, Mark James, Birmingham, AL.

E

Eby, James W, Winston-Salem, NC; Edgley, Steven Richard, Salt Lake City, UT; Elgamal, Ahmed H, Addison, IL; Epperson, David Michael, Kennesaw, GA; Erragolla, Srinivas, West Allis, WI; Estela, Cesar Augusto, Henderson, NV.

F

Farhat, Robert P, Ann Arbor, MI; Ferraro, Joseph V, Gainesville, FL; Ferrillo, Martin Gerard, San Antonio, TX; Fiorini, Raymond, E Syracuse, NY; Fraley, Andrea Lyn, Chicago, IL; Freas, Damean William, New York, NY; Friedman, Benjamin J, Skokie, IL; Fu, Jack B, The Woodlands, TX.

G

Garcia-Lopez, Francisco J, Palm Beach Gardens, FL; Ghosh, Sherry, Wayne, NJ; Gluzman, Arie, Mission Viejo, CA; Goff, Brandon Jesse, Silver Spring, MD; Gopalan, Anisa F, Houston, TX; Gorr, Jessica H, Kitty Hawk, NC; Govil, Harsh, Lakewood, OH; Gowda, Alpana Raghava, Palo Alto, CA; Grabowski, Susan Ruth, Grose Poente Farms, MI; Gratton, Howard, Loma Linda, CA; Green, Jonah Steven, Flushing, NY; Greenberg, Karin, Pittsburgh, PA; Grossman, Marc Jonathan, New York, NY; Gutierrez, Susan Eileen, Danville, CA.

H

Habib, Rokeya, New Hartford, NY; Haddad, Kayvan Don, Davis, CA; Hahn, Robert F, Stratford, NJ; Hammer, Adam, New York, NY; Han, Sung Joon, Anderson, SC; Hanjan, Tiva, Honolulu, HI; Hanna, Ghada, Troy, MI; Harrell, John, Cincinnati, OH; Harris, Tanya S, Norfolk, VA; Harrison, Victoria Chan, New York, NY; Harwood, David Matthew, Chico, CA; Hata, Justin Teruo, Huntington Beach, CA; Helper, Steven Randall Matthew, Philadelphia, PA; Herbert, Bettina, Wyncote, PA; Hernandez-Gonzalez, Liza Mayrim, San Juan, PR; Hirschberg, Ronald Edward, Boston, MA; Ho, Jeffrey Tan, Westminster, CA; Ho, Joyce, New York, NY; Hoang, Julia Tu, Ann Arbor, MI; Hou, Andrew, Mechanicsville, VA; Hsu, Michael, Ann Arbor, MI; Hughes, Terrance Lamale, Athens, GA; Humphreys, Benjamin Rich, Scottsdale, AZ; Hurlong, Shermaz K, Syracuse, NY.

I

Ikrampuddin, Farha Sayeed, Eden Prairie, MN; Im, Brian Sung-Hoon, White Plains, NY.

J

Jackson, Thomas R, Red Lion, PA; Jacob, Sindhu, St Louis, MO; Jarrard, Kristin Anne, Little Rock, AR; John, Chinhve, Washington, DC; Jones, Antoine Dante, Miami, FL; Julian, Allison Elizabeth, Indianapolis, IN.
Thompson, Victor Brandon, Powell, OH; Thurman, Regina E, Little Rock, AR; Tobias, Kerry, Sacramento, CA; Travillion, David Antonio, Evans, GA; Tsai, Nancey T, Poulsbo, WA; Tugaoen, Mary Antoniette, Honolulu, HI.

U

Udwadia, Jamie, Clayton, NC.

V

Vargas, Monica, Tarpon Springs, FL; Varghese, Ebby G, Atlanta, GA; Vemuri, Sameer, Chattanooga, TN; Vesali, Fariba, Arcadia, CA; Viscarra, Merrie Lee, Chicago, IL; Visco, Alexander Joseph, Riverdale, NY; Vonderau, Peter Edward, Knoxville, TN; Vova, Joshua, Denver, CO.

W

Walker, Heather W, Chatham, NJ; Wallach, Perry, Tyler, TX; Walters, Nathan Scott, Los Angeles, CA; Wang, Paul David, Scottsdale, AZ; Wang, Yulan, Newton, MA; Ward, Claudine A Tinio, Syracuse, NY; Ward, Joshua James, Mill Creek, WA; Weissman, Tanya Vолодарский, East Brunswick, NJ; Weng, Jenpin, Scottsdale, AZ; Whittington-Cirton, Julie, Chicago, IL; Willett, Kristen, Mableton, GA; Williams, Jeffrey W, Wheelersburg, OH; Wilson, Richard Dwillis, Cleveland, OH; Wisniewski, Stephen John, Rochester, MN; Witter, David M, Salt Lake City, UT; Wolff, Erin Thor, Summit, NJ; Wright, Harry Jeffrey, Harker Heights, TX; Wunderlich, Colleen A, Richmond, VA.

Y

Yang, Yan, Santa Fe, NM; York, Henry S, Baltimore, MD; Young, Eva, Seattle, WA; Young, Timothy Paul, Charlotte, NC.

Z

Zhang, Jun, Setauket, NY.
ARTICLE OBJECTIVES:

Article One: Function-Centered Rehabilitation Increases Work Days in Patients With Nonacute Nonspecific Low Back Pain: 1-Year Results From a Randomized Controlled Trial
Learning Objective: After completing this article and with appropriate self-study, the participant will be able to:
   a) Describe the components of function-centered and pain-centered treatment programs for work-related low back pain.
   b) List 3 characteristics associated with a higher unemployment rate, in this study.
   c) Discuss the differences in work days, unemployment, and disability between the 2 groups in the study.

Article Two: Effect of a Home Leisure Education Program After Stroke: A Randomized Controlled Trial
Learning Objective: After completing this article and with appropriate self-study, the participant will be able to:
   a) List 3 activities or categories of activities that would be classified as active or passive leisure activities.
   b) Describe the shift from passive to active leisure activities in the experimental group over the course of the study.
   c) Discuss the effect of leisure activity on depression, quality of life, and sense of well-being.

Article Three: Construct and Predictive Validity of a Self-Reported Measure of Preclinical Mobility Limitation
Learning Objective: After completing this article and with appropriate self-study, the participant will be able to:
   a) List 3 task modifications that are associated with preclinical disability.
   b) Describe the relationship between preclinical disability and maximal walking speed and leg muscle power.
   c) Discuss the predictive value of self-described preclinical disability and developing major manifest mobility limitations within 2 years.

INDICATE THE DEGREE TO WHICH YOU AGREE OR DISAGREE WITH EACH STATEMENT

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<th>Strongly Disagree</th>
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<th>Not Certain</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<td>6. I plan to implement a change(s) to my practice as a result of this material D D NC A SA</td>
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If you circled “Agree” or “Strongly Agree,” please give one example:

7. In what ways did/will you utilize the information from these articles in your medical practice? I have used/will use it to:
   (Check all that apply.)
   □ Confirm previous knowledge and reinforce clinical practice
   □ Study for recertification examination
   □ Serve as initial resource for clinical problems
   □ Apply new techniques/procedures to the care of my patients
   □ Use the information to train staff
   □ Share the information with colleagues
   □ Help develop new policy and procedures
   □ Other (please specify):

8. The material was fair, objective, and unbiased toward any product or program. Yes No

9. Please share any general comments, recommendations, or an elaboration of any item on this form:

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Evaluation data collected from this form will be processed confidentially by a third party and will only be reviewed by Academy staff in the aggregate.

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AND
APPLICATION

CME Certificates will not be processed without the completion of the Evaluation

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The American Academy of Physical Medicine and Rehabilitation is accredited by the Accreditation Council for Continuing Medical Education to provide continuing medical education for physicians. The AAPM&R designates this educational activity for a maximum of 3 AMA PRA Category 1 Credits™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

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2007 Academy Annual Assembly Abstracts

Provided here are the abstracts of scientific papers and posters to be presented at the 68th Annual Assembly of the American Academy of Physical Medicine and Rehabilitation in Boston, MA, September 27–30, 2007. Papers and posters were chosen by selected members of the Academy’s Program Planning Subcommittee, Research Committee and PASSOR Research Committee. The abstracts have not been subjected to formal peer review by the Editorial Board of the Archives of Physical Medicine and Rehabilitation.

Paper Presentations

Paper (oral) presentations are scheduled to take place at the John B. Hynes Veterans Memorial Convention Center at the sessions listed below. Room locations are subject to change. Please check the Official Program to confirm the room location.

Thursday, September 27, 2007
7:30—9:00 AM
Room 309, Convention Center

Electromyography Clinical Pearls and Papers

Course Number 433
Electrodiagnostic Medicine
Dynamic Electromyographic Activities of Scapulothoracic Muscles in Patients With Frozen Shoulder Syndrome. Jung-Min Kim (IlSan Paik Hospital, Gyounggi-do, Republic of Korea); Kil-Byung Lim; Sung-Joo Joo, Hong-Jae Lee; Sung-Sik Lim; Duck-Young Kim. Disclosure: J. Kim, None; K. Lim, None; S. Joo, None; H. Lee, None; S. Lim, None; D. Kim, None.

Objective: To investigate the characteristics of electromyographic activities of scapulothoracic muscles in patients with frozen shoulder syndrome using dynamic electromyography. Design: Dynamic electromyographic activities of 6 muscles of scapulothoracic area of patients with unilateral frozen shoulder syndrome were measured during arm elevation and the affected shoulders were compared with the unaffected shoulders. Setting: Not provided. Participants: 20 patients with unilateral frozen shoulder syndrome. Interventions: Not applicable. Main Outcome Measures: Data were gathered during static arm elevation at 6 different testing positions: 60° and 120° of flexion, abduction in frontal plane, and abduction in scapular plane. Results: Affected shoulders revealed increased upper trapezius, lower trapezius (except at the 60° of flexion position) and serratus anterior (except at the 60° of abduction position) activity at all testing positions compared with unaffected sides (P<.05). In particular, anterior electromyographic activity at the 120° positions was greater for 3 muscles than at the 60° positions. Mid-deltoid electromyographic activity were increased at 120° in the flexion and abduction positions in the scapular plane (P<.05). However, for middle trapezius and anterior deltoid electromyographic activity, there were no significant differences between shoulders. Conclusions: The results showed that limited gle-nohumeral joint motion in frozen shoulder induced overactivity scapular elevation, and lateral rotation on affected muscles, and increased activity during higher arm elevation. Key Words: Electromyography; Rehabilitation; Shoulder.

Course Number 433
Electrodiagnostic Medicine
Electrosenodiagnosis of Post-Transposition Ulnar Neuropathy: A Case Report. Marko Bodor, MD (Queen of the Valley Hospital, Napa, CA); Stacey Harris-Carriman, MD. Disclosure: M. Bodor, None; S. Harris-Carriman, None.

Setting: Outpatient private practice. Patient: A 56-year-old insurance executive with numbness in the little and ring fingers and aching in the forearm. Case Description: Patient had an ulnar nerve transposition 7 years ago, with marginal improvement of symptoms. He presented with persistent numbness in the little and ring fingers and aching in the forearm. His symptoms were exacerbated by exercise, golf, softball, and weight-lifting. He had decreased pinprick sensation in the right fourth and fifth digits and 5—/5 strength in the first dorsal interosseous muscle. A positive Tinel sign was noted above the medial epicondyle. Nerve conduction study showed reduced ulnar sensory and dorsal ulnar cutaneous amplitudes, and reduced ulnar motor conduction across the elbow (37m/s) with normal amplitudes. High-frequency diagnostic ultrasound (15MHz) revealed focal ulnar nerve enlargement (from 8 to 24mm2) near the medial epicondyle where it passed under the flexor carpi ulnaris muscle. After the course of the ulnar nerve was drawn on the skin using ultrasound visualization, an ulnar motor inching study showed substantial focal slowing (20m/s) at the point of nerve enlargement. Assessment/Results: The diagnosis is a moderate-to-severe persistent chronic demyelinating ulnar neuropathy at the superior margin of the flexor carpi ulnaris muscle. Discussion: The evaluation of persistent symptoms following ulnar nerve transposition can be challenging. High-frequency diagnostic ultrasound can be useful in demonstrating (1) the site of focal nerve enlargement and (2) the exact course of the transposed ulnar nerve. Outlining the exact course of the transposed ulnar nerve facilitates an accurate inching study, which can demonstrate significant focal demyelination or conduction block. Conclusions: The combination of high-frequency diagnostic ultrasound and nerve conduction studies (electrosenodiagnosis) can be very useful in the diagnosis and treatment of ulnar neuropathies following transposition. Key Words: Rehabilitation; Ulnar neuropathies; Ultrasound, interventional.
Course Number 433
Electrodiagnostic Medicine

Entrapment Neuropathy of the Posterior Branch of the Axillary Nerve in a Football Player: A Case Report. Douglas H. Buxton, MD (Temple University Hospital/Moss Rehab Hospital, Philadelphia, PA); Robert Roberts III, MD; Channarayapatn R. Sridhara, MD.

Disclosure: D.H. Buxton, None; R. Roberts, None; C.R. Sridhara, None.

Setting: Electrodiagnostic laboratory. Patient: A 20-year-old male college football player with no known history of injury to the left shoulder. Case Description: The patient suffered a football-related injury to the left shoulder in which his left arm was “jammed” while the shoulder was in a flexed and abducted position. He immediately developed burning pain radiating to the left arm and hand with a “dead arm” sensation, which resolved after a few minutes. Symptoms transiently recurred at least 4 more times over the next 5 days during football practice. Assessment/Results: Physical examination revealed mild weakness on empty can test and end-range crepitus with external rotation and abduction in the left shoulder. There was no weakness or pain with left shoulder abduction or external or internal rotation. Motor and sensory nerve conduction studies were normal. Needle electromyography revealed polyphasicity in the left posterior deltoid and teres minor, with normal motor unit action potentials in other C5-6 and posterior cord muscles tested, including the anterior deltoid. Discussion: The patient’s electrodiagnostic findings are indicative of a left axillary neuropathy involving only the posterior branch of the axillary nerve. This injury pattern is difficult to diagnose on the basis of clinical examination. Review of the literature indicates that the axillary nerve is commonly injured in the region of the quadrilateral space. Isolated injuries to the posterior branch have been demonstrated on magnetic resonance imaging and have been correlated to a limited extent with electrodiagnostic studies. Conclusions: Detailed electrodiagnostic testing, including the teres minor and anterior and posterior deltoid, should be employed alone or in conjunction with magnetic resonance imaging to diagnose injuries selectively involving the posterior branch alone, or of the axillary nerve in muscular patients with shoulder pain related to injuries. Key Words: Electrodiagnosis; Nerve compression syndromes; Rehabilitation.
The Effect of Electromyostimulation on Apoptosis in Denervation and Reinnervation of Rat Skeletal Muscles. Jae Young Lim, MD (Seoul National University College of Medicine, Seoul, Republic of Korea); Tai Ryoon Han, MD, PhD; Sun Gun Chung, MD, PhD. Disclosure: J.Y. Lim, None; T.R. Han, None; S.G. Chung, None.

Objective: To determine the effect of the electromyostimulation (EMS) on intramuscular change and apoptosis during denervation and reinnervation after experimental nerve injury. Design: Prospective randomized allocation. Setting: Research laboratory. Animals: 48 male Sprague-Dawley rats. Interventions: The right sciatic nerves of rats were completely denervated by transection and partially denervated by crushing injury. EMS was applied on the right gastrocnemius muscle of each denervation for 2 weeks from 1 week after injury. The muscle weights of EMS group were greater than those of non-EMS group 4 weeks after partial denervation (66% vs 55%, P<.05). Apoptotic myonuclei by TUNEL were most frequently detected in the completely denervated nerves and less frequently in the partially denervated nerves 4 weeks after injury (27.6%±8.8% vs 10.4%±5.3%). The positive nuclei of the partially denervated nerves were detected rarely 12 weeks after injury (4.3%±2.8%) or after EMS (6.5%±2.1%). The expression of Bax and Bcl-2 showed a decline in follow-up evaluations by 12 weeks, but upregulated expressions persisted. EMS group showed significantly reduced expression 4 weeks after partial denervation (Bax, 1.00±0.03 to 0.58±0.04; Bcl-2, 0.97±0.03 to 0.57±0.05). The effect persisted until 12 weeks. Conclusions: EMS can delay the muscle atrophy after partial denervation and reduce the upregulation of Bax and Bcl-2 expression. We suggest the possibility of enhancement of anti-apoptotic mechanism by EMS under the control of apoptotic-related factors. Key Words: Apoptosis; Denervation; Electric stimulation; Rehabilitation.
Objective: To compare the efficacy of high particulate (Kenalog) versus low particulate (dexamethasone) corticosteroids in the treatment of low back pain (LBP) and lumbar radiculopathy when administered via a transforaminal epidural injection. Design: A double-blinded, randomized clinical trial. Setting: An outpatient private practice physiatry facility. Participants: 100 consecutive new patients with the diagnosis of LBP or lumbar radiculopathy who were candidates for a lumbar transforaminal epidural steroid injection. Interventions: Patients who elected to be in the study were randomized into either the Kenalog or dexamethasone cohorts. The patient and examining physician were blinded as to which cohort the patient was assigned. The volumes of administration were configured such that there was no difference in the potencies of the 2 corticosteroids being injected. There was no placebo arm of the study. Once enrolled, study patients underwent a lumbar transforaminal epidural steroid injection and follow-up with the examining physician 2 weeks later. The examining physician recorded pain based on a visual analog score (VAS). The end point of the study for each patient was a total of 3 epidural steroid injections, pain that has resolved, or pain that remained at less than 3 on a VAS for at least 4 weeks. Main Outcome Measures: Average change in VAS scores between the corticosteroid groups and average number of injections per subject per corticosteroid group. Results: Preliminary data suggest that there is a significant difference in the change of VAS scores between the Kenalog (−3.08) and the dexamethasone (−1.23) cohorts (P=.02). Conclusions: Despite the increased risk of microvascular embolization with high particulate corticosteroids, preliminary data suggest that Kenalog is more effective than dexamethasone in the treatment of LBP and lumbar radiculopathy via a transforaminal epidural injection. Key Words: Injections, epidural; Low back pain; Rehabilitation.
Geriatric Scientific Paper Presentation and Clinical Pearls

Course Number 410
Geriatrics

Safety and Efficacy of Percutaneous Vertebroplasty for Vertebral Insufficiency Fractures in Nonagenarians. Michael E. Frey, MD; Michael J. DePalma, MD (Virginia Commonwealth University, Richmond, VA); David X. Cifu, MD; William F. Carne, PhD.

Disclosure: M.E. Frey, Stryker Interventional Pain; M.J. DePalma, Stryker Interventional Pain; D.X. Cifu, None; W.F. Carne, None.

Objective: To assess the safety and efficacy of vertebroplasty in treating osteoporotic vertebral compression fractures in nonagenarians.


Setting: Private practice, office-based pain management center.

Participants: Osteoporotic nonagenarians with painful vertebral compression fractures (61 patients; 47 women; mean age, 94.8y; mean symptom duration, 33.4d).

Interventions: 2 to 3mL of polymethylmethacrylate were injected via a bipedicular approach into each fractured vertebral body under light intravenous conscious sedation with fluoroscopic control.

Main Outcome Measures: Baseline visual analog scale (VAS) rating, analgesic usage, and duration of symptoms were recorded. Subsequent VAS ratings were assessed within 30 minutes after the procedure, at 2, 4, 12, 24, 52, and 104 weeks postprocedure. Analgesic usage and patient satisfaction were assessed at final follow-up.

Results: All patients were available at each follow-up interval except 3 patients who died due to unrelated pulmonary disease between the 12- and 52-week follow-up. The mean VAS score at baseline was 7.80, 3.15 within 30 minutes after the procedure, 2.07 at 2 weeks, 1.59 at 4 weeks, 1.30 at 12 weeks, 1.08 at 24 weeks, 0.79 at 52 weeks, and 0.62 at 104 weeks. Improvement at each interval and overall was statistically significant using analysis of variance (F test, P<.005). No complications were encountered at any follow-up interval.

Conclusions: Percutaneous vertebroplasty appears to be a safe and effective treatment for painful vertebral compression fractures in nonagenarians. The rate of improvement is rapid and sustained through 1 year.

Key Words: Fractures; Geriatrics; Osteoporosis; Rehabilitation.

Interventions: Not applicable. Main Outcome Measures: Rehabilitation efficiency (equal to [FIM discharge rating − FIM admission rating] / length of stay in days).

Results: Patients with a PDD had a significantly higher rehabilitation efficiency score compared with the myopathy group (1.78 vs 1.59, P<.001), but a significantly lower rehabilitation efficiency score compared with the hip fracture and CDD groups (1.86 and 1.90, respectively; P<.001).

Conclusions: From a statistical standpoint, older adult patients with a PDD have a more rapid functional recovery during acute inpatient rehabilitation compared with patients with myopathy, but a slower recovery than patients with hip fracture or a CDD. However, from a clinical perspective, the rate of functional recovery of the PDD patients is essentially the same as that of patients receiving acute rehabilitation for hip fracture or myopathy. Because the functional recovery of these 3 patient groups was virtually the same, and because hip fracture and myopathy are qualifying conditions, according to the Centers for Medicare and Medicaid Services 75% rule, debility warrants consideration for inclusion as a qualifying diagnosis under this rule. However, further research is needed to identify those patients with debility who are most likely to benefit from acute inpatient rehabilitation.

Key Words: Aged; Geriatrics; Muscle weakness; Rehabilitation.
Course Number 236

Brain Injury

Delayed and Chronic Buspirone Treatment After Experimental Traumatic Brain Injury Enhances Spatial Acquisition. Anthony E. Kline, PhD (University of Pittsburgh, Pittsburgh, PA); Adam S. Olsen, BS; Ross D. Zafonte, DO; Christopher N. Sozda, BA; Haris A. Aslam, BS; Jeffrey P. Cheng, BS. Disclosure: A.E. Kline, None; A.S. Olsen, None; R.D. Zafonte, None; C.N. Sozda, None; H.A. Aslam, None; J.P. Cheng, None.

Objective: To determine the optimal dose of chronic buspirone (BUS) treatment that enhances functional outcome after experimental traumatic brain injury (TBI). Design: Randomized controlled study. Setting: Experimental research laboratory. Animals: 84 adult male rats. Interventions: Anesthetized rats received a cortical impact or sham injury and then were randomly assigned to 6 TBI (BUS .01, .05, 0.1, 0.3, or 0.5mg/kg, or vehicle [VEH] 1mL/kg; n=12 per group) or 2 sham (BUS 0.5mg/kg or VEH; n=6 per group) groups. Treatments were administered (intraperitoneal) 24 hours after surgery and every day thereafter for 20 days. Function was assessed by established motor and cognitive tests on postoperative days 1 through 5 and 14 through 18, respectively.

Main Outcome Measures: Time (in seconds) to maintain beam balance, traverse a narrow elevated beam, and to locate a submerged platform in a spatial acquisition task in a Morris water maze. Results: No differences were observed between the BUS and VEH sham groups in any task and thus the data were pooled. Repeated-measures analysis of variance revealed that the 0.3mg/kg dose of BUS enhanced cognitive recovery relative to the other BUS doses and VEH, but did not significantly impact motor function. No significant behavioral differences were observed among the remaining BUS doses versus VEH. Conclusions: These data indicate that BUS has a narrow therapeutic dose profile and that the dose of 0.3mg/kg is optimal for enhancing spatial learning and memory in this experimental paradigm. Future studies will examine whether combining the optimal dose of BUS with environmental enrichment produces an additive effect on cognitive and perhaps motor function. The findings may have clinical relevance for TBI patients.

Key Words: Amnesia, anterograde; Brain injuries; Glasgow Outcome Scale; Rehabilitation.

Course Number 236

Stroke

Prediction of Motor Recovery Outcome Using Diffusion Tensor Tractography in Patients With Hemiparetic Stroke. Suk Hoon Ohn, MD, MS (Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Republic of Korea); Yun-Hee Kim, MD, PhD; Sung Joon Park, MD; Sung-Tae Kim, MD, PhD; Yong Taek Lee, MD, MS; Peter K. Lee, MD, PhD. Disclosure: S. Ohn, None; Y. Kim, None; S. Park, None; S. Kim, None; Y. Lee, None; P. Lee, None. Supported by a Samsung Medical Center Clinical Research Development Program grant.

Objective: To investigate the involvement of corticospinal tract using diffusion tensor tractography (DTT) and its relationship with the motor recovery in patients with hemiparetic stroke. Design: Clinical outcome study. Setting: University hospital. Participants: 25 patients (men 13, women 12; age, 58.2±11.3y) with hemiparetic stroke. Interventions: Diffusion tensor imaging (DTI) was performed using 3T Philips Achieva scanner at the mean interval of 26.4 days poststroke. DTI applied diffusion gradient encoding in 45 noncolinear directions using a single-shot echo planar imaging sequences (repetition time, 6616ms; echo time, 60ms; slice thickness, 22.5mm; field of view, 220mm; matrix, 112×112; b value, 1000s/mm²). We set regions of interest (ROI) in the anterior pons and the motor cortex. For the 3-dimensional reconstructions of the corticospinal tract, PRIDE 3.0 software was used and end-operation technique was applied on the 2 ROIs. The termination criteria were fractional anisotropy less than 0.2 at an angle greater than 70°. Main Outcome Measures: We measured fractional anisotropy, apparent diffusion coefficient, fiber number, and ratio of the ipsilateral and contralateral corticospinal tract acquired in DTT. Motor function was assessed using Fugl-Meyer Assessment (FMA) score, motricity index, Functional Ambulation Category, grip power, and box-and-block test (BBT) at 1 and 6 months after stroke. Results: In the affected corticospinal tract, fractional anisotropy value and fiber number were significantly reduced compared with the unaffected side (P<.05). However, the apparent diffusion coefficient was not significantly increased compared with the unaffected side. The fractional anisotropy value of the affected corticospinal tract correlated positively with the FMA score, motoricity index, and BBT scores at 6 months after stroke (P<.05). Conclusions: The fractional anisotropy value, but not the apparent diffusion coefficient, fiber number, or fiber ratio of the corticospinal tract, obtained at 1 month after stroke has a prognostic value for the motor recovery and hand function acquisition in patients with hemiparetic stroke.

Key Words: Anisotrophy; Corticospinal tracts; Rehabilitation; Stroke.
Pediatric Clinical Pearls and Papers

Course Number 431
Pediatrics

Relationship Between Health-Related Quality of Life and Caregiver Stress in Children With Cerebral Palsy Receiving Intrathecal Baclofen Therapy. Rita N. Ayyangar, MD (University of Michigan, Ann Arbor, MI); Lindsay Enebak; Hugh J. Barton, MD, MHSc; Margaret Fox, RN.

Disclosure: R.N. Ayyangar, Medtronic sponsored-investigator initiated research funding; L. Enebak, None; H.J. Barton, None; M. Fox, None.

Objective: To investigate the relationship between caregiver stress and health-related quality of life (HRQOL) in children with cerebral palsy (CP) receiving intrathecal baclofen (ITB) therapy. Design: Longitudinal cohort study. Setting: Tertiary care facility. Participants: 23 children (12 boys), with CP (Gross Motor Function Classification System levels V [n=21], IV [n=1], III [n=1]), aged 4 to 20 years (mean, 12.5y) receiving chronic ITB therapy. Interventions: We performed bivariate correlation analyses comparing the responses on the Child Health Questionnaire—28 (CHQ) and Questionnaire on Resources and Stress (QRS) at baseline (pre-pump) and follow-up (1–4y) with majority at 1 year (n=10). A Bonferroni-adjusted P value of .003 was accepted as significant. Main Outcome Measures: The CHQ and QRS. Results: There was stability in the CHQ and QRS, except for CHQ change in health subscale, which increased considerably from baseline to follow-up. Analyses between questionnaires showed that greater caregiver time limitations due to the child’s condition correlated with higher child bodily pain (P=.001) and decreased family activities (P=.001). Higher self-esteem correlated with fewer social limitations due to physical impairments (P<.001). Certain associations between caregiver stress and HRQOL were unanticipated, as caregiver stress about life span care was associated with lower child bodily pain (P<.001) and better health perspective (P=.001). Although greater bodily pain seemed to correlate with more behavioral concerns (P=.012) and less family disharmony seemed to correlate with fewer perceived limitations on family activities (P=.035), these failed to reach our predetermined level of significance. Conclusions: These results support an inverse relationship between HRQOL and caregiver stress. Trends of increased stress with more parental involvement were noted with some unanticipated associations between stress and HRQOL. The paradoxical finding of increased stress relating to life span care for children with higher HRQOL scores is intriguing and needs further investigation. Key Words: Baclofen; Quality of life; Rehabilitation; Stress.

Course Number 431
Pediatrics

Auto Safety Improvements and Reduction in Pediatric Traumatic Brain Injury. Elliot B. Bodofsky, MD (UMDNJ-Cooper University Hospital, Camden, NJ); Frank Camaratta, MSPT.

Disclosure: E.B. Bodofsky, None; F. Camaratta, None.

Objective: To determine the effect of changes in motor vehicle restraint usage on pediatric brain injuries in the United States. Design: Review of data from the Health Care Utilization Project (HCUP) and the National Highway Transportation Safety Agency (NHTSA). Setting: A stratified national study of all hospital discharges for the years 1997 to 2003 (HCUP) and a randomized survey of motor vehicle occupants 1994 to 2006 (NHTSA). Participants: Patients discharged from U.S. hospitals (HCUP) and U.S. motor vehicle occupants (NHTSA). Interventions: Not applicable. Main Outcome Measures: Changes in the number of pediatric brain injury discharges and deaths 1997 to 2003. Usage of restraints in the United States from 1997 to 2003. Results: Total pediatric brain injury discharges fell from 33,988 in 1997 to 26,203 in 2003, a decline of 22.9% (z=3.98, P=.000). Declines were seen for all age groups, the largest (36.0%) in the 5- to 9-year-old age group (z=5.14, P<.000). Inpatient pediatric brain injury deaths fell from 1631 to 1277, a 21.7% decline (z=2.55, P=.011). During the same time, seat belt usage rose from 61% in 1997 to 79% in 2003. Previous studies have shown that unrestrained passengers have a 5 to 6 times higher likelihood of sustaining serious injury, including brain injury. This would have been projected to have resulted in a 28% decline in serious injuries, similar to what was observed. Conclusions: The number of pediatric brain injury discharges and deaths fell significantly between 1997 and 2003. Motor vehicle crashes (MVCs) are the major cause of pediatric brain injury, so this decline is likely related to a decrease in MVC-related pediatric brain injury. The similarity between expected and actual declines in pediatric brain injury cases gives further support to this theory. Overall, it appears that increased usage of restraints between 1997 and 2003 resulted in a significant decline in pediatric brain injury. Key Words: Brain injuries; Motor vehicle; Rehabilitation.

Course Number 431
Pediatrics

Functional Outcome in Rett Syndrome Based on Genotype. Frank S. Pidcock, MD (Johns Hopkins University School of Medicine, Baltimore, MD); Genila M. Bihut, MD; Cynthia F. Salorio, PhD; Jennifer O. Swain, PT, MPT; Jocelyn M. Scheller, MOT/L; SakkuBai Naidu, MD.

Disclosure: F.S. Pidcock, NICHD grant no. HD23444; FDA grant no. FD-R-002408; G.M. Bihut, NICHD grant no. HD23448; FDA grant no. FD-R-002408; Johns Hopkins GRC grant no. M01-RR00052; C.F. Salorio, None; J.O. Swain, NICHD grant no. HD23448; FDA grant no. FD-R-002408; J.M. Scheller, NICHD grant no. HD24448; FDA grant no. FD-R-002408; S. Naidu, NICHD grant no. HD23448; FDA grant no. FD-R-002408; Johns Hopkins GRC grant no. M01-RR00052.

Objective: To determine if functional impairment is associated with the type and location of mutation in Rett syndrome. Design: Cohort study (retrospective). Setting: University hospital. Participants: 158 Rett syndrome patients with mutation in the MeCP2 (methyl-CpG-binding protein 2) gene with ages ranging from 1 to 39 years. The average age at assessment was 7.7 years. Interventions: Not applicable. Main Outcome Measures: Gross motor, fine motor, and adaptive skills based on neurologic examination, parental reports, and WeeFIM. Results: Chi-square and analyses of variance were performed to examine the relationships between function and genotype. Of the 8 most common mutations in the MeCP2 gene, patients with R133C had better functional outcome while those with T158M had poorer outcome. 100% of Rett syndrome patients with R133C and 92% with R294X mutations achieved independent ambulation and pincer grasp. Patients with R133C mutation had preservation of hand use (finger feeding and use of utensils). Patients with mutations in the proximal portion of the gene, with the exception of the R133C mutation, had worse functional outcome than those with distal mutations (P<.05). Overall, patients with deletions, which are mainly in the distal portion of the gene, attained better gross and fine motor skills as well as adaptive skills compared with other mutations in both the proximal and distal portions of the gene (P<.05). Age did not differ significantly across mutation groups. Conclusions: Rett syndrome is manifested by developmental delay and regression of previously acquired gross and fine motor skills. Functional impairment can be correlated with the type and location of the mutation in the MeCP2 gene. Understanding the relationship between genetic defect and performance of fine motor and gross motor tasks may help to identify appropriate early rehabilitation programs to promote function. Key Words: Mutation; Pediatric; Rehabilitation; Rett syndrome.
administration

Poster 1
National Survey of Inpatient Rehabilitation Practitioners’ Impressions on the Quality of Discharge Summary Materials Received From Transferring Facilities. Necolle Morgado, DO (Mount Sinai School of Medicine, New York, NY); Howard Choi, MD, MPH.
Disclosure: N. Morgado, None; H. Choi, None.
Objective: To determine the impressions of practitioners at inpatient rehabilitation facilities (IRFs) on the quality of discharge summaries accompanying inpatient admissions received from transferring facilities, as well as the potential impact problematic discharge summaries may have on health care delivery and outcomes. Design: Mailed survey. Setting: Academic rehabilitation centers in the United States. Participants: Health care providers with at least 6 months of recent experience admitting patients to IRFs from outside hospitals and institutions. Interventions: Not applicable. Main Outcome Measures: Practitioners’ impressions of the frequency that information (eg, discharge medication lists, antibiotic instructions, deep venous thrombosis (DVT) prophylaxis instructions, weight-bearing status, imaging and Doppler results, and provider contact information) is problematic (ie, missing or inconsistently reported) on discharge summaries. Practitioners’ impressions of whether these inconsistencies impact health care delivery and outcomes (eg, unnecessary tests, medication errors, adverse events, increased length of stay [LOS], increased health care costs). Results: Survey respondents to date reported discharge summaries were frequently or very frequently problematic with regard to discharge medication lists (26.7%), antibiotic instructions (60%), DVT prophylaxis instructions (46.7%), imaging and Doppler results (50%), and contact information for discharging providers (70%). Respondents agreed or strongly agreed that problematic discharge summaries may result in unnecessary tests (100%), medication errors (93.1%), increased morbidity (75.9%), increased mortality (65.5%), increased LOS (82.8%), and increased health care costs (96.6%). Conclusions: Survey respondents reported that discharge summaries accompanying inpatient admissions received from transferring facilities frequently have missing or inconsistently reported health care information and instructions for further care. The respondents strongly felt that problematic discharge summaries can impact health care costs and outcomes. Key Words: Discharge planning; Health care surveys; Rehabilitation.

Poster 2
Disclosure: R.S. Kaplan, None.
Setting: Semi-rural community hospital. Program: An 11-bed acute rehabilitation unit. Program Description: A small community hospital in Appalachia faced imminent closure of its 11-bed acute rehabilitation unit because of recent changes in Medicare admission requirements. Simultaneously, the hospital faced an overwhelming community demand for acute medicine services due to the closure of another nearby community hospital. Our hospital was able to negotiate with governmental and regulatory entities for a special needs exemption to permit acute medical and surgical patients to be cared for in unused acute rehabilitation beds. This result solved 2 critical medical service needs of the community. Assessment/Results: Flexible use of acute rehabilitation unit physical resources—if permitted by regulation—would improve health care access without additional cost. Discussion: This report shows how flexibility in acute rehabilitation bed utilization regulations can help a semi-rural hospital meet the needs of its community without adding cost to the medical system, a true win-win. This concept should be considered on a broader geographical scale. Conclusions: The concept of a dual-use acute rehabilitation unit is worthy of further governmental consideration. Key Words: Rehabilitation; Resource allocation; Rural health services.

Poster 3
Delivering Health Care for Wounded Soldiers: Experience from a Veterans Affairs Polytrauma Network Site. Henry L. Lew, MD, PhD (VA Palo Alto Health Care System, Palo Alto, CA); John Poole, PhD; Annabel Castaneda, MD, MPH; Sylvia Guillory, BS; Sharon Dekelboum, OT; Barbara Sigford, MD, PhD.
Disclosure: H.L. Lew, None; J. Poole, None; A. Castaneda, None; S. Guillory, None; S. Dekelboum, None; B. Sigford, None.
Setting: Tertiary medical center. Program: Veterans Affairs (VA) polytrauma network sites. Program Description: As soldiers return from combat in Iraq and Afghanistan, the United States is seeing a large influx of patients into the VA Healthcare System. The growing population of new combat veterans prompted the VA to establish a polytrauma system of care with inpatient to outpatient programs. The polytrauma network sites (PNS) are designated to coordinate patient care on an outpatient basis. We report our local PNS experience, with the hope that lessons learned are shared among other PNS clinics across the country. An electronic screening process is automatically triggered at a veteran’s first point of contact within our regional network. A case worker reviews the referrals and determines who would need further assessment through phone interviews. Those who need and desire further evaluation and treatment are scheduled in-person evaluations. Assessment/Results: From its inception in July 2006 to January 2007, our PNS clinic received a total of 135 referrals, 86 of whom completed phone screening, and 51 of whom were scheduled for appointments. Each patient was systematically evaluated by members of the PNS team. Individualized treatment planning was provided via interdisciplinary team meetings. While 76% of the patients were exposed to blasts or explosions, 56% had transient alteration of consciousness. We found a high prevalence of post-traumatic stress disorder (70%) and cognitive impairment (50%). Moreover, 36% of patients failed the hearing screening, 50% reported tinnitus, and 15% reported vertigo. While 65% of patients reported vision-related complaints, only 29% had visual acuity impairments.

Poster Presentations

Poster Presentations will be displayed from Thursday, September 27 starting at 5:00 PM until Saturday, September 29, at 2:00 PM in Exhibit Hall C-D at the John B. Hynes Veterans Memorial Convention Center. Authors will be present at their posters to discuss their work on Saturday, September 29, 2007, from 9:30–11:00 AM.
Discussion: The local PNS clinic provided comprehensive screening, rehabilitation, and care coordination for veterans with physical and emotional traumas. Conclusions: Through the PNS, health care is being delivered to many of our wounded soldiers. Key Words: Brain injuries; Rehabilitation; Stress disorders, post-traumatic; Trauma.

Poster 4
Transfer to Acute Care Hospitalization From Inpatient Rehabilitation Secondary to Acute Medical or Surgical Illness: A Retrospective Study on the Effect of Implementation of the 75% Rule.
Peter Gemelli, MD (East Carolina University, Greenville, NC); Mark Harris, MD, MPH; Derek Watson, MD; James Wells, MD, MPH; Clinton Faulk, MD.
Disclosure: P. Gemelli, None; M. Harris, None; D. Watson, None; J. Wells, None; C. Faulk, None.

Objective: To discern whether implementation of the 75% rule has caused the proportion of patients returning to an acute care hospitalization. Design: Retrospective cohort study. Setting: Inpatient regional rehabilitation center within a level 1 trauma center and tertiary care center. Participants: Inpatient data, excluding protected health information but including return to acute care data, on all patients admitted to the rehabilitation center from March 1, 2005 through December 31, 2006 (admitted=1989, returned to acute care=215). This period included data from 11 months prior to and 11 months after implementation of the 75% rule at this facility. Interventions: Not applicable. Main Outcome Measure: Rate of patients returning to acute care hospitalization from inpatient rehabilitation. Results: There has been a 2% increase in return to acute care hospitalization, post 75% rule implementation, versus discharge to home (P=.02). Conclusions: Implementation of the 75% rule has caused changes in the discharge pattern of patients admitted to our regional rehabilitation center, possibly due to increased acuity. Further research is needed to evaluate how the 75% rule will impact inpatient rehabilitation discharge patterns and quality of care on a local and nationwide basis. Key Words: Admitting department, hospital; Patient discharge; Rehabilitation; Retrospective studies.
AIDS/HIV

Poster 5
Human Immunodeficiency Virus–Associated Vacuolar Myelopathy: A Case Report. Allen Kao, MD (Temple University Hospital, Philadelphia, PA); Jeffrey Degen, MD; Ernesto Cruz, MD.

Disclosure: A. Kao, None; J. Degen, None; E. Cruz, None.

Setting: Tertiary care hospital. Patient: A 42-year-old man with acquired immune deficiency virus develops bilateral lower-extremity weakness. Case Description: The patient presented with urinary incontinence and ambulatory dysfunction from bilateral lower extremity weakness that began the week prior to admission. Physical exam was remarkable for symmetrical weakness of both lower extremities: hip flexion, 2/5; knee flexion and extension, 2/5; dorsiflexion, 3/5; and plantarflexion, 4/5. He was hyperreflexic with sustained clonus at both ankles, had bilateral upgoing Babinski sign, increased tone, and decreased vibratory sense in both legs. His gait was ataxic and exhibited decreased knee flexion and clearance of his feet. His CD4 count was 168. Magnetic resonance imaging of his spine showed striking atrophy of the cervical and thoracic cord consistent with vacuolar myelopathy seen in human immunodeficiency virus (HIV). Assessment/Results: The patient was diagnosed with vacuolar myelopathy of his thoracic and distal cervical spinal cord. After his treatment with intravenous steroids and a stay in acute rehabilitation, strength around his hips and knees improved to 3/5. For ambulation and transfers, he progressed with rolling walker from minimal assistance to a supervision level. Discussion: Vacuolar myelopathy seen with HIV is a progressive disease that causes vacuolation of the lateral and posterior spinal cord. Usually, presentation includes spastic paraparesis, ataxia, and incontinence. Differentials include human T-cell lymphotrophic virus type 1 myelopathy, vitamin B₁₂-deficiency, cytomegalovirus, and syphilis. The pathogenesis of vacuolar myelopathy is not established, although a dysfunction due to HIV in the B₁₂-dependent transmethylation pathway in myelin formation has been implicated. Although a pilot study with oral methionine shows promise, current standard treatments for HIV myelitis, it is important to provide the optimal rehabilitation therapy that we can to all patients, with the hope that their condition will improve. Key Words: AIDS; HIV; Myelitis; Rehabilitation.

Arthritis

Poster 7
Validation of the Arthritis Impact Measurement Scales 2 Short Form Adapted for Filipino Patients With Osteoarthritis. Maria Jenelyn M. Alviar, MD, MSc (University of the Philippines Manila, Manila, Philippines).

Disclosure: M.M. Alviar, Philippine Council for Health Research and Development; Research Implementation and Development Office-University of the Philippines College of Medicine.

Objectives: To develop a cross-cultural adaptation of the Arthritis Impact Measurement Scales 2 Short Form (AIMS2-SF) for Filipino patients with osteoarthritis and to determine its reliability and validity.

Design: 2-phase cross-sectional. Setting: Tertiary government hospital. Participants: Phase 1: 300 patients with osteoarthritis. Interventions: Development of the AIMS2-SF Filipino version: The AIMS2-SF was adapted by forward-backward translation, committee review, and pretesting. Reliability and validity testing: The developed tool was administered to the participants after recording their sociodemographic and clinical characteristics. Main Outcome Measures: Internal consistency and content validity (content relevance and content coverage, convergent validity, construct validity). Results: The cross-cultural adaptation of the AIMS2-SF (“Pag-sukat sa Kalagayan ng Pasyente na may Arthritis”) has a 5-domain structure (physical/function, pain/symptom, affect, social, role/work) with 26 items. Cronbach α is good in all scales (range, .65–.77) except the social scale (.40). The tool covers relevant domains (content relevance) and the items adequately cover each domain (content adequacy). Pearson correlation coefficients were significant for 8 of the 10 a priori hypotheses, indicating convergent validity. Factor analysis identifies the 5 major factors corresponding to the scales of the tool, reflecting construct validity. The items on the physical scale load on 2 separate factors, suggesting that upper-body activities should be distinguished from lower-body activities. Conclusions: The tool “Pag-sukat sa Kalagayan ng Pasyente na may Arthritis” is a cross-cultural adaptation of the AIMS2-SF that has a 5-component structure (physical/function, pain/symptom, affect, social, role/work) with 26 items. It is a reliable and valid tool for assessing health status in Filipino patients with osteoarthritis. Key Words: Arthritis; Quality of life; Rehabilitation; Validation studies (publication type).
Poster 8
Newly Diagnosed Seronegative Rheumatoid Arthritis in the Setting of Postoperative Rehabilitation for Total Knee Arthroplasty: A Case Report. Sandeep Rathi, MD (Hospital for Joint Diseases, NYU Medical Ctr, New York, NY); Kenneth Vitale, MD; Arthur Jimenez, MD.

Disclosure: S. Rathi, None; K. Vitale, None; A. Jimenez, None.

Setting: Urban orthopedic rehabilitation unit. Patient: A 62-year-old woman with history of glenohumeral osteoarthritis, fibromyalgia, left total knee arthroplasty (TKA), and recent right TKA. Case Description: Patient had slow range of motion (ROM) and mobility improvements despite aggressive physical therapy. 3 months after right TKA, she experienced progressive functional decline. She presented with acute-on-chronic bilateral shoulder pain refractory to steroid injections, worsening knee stiffness and pain, and new complaints of bilateral wrist and right ankle pain, left leg decreased sensation, and profound fatigue. She was admitted to inpatient rehabilitation in attempt to restore activities of daily living (ADL) independence. Examination revealed markedly limited bilateral shoulder ROM to 45° of abduction and 50° of flexion; caput ulna left hand; limited knee flexion to 90° bilaterally; and right ankle blanching erythema. She required moderate assistance with ADLs. Erythrocyte sedimentation rate was elevated. A diagnosis of polymyalgia rheumatica was suggested and oral steroids started. There was no evidence of right Charcot ankle by exam or x-rays. Electrodiagnosis showed moderate axonal sensorimotor polyneuropathy. Hand x-rays revealed metacarpal head erosions and metacarpophalangeal joint space narrowing. Full rheumatoid laboratory workup was performed and was negative. Rheumatology consult suggested a seronegative rheumatoid arthritis (RA); she continued steroids and began methotrexate. The patient improved and was discharged home. Assessment/Results: After diagnosis of seronegative RA, the patient improved with appropriate treatment. Discussion: A diagnosis of seronegative RA following TKA is uncommon and represents a diagnostic and therapeutic challenge to physiatrists. Simultaneous diagnoses of glenohumeral arthritis, fibromyalgia, and possible polymyalgia rheumatica can complicate the clinical picture. Radiologic images, laboratory workup, clinical photos, and electrodiagnostic testing are presented. Conclusions: Physicians involved with orthopedic rehabilitation must be wary of possible rheumatologic conditions that may prolong rehabilitation and cause functional decline. Timely diagnosis and initiation of proper treatment is essential to restoration of ADL independence. Key Words: Arthritis, rheumatoid; Arthroplasty, replacement, knee; Postoperative care; Rehabilitation.

Poster 9
Effect of Combined Garlic Therapy and Comprehensive Rehabilitation Program Versus Comprehensive Rehabilitation Program Alone on Control of Clinical Manifestations and Quality of Life of Knee Osteoarthritis Patients. Naglaa A. Hussein, MD, PhD (Alexandria University, Alexandria, Egypt); Gihan Mohamed Sharara, MD, PhD.

Disclosure: N.A. Hussein, None; G.M. Sharara, None.

Objective: To compare the effect of a comprehensive rehabilitation program versus combined garlic therapy and comprehensive rehabilitation program in controlling the clinical manifestations and quality of life in patients with knee osteoarthritis. Design: Randomized clinical trial. Setting: Outpatient. Participants: 43 patients with knee osteoarthritis randomized to group I (comprehensive rehabilitation) (n=15) and group II (combined garlic therapy and comprehensive rehabilita-

Poster 10
Unilateral Hip Pain as a Presenting Symptom in a Patient With Disseminated Tuberculosis: A Case Report. Lauren T. Shapiro, MD (Rehabilitation Institute of Chicago Feinberg School of Medicine, Northwestern University, Chicago, IL).

Setting: Tertiary care hospital. Patient: A 68-year-old Asian woman with a history of systemic lupus erythematosus on chronic steroid therapy. Case Description: The patient presented with a 1-day history of an inability to ambulate secondary to severe left hip pain. She had sought evaluation for this pain on prior occasions during the preceding month and had undergone hip radiographs, computerized tomography (CT) scan of her pelvis, and bone scan, all of which were unremarkable. She denied any recent trauma to the area and could not identify a precipitant. She also reported having intermittent chills, and on review of systems, admitted to abdominal discomfort, weight loss, and dyspnea on exertion. On examination, the patient was in no apparent distress, with a regular heart rate and rhythm, clear lungs to auscultation, and a soft nontender abdomen. Pain was elicited with left hip internal and external rotation and with manual muscle testing of her left lower limb. There was no evidence of active synovitis on examination. Assessment/Results: Initial laboratory studies were remarkable for leukocytosis with neutrophilia, microcytic anemia, and an erythrocyte sedimentation rate of 52mm/h. Left hip radiographs were unchanged from prior films and did not reveal any fracture or dislocation. Chest radiographs revealed diffuse interstitial and alveolar opacities, and a CT scan of her chest revealed diffuse miliary micronodules. Synovial fluid aspirate from her left hip returned positive for acid-fast bacilli, prompting the initiation of treatment for tuberculosis. Discussion: Tuberculous arthritis may go undetected because of its nonspecific presentation, particularly in patients who have comorbidities associated with joint pain and constitutional symptoms. Conclusions: A high index of suspicion for tuberculous arthritis in immunocompromised patients presenting with joint pain, constitutional symptoms, and chest radiograph abnormalities is necessary for prompt recognition and treatment of potentially fatal disseminated tuberculosis. Key Words: Arthritis, infectious; Rehabilitation; Tuberculosis.
Poster 11
The Significance of Radiographs in Hip Pain. Dexter Wong, MD (Stanford University, Palo Alto, CA); Darren Don, MD; Esther Kim, MD; Navjeet Boporai, MD; David Ben-Aviv, MD; Raj Mitra, MD.
Disclosure: D. Wong, None; D. Don, None; E. Kim, None; N. Boporai, None; D. Ben-Aviv, None; R. Mitra, None.
Objective: To determine if there is a correlation between the severity of hip arthritis and response to fluoroscopically guided steroid injections to the hip; and to investigate whether there is significant improvement from injections in those with severe hip pain. Design: Fluoroscopically guided intra-articular steroid injections were performed on 10 patients. The data were retrospectively reviewed. Setting: Spine and pain clinic over a 2-year period. Participants: 10 of 130 men and women with hip pain. Interventions: Fluoroscopic guidance was used to place a 25-gauge 3.5-in needle into the hip joint; placement was confirmed with Omnipaque 240 contrast dye, which revealed a hip arthrogram. All patients received an injection mixture of 80mg of triamcinolone and 4mL of 1% lidocaine. Their responses were recorded by visual analog scale (VAS) for pain, obtained before and 3 weeks after the procedure. Hip arthritis severity was measured by the Kellgren-Lawrence grading scale. Main Outcome Measures: Change in VAS and patient’s severity of hip arthritis as described above. Results: Based on the Fisher exact test, there was no correlation between hip arthritis and steroid injection (P=.45). Also, people with the most severe pain, based on a VAS score, did not seem to have additional significant benefit from steroid injection (P=.46). However, 83.3% of injections resulted in significant improvement from the intervention, while 0% injections resulted in worsening pain. Conclusions: The severity of hip osteoarthritis on radiographs is not a good predictor of clinically significant hip osteoarthritis, as determined by positive response to hip steroid and local anesthetic injections. Key Words: Injections; Rehabilitation; Steroids; Visual analogue pain scale.

Brain Injury

Poster 12
Fatigue After Traumatic Brain Injury and Potential Contributing Factors. Jeffrey Englander, MD (Santa Clara Valley MedicalCtr, San Jose, CA); Tamara Bushnik, PhD.
Disclosure: J. Englander, NIDRR grant no. H133N020524 and Pfizer Inc; T. Bushnik, NIDRR grant no. H133N020524 and Pfizer Inc.
Objective: To examine the association between fatigue after traumatic brain injury (TBI) and factors that have been suggested as contributing to fatigue. Design: Prospective, observational. Setting: Hospital research laboratory. Participants: 144 subjects with TBI of at least 1 year in duration completed questionnaires and underwent neuroendocrine testing. Interventions: Not applicable. Main Outcome Measures: Fatigue Severity Scale (FSS); Global Fatigue Inventory (GFI); neuroendocrine levels, including peak growth hormone (GH) levels after intramuscular glucagon stimulation; pain visual analog scale (VAS); Beck Depression Inventory–II (BDI-II); Pittsburgh Sleep Quality Index; Neurobehavioral Functioning Inventory (NFI) somatic, memory, and motor subscales. Results: 63% had abnormal peak GH levels (32%, <3ng/mL; 31%, 3–9.9ng/mL); 11% had central hypothyroidism; 11% of men had low testosterone; and 60% presented with low basal cortisol (<15μg/dL). Multiple regression analyses revealed that the independent variables predicted 45% of the FSS variance (F=13.467, P<.001) and 59% of the GFI variance (F=23.364, P<.001). For the FSS, the BDI-II and NFI memory subscales were the 2 significant predictors (P=.003, P=.044, respectively). For the GFI, 3 variables were significant predictors: the pain VAS (P<.001), BDI-II (P=.001), and NFI memory subscale (P=.013). None of the other variables significantly contributed to prediction of FSS or GFI scores. Conclusions: Fatigue after TBI is a widespread problem. Depression and memory problems both contributed significantly to the prediction of FSS and GFI scores. A third variable, pain, was found to significantly predict GFI scores; this suggests that the 2 fatigue scales may be sensitive to different aspects of fatigue. Pain, depression, sleep disorders, and hypothyroidism are the most readily treatable conditions associated with fatigue. Compensation for memory difficulties probably contributes to fatigue. Key Words: Brain injuries; Depression; Endocrine diseases; Fatigue; Rehabilitation.

Poster 13
Screening for Pain Using the Scale of Pain Intensity: A Pain Assessment Tool Designed for Patients With Cognitive and Communication Deficits Following Acquired Brain Injury. Lynne Turner-Stokes, DM, FRCP (King’s College London, London, UK); Rebecca Disler, MSc; Heather Williams, MSc.
Disclosure: L. Turner-Stokes, None; R. Disler, None; H. Williams, None.
Objective: To examine the validity, reliability, and utility of the Scale of Pain Intensity (SPIN) as a screening tool for pain in patients with complex neurodisability. Design: A prospective cohort analysis. Setting: A tertiary inpatient neurorehabilitation service for severely disabled younger adults. Participants: 57 of 65 consecutive admissions with a median age of 50 years (IQR, 31–55) and male to female ratio of 1:1. All had physical disability: 75% had communicative and 30% had cognitive deficits. Interventions: Screening according to a standardized protocol, which includes inquiry for pain symptoms, administration of the SPIN, and a Numbered Graphic Rating Scale (NGRS) for those (n=36) who were able. Repeat (blind) assessment of the SPIN was undetected in 24 hours (n=23). Main Outcome Measures: The SPIN (possible score range, 0–5) and converted NGRS (normative range, 0–10; divided by 2 to range, 0–5). Results: 46 of 57 (80%) patients were able to use the SPIN screen (5 unable, 6 uncertain). Of 32 (60%) patients who reported pain, the median SPIN score was 2 (range, 1–4), compared with 0 (range, 0–2) in those reporting no pain (Mann-Whitney z=5.9, P<.001). There was a strong correlation between the SPIN and NGRS (Spearman ρ=.96, P<.001). Weighted Cohen κ tests showed excellent agreement with the converted NGRS score (.94). Of those who had a repeat assessment, 14 (60.9%) indicated that their level of pain had changed since the day before and 6 (26.1%) indicated the same level of pain. These changes were reflected in their SPIN scores, with correspondingly reduced agreement (κ=.59) with the initial SPIN assessment. Conclusions: The SPIN appears to provide a valid screening instrument for the presence of pain, which was also sensitive to change. It also seemed to be more accessible to more patients with cognitive and communicative deficits than conventional pain scales such as the NGRS. Further testing is now warranted. Key Words: Pain assessment; Rehabilitation.

Poster 14
Increasing Incidence of Traumatic Brain Injury in the Elderly. Elliot B. Bodofsky, MD (UMDNJ-Cooper University Hospital, Camden, NJ); Frank Camaratta, MSPT.
Disclosure: E.B. Bodofsky, None; F. Camaratta, None.
Objective: To determine changes in the incidence of brain injury in the elderly, as well as possible causes. Design: Review of data from the HealthCare Utilization Project. Setting: A stratified random survey
of hospital discharges in the United States. **Participants:** Randomly selected inpatient hospital patients 65+ years of age, from 1997 to 2004. **Interventions:** Not applicable. **Main Outcome Measures:** Changes in the number of discharges for brain injury in patients 65+ years for the period 1997 to 2004, as well as number of deaths. Overall discharges for patients 65 years and older involved in motor vehicle crashes as well as falls. **Results:** In the 65- to 84-year-old age group, hospital discharges rose from 30,563 in 1997 to 41,981 in 2004, an increase of 37.4% (z=4.87, P<.001). For the 85+ age group, brain injury discharges rose from 12,058 to 17,113, an even larger increase of 41.9% (z=5.47, P<.001). Inpatient brain injury deaths rose even more, up 54.5% in the 65- to 84-year-old group (z=4.44, P<.001) and 57.9% in the 85+ age group (z=4.51, P<.001). By contrast, total hospital discharges for patients in these age groups for motor vehicle crashes decreased by 14.8% and 11.2%, while total discharges for falls rose by 14.1% and 19.1% during the same interval. **Conclusions:** The incidence of brain injury in the elderly is rising very rapidly. Deaths from brain injury in the elderly are rising even faster, indicating a probable increase in severity of the injuries. The causes for this rapid increase are not clear. Rehabilitation facilities can expect increasing numbers of elderly brain injury patients in the future. **Key Words:** Brain injuries; Rehabilitation.

**Poster 15**

**Acute Inpatient Rehabilitation Outcomes for Brain Tumor Patients.** Sharon K. Mcdowell, MD (Ohio State University, Columbus, OH); Matthew Owens, MD; Susan Bell, RN, CNP, CNRN; Robert Vaneecko, PT, MS; John McGregor, MD.

**Disclosure:** S.K. Mcdowell, None; M. Owens, None; S. Bell, None; R. Vaneecko, None; J. McGregor, None.

**Objective:** To compare immediate and 3-month functional outcomes and discharge disposition of brain tumor patients following inpatient rehabilitation. **Design:** Longitudinal design with retrospective analysis of patients admitted to an inpatient rehabilitation center following craniotomy from 2004 to 2006. **Setting:** University medical center and academic rehabilitation hospital. **Participants:** 96 consecutively admitted brain tumor patients (2004–2006). **Interventions:** Not applicable. **Main Outcome Measures:** Admission and discharge FIM instrument scores and FIM subsets, length of stay (LOS), and discharge disposition. **Results:** Results have been analyzed for year 1 (41 patients) and the results for year 2 (55 patients) were completed in March 2007. 41 patients were divided into 3 groups based on tumor type (metastic, n=8; high-grade glioma [HGG] n=15; low-grade glioma [LGG] n=18). Mean LOS for acute care and rehabilitation did not differ statistically between the 3 groups. The majority of patients were discharged to home (metastic=100%; HGG=67%; LGG=94%). There was a statistically significant improvement in FIM scores for all tumor groups (P<.01, P<.05, P<.01, respectively). There was significant improvement (P<.01) in all the FIM subcategories (activities of daily living, mobility, cognition) for metastatic and LGG. FIM differences were noted between HGG and LGG for mobility only (P<.05). FIM improvement for activities of daily living and cognition were significantly worse for subjects with glioblastoma multiforme compared with oligodendroglioma and metastatic tumors. **Conclusions:** Intracranial neoplasms are a significant source of disability. Following surgery, the disability often prevents patients from returning home safely. All groups experienced an overall mean increase in FIM score at the time of discharge, although there were significant differences between tumor types. Overall, 86% of the patients were discharged to home. Rehabilitation services may offer a unique opportunity to influence functional outcomes in these people and decrease caregiver burden. **Key Words:** Brain neoplasms; Outcomes assessment (health care); Rehabilitation.

**Poster 16**

**Occlult Cervical Syringomyelia in a Child With Traumatic Brain Injury Following Head Trauma: A Case Report.** Douglas H. Buxton, MD (Temple University Hospital/Moss Rehab Hospital, Philadelphia, PA).

**Disclosure:** D.H. Buxton, None.

**Setting:** Tertiary care pediatric and inpatient rehabilitation hospital. **Patient:** A 15-year-old boy with traumatic brain injury (TBI) and cervical spinal cord post-traumatic syringomyelia following assault. **Case Description:** The patient suffered an assault to the head region, resulting in loss of consciousness and incontinence of urine and bowel at the scene. Computed tomography (CT) of the brain revealed a mixed subdural and subarachnoid hemorrhage in the anterior interhemispheric fissure and a punctate subcortical parenchymal hemorrhage in the left frontal parasagittal region. CT of the cervical spine did not reveal any abnormalities, except for reversal of the normal cervical lordosis. During the acute hospitalization, the physical examination revealed no neurologic abnormalities except for bilateral Hoffmann’s sign. The patient had intact sensation throughout his body, but complained of extreme pain in the upper limbs and shoulders with touch. On transfer to the inpatient rehabilitation facility, the complaints of allodynia of the upper limbs (with sparing of the hands), shoulders, upper chest, and upper back persisted to the point that the patient refused to wear upper torso clothing. The patient was resistant to therapy and examination, and had fluctuations in the pattern of his dysesthesias. **Assessment/Results:** The patient’s TBI resulted in moderately significant cognitive deficits. A magnetic resonance imaging study of the cervical spine revealed signal abnormalities of the cervical spinal cord at the C3 through C5 levels suggestive of a post-traumatic syringomyelia, which provided an explanation for the sensory complaints. **Discussion:** TBI in the pediatric population poses diagnostic challenges due to the complex behavioral difficulties. Even after a thorough acute hospitalization evaluation, these patients may possess undiagnosed occult abnormalities, making ongoing re-evaluation in the rehabilitation setting essential. **Conclusions:** TBI in the pediatric population can lead to significant challenges in diagnosing comorbidities associated with trauma. **Key Words:** Brain injuries; Pediatrics; Rehabilitation; Syringomyelia.

**Poster 17**

**Functional Outcome After High Altitude Cerebral Edema: A Case Report.** Rachel A. Brakke, MD (University of Washington, Seattle, WA); Christine Jette, BA; Kathleen R. Bell, MD, RN.

**Disclosure:** R.A. Brakke, None; C. Jette, None; K.R. Bell, None.

**Setting:** Acute rehabilitation hospital. **Patient:** A 54-year-old ethnic Chinese woman. **Case Description:** This patient developed severe high altitude cerebral edema (HACE) at 4200m (14,000ft) while visiting China. She suffered from dizziness and confusion, progressing to coma. She was stabilized locally before moving to Taipei, where she was treated with steroids and hyperbaric oxygen. She was transferred to an acute hospital in the United States 2 months later. Brain magnetic resonance imaging showed increases in the T2 flair within the deep white matter of the splenium of the corpus callosum, consistent with HACE. She was transferred to an inpatient rehabilitation unit 3 months after injury. On admission, she was noted to have restricted end gaze of eye movements, contractures of shoulders, elbows, hips, knees, and ankles, and severe left upper-extremity apraxia, along with cognitive deficits. She had no memory of events, poor carryover, and trouble understanding or speaking more than phrases. **Assessment/Results:** During her 3-week stay in acute rehabilitation, she progressed in range of motion, balance, cognition, and communication. She was able to walk less than 150m (500ft) with stand-by assistance and demonstrated some insight into her deficits. After 3.5 weeks, she was dis-
charged to home with family supervision. She has resumed part-time work but continues to demonstrate cognitive impairment. Neuropsychologic test results will be presented along with follow-up imaging. **Discussion:** Neuropsychologic progress was quite delayed in this case of severe HACE, but dramatic clinical improvement ensued with a successful community discharge and return to work. **Conclusions:** No description of long-term outcome for HACE has been documented in medical literature. Based on this case, optimism is warranted even with the most severe neuropsychologic presentation; long-term prediction of outcome should be delayed for at least 3 to 4 months. **Key Words:** Altitude sickness; Brain injuries; Outcome assessment (health care); Rehabilitation.

**Poster 18**

**Amantadine Induced Psychosis in a 14-Year-Old Girl With a Traumatic Brain Injury: A Case Report. Loren T. Davidson, MD (The Children’s Hospital, Denver, CO); Joyce L. Oleszek, MD; Pamela E. Wilson, MD.**

Disclosure: L.T. Davidson, None; J.L. Oleszek, None; P.E. Wilson, None.

**Setting:** Tertiary care pediatric hospital. **Patient:** A 14-year-old girl involved in a pedestrian versus automobile collision, with resultant traumatic brain injury (TBI). **Case Description:** The patient’s initial Glasgow Coma Scale score was 6. Head computed tomography revealed a left fronto-temporal epidural, right parieto-occipital subdural, right lateral ventricular bleeds, and associated left temporal and zygomatic bone fractures. The patient was managed nonoperatively. There was no history of psychiatric disorder. On day 14 postinjury, the patient was transferred from the acute hospital to the inpatient rehabilitation service. On arrival at the rehabilitation service, the patient had a Rancho Los Amigos level of 5. Secondary to symptoms of fatigue, poor initiation, impairments in sustained attention, and poor concentration, the team elected to initiate pharmacologic stimulation with amantadine hydrochloride. The starting dose was 100mg twice daily, which resulted in improvements on initiation. On day 6, the patient was discharged home with a maintenance dose. The patient presented to the emergency department on day 13 of amantadine therapy with symptoms of visual and auditory hallucinations, homicidal threats, and mania. The symptoms resolved within 36 hours with discontinuation of the medication. **Assessment/Results:** Acute psychosis precipitated by amantadine hydrochloride in a patient with TBI. **Discussion:** Amantadine is a commonly used psychostimulant in brain injury rehabilitation. Review of the literature reveals increasing numbers of case reports, retrospective analyses, and more recently, a prospective, double-blind, randomized trial that supported its use in patients with symptoms of frontal lobe dysfunction. The medication is reportedly well tolerated, with a largely benign side-effect profile. We analyze a series of illustrative cases. **Design:** Retrospective case series analysis. **Setting:** Academic university medical center and rehabilitation hospital. **Participants:** 4 consecutive patients with resection of left medial frontal brain tumors treated between 2004 and 2005. **Interventions:** Not applicable. **Main Outcome Measures:** Volumetric brain lesion analysis, Geschwind Aphasia Categorization, manual motor testing, and FIM instrument scores. **Results:** 3 of the 4 patients experienced severe speech disorders (mutism and global reduction in spontaneous speech) and significant contralateral hemiparesis in the immediate postoperative period. These same 3 patients experienced varying degrees of hemineglect and impairment of voluntary motor function. Within 3 weeks, most speech and motor functions were recovered in the 3 affected patients. **Conclusions:** We summarize initial speech and motor deficits and subsequent recovery demonstrated by 4 patients during rehabilitation for resection of tumors from the left medial frontal brain region. Because all patients recovered their speech and motor function within 3 weeks postoperatively, we believe that these results confirm the transient nature of speech and motor deficits associated with supplementary motor area syndrome. In addition, some surgical factors appear to play a role in postoperative presentation of supplementary motor area syndrome, specifically the extent of tumor resection and cingulated gyr manipulation. **Key Words:** Cingulate gyrus; Frontal lobe; Hemiparesis mutism; Rehabilitation.

**Poster 20**

**Utility of the Abbreviated Injury Scale as an Assessment Tool Following Traumatic Brain Injury. Frederick W. Terry, DO (UVA, Charlottesville, VA); Paul T. Diamond, MD.**

Disclosure: F.W. Terry, None; P.T. Diamond, None.

**Objective:** To examine the utility of the Abbreviated Injury Scale (AIS) as an assessment tool for measuring brain injury severity and determining rehabilitation needs. **Design:** Retrospective analysis of a trauma registry database. **Setting:** University hospital level 1 trauma center. **Participants:** 528 consecutive patients presenting with acute trauma to the head. **Interventions:** Subjects were categorized into 5 groups based on assigned AIS scores. Analyses were performed to examine group differences in Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), hospital length of stay (LOS), survival, and discharge disposition. **Main Outcome Measures:** LOS; discharge disposition (home vs acute inpatient rehabilitation); and survival. **Results:** In patients with AIS scores of 1 to 4, mean GCS score was 14.0 (range, 13.6–15.0), mean LOS was 5.1 days (range, 1.3–8.1d), 87.7% were discharged home, 9.2% received acute inpatient rehabilitation, and 1.5% died. In patients with an AIS score of 5, mean GCS score was 6.37, mean LOS was 15.1 days, 20.8% were discharged home, 48.5% received acute inpatient rehabilitation, and 27.7% died. **Conclusions:** AIS scores of 1 to 4 had mild brain injury by GCS criteria and often did not require acute inpatient rehabilitation. Only patients with AIS scores of 5 had severe brain injury by GCS criteria and were likely to require acute inpatient rehabilitation at discharge. The AIS is a poor measure of brain injury severity and should not be used to assess brain injury rehabilitation needs. **Key Words:** Brain injuries; Injury severity score; Outcome assessment (health care); Rehabilitation.

**Cancer**

**Poster 21**

**Functional Outcomes of Cancer Patients in an Inpatient Rehabilitation Setting. San San Tay, MRCP (Singapore General Hospital, Singapore, Singapore); Peter A. Lim, MD; Yee Sien Ng, MRCP.**

Disclosure: S. Tay, None; P.A. Lim, None; Y. Ng, None.
**Objectives:** To establish the demographics and functional outcome data for patients with cancer and to compare these data with noncancer patients. **Design:** Prospective cohort study. **Setting:** Inpatient rehabilitation unit within a tertiary teaching hospital. **Participants:** 53 consecutive patients admitted for impairments related directly to cancer over a 4-year period. The mean age was 57.4 ±15.9 years and 64.2% were men. **Interventions:** Not applicable. **Main Outcome Measure:** FIM instrument scores. **Results:** This cancer cohort constituted 3.0% (53/1750) of all patients admitted to our inpatient rehabilitation unit. There were 45 patients with solid tumors (85.0%) and 8 patients with hematologic malignancies (15.0%). 55.6% of patients with solid tumors had metastatic disease. The mean rehabilitation length of stay was 14.3 days and 84.9% were discharged home. The admission and discharge total FIM scores were 69.3 ±19.3 and 85.0±20.7, respectively. The FIM gain was highly significant at 15.7±12.0 points (P<.001) and the FIM efficiency was .840±.813 points/day. Compared with the noncancer group, there was no difference in FIM gain or FIM efficiency (P=.811, P=.727, respectively). The most common complication in cancer rehabilitation was urinary tract infection (39.6%), followed by depression (24.5%) and pneumonia (18.9%). **Conclusions:** Cancer patients make good significant functional improvements equivalent to noncancer patients. Cancer patients should be offered a comprehensive inpatient rehabilitation program to maximize functional outcomes. **Key Words:** Cancer; Rehabilitation; Treatment outcome.

**Poster 22**

Monoclonal Gammopathy of Unknown Significance as a Cause of Noncompressive Radiculopathy: A Case Report. Patrick Sonser, MD (New York Presbyterian Hospital, New York, NY); Michael D. Stubblefield, MD; Christian M. Custodio, MD. Disclosure: P. Sonser, None; M.D. Stubblefield, None; C.M. Custodio, None.

**Setting:** Tertiary cancer care hospital. **Patient:** A 59-year-old woman with history of monoclonal gammopathy of unknown significance (MGUS) and right-sided breast cancer status post lumpectomy, chemotherapy, and radiation. **Case Description:** The patient presented with a 2-year history of bilateral burning, numbness, and tingling in the soles of her bilateral feet and toes with left greater than right. She denied any low back pain, weakness, or bowel and bladder changes. Manual muscle testing demonstrated 5/5 strength throughout bilateral upper and lower extremities. All reflexes were 2+ and symmetric bilaterally. Sensation was intact to light touch, proprioception, thermal perception, and pinprick throughout. Magnetic resonance imaging of the lumbar spine demonstrated minimal early degenerative changes without central or neuroforaminal stenosis. Nerve conduction studies exhibited normal motor and sensory nerve amplitude, distal latency, and conduction velocities. F waves were normal except for a minimally prolonged left tibial F-response latency. Electromyography revealed fibrillation potentials and positive sharp waves in the left tibialis anterior and centered on paraspinal muscles innervated by L5. Polyphasic motor units with increased amplitude and duration were noted in the left tibialis anterior. Needle electromyography was normal elsewhere. Laboratory evaluation, including complete blood count, antinuclear antibody, erythrocyte sedimentation rate, rheumatoid factor, C-reactive protein, vitamin B₁₂, glycosylated hemoglobin, cryoglobulins, and Lyme titers, were all negative. **Assessment/Results:** MGUS associated noncompressive radiculopathy. **Discussion:** MGUS is a common cause of chronic idiopathic demyelinating polyradiculoneuropathy (CIDP). Noncompressive radiculopathy is a component of CIDP and can exist in isolation from other peripheral nervous system dysfunction, in part due to anatomic and physiologic differences in the nerve root as well as the potentially vasculitic nature of CIDP. **Conclusions:** Noncompressive radiculopathy can be seen as a component of MGUS associated CIDP and can exist without electrophysiologic evidence for neuropathy. **Key Words:** Monoclonal gammopathies; Polyradiculoneuropathy, chronic idiopathic demyelinating; Radiculopathy; Rehabilitation.

**Poster 23**

Electrodiagnostic Testing Leading to a Diagnosis of Pancoast’s Tumor: A Case Report. Vladimir Salomon, DO (Nassau University Medical Ctr, East Meadow, NY); Glorisel Rodriguez, MD; Lyn Weiss, MD; Walter Gaudino, MD. Disclosure: V. Salomon, None; G. Rodriguez, None; L. Weiss, None; W. Gaudino, None.

**Setting:** Electrodiagnostic medicine clinic. **Patient:** A 55-year-old man. **Case Description:** The patient is right-handed dominant male painter with a 20-pack-year smoking history and a history of back injury 1 year ago. 6 months ago, he developed sudden pain in the left shoulder, numbness in the left forearm, and sharp hand burning pain. The patient also presented with atrophy of the medial left hand intrinsic muscles. He denied any neck pain. He was referred to the electrodiagnostic clinic to assess for cervical radiculopathy. **Assessment/Results:** Electromyography and nerve conduction study showed electrodiagnostic evidence of severe axonotmetic left lower-trunk plexopathy with sensory axonal peripheral neuropathy. In light of the patient’s electrodiagnostic findings and history of smoking, a chest computed tomography (CT) was recommended to rule out carcinomatous process. CT of the chest revealed a mass in the left superior sulcus of the lung, which was suspicious for Pancoast’s tumor. The patient then underwent surgical resection of the left upper lobe with excision and biopsy of the mass. On biopsy, the lung mass was compressing the lower trunk of the brachial plexus. The biopsy report showed evidence of poorly differentiated stage 2 adenocarcinoma with extension into visceral pleura, with no regional lymph node involvement. **Discussion:** Pancoast’s tumors are much less common than other lung cancers. These tumors comprise 1% to 3% of all lung cancers. After resection of the tumor, the patient had increased strength and sensation in the left hand as well as decreased shoulder pain. **Conclusions:** It is important to rule out Pancoast’s tumor in patients with lower-trunk plexopathies. A diagnosis of carcinomatous neuropathy should be strongly considered in a patient with sensory axonal neuropathy. The symptoms produced by the disorder can be mimicked by numerous neurologic or musculoskeletal disorders, thus delaying diagnosis. A careful neurologic exam, radiographs, and electromyography and nerve conduction studies guide and verify the diagnosis. **Key Words:** Brachial plexopathy; Pancoast’s syndrome; Rehabilitation.

**Poster 24**

Pancratic Cancer Presenting as Thoracic Spine Pain: A Case Report. Jonah E. Fox, MD, MHA (UVA Health System, Charlottesville, VA); Ward G. Gypson, MD; Mary G. Bryant, MD. Disclosure: J.E. Fox, None; W.G. Gypson, None; M.G. Bryant, None.

**Setting:** Academic outpatient PM&R clinic. **Patient:** A 57-year-old woman with a 3-month history of mid-thoracic spine pain. **Case Description:** The patient developed constant, aching, nonradiating mid-thoracic pain suddenly with no change in her activity, acute injury, weight loss, or exacerbating factors. She was initially treated for muscle strain with antispasmodics, a transcutaneous electric nerve stimulation unit, physical therapy, and narcotics, with little relief. She was seen in an orthopedic clinic and magnetic resonance imaging of the thoracic spine was ordered, which was negative. She was referred to our PM&R clinic. The patient had a normal sensory and motor exam and pain could not be elicited with maneuvers, and referred pain from
Objective: To examine the major clinical and economic outcomes of cardiopulmonary patients referred for inpatient rehabilitation or skilled nursing care. Design: Retrospective, comparative study. Setting: Inpatient rehabilitation facilities (IRF) and matched skilled nursing facilities (SNF) in central Virginia. Participants: Cardiovascular and pulmonary patients (N = 504; age, 76.2 ± 5.9y) with major diagnoses and procedures of coronary artery disease, bypass grafting, myocardial infarction, peripheral arterial disease, aneurysm, heart failure, chronic obstructive pulmonary disease, pneumonia, and pulmonary embolisms. Interventions: Not applicable. Main Outcome Measures: Changes in functionality (assessed by the FIM instrument and Minimum Data Set), length of stay (LOS), total and itemized facility charges, and discharge disposition. Results: Participation in physical and occupational therapies occurred during 72% to 78% and 48% to 51% of total days in the IRF and SNF, respectively (P < .001). Changes in eating, grooming, bathing, dressing, toileting, bed to chair transfers, walking, verbal expression, problem solving, and auditory comprehension were greater in patients from the IRF than the SNF (all P < .001). LOS was longer in the SNF than the IRF (34.7 ± 3.4d vs 14.9 ± 0.5d, P < .001). In the IRF compared with the SNF, total charges ($22,162 vs $10,873), pharmacy charges ($3104 vs $1604), and combined physical and occupational therapy charges were higher ($5225 vs $3582) (all P < .001). More IRF patients were discharged home (77.5% vs 44.1%), and fewer were discharged to acute care (15.8% vs 23.2%) or died (1.3% vs 13.6%) than SNF patients during their stay. Conclusions: Functional outcomes, LOS, and discharge dispositions are significantly better in the IRF than the SNF, and this is associated with a higher cost of care. The poorer outcomes in the SNF may be related to advancing age, severity and type of illness, greater frequency of cognitive decline, and inability to fully participate in therapies. Key Words: Pulmonary diseases; Rehabilitation; Treatment outcome.

Poster 27
Free Fat Mass Helps Predict Exercise Capacity Better Than Weight During Cardiopulmonary Exercise Test in Normal Subjects. Hildegarde Paz-Diaz, MD (St Elizabeth Medical Ctr, Tufts University School of Medicine, Boston, MA); Harpreet Toor, MD; Bartolome Celli, MD; Victor Pinto-Plata, MD.
Disclosure: H. Paz-Diaz, None; H. Toor, None; B. Celli, None; V. Pinto-Plata, None.
Objective: To test the hypothesis that the predictive value of maximal exercise capacity (\(V_{\text{O2max}}\)) would be more precise if the oxygen uptake was estimated using fat free mass (FFM) instead of total body weight. Design: Body weight was measured in kilograms and body mass index calculated as body weight/height\(^2\). Body composition analysis was assessed using the Bodystat 1500. From this we determined fat weight, lean weight, total body water, and calculated fat free mass index (FFMI). Setting: Not provided. Participants: We studied 44 men and 25 women. Patients had a mean age of 63 ± 7 years, height of 169 ± 9m, weight of 79 ± 18kg, and forced expiratory volume in 1 second of 90% ± 15% of predicted. Interventions: Not applicable. Main Outcome Measures: Cardiopulmonary exercise test (CPET) was performed on a cycle ergometer while breathing room air. After a 2-minute baseline resting period and a 3-minute unloaded cycling, power was increased by 16W every minute until exhaustion to determine the maximal workload. Regression equations were built for \(V_{\text{O2max}}\) using either body weight (in kilograms) or FFM weight. Results: Body mass analysis showed an FFM of 61 ± 17kg and an FFMI of 25 ± 7kg/m\(^2\). A stronger significant correlation with tighter 95% confidence interval bands was seen between maximal \(V_{\text{O2max}}\) and FFMI (r = .66, P < .001) than between maximal \(V_{\text{O2max}}\) and absolute weight (r = .43,
P<.002). Conclusions: Our results indicate that during CPET, the use of FFM rather than absolute weight provides a more accurate prediction of exercise capacity. Key Words: Exercise test; Nutrition; Rehabilitation.

Poster 28
Predictors of Readmission to Acute Care and Mortality in the Inpatient Rehabilitation Setting Among Cardiovascular Patients. Heather K. Vincent, PhD, MS (University of Florida, Gainesville, FL); Sally Gamon, RN; Kevin R. Vincent, MD, PhD. Disclosure: H.K. Vincent, ARA Research Institute, AMRPA; S. Gamon, None; K.R. Vincent, None.

Objective: To identify factors associated with readmission to acute care and mortality in the inpatient rehabilitation facility (IRF). Design: Retrospective study. Setting: A free-standing university-affiliated IRF.

Participants: Cardiovascular patients who received acute care and subsequent inpatient rehabilitation (N=138; 64.1% men; age, 72.4±11.8y; 80.8% Medicare insured) from December 1, 2002, to March 31, 2006. Diagnoses included coronary artery disease, heart failure, peripheral vascular disease, aneurysms, acute myocardial infarction (MI), heart valve repair or replacement, heart transplant, and peripheral bypass graft.

Interventions: Not applicable. Main Outcome Measures: Patient variables (interventions, diagnostic test results, care needs, FIM instrument scores), discharge disposition, readmissions to acute care, and mortality. Results: 15.4% of patients were readmitted to acute care for MI symptoms, failure to thrive, falls, mental status change, and infection. 2.4% of patients expired during rehabilitative care; causes of death included second infarction, heart failure exacerbation, and blood loss. Patients readmitted to acute care had a longer IRF length of stay (LOS) than remaining patients (23.2±5.1d vs 13.8±7.8d, respectively; P<.05) but total IRF charges did not differ statistically ($23,550 vs $19,567, P=.279). Age- and sex-adjusted regression models revealed that independent predictors of readmission to acute care included presence of dysrhythmias or foot ulcers, an indwelling catheter, angina, peripheral vascular disease, anxiety, lung atelectasis, development of infections, percentage of days active with therapies, and IRF LOS (all models, P<.05). Independent predictors of mortality in the IRF included previous infarction prior to rehabilitation, angina, presence of diabetes, and specific admission low FIM subscores (bathing, verbal expression, problem solving, memory, auditory comprehension) (all P<.05). Conclusions: Prediction of acute care readmission and mortality is multifaceted, and these preliminary findings can be used to start identifying which patients are less likely to succeed in the IRF.

Key Words: Mortality; Rehabilitation.

Poster 29
Inpatient Rehabilitation Outcomes Are Influenced by Cognitive Status, Comorbidities, and Skin Quality in Cardiopulmonary Patients. Heather K. Vincent, PhD, MS (University of Florida, Gainesville, FL); Sally Gamon, RN; Kevin R. Vincent, MD, PhD. Disclosure: H.K. Vincent, ARA Research Institute, AMRPA; S. Gamon, None; K.R. Vincent, None.

Objective: To identify factors in cardiovascular and pulmonary patients that are associated with good clinical outcomes during inpatient rehabilitation. Design: A retrospective, exploratory study. Setting: 2 inpatient rehabilitation facilities. Participants: Patients admitted for inpatient rehabilitation following acute care (N=311). Patients were categorized by major ICD-9 classifications. Interventions: Not applicable. Main Outcome Measures: Length of stay (LOS), facility charges, patient variables (demographics, medical conditions, diagnostic labwork and tests, therapy volume, skin and continence treatments, nutrition, cognitive status). Results: Cardiovascular patients accumulated fewer occupational therapy hours during rehabilitation than pulmonary patients (12.0±0.6h vs 14.1±0.6h, P=.018), while the volume of physical therapy did not differ between groups (13.7±0.8 vs 15.1±0.6). Pulmonary patients had higher total ($24,373 vs $19,975), therapy, and pharmacy costs than cardiovascular patients, while LOS did not differ between groups (15.1d vs 14.7d, respectively). The longest LOS was found in pulmonary fibrosis and pleural effusion and femoral artery bypass (19.2–224), and shortest in aortic valve replacement and respiratory failure (10.0–11.9d). Highest total charges occurred in lung transplant and pulmonary fibrosis ($35,807 and $35,330) and the lowest in valve replacement and coronary artery bypass graft ($12,295 and $15,590). Age- and sex-adjusted regression models for longer LOS revealed that significant contributors included duration of illness, depression, presence of indwelling catheter, disorientation, skin treatments, ulcer care, foot lesions (Braden scale value), development of infection, readmissions to acute care, total medications, comorbidity number, and Charlson Index (all models, P<.01). Adjusted models found that significant predictors for high total facility charges included these factors and parental nutrition and development of mental confusion during the stay (P<.05). Conclusions: Contributors to LOS and hospital charges are complex and are dependent on multiple individual patient variables. The patient as an entity should be considered when preparing for resource allocation and discharge plans. Key Words: Outcome assessment (health care); Pulmonary diseases; Rehabilitation.

Poster 30
Prevalence of Musculoskeletal Complaints, Pain Medication Usage, and Impact on Health-Related Quality of Life of an Outpatient Exercise Intervention as a Part of a Phase II Cardiac Rehabilitation Program. Manoj Mithal, MD, PhD (UB PM&R, Tonawanda, NY); John P. Naughton, MD; Jong-Chaur Shieh, MD; Carl V. Granger, MD; Danielle Rhodes, RN; Jennifer D. Jones, RN. Disclosure: M. Mithal, None; J.P. Naughton, None; J. Shieh, None; C.V. Granger, None; D. Rhodes, None; J.D. Jones, None.

Objectives: To assess prevalence of musculoskeletal complaints in patients participating in outpatient cardiac rehabilitation; to assess the impact of outpatient cardiac rehabilitation on health-related quality of life (HRQOL); and to assess pain medication usage during participation in outpatient cardiac rehabilitation. Design: Pre- to postintervention study. Setting: Outpatient phase II cardiac rehabilitation (CR) program. Participants: 31 patients, 19 of whom completed the study. The patients were all men who had a mean age of 67.4 years (n=19). Intervention: 12-week outpatient phase II CR program with 24 sessions of aerobic exercise and 12 weeks of resistance exercise. Main Outcome Measures: Musculoskeletal complaints were recorded as a part of each patient’s history and physical. A graded exercise test was used to assess patients’ aerobic exercise capacity, expressed in metabolic equivalents (METS). The LIFEware Cardiac Assessment Instrument and the Short-Form 36-Item Health Survey were used for HRQOL. Medication usage was monitored using the electronic medical record. Results: Percentage increase in METS pre to post cardiac rehabilitation was 37.7%. 37% of the patients reported musculoskeletal complaints. Knee pain was the most common. Improvement in HRQOL was statistically significant. Pain medication usage was 68% at pre, 47.4% at 12 sessions, and 42.1% at 24 sessions. Conclusions: Despite musculoskeletal complaints, patients derived significant benefit from CR, resulting in cardiovascular risk reduction. A decline in pain medication usage from pre to 24 sessions reflects a favorable trend as pain medications, especially nonsteroidal anti-inflammatories, increase cardiovascular risk. Improved tracking of musculoskeletal complaints is needed to better assess the affect of CR on
musculoskeletal limitation. **Key Words:** Cardiac care facilities; Pain; Quality of life; Rehabilitation.

**Clinical Outcomes**

**Poster 31**

**Treatment Outcomes of a 1.5-Day Fibromyalgia Treatment Program.** Michele Stueve, MD (Mayo Clinic, Rochester, MN); Terry Oh, MD; Connie Luedtke, MA, RN; Tanya Hoskin, MS; Jeffrey Thompson, MD.

**Disclosure:** M. Stueve, None; T. Oh, None; C. Luedtke, None; T. Hoskin, None; J. Thompson, None.

**Objective:** To evaluate the efficacy and long-term benefit of a 1.5-day multidisciplinary fibromyalgia treatment program (FTP). **Design:** Retrospective, cohort study. **Setting:** The FTP within a tertiary care center. **Participants:** 1016 subjects who were confirmed to have fibromyalgia and underwent the FTP from May 2001 through May 2004. Age ranged from 15 to 87 years (mean age, 48.3y); 94.2% were women and 5.8% were men. **Intervention:** 1.5-day multidisciplinary FTP administered by physicians, nurses, and physical and occupational therapists, which consisted of evaluation to confirm the diagnosis of fibromyalgia, cognitive behavioral techniques, and education on self-management strategies, exercise, and activity modification. **Main Outcome Measures:** The Fibromyalgia Impact Questionnaire (FIQ) and Health Status Questionnaire (HSQ) 2.0 were administered at baseline, 6 months post treatment, and 12 months post treatment. Changes were assessed between baseline and each of the post-treatment surveys using paired t tests. **Results:** Compared with baseline, the total score on the FIQ was reduced by a mean of 5.8 points after 6 months (P<.001) and 5.6 after 12 months (P<.001). FIQ subscales that showed statistically significant improvement at both 6 and 12 months included: physical functioning, pain, fatigue, morning tiredness, stiffness, job difficulty, anxiety, days of work missed, and overall well-being in the past week. No change was seen in the depression score. Statistically significant improvements on the HSQ 2.0 were noted in both physical and mental component scales (P<.001) at 6 months and were maintained at 12 months. **Conclusions:** A brief, 1.5-day multidisciplinary FTP is effective in reducing fibromyalgia impact and the benefit is maintained at 1-year follow-up. Most current fibromyalgia programs offer treatment that is weeks to months in length. A brief FTP may be a cost-effective alternative for those with fibromyalgia. **Key Words:** Fibromyalgia; Outcome assessment (health care); Rehabilitation.

**Poster 32**

**Use of Propranolol for Treating Tacrolimus-Induced Tremors: A Case Report.** Timothy Yoon, MD, MPH (University of Michigan Hospitals, Ann Arbor, MI); Brian M. Kelly, DO; Joseph Hornyk, MD, PhD.

**Disclosure:** T. Yoon, None; B.M. Kelly, None; J. Hornyk, None.

**Setting:** Academic university hospital. **Patient:** A 50-year-old man with resting and intention tremors 2 months after right orthotopic lung transplantation. **Case Description:** The patient was maintained on tacrolimus, azathioprine, and prednisone therapy postoperatively. The patient demonstrated both resting and intention tremors on admission to acute rehabilitation. The tremors began to impact the patient’s activities of daily living, requiring supervision for eating and minimal assistance for grooming, bathing, and dressing. **Assessment/Results:** The patient’s tacrolimus dose was increased, with corresponding elevations in serum levels. At this point, propranolol therapy was initiated at 10mg every 12 hours, with a final dose of 10mg every 8 hours. Within 48 hours, the patient subjectively reported decreased frequency and severity of tremors. 3 weeks later, the patient was independent for eating and at a modified independent level for grooming, bathing, and dressing. This demonstrated a marked improvement of at least 1 FIM instrument level prior to propranolol treatment. This was unchanged at a 2-month outpatient follow-up. **Discussion:** Tacrolimus’s primary mechanism of action is to inhibit calcineurin activity. Research into the pathophysiology of tacrolimus-induced hypertension has demonstrated the presence of calcineurin and tacrolimus-binding proteins within the peripheral and central nervous system. These animal studies showed that binding to these proteins results in higher sympathetic nerve activity. Propranolol, a β-adrenoreceptor antagonist, is used as treatment for essential tremors. However, no studies have shown its utility in treating tacrolimus-induced tremors. Animal models of tremor have demonstrated that propranolol’s effects are mediated via antagonism of central adrenoreceptors. Another study using preferential antagonists of peripheral β-adrenoreceptors found that they reduce essential tremors. **Conclusions:** The pharmacologic treatment of essential tremor has been well documented. In situations of drug-induced tremors in which the offending agent may not be discontinued, propranolol appears to be an efficacious treatment option. **Key Words:** Essential tremor; Rehabilitation.

**Poster 33**

**Implementation of an Ultrasonic Bladder Scanning Protocol for Assessment and Management of Urinary Retention is Associated With a Reduction in Urinary Tract Infections in an Acute Inpatient Rehabilitation Hospital.** Kate W. Paylo, DO (University of Virginia, Charlottesville, VA); Mary G. Bryant, MD; Heather Cosner, RN; Alan P. Alano, MD; Lori Aylor, RN; Jonathan Evans, MD, MPH.

**Disclosure:** K.W. Paylo, None; M.G. Bryant, None; H. Cosner, None; A.P. Alano, None; L. Aylor, None; J. Evans, None.

**Objective:** To evaluate the effect of a hospital-wide ultrasonic bladder scanning protocol on reducing the incidence of hospital-acquired urinary tract infections (UTIs). **Design:** Intervention study (pre-post design). **Setting:** 50-bed academic acute inpatient rehabilitation hospital. **Participants:** Adult patients for whom assessment of postvoid residual urine volume was clinically indicated. **Implementation:** Implementation of a bladder scanning protocol for the evaluation and management of urinary retention. **Main Outcome Measures:** Rates of hospital-acquired UTIs per 1000 patient-days before and after implementation of the clinical protocol. **Results:** UTI rates fell significantly from 7.13 to 3.88 per 1000 patient-days over a 2-year period, despite an increase in the severity of clinical illness (case-mix) over the same time period. There was also a significant reduction in the number of intermittent catheterizations (ICs) performed. **Conclusions:** Urinary retention is common among hospitalized patients undergoing acute inpatient rehabilitation and may arise in a variety of clinical conditions. IC of the bladder has been a mainstay of evaluating, monitoring, and treating urinary retention. The implementation of a hospital-wide bladder scanning protocol was associated with a clinically meaningful overall reduction in the incidence of UTIs. Because ICs were also reduced, it is plausible to conclude that UTIs were prevented through the avoidance of ICs, particularly for diagnostic purposes. Reduction in hospital-acquired UTIs is a desirable outcome, irrespective of the mechanism by which it was achieved. Nevertheless, there are several other potential explanations for the reduction in UTIs. Reported rates of hospital-acquired UTIs are confounded by asymptomatic bacteriuria. Consequently, reduction in ICs is expected to reduce the rate of testing for UTIs, which in turn reduces the rate at which asymptomatic bacteriuria is identified. **Key Words:** Rehabilitation; Urinary retention.
Poster 34
Extended-Release Morphine Sulfate With Sequestered Naltrexone is Effective in Treating the Pain of Osteoarthritis. Alan Kivitz, MD (Altoona Ctr for Clinical Research, Duncansville, PA); Franklin Johnson, MS; Linda Fox, BS; James Jones, MD, PharmD; Stephen Sun, MD; Joseph Stauffer, DO.
Objective: To assess the efficacy, tolerability, and pharmacokinetics of an extended-release morphine sulfate plus sequestered naltrexone compound (SNC) (naltrexone released if product tampering occurs) compared with polymer-coated extended-release morphine sulfate (P-ERMS; Kadian). Design: Prospective, randomized, double-blind crossover.
Setting: Outpatient research sites. Participants: Adults (N=113) unable to control osteoarthritis (hip, knee) pain with nonopioid analgesics or received ≤40mg/d of oral morphine equivalents. Patients (median age, 57.0y) were mostly women (68.5%) and white (88.3%). Interventions: Washout from previous medication, P-ERMS dose titration to effective analgesia, two 14-day treatment periods (P-ERMS or SNC), 7 days P-ERMS after each treatment period. Main Outcome Measures: Average pain intensity (0—10 scale); daily Brief Pain Inventory (BPI) (worst, least, average, current; 0—10 scales); Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index; Patient Global Assessment of Medication (1 [poor] to 5 [excellent]); morphine, naltrexone, and 6-β naltrexol pharmacokinetics. Results: Mean pain intensity after washout was 7.1; after P-ERMS titration, 2.1. For treatment days 7 and 14, intensities were: P-ERMS, 2.3 and 2.4; SNC, 2.4 and 2.3 (P=NS), respectively. For the BPI scales, P-ERMS and SNC were similar across the 14-day periods. WOMAC pain, physical function, and composite scores were similar between treatments. Most patients rated medications as good to excellent (P-ERMS, 78.9%; SNC, 91.5%). Steady-state morphine exposure area under the curve was similar between treatments. Most naltrexone levels were below limits of quantification; 6-β naltrexol levels were low or below limit of quantification. Adverse events were mostly mild to moderate; most common were: constipation (double-blind P-ERMS, 12.7%; SNC, 15.5%); nausea (8.5%; 9.9%); and somnolence (8.5%; 9.9%). Conclusions: SNC provided similar pain relief to P-ERMS; most patients rated P-ERMS and SNC as good to excellent. Naltrexone was adequately sequestered; low levels, when present, did not negatively impact patients’ pain scores or produce symptoms associated with opioid withdrawal. Key Words: Arthritis; Morphine; Rehabilitation; Substance abuse.

Poster 35
Spinal Cord Stimulation Versus Conventional Medical Management: A Multicenter Randomized Controlled Trial of Patients With Failed Back Surgery Syndrome. Richard North, MD (The Johns Hopkins University, Baltimore, MD).
Disclosure: R. North, employee of Johns Hopkins University (JHU). JHU receives some grant or contract support from Medtronic, ANS, and Advanced Bionics; JHU may receive royalties from an arrangement with ANS, a portion of which would go to North as an inventor’s share.
Objective: To evaluate the clinical (and cost-) effectiveness of the addition of spinal cord stimulation (SCS) to conventional medical management (CMM) of patients with failed back surgery syndrome (FBSS). Design: Randomized controlled trial. Patients were followed up to 24 months, with crossover after the 6-month visit on patient request. Setting: 12 hospitals in Europe, Canada, and Australia. Participants: 100 patients suffering from persistent neuropathic pain predominately in the legs. Intervention: SCS plus CMM versus CMM alone. Patients in either group received appropriate adjuvant therapy (excluding spinal surgery or intrathecal drug delivery). Main Outcome Measures: Pain relief (>50% change on visual analog scale), functional capacity (Oswestry Disability Index), and health-related quality of life (HRQOL) (assessed by the Short-Form 36-Item Health Survey), patient satisfaction, and adverse effects. Results: In an intention-to-treat analysis at 6 months, patients randomized to SCS experienced the following improvements when compared with CMM alone: significantly more leg pain relief (P<.000), improved functionality (P=.000), improved HRQOL in 7 of 8 domains (P range, .02—.000), and greater satisfaction with their treatment (P<.000). 14 (29%) of the 48 patients who received a stimulator had a complication that required additional surgery. Conclusions: Compared with CMM alone, SCS improves pain relief, HRQOL, and functionality in predominately neuropathic FBSS patients at 6 months. The 12-month follow-up was completed in July 2006. Key Words: Electric stimulation; Pain; Rehabilitation; Reoperation.

Poster 36
Rare Case of Blastomycosis of the Spine With Central Nervous System Manifestations in a Nonimmunocompromised Patient: A Case Report. Jafar W. Siddiqui, MD (Rush University Medical Ctr, Chicago, IL); James Young, MD; Xuong K. Tang, DO; Hoang Vu, DO; Blaine Washington, MD.
Disclosure: J.W. Siddiqui, None; J. Young, None; X.K. Tang, None; H. Vu, None; B. Washington, None.
Setting: Tertiary care hospital. Patient: A 47-year-old man with bilateral lower extremity (LE) weakness and numbness. Case Description: Patient without significant medical history presented with atraumatic bilateral LE weakness, parasthesia, back pain, and 1 episode of stool incontinence. Imaging studies revealed left apical and mediastinal lung masses with an epidural mass lesion causing significant spinal stenosis and cord compression at T3-8. Assessment/Results: The patient underwent immediate laminectomy (T3-5) and debulking of the epidural mass. Biopsy revealed granulomatous inflammation with necrosis, containing yeast consistent with blastomycosis. Patient was started on voriconazole for 6 months. On discharge, the patient was independent for functional transfers and modified independent for ambulation 90m (300ft) with a rolling walker. He was fitted with an ankle-foot orthosis for partial right LE residual weakness. Follow-up magnetic resonance imaging revealed only mild spinal stenosis and thecal sac compression. Discussion: Fungal infections of the spine are uncommon. Blastomycosis is endemic to the southeastern and midwestern United States, usually found in mold form in the soil. It commonly begins as a pulmonary infection from inhalation of the spore and subsequent hematogenous spread in its disseminated form. It can affect multiple organ systems and typically involves the lungs, skin, bone, genitourinary, and infrequently the central nervous system (CNS). The most common CNS infections are meningitis and cranial abscesses, and they rarely occur in the spinal cord. Because blastomycosis has nonspecific symptoms, diagnosis is difficult and it is often mistaken for a neoplasm. Thus, biopsy is mandatory. Treatment consists of long-term antifungal therapy and/or abscess drainage. Conclusions: Although rare, blastomycosis of the spine with or without CNS symptoms should be included in the differential diagnosis of epidural lesions. For preservation of function, prompt diagnosis and aggressive treatment with pharmacotherapy, rehabilitation, and surgery if necessary, should be instituted to prevent crippling spinal deformity and disability. Key Words: Blastomycosis; Rehabilitation; Spinal cord.
Poster 37
Long-Term Effectiveness of Sustained-Release Opioids in the Treatment of Nonmalignant Pain. Michael Rivera-Weiss, MD (Doctors Hospital, Massillon, OH).
Disclosure: M. Rivera-Weiss, Research support: Alpharma Branded Products Division Inc; Honoraria: Alpharma Branded Products Division Inc; Speakers bureau: Alpharma Branded Products Division Inc; Honoraria: Alpharma Branded Products Division Inc; Speakers bureau: Alpharma Branded Products Division Inc; Honoraria: Alpharma Branded Products Division Inc; Speakers bureau: Alpharma Branded Products Division Inc.
Objective: To examine short-term (3mo), mid-term (6mo), and long-term (12mo) effectiveness and dosing of 3 sustained-release opioids (SROs) in managing chronic, moderate to moderately severe, nonmalignant pain. Design: Retrospective chart review of defined patient population. Setting: Hospital-based outpatient pain management center. Participants: Records of adult outpatients (N=105) with chronic, nonmalignant pain of moderate to moderately severe intensity who failed to achieve satisfactory pain management from their prior short-acting opioid and subsequently took a selected SRO for ≥1 year. Overall, patients had a mean age of 53.8 years and 62.9% were women.
Interventions: Records were reviewed on patients taking polymer-coated extended-release morphine sulfate (P-ERMS; Kadian) (n=41), transdermal fentanyl (Duragesic) (n=40), or controlled-release oxycodone (OxyContin) (n=24) for ≥1 year. Main Outcome Measures: Visual analog scales (0 [best] to 10 [worst]) for pain and quality of life outcomes (activity, work, relations, sleep, enjoyment). Results: There were no statistically significant demographic differences between treatment groups, with the exception that a higher percentage of patients on P-ERMS versus controlled-release oxycodone were men (46.3% vs 20.8%; P=.040). The most common conditions requiring pain relief were degenerative disk disease, osteoarthritis, and postlaminctomy syndrome. Pain scores improved from baseline through 3, 6, and 12 months as follows: P-ERMS (7.6, 6.5, 6.7, 6.3); transdermal fentanyl (8.3, 6.6, 6.5, 6.0); and controlled-release oxycodone (8.1, 7.0, 6.4, 6.3) (all comparisons vs baseline, P<.05). Similar significant changes were reported on the activity, work, relations, sleep, and enjoyment scales. The biggest change in dose of SRO was from baseline to 3 months. Conclusions: Patients who remained on SRO formulations for 12 months demonstrated significant reductions in pain and improvements in other quality of life measures that were evident at 3 months and were maintained through 12 months of therapy. Key Words: Fentanyl; Morphine; Oxycodone; Rehabilitation.

Poster 38
Intrathecal Baclofen for Spasticity Management: A Comparative Analysis of Spasticity of Spinal Versus Cortical Origin. April M. Saval, MS, PA-C (University of Michigan, Ann Arbor, MI); Anthony Chiodo, MD.
Disclosure: A.M. Saval, None; A. Chiodo, None.
Objective: To examine the differences in intrathecal baclofen (ITB) management of patients with spasticity from cortical versus spinal etiologies. Design: Retrospective chart review. Setting: Outpatient clinic. Participants: 44 people with diagnoses of spinal cord injury (SCI), multiple sclerosis (MS), cerebral palsy (CP), and traumatic brain injury (TBI) with severe spasticity requiring an ITB pump.
Interventions: Not applicable. Main Outcome Measures: Dosage of medication required, impact on function, complex versus simple continuous delivery modes, physician contact, need for other spasticity treatment, and complications. Serial measurements of these parameters were taken at baseline and multiple follow-up visits. Results: Patients with CP and TBI had less physician contact than MS patients, patients with incomplete SCI, and ambulatory patients in the first 6 months. There was more intragroup variation in dosing than between groups, varying from 37 to 900ug/d, with 33% of patients on simple continuous mode. Increasing dosages after the 1-year period were needed in 40% of patients, 40% of patients after 2 years, 16% of whom were diagnosed with SCI and 12% with MS. Many patients who needed increases after 2 years had new onset triggers for spasticity or catheter malfunctions. 5 patients, 80% with TBI or CP, required botulinum toxin after pump implants. 5 subjects had catheter complications—3 from falls or trauma and 2 from catheter migration. Conclusions: Ambulatory patients, predominantly patients with MS and SCI, required more dosing changes than nonambulatory patients and had issues with strength and motor planning, even after spasticity had been optimized. Ongoing dose increases 1 to 2 years after the pump has been placed may denote underlying spasticity triggers or problems with the pump. Patients with CP or TBI appear to have stable spasticity after 6 months to 1 year, but may need other focal treatments. Key Words: Baclofen; Muscle spasticity; Rehabilitation.

Poster 39
A Multicenter Examination of the Effect of Body Mass Index on Inpatient Rehabilitation Outcomes Following Total Knee Arthroplasty. Heather K. Vincent, PhD, MS (University of Florida, Gainesville, FL); Kevin R. Vincent, MD, PhD.
Disclosure: H.K. Vincent, None; K.R. Vincent, None.
Objective: To examine whether inpatient rehabilitation outcomes following total knee arthroplasty (TKA) were influenced by body mass index (BMI). Design: A multicenter, retrospective study. Setting: 15 inpatient rehabilitation facilities along the U.S. east coast. Participants: Patients who underwent TKA and were subsequently admitted to an inpatient rehabilitation facility for interdisciplinary rehabilitation (N=5428). Patients were separated into 4 groups based on BMI: nonobese (<30kg/m²), moderately obese (30–40kg/m²), severely obese (40.1–50kg/m²), and very severely obese (≥50kg/m²). Interventions: Not applicable. Main Outcome Measures: Data were obtained using a computerized medical database and medical records. Changes in functionality (assessed by FIM instrument), FIM efficiency (points gained/d), length of stay, total and itemized facility charges, and discharge disposition. Results: The percentage of total FIM change was 7.5% greater by discharge in the nonobese than very severely obese (P<.05). FIM efficiency was lower in the very severely obese than in the remaining groups (3.7 points/d vs 4.0–4.3 points/d; P<.05). The change in the FIM motor score from admission to discharge was 6.7% to 15.6% greater in the nonobese than in the remaining 3 groups (P<.05). The change in FIM cognition, “toilet transfers,” and “walking without assistance” scores were higher in the nonobese than in the very severely obese group (P<.05). The very severely obese group had higher total, physical and occupational therapy, and pharmacy charges than the remaining groups (P<.001). There were no differences in discharge frequencies to home, acute care, or other locations among the 4 BMI groups. Conclusions: An excessive BMI does not prevent gains during inpatient rehabilitation, however, these gains are made less efficiently and at a higher cost than those made when BMI is low. Key Words: Arthroplasty, replacement, knee; Body mass index; Outcome assessment (health care); Rehabilitation.

Poster 40
Relationship of Admission Hematocrit Level to Inpatient Rehabilitation Outcomes Following Total Knee Arthroplasty: A Multicenter Examination. Heather K. Vincent, PhD, MS (University of Florida, Gainesville, FL); Kevin R. Vincent, MD, PhD.
Disclosure: H.K. Vincent, None; K.R. Vincent, None.
Objective: To examine the relationship of admission hematocrit (HCT) levels on inpatient rehabilitation outcomes following total knee arthroplasty (TKA). Design: A multicenter, retrospective study. Set-
ting: 15 inpatient rehabilitation facilities (IRF) along the U.S. east coast. Participants: Patients who underwent TKA and were subsequently admitted to an IRF for interdisciplinary rehabilitation. Interventions: Not applicable. Main Outcome Measures: Changes in functionality (FIM instrument), FIM efficiency (points gained/d), length of stay (LOS), total and itemized charges, and discharge location. Results: Total, motor, and cognition FIM scores at admission and discharge and FIM change scores during the inpatient stay did not differ significantly among HCT groups. LOS was 6.1% to 10.6% longer in the very low HCT group than in the low and normal groups, respectively (P<.001). Total hospital charges were $1158 to $1590 higher in the very low HCT than in the low and normal HCT groups, respectively (P=.000). Similarly, pharmacy charges were 16.3% to 21.4% higher in the very low HCT than in the remaining groups (P=.000). The frequency of discharge dispositional differences did not differ among the groups: 92% to 94% of patients returned home in all groups. Regression analyses revealed that HCT was a significant predictor in models for total charges, LOS, and FIM efficiency (all P<.001). Conclusions: While functional gains were not adversely influenced by admission HCT, a very low HCT is associated with a longer LOS and higher hospital charges. Low HCT may be accompanied by greater prevalence of revision or bilateral TKA surgeries, both of which are associated with suboptimal outcomes. This information can be used to plan expectations for discharge and inpatient hospital resources. Key Words: Arthroplasty, replacement, knee; Hematocrit; Rehabilitation; Treatment outcome.

Poster 41
The Clinical Correlation Between Physical Findings of Weakness or Positive Dural Tensions Signs on Examination and the Response to Transformaminal Epidural Injections. Binh D. Luu, MD (Stanford, Palo Alto, CA); Esther Kim, MD; Edgar Han, DO; David Ben-Aviv, MD; Navjeet Boparai, MD; Raj Mitra, MD. Disclosure: B.D. Luu, None; E. Kim, None; E. Han, None; D. Ben-Aviv, None; N. Boparai, None; R. Mitra, None.
Objective: To determine the predictive value of the straight-leg raise (SLR) test and motor weakness in patients receiving epidural steroid injections. Design: Retrospective chart review. Setting: University hospital outpatient clinic. Participants: 53 consecutive patients (28 men, 25 women; average age: 47.7y) with the diagnosis of lumbar radiculopathy over 2 years. Intervention: Each patient underwent a fluoroscopically guided transformaminal epidural injection procedure using a 25-gauge, 3.5-in needle. A mixture of 3mL of 80mg triamcinolone and 1mL of 1% lidocaine was injected in each patient after epidural spread was confirmed with contrast dye. Main Outcome Measures: Preinjection verbal analog scale (VAS) and postinjection VAS on the day of the injection were documented. A positive response to the injection was defined as at least a 50% improvement between the pre- and postinjection. Results: The Fisher exact test was used to determine the significance of the relationship between a physical finding of L5 myotome weakness or positive SLR test and a positive response to the transformaminal epidural injection. The Fisher exact test analysis demonstrated no statistical significance between clinical findings of L5 myotome weakness (P=.769) or positive SLR test (P=.762) and a positive response to a transformaminal epidural injection. Conclusions: The results from our study suggest that clinical findings of L5 myotome weakness or positive SLR test may not be a positive predictor of a patient's positive response to a transformaminal epidural injection. Key Words: Back pain; Injections, epidural; Rehabilitation.

Poster 42
Reduction in Urinary Tract Infection During Rehabilitation by Using the Clinical Practice Improvement Methodology. Sherry H. Young, MD (Changi General Hospital, Singapore, Singapore). Disclosure: S.H. Young, None.
Objective: To reduce the incidence of newly acquired urinary tract infections (UTIs) in the rehabilitation ward by using the clinical practice improvement (CPI) methodology. Design: The team first brainstormed about the possible causes. Team members then voted and the top causes were targeted for intervention. Setting: General rehabilitation ward in an 800-bed teaching hospital. Participants: Patients undergoing inpatient rehabilitation. Interventions: Review and audit of hand-washing techniques, review and audit of aseptic catheterization technique, standard procedure for catheterization on the catheterization trolley, single-use lubricant for catheterization to avoid cross-contamination, basic bladder care protocol for all patients, and definition of UTI from the Center for Disease Control and Prevention’s National Nosocomial Infection Surveillance by all clinicians. Main Outcome Measures: Not provided. Results: After implementation of the interventions, the mean UTI rate dropped from 11.9 to 2.4 per thousand patient days. The cost of antibiotics used also dropped from a mean of $2451.28 to $140.67 per month. Conclusions: This project showed that a multidisciplinary approach using the CPI methodology resulted in reduction of UTI rates and treatment cost for patients. Key Words: Rehabilitation; Urinary tract infection.

Poster 43
Inpatient Rehabilitation Trends in the Morbidly Obese Population. Paul Thananopavarn, MD (Dept Physical Medicine and Rehabilitation, Greenville, NC); Monica Carrión-Jones, MD; Ann Nunez, MD; Stephanie Slayton, PT; Daniel Wong, PhD. Disclosure: P. Thananopavarn, None; M. Carrión-Jones, None; A. Nunez, None; S. Slayton, None; D. Wong, None.
Objective: To evaluate the hypothesis that inpatient rehabilitation patients with morbid obesity have lower FIM instrument gains and longer lengths of stay (LOS) than patients without morbid obesity. Design: Retrospective chart review. Setting: Regional rehabilitation center in a tertiary care center in eastern North Carolina. Participants: Patients admitted to an acute rehabilitation center between January 2002 and November 2006 with morbid obesity as a diagnosis code (278.01). This group was compared with the population of patients admitted to the same rehabilitation center without morbid obesity as a diagnosis code. Interventions: Not applicable. Main Outcome Measures: All medical records of patients admitted to inpatient rehabilitation with a morbid obesity diagnostic code of 278.01 (n=383) were reviewed and compared with medical records of patients without a morbid obesity code (n=5384). A simple t test was used to compare the 2 groups. Admission FIM scores, discharge FIM scores, FIM gain, LOS, and LOS efficiency. Results: On average, the morbidly obese group had an admission FIM score of 66.8 and a FIM gain of 17.96. The nonobese (control) population had an admission FIM score of 64.02 and a FIM gain of 17.90. The nonobese group had an LOS of 17 days and an LOS efficiency of 1.08. The control group had an LOS of 14 days and an LOS efficiency of 1.25. Statistical analysis showed a significant difference in LOS (P=.025) but no significant difference in FIM gain or LOS efficiency. Conclusions: Morbidly obese rehabilitation patients require a greater LOS to achieve FIM gains comparable to those of the non–morbidly-obese population. Key Words: Obesity, morbid; Rehabilitation.
Acute Hospital Length of Stay Predictive of Rehabilitation Outcome Following Multiple Trauma. Michael S. Cicchetti, MD (University of Virginia, Charlottesville, VA); Mark R. Conaway, PhD; Paul T. Diamond, MD.

Disclosure: M.S. Cicchetti, None; M.R. Conaway, None; P.T. Diamond, None.

Objective: To examine the association between early select variables and rehabilitation outcome following multiple trauma. Design: Retrospective analysis of a trauma registry and rehabilitation outcomes database. Setting: University hospital level 1 trauma center and acute rehabilitation hospital. Participants: 525 subjects (age range, 18–55y) with multisystem blunt trauma, lower-extremity long bone fracture and/or major pelvic fracture, who were functionally independent prior to trauma. Interventions: Separate analyses were done for age, sex, race, total Abbreviated Injury Scale (AIS) score, and acute care hospital length of stay (LOS) to identify correlations with rehabilitation outcome. Main Outcome Measures: Admission FIM, discharge FIM, change in FIM, and rehabilitation hospital LOS. Results: 75 (15%) subjects received acute inpatient rehabilitation. Of these, 48% were men, 52% were women, 85% white, 13% African American, and 2% other. Total AIS score correlated negatively with admission FIM (\(P<.004\)). Acute care LOS correlated negatively with admission FIM (\(P<.001\)) and correlated positively with change in FIM (\(P<.009\)). Age, sex, and race did not correlate with any of the selected outcome measures. Conclusions: Acute care LOS following multiple trauma is a better predictor of functional gains during acute rehabilitation than total AIS score. Further study of predictors of outcome following multiple trauma is indicated. Key Words: Rehabilitation; Treatment outcome; Wounds and injuries.

Individual Goal Attainment Scaling Versus Standardized Measures for Evaluation Outcome in Rehabilitation. Lynne Turner-Stokes, DM, FRCP (King’s College London, Middlesex, UK); Heather Williams, MSc; Jane Johnson, MSc.

Disclosure: L. Turner-Stokes, None; H. Williams, None; J. Johnson, None.

Objective: To compare Goal Attainment Scaling (GAS) and standardized measures in the evaluation of outcome following rehabilitation. Design: A prospective cohort analysis. Setting: A tertiary inpatient neuorrehabilitation service for younger adults with complex neurologic disability. Participants: Consecutive patients (n=77; male/female ratio, 3:2; mean age ± SD, 45.5±14y) admitted for rehabilitation between January 3, 2005, and January 8, 2006, with diagnosis of 65% strokes, 22% other brain injury (eg, trauma, anoxia inflammation), and 13% other neurologic conditions. Interventions: An individualized goal-oriented rehabilitation program. Main Outcome Measures: Functional Assessment Measure (UK FIM+FAM), FIM instrument, and Barthel Index were measured on admission and discharge. GAS-rated achievement of 1 to 6 individual priority goals selected by the patients and agreed to by the treating team. Results: Mean length of stay was 82±45 days. All measures changed significantly between admission and discharge (\(P<.001\)). The mean GAS score was 32.2±5.0 at baseline and 45.9±7.2 at discharge. Median FIM+FAM scores were 124 (IQR, 93–151) baseline, and 168 (IQR, 136–191) at discharge. There was a moderately strong correlation between change in FIM+FAM and change in GAS score (Spearman \(\rho=0.4, P<.001\)); and slightly weaker correlations with change in FIM and Barthel Index (\(\rho=.35, P<.001\)). Of 317 goals set, 241 were achieved or partially achieved, of which 10% were in areas not reflected in the standard measures (eg, parenting, work-related, use of computers). Conclusions: GAS provides an alternative individualized approach to assessment of outcome following rehabilitation, which may be used to assess change in areas of critical importance to the individual. While many goals overlap with items in commonly used standardized outcome measures, the relationship is only moderate, suggesting that GAS may perhaps offer added value as an adjunct to outcome measurement in patients with complex disability. Key Words: Outcome assessment (health care); Rehabilitation.

Is Smoking Associated With an Increased Likelihood of Developing Foot Ulcers in Patients With Type 2 Diabetes Mellitus? David Berbrayer, MD, FRCP (University of Toronto, Thornhill, ON, Canada).

Disclosure: D. Berbrayer, None.

Objectives: To determine if there is an association between smoking and the development of ulcers in type 2 diabetes (T2D) mellitus. Design: A 3-month case-control study. Setting: Not provided. Participants: 26 people with T2D were interviewed. They were divided into an ulcer group (n=17) and nonulcer group (n=9). Interventions: Not applicable. Main Outcome Measures: A detailed smoking history was obtained. A comparison of smoking exposure (yes, no) between groups (ulcer vs nonulcer) was conducted. Kaplan-Meier survival curves were plotted for groups divided by smoking exposure. A comparison of the median pack-year history between ulcer and control groups was made. Results: There was a significant difference in smoking exposure between the ulcer and control groups (\(P=.02\)). The cumulative incidence of new ulcers was significantly higher in the smoking group compared to the non-smoking group (\(P=.04\)). Further investigation of the tool is warranted with people with upper-limb impairment to determine the limits of normality. Key Words: Handedness; Rehabilitation; Upper extremity.
nonulcer groups was completed. Statistical methods included the Fisher exact test, log-rank analysis (of the Kaplan-Meier curves), and the Mann-Whitney test. Results: Although 20% more in the ulcer group smoked (53% vs 33%), the difference was not statistically significant ($P=0.296$). Time from diagnosis to ulcer (survival) did not differ significantly between smokers and nonsmokers ($P=0.296$). No significant difference was found for median number of pack-years smoked between the ulcer and nonulcer group ($P=0.290$). Conclusions: Type 2 diabetics with ulcers were not found to have different smoking histories than those without ulcers. Smokers were not found to develop ulcers earlier than nonsmokers. Key Words: Diabetes mellitus; Diabetic foot; Rehabilitation; Smoking.

Poster 48  
Hypersensitivity to Furosemide: A Case Report. Catherine I. Dalton, MD (UAMS, Little Rock, AR); Marilyn S. Pacheco, MD.  
Disclosure: C.I. Dalton, None; M.S. Pacheco, None.  
Setting: Free-standing rehabilitation hospital. Patient: A 57-year-old white woman with pyoderma gangrenosum, psoriasis, deconditioning, hypertension, diabetes mellitus, ulcerative colitis, multiple food and medication hypersensitivities, asthma, and morbid obesity. Case Description: The patient presented from an outside hospital to inpatient acute rehabilitation due to her mobility and activities of daily living impairment after acute hospitalization for right lower-extremity pyoderma gangrenosum and bilateral lower-extremity cellulitis. Examination was most remarkable for her skin condition and her size. But it was her dermatologic condition that caused depression and social isolation. Her psoriasis consisted of erythematous desquamating lesions resistant to most medications. Her medications consisted of furosemide for hypertension and congestive heart failure, with pimecrolimus, ammonium lactate, and coal tar shampoo topical ointments for her skin. The patient did not respond to treatments after a few weeks. Dermatology was consulted. The recommendation was made to discontinue her furosemide, suggesting that this medication was the culprit leading to the skin peeling; the patient was placed on bumatane. The ammonium lactate was discontinued and a topical cream of aquaphor and triamcinolone was added. Assessment/Results: Dermatology described the lesions in her scalp, face, chest, back, and limbs as plaquel, generalized, disseminated, and symmetrical. Overnight, the patient’s skin dramatically improved. Discussion: Furosemide has sulfonamide moiety that is part of the chemical structure of loop diuretics. An allergy to sulfonamide was not listed among patient’s list of allergies. In the case of this patient with multiple hypersensitivities, it was an error to assume that her known list of drug allergies was exhaustive. In looking at a pre-existing diagnosis in a patient, if the known treatments are not improving the symptoms, other differentials should be considered. Conclusions: Substituting a single medication can resolve dermatologic issues that can cause discomfort physically and socially over the course of a few hours. Key Words: Furosemide; Hypersensitivity; Psoriasis; Rehabilitation.

Poster 49  
Clinical Characteristics and Functional Outcomes of Inpatients With Parkinson’s Disease in an Acute Rehabilitation Facility. Christina Marciniak, MD (Rehabilitation Institute of Chicago, Chicago, IL); Santiago Toledo, MD; Andrea Quandt, DO.  
Disclosure: C. Marciniak, None; S. Toledo, None; A. Quandt, None.  
Objectives: To describe the demographics, clinical profile, and functional outcomes of patients treated for impairments related to Parkinson’s disease during rehabilitation and their discharge disposition. Design: Retrospective study of patients diagnosed with Parkinson’s disease admitted to acute inpatient rehabilitation. Setting: Free-standing urban rehabilitation hospital in the United States. Participants: 23 consecutive patients with Parkinson’s disease (mean age, 73.3y) as their primary impairment hospitalized over a 2-year period. Intervention: Inpatient interdisciplinary comprehensive rehabilitation program. Main Outcome Measures: Demographic, clinical, and discharge disposition information was collected. Functional status was measured using the FIM instrument, recorded at admission and discharge. The main outcome measures were total FIM score on discharge, change in total FIM score, and discharge disposition. Results: Patients were most often admitted from acute care following hospitalizations for falls, mental status changes, infection, or following implantation of an intracerebral stimulator. 22 showed some degree of cognitive impairment, as measured by admission cognitive FIM (mean, 18.6±8.78). Patients made significant functional changes during inpatient rehabilitation, with a total FIM score of 19.7±11.26, mean motor change of 14.3±8.92, cognitive of change of 5.3±5.5, and overall FIM efficiency of 1.37. The most common comorbidities identified during their stay were depression (n=13) and cardiac disease (n=12), including 4 patients who required treatment for hypertension. 8 patients required interventions for dysphagia. Following an average length of stay of 16.2 days, 20 (87%) patients were discharged home. Conclusions: Significant motor and cognitive impairments may be seen following acute care hospitalizations in patients with Parkinson’s disease, often with comorbid conditions. Good functional gains are achievable after a comprehensive inpatient rehabilitation program. Despite advanced age, patients with Parkinson’s disease have a high rate of discharge to home. Key Words: Parkinson disease; Rehabilitation; Treatment outcome.
**Electrodiagnostic Medicine**

**Poster 51: Paper presentation.**

**Poster 52: Paper presentation.**

**Poster 53: Paper presentation.**

**Poster 54**

Patterns of Peripheral Nerve Injuries Sustained by Polytrauma Active Duty Service Members. Bryan P. Merritt, MD (University of South Florida, Tampa, FL); Faiza Humayun, MD; Hung Tran, MD.

Disclosure: B.P. Merritt, None; F. Humayun, None; H. Tran, None.

**Objective:** To study the patterns of peripheral nerve injuries sustained by Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) polytrauma patients. **Design:** Retrospective cohort study. **Setting:** Veteran’s Administration polytrauma rehabilitation center. **Participants:** 33 active duty service members (32 men, 1 woman; average age, 27y) who sustained polytrauma injuries while serving in OIF and OEF and underwent electrodiagnostic testing from October 2003 to January 2007. **Interventions:** Not applicable. **Main Outcome Measures:** Nerve conduction studies and electromyography consistent with traumatic, peripheral nerve injuries. **Results:** Of the 33 cases, 5 showed no evidence of traumatic peripheral nerve injury. Of the remaining 28 cases, the mechanism of injury was divided between 10 injuries related to blast, 8 from gunshot wounds, 9 from motor vehicle collisions, and 1 crush injury. Nine brachial plexopathies, 1 lumbosacral plexopathy, 11 multiple nerve injuries, and 9 single-nerve injuries were sustained. The upper extremities were involved more than twice as often (n=27) as the lower extremities (n=11). There was 1 case of facial nerve injury and 1 case of phrenic nerve injury. **Conclusions:** There needs to be a high index of suspicion for peripheral nerve injuries associated with polytrauma. Due to the complex nature of their injuries, these patients may have plexopathies, multiple nerve injuries, or single nerve injuries that coexist with orthopedic and soft tissue damage to an extremity. Electrodiagnostic testing should be performed on any neuromuscular deficit not explained by a central nervous system process. **Key Words:** Brachial plexus neuropathies; Electromyography; Peripheral nerves; Rehabilitation.

**Poster 55**

Reproducibility and Comparison of Nerve Conduction Study Parameters in Normal and Diabetic Neuropathy. Chang-Hwan Kim, MD (Dept of Rehabilitation Medicine, Incheon, Republic of Korea); Eun-Young Kim, MD.

Disclosure: C. Kim, None; E. Kim, None.

**Objectives:** To understand the most reproducible parameters in nerve conduction studies and to make guidelines for meaningful difference in sequential tests in normal and diabetic neuropathy. **Design:** Randomized blinded study. **Setting:** Tertiary hospital rehabilitation department. **Participants:** 22 normal controls were assigned for interexaminer test, and 50 diabetic patients for interexaminer (30 subjects) and intraexaminer (20 subjects) tests. **Interventions:** Nerve conduction studies on median, ulnar, peroneal, tibial, and sural nerves were done with F waves. **Main Outcome Measures:** Reproducibility was measured with the intraclass correlation coefficient. The minimal difference was compared with t test. **Results:** The reproducibility in controls and diabetics was lower in motor conduction velocities and sensory amplitudes. These were higher in the F waves and motor distal latencies of the motor and sensory conduction studies. The smallest detectable differences in the controls and diabetics were not significant (P<.05). **Conclusions:** Understanding the smallest detectable difference in the diseased condition and the most reproducible factors are the baselines for an evaluation of the outcome measure of peripheral neuropathy rehabilitation. **Key Words:** Nerve conduction; Peripheral neuropathies; Rehabilitation; Reproducibility of results.

**Poster 56**

Diagnostic Dilemma Involving Weakness in a Patient With Acute Lymphoblastic Leukemia and Multiple Risk Factors. Leon Chandler, MD (Temple University Hospital, Philadelphia, PA); Carmen Angles, MD.

Disclosure: L. Chandler, None; C. Angles, None.

**Setting:** Major metropolitan medical rehabilitation unit. **Patient:** A 43-year-old white male admitted for rehabilitation after being diagnosed with pre-B cell acute lymphoblastic leukemia (ALL) and completing phase 1 of the Eastern Cooperative Oncology Group (ECOG) 2993 chemotherapy protocol. Prior to diagnosis, the patient was functionally independent. **Case Description:** Medical history was significant for hypertension and gout. The acute care course was complicated, including intensive care unit admission for sepsis. Examination revealed asymmetric weakness, with the lower limbs affected more than the upper limbs. There was atrophy of bilateral hand intrinsic, thigh, and anterolateral leg muscles. Electrodiagnostic consultation yielded diagnosis of probable critical illness myopathy with symmetric distal sensorimotor axonal loss neuropathy. This was possibly due to vincristine use or alternatively to critical illness polyneuropathy. There was also evidence for entrapment neuropathy at various sites in the lower limbs. We considered the possible role of leukemia itself, as well as other factors such as corticosteroids and deconditioning. **Assessments/Results:** A literature review outlined the ECOG 2993 medications and evidence concerning neuromusculoskeletal side effects, focusing on myopathy and neuropathy, was performed. Reports and trials document the potential of prednisone and vincristine to produce myopathy and neuropathy, respectively. There is less evidence that other agents, dexamethasone, L-asparaginase, and methotrexate in isolation, produce similar effect. Other neurologic or musculoskeletal complications were found. Evidence supports the role of leukemia and gout as causes of neuropathy. **Discussion:** Understanding chemotherapeutic agents’ influence on muscle and nerve function, with recognition of the clinical and electrodiagnostic features of the critically ill patient with ALL, engenders appropriate diagnosis, prognostication, and management. **Conclusions:** Weakness in complicated cases of ALL can be a diagnostic dilemma. Physiatrists must have knowledge of pharmacology, electrophysiology, and pathophysiology. **Key Words:** Critical illness; Leukemia; Muscle weakness; Neuropathy; Rehabilitation.

**Poster 57**

A Case of Right Medial Plantar Nerve Entrapment After Ankle Surgery. Ali I. Khawaja, MD (Nassau University Medical Ctr, East Meadow, NY); Sarah Sheikh, SPT; Ajendra Sohal, MD; Lyn Weiss, MD.

Disclosure: A.I. Khawaja, None; S. Sheikh, None; A. Sohal, None; L. Weiss, None.

**Setting:** Electrodiagnostic laboratory and outpatient rehabilitation unit. **Patient:** A 14-year-old girl. **Case Description:** The patient had a history of right ankle bimalleolar fracture for which she underwent open reduction and internal fixation. She was referred for intermittent right foot pain 2 months after surgery. **Assessment/Results:** The patient presented with an antalgic gait. Clawing of the right medial 2 toes was noted along with a positive Tinel sign. She had decreased sensation to touch and pain on the medial two thirds of the sole of the foot. **Conclusions:** Understanding the smallest detectable difference in the diseased condition and the most reproducible factors are the baselines for an evaluation of the outcome measure of peripheral neuropathy rehabilitation. **Key Words:** Nerve conduction; Peripheral neuropathies; Rehabilitation; Reproducibility of results.

foot. Electrodiagnostic studies were done, which showed fibrillation potentials, positive sharp waves, decreased recruitment, and increased insertional activity in the right abductor hallucis. Magnetic resonance imaging confirmed medial planar nerve entrapment in scar tissue.

Discussion: Compression of the posterior tibial nerve or one of its branches can occur because of intrinsic neural abnormalities or can be a result of external compression. External compression etiologies include fibrosis, neurilemomas, ganglion cysts, lipomas, osteochon-

dromas, varicosities, other benign and malignant tumors, tight tarsal canal, hypertrophic abductor hallucis, anomalous artery, and anomalous extra muscles such as the flexor digitorum accessorius longus.

Conclusions: After clinical assessment, electrodiagnostic and imaging studies are helpful in diagnosing, localizing, and prognosticating peripheral entrapment neuropathies and should be considered early during the course of the diseases. We present an unusual case of medial planar nerve entrapment secondary to entrapment in scar tissue.

Key Words: Foot; Medial plantar nerve; Pain; Rehabilitation; Tarsal tunnel syndrome.

Poster 58
Effect of Body Mass Index on Ulnar Nerve Entrapment Site at the Elbow. Jenny Andrus, MD (Virginia Commonwealth University, Richmond, VA); Yaoming Gu, MD; David X. Cifu, MD; William F. Carne, PhD.

Disclosure: J. Andrus, None; Y. Gu, None; D.X. Cifu, None; W.F. Carne, None.

Objective: To test the hypothesis that thinner persons have less mechanical protection of the nerve and would be more likely to have entrapment distal to the medial epicondyle, while heavier persons would be more likely to have proximal entrapment due to excess subcutaneous tissue. Design: Retrospective chart review. Setting: Outpatient electrodiagnostic clinic. Participants: A total of 29 patient charts and 31 arms were reviewed from an electronic database. All had ulnar neuropathy at the elbow diagnosed by electrodiagnostic nerve conduction studies with location determined by short segmental study.

Interventions: Not applicable. Main Outcome Measures: Age, body mass index (BMI), proximal versus distal location of ulnar nerve entrapment as found on short segmental electrodiagnostic study. Results: 30 arms had abnormal values proximally and 18 abnormal distally, 1 arm had normal proximal values and 13 had normal distal values. 55% had both proximal and distal abnormal values. Mean BMI ± SD was 30.36±7.3kg/m². There was no significant difference in the site of ulnar nerve entrapment in those with a BMI greater or less than 30kg/m². There was no significant difference between age and entrapment site. Conclusions: As found by others, the most frequent site of ulnar nerve entrapment is proximal to the epicondyle. No difference in site of ulnar nerve entrapment was found between those with lower and higher BMIs. This may be explained by the relatively high BMI cutoff (30kg/m²). Future research should focus on those with low BMI and early symptoms to help determine if differences exist. Key Words: Body mass index; Electromyography; Rehabilitation; Ulnar neuropathies.

Poster 60
Postinfectious Autoimmune Polyradiculoneuropathy With Asymptomatic Encephalitis: A Case Report. Franz J. Macedo, DO (University of Wisconsin, Middleton, WI); Kelly Logan, DO; Hemalatha Narra, MD.

Disclosure: F.J. Macedo, None; K. Logan, None; H. Narra, None.

Setting: University hospital, inpatient ward, and outpatient clinic.

Patient: A 23-year-old woman with 2 weeks of postinfectious progressive weakness. Case Description: The patient presented with progressive weakness and soreness of distal lower extremities and gait changes 10 days following diagnosis of gastroenteritis. She denied sensory loss, visual changes, or bowel and bladder dysfunction. There was no recent travel abroad. On exam, there was distal greater than proximal upper- and lower-extremity weakness and no sensory abnormalities. Distal reflexes diminished on day 2. Magnetic resonance imaging (MRI) head findings were consistent with focal encephalitis versus demyelination of left frontal lobe. MRI spine showed focal enhancement of upper ventral roots of cauda equina and conus with edema and enhancement of paraspinal musculature. Abnormal laboratories included a sedimentation rate of 53mm/h. Cerebrospinal fluid showed lymphocytic predominance without elevated protein, elevated immunoglobulin G index, or elevated GM1 ganglioside antibody level. Atypical Guillain-Barré syndrome was considered and she was treated with intravenous immunoglobulin (IVIG) for 5 days. Proximal greater than distal strength and reflexes improved and she remained without sensory symptoms. She was discharged after 5 days. Electromyography 3 months later showed polyradiculoneuropathy, purely motor, with multifocal conduction blocks and axonal damage. After 2 months of physical therapy, strength markedly improved. Repeat electromyography, 5 months after discharge, showed purely motor polyradiculoneuropathy, now without conduction block, and evidence of reinervation. Assessment/Results: History and clinical data support a diagnosis of postinfectious autoimmune polyradiculoneuropathy. Discussion: Polyradiculoneuropathies of this type are most often due to campylobacter (67%) or Haemophilus (13%) and are rare in the United States. Weakness is typically distal greater than proximal with

Key Words: Electromyography; Rehabilitation.
the cranial nerve involved 25% of the time. Lab findings show positive antibodies to GM1 ganglioside in 40% to 50% of cases. 

**Conclusions:** Documented here is a case of polyradicular neuropathy following infection resulting in progressive weakness without sensory changes. Treatment is IVIG and/or plasmapheresis. 

**Key Words:** Radiculopathy; Rehabilitation.

**Poster 61**

Transposition of the Lateral Antebrachial Cutaneous Nerve Following Biceps Tendon Repair: A Case Report. Jeffrey R. Beer, MD (Kessler Institute for Rehabilitation, West Orange, NJ); Casey J. O’Donnell, MD.

**Disclosure:** J.R. Beer, None; C.J. O’Donnell, None.

**Setting:** Outpatient musculoskeletal practice. 

**Patient:** A 47-year-old man with left elbow and lateral forearm pain. 

**Case Description:** The patient presented 6 years following a left biceps tendon repair with persistent numbness and tingling in the left lateral forearm and hand, suggesting a lesion of the left lateral antebrachial cutaneous nerve (LACN). Nerve conduction studies in the upper extremities were performed to confirm our clinical diagnosis. 

**Assessment/Results:** Initially, a left LACN response was absent when stimulation was performed over the lateral aspect of the antecubital fossa. A normal right LACN response was elicited using the same technique. However, after recording over the left lateral forearm and stimulating over the medial aspect of the left antecubital fossa, a normal LACN response was obtained. 

**Discussion:** The nerve conduction study findings indicated that the LACN was transposed, likely during the operative procedure, from the lateral to the medial aspect of the antecubital fossa. LACN injury is an established complication following biceps tendon repair. However, to our knowledge, this is the first reported case of transposition of the nerve following this procedure. 

**Conclusions:** When attempting to elicit an LACN response, especially following biceps tendon repair, the electrophysiologist should remain aware of this possibility. Stimulation over the medial antebrachial area should always be performed when lateral antebrachial stimulation fails to produce a normal response. 

**Key Words:** Electrodiagnosis; Musculocutaneous nerve; Neural conduction; Rehabilitation.

**Poster 62**

Neurologic Injury Associated With Pelvic Fracture: Radiologic and Electromyographic Evaluation and Relationship to Pain and Functional Outcome. Anthony Chiodo, MD (University of Michigan Hospital, Ann Arbor, MI).

**Disclosure:** A. Chiodo, None.

**Objectives:** To study the electrodiagnostic presentation of patients with lower-extremity nerve injury related to pelvic fracture; to assess if there is a relationship between fracture type and electrodiagnostic presentation; to assess functional outcome and correlation to fracture type and electrodiagnostic data; and to study the incidence of pain postinjury and the relationships between injury type and electrodiagnostic evaluation and pain type. 

**Design:** Retrospective review. 

**Setting:** Tertiary care university hospital. 

**Participants:** 78 patients who presented with lower-extremity nerve injury associated with pelvic fracture. 

**Interventions:** Not applicable. 

**Main Outcome Measures:** Electromyogram results; the relationship between electrophysiologic presentation and fracture or injury type; and gait and pain outcomes. 

**Results:** The characteristic neurologic injury in patients with pelvic fractures was a lumbosacral plexus injury. Sciatic nerve injuries were more common in patients with isolated acetabular fractures. Neurologic outcome was related to electrodiagnostic study abnormality and severity. Functional outcome was best predicted by abnormalities in peroneal motor nerve conduction and anterior tibialis needle examination. Neuropathic pain was seen in patients with any degree of gait abnormality. Orthopedic pain was seen in patients with an acetabular fracture. 

**Conclusions:** Lumbosacral plexus injury after pelvic fracture is a characteristic disorder that commonly is associated with severe long-term implications from the standpoint of pain and functional outcome. Better understanding of the interaction of injury mechanism, fracture type, and neurologic impairment will allow for better prevention and better understanding of the functional outcome of these injuries. 

**Key Words:** Electromyography; Lumbosacral plexus; Pelvis; Rehabilitation.

**Poster 63**

Replication of a Novel Technique for Motor Conduction of the Serratus Anterior Muscle and Long Thoracic Nerve in a Pediatric Patient: A Case Report. Eric L. Altschuler, MD (UMDNJ, Newark, NJ); Ariz Mehta, MD.

**Disclosure:** E.L. Altschuler, None; A. Mehta, None.

**Setting:** Tertiary care university hospital. 

**Patient:** An 11-year-old girl. 

**Case Description:** The patient was referred for electrodiagnostic studies for a unilateral “shoulder problem.” The family reported birth trauma. The patient had complaints of difficulty with some movements of the shoulder of the affected arm. She was healthy and normal except for the affected arm. In that arm, sensation and strength was intact except for poor external rotators of the shoulder. 

**Assessment/Results:** We thought that the novel conduction study of the serratus anterior muscle and long thoracic nerve described by DePalma et al might be useful in studying root versus upper brachial plexus as the site of the patient’s lesion: in a plexus lesion, one would expect normal studies from the serratus anterior muscle as the long thoracic nerve comes directly off the cervical roots before the brachial plexus. Our findings revealed a right serratus compound muscle action potential distal motor latency (average of 3 stimulations) of 2.15ms on the unaffected side and 2.05ms on the affected side, and an amplitude of 2.1mV on the unaffected side and 1.4mV on the affected side. The values of these latencies and amplitudes and the side-to-side differences were within the normal true ranges found by DePalma. As well, our wave forms had an initial positive deflection, as did those of DePalma. 

**Discussion:** We have replicated in a pediatric patient the novel motor conduction technique of DePalma. As in our case, the novel and easy-to-perform technique for study of the serratus anterior may be useful in assessing questions of upper cervical root versus upper trunk of the brachial plexus lesions. 

**Conclusions:** In adults or pediatric cases, the technique of DePalma is a useful addition to the electrophysiologist’s armamentarium. 

**Key Words:** Brachial plexus; Electrodiagnosis; Pediatrics; Rehabilitation.

**Poster 64**

Correlation of Clinical Findings, Electrodiagnosis, and Magnetic Resonance Imaging Study in Cervical Roots Lesion. Seymmodoor Rayegani, MD (Shohada Medical Ctr, Shaheed Beheshti Medical University, Tehran, Iran); Laili Shaghholi, MD; Mostafa Mohseni, MD; Mohamadhasan Bahrami, MD; AliReza Rajaei, MD; Bahram Jafroodi, MD.

**Disclosure:** S. Rayegani, None; L. Shaghholi, None; M. Mohseni, None; M. Bahrami, None; A. Rajaei, None; B. Jafroodi, None.

**Objective:** To determine the correlation between clinical findings and magnetic resonance imaging (MRI) and electrodiagnostic studies in the diagnosis, determination of severity, and differential diagnosis of cervical radiculopathy. 

**Design:** Cross-sectional analysis. 

**Setting:** Tertiary care university hospital.
Electrodiagnosis clinic of a medical center. **Participants:** 40 persons with clinical signs and symptoms of cervical radiculopathy. **Interventions:** Not applicable. **Main Outcome Measures:** All subjects had cervical MRI as diagnosed by 1 radiologist. The electrodiagnostic clinic history and physical examination were done by an attending physiatrist and recorded in a special chart; then electrodiagnostic study, including nerve conduction and electromyography, was done by another physiatrist who was blinded to MRI and clinical examination. Collected data were analyzed. **Results:** All cases had at least 1 positive clinical finding, however, MRI was positive in 36 cases and electrodiagnosis was positive in 33 cases. The overall correlation of MRI and electrodiagnosis was 87.5%, but for each specific nerve root the correlation was only 45%. Electrodiagnostic and clinical examination had a 75% correlation. This correlation was only 52% for MRI and clinical examination. Electrodiagnostic findings were more prominent in cases with clinical findings of numbness, decreased or absent deep tendon reflex or weakness, and positive Spurling test. The most involved root was C6. The most involved muscles with prominent findings in each root were the deltoid (C5), pronator teres (C6), triceps brachii (C7), and abductor pollicis brevis (APB) (C8) muscles. The most prominent active denervation potentials were found in the pronator teres. **Conclusions:** Although MRI is an excellent imaging tool with which to study cervical radiculopathy, application of electrodiagnosis and its correlation with MRI and clinical examination is very helpful for a more precise determination of the involved root. We recommend the deltoid, pronator teres, triceps brachii, and APB as the muscles of choice in electrodiagnostic study of cervical roots lesion. **Key Words:** Electrodiagnosis; Magnetic resonance imaging; Rehabilitation.

**Poster 65**

Use of Electrodiagnostic Testing to Differentiate an Accessory Muscle From a Cyst: A Case Report. Vladimir Salomon, DO (Nassau University Medical Ctr, East Meadow, NY); Lynn Weiss, MD.

**Disclosure:** V. Salomon, None; L. Weiss, None.

**Setting:** Electrodiagnostic medicine clinic. **Patient:** A 17-year-old man. **Case Description:** The patient had no significant medical history when he presented to the electrodiagnostic clinic with an enlarged soft tissue mass on the dorsal proximal carpal row. The patient reported that the mass was first seen when he was 5 years old. He denied any symptoms. The patient was initially diagnosed with a ganglion cyst based on physical examination. Magnetic resonance imaging (MRI) showed evidence of fusiform soft tissue on the dorsal proximal carpal row. Electromyography was used to differentiate an accessory muscle from a ganglion cyst. **Assessment/Results:** Needle electromyography of the mass showed normal motor unit action potentials with a normal recruitment pattern. This confirmed the presence of an extensor digitorum brevis manus (EDBM) muscle. No surgical intervention was needed to excise the mass because the patient was asymptomatic. **Discussion:** The EDBM is a relatively rare anomalous muscle. It is an accessory muscle that lies along the ulnar side of the extensor tendon of the index finger. MRI scans can usually help to distinguish EDBM from tumors. Electromyography helps confirm the presence of the EDBM. This accessory muscle has been found in only 1.1% of patients. It is usually asymptomatic and frequently mistaken for a ganglion or other mass. **Conclusions:** The EDBM should be included in the differential diagnosis of soft tissue masses on the dorsal aspect of the wrist and hand. It may be diagnosed by MRI. Electromyography will help definitely confirm the presence of this anomalous muscle. Unnecessary surgery can be avoided, especially if the patient’s symptoms are minimal or asymptomatic. **Key Words:** Electromyography; Muscle, skeletal; Rehabilitation.

**Poster 66**

Brachial Plexopathy Due to Deep Venous Thrombosis: A Case Report. Priti Vohra, DO (Nassau University Med Ctr, East Meadow, NY); Gautam Kothari, DO; Lynn Weiss, MD; Adam Isaacson, MD.

**Disclosure:** P. Vohra, None; G. Kothari, None; L. Weiss, None; A. Isaacson, None.

**Setting:** Tertiary care hospital. **Patient:** A 67-year-old man. **Case Description:** The patient, with medical history of severe peripheral vascular syndrome, chronic renal insufficiency, idiopathic thrombocytopenia, and above-knee amputation of the left lower extremity, presented with right-hand and forearm weakness, numbness, and loss of sensation after being diagnosed with a deep venous thrombosis (DVT) of the right subclavian and proximal right axillary veins. The patient later developed a right upper-extremity post thrombotic syndrome as well. On physical examination, the patient was found to have significant edema of the extremity, along with erythema, hyperpigmentation, and skin ulceration. The patient had significant impairment in motor strength graded 1–2/5 in the distal forearm. The patient’s distal ventral and dorsal hand was insensitive and the proximal forearm was sensitive only to deep pressure. **Assessment/Results:** Nerve conduction and electromyography studies demonstrated a severe right brachial plexopathy of predominantly the middle and lower trunk, with less involvement of the upper trunk. On discharge from the rehabilitation unit, the patient had minimal to no improvement of his right upper-extremity symptoms. **Discussion:** DVT generally affects the leg veins, but has recently been recognized as being more common in the upper extremity. Many complications, such as life-threatening pulmonary embolism, persistent upper-extremity pain with swelling and blisters (post thrombotic syndrome), superior vena cava syndrome, and thoracic outlet syndrome, can be disabling and devastating. Brachial plexus damage may also follow subclavian and axillary vein damage or compression by a thrombus. The prognosis for nerve recovery is less favorable when it is associated with concomitant neurovascular involvement. **Conclusions:** The physiatrist should be made aware that an upper-extremity DVT may lead to a severe brachial plexopathy, and electromyography may be warranted for both diagnostic as well as prognostic purposes. **Key Words:** Brachial plexopathy; Deep vein thrombosis; Electromyography; Rehabilitation.

**Poster 67**

Polyradiculopathy Following an Exacerbation of Herpes Zoster Reactivation: A Case Report. Jerry Lin, DO (Rusk Institute of Rehabilitation Medicine/New York University School of Medicine, New York, NY).

**Disclosure:** J. Lin, None.

**Setting:** Acute rehabilitation hospital. **Patient:** A 68-year-old woman with a medical history of liver transplant secondary to hepatitis C, and arthritis for 10 years. **Case Description:** The patient ambulated with a cane independently prior to entering the emergency department with acute left hip pain; wing radiography determined that she had bilateral avascular necrosis of the hips, with the left hip having collapse and greater involvement. She was simultaneously diagnosed with recurrent herpes zoster and started on intravenous acyclovir. Clinically, she showed left L3-5 hypesthesia over dried lesions. The patient went on to have a left total hip arthroplasty without complications. On postoperative day 4, she was switched to 800mg of oral famciclovir (Famvir) by mouth 5 times a day for 14 days and transferred to acute rehabilitation. The patient had 4/5 gross muscle strength.
in the proximal region left extremity and made significant functional gains. At 2 weeks into the program, she ambulated 45m (150ft) and climbed 10 stairs. However, despite resolution of her skin lesions, she began experiencing itching, burning, swelling, stiffness, and pain in the same dermatome. Her muscle strength deteriorated rapidly to 1−2/5 throughout her left lower extremity. The patient stayed another 2 weeks with the same baseline strength, but was able to carry out functions moderately independently. Her dysesthesia improved and she was discharged home. **Assessment/Results:** The patient was clinically diagnosed with herpes zoster radiculopathy. Electromyography revealed results compatible with left polyradiculopathy from L1-5, nearly affecting the upper roots, with minor involvement of the S1 root. **Discussion:** Although the cutaneous manifestation of herpes zoster may show resolution, it is important to bear in mind that the underlying pathology may still occur. **Conclusions:** Herpes simplex virus reactivation may lead to motor impairments by nerve root involvement. **Key Words:** Herpes zoster; Rehabilitation.

**Poster 68**

**Disclosure:** T.E. McNalley, None.

**Setting:** University hospital. **Patient:** A 49-year-old woman with achondroplasia and a history of prior spinal fusion. **Case Description:** The patient had achondroplasia and a history of spinal stenosis. In 2006, she reported ongoing weakness and was evaluated using a computed tomography myelogram. During the procedure, she had acute onset of mid-thoracic pain and weakness. She also noted sensory changes. Repeat magnetic resonance imaging (MRI) showed multi-level stenosis and she was readmitted for further work-up, including electromyography and somatosensory evoked potentials (SEPs). **Assessment/Results:** Examination showed upper-extremity strength was 5/5 bilaterally. The lower-extremity exam was consistent with myelopathy, showing decreased strength and sensation bilaterally and some hyperreflexia at the patellas. A rectal exam showed decreased tone and sensation but she was able to contract voluntarily. SEPs showed as follows: for the T2 dermatome, normal waveforms and latencies; for the T4 dermatome, bilaterally symmetrical responses, normal latencies, but she had very reduced amplitudes; for the T6 dermatome, responses questionably recorded at the left T6 with prolonged latencies, and reduced amplitudes; and for the T8-S1 dermatomes, bilateral absent responses. Electromyography showed the patient was not able to consistently contract muscles on command. There was weak evidence for acute denervation in 1 lower-extremity muscle only. Otherwise, chronic denervation was noted in bilateral lower extremities. The patient underwent a mid-thoracic decompressive laminectomy and reported increased strength and sensation in the bilateral lower extremities. She was transferred to the rehabilitation service and was ambulating with use of a walker prior to discharge. **Discussion:** Spinal stenosis is common in achondroplastics. In this case, prior surgeries and the unusual onset of symptoms during a lumbar myelogram confounded the normal radiographic work-up of myelopathy. Dermatomal SEPs showed normal conduction at T2, reduced amplitude at T4, and absent responses distally. **Conclusions:** Dermatomal SEPs provide a crucial adjunct to diagnosis of a specific level of myelopathy with multilevel lesions. For patients with prior spine instrumentation or barriers to radiography, dermatomal SEP assists in providing localization of spinal cord compromise. **Key Words:** Achondroplasia; Evoked potentials, somatosensory; Myelopathy; Rehabilitation.
usually affects sensory nerves more than motor nerves. The peripheral neuropathy, which typically does not occur early in the course of SLE, may be due to vasculopathy of the small arteries supplying the affected nerves. **Conclusions:** The physiatrist should be made aware that a severe peripheral neuropathy may occur early and should be kept in mind as part of the neurologic spectrum in SLE. **Key Words:** Electromyography; Erythematous, systemic lupus; Peripheral neuropathies; Rehabilitation.

**Poster 71**

Neuromuscular Disorders of the Biceps and Brachioradialis: Erythematous, Systemic Lupus; Peripheral Neuropathies.

**Setting:** University hospital, outpatient clinic. **Patient:** A 45-year-old man with acute onset of left elbow pain and progressive weakness of the left upper extremity causing significant debilitation. **Description:** The patient presented for neuromuscular evaluation after 3 months of progressive weakness of the left arm and hand. Primary complaint was excruciating pain about the left elbow, worse with extension and pronation. Within 48 hours of symptoms, he noticed weakness in his hand and wrist. Pain subsided after 2 weeks, but weakness persisted. There was no trauma, but a positive history of recent viral infection. **Assessment/Results:** Physical exam and electromyographic findings were consistent with a posterior interosseous neuropathy, axonal and severe; also neurogenic changes in the left pronator teres were consistent with a neuropathic process affecting the median nerve branch. History and clinical and diagnostic exams were consistent with neurogenic amyotrophy affecting the posterior interosseous nerve as well as the median nerve branch to the pronator teres. The patient started a physical therapy protocol. At 6 months there was clinical improvement in overall strength and function. Follow-up MRI was consistent with denervation edema. Repeat electromyography exhibited evidence of ongoing denervation with reinnervation changes present. **Discussion:** Neuromuscular disorders of the biceps and brachioradialis are rare but recognized. **Key Words:** Neuromuscular disorders; Erythematous, systemic lupus; Peripheral neuropathies.

**Poster 72**

Entrapment of the Ulnar Nerve at the Exit of the Flexor Carpi Ulnaris for 6 Months. **Case Description:** Paresthesias in left fourth and fifth digits for 6 months. **Key Words:** Electromyography; Erythematous, systemic lupus; Peripheral neuropathies; Rehabilitation.

**Setting:** Outpatient clinic. **Patient:** A 54-year-old woman with paresthesias in left fourth and fifth digits for 6 months. **Case Description:** The patient reported symptoms after frequent use of hand weights. Physical exam was notable for sensory impairment involving the left fourth and fifth digits and hypothenar region. There was no weakness or atrophy of hand and forearm muscles. Left ulnar sensory nerve conduction study (NCS) was normal. Left ulnar motor NCS revealed marked decrease in amplitude over the exit of the nerve from the flexor carpi ulnaris (FCU). Inching of the ulnar nerve revealed a decline in amplitude and an increase in duration of the motor wave at the exit of the FCU. Needle electromyography was normal in the first dorsal interosseous (FDI), FCU, and flexor digitorum profundus (4th, 5th digits). Bilateral median motor NCS to the FDI revealed motor response of large amplitude with stimulation at the elbow and minimal amplitude with stimulation at the wrist. **Assessment/Results:** NCS and electromyography were consistent with left ulnar nerve entrapment at the exit from the FCU without evidence of axonal injury in a patient with bilateral Martin-Gruber anastomosis. Relevant waveforms will be presented. Magnetic resonance imaging of the left forearm showed no evidence of focal mass. Ulnar nerve entrapment was likely secondary to repetitive trauma between the heads of the FCU muscle. **Discussion:** This is the first reported case, to our knowledge, of bilateral Martin-Gruber anastomosis and demyelinating ulnar neuropathy at the exit from the FCU without evidence of axonal injury. **Conclusions:** Electromyography should be performed in ulnar-innervated muscles to document axonal neuropathy at the exit from the FCU. The presence of Martin-Gruber anastomosis should be considered in patients with evidence of ulnar amplitude decline in the upper forearm. **Key Words:** Electromyography; Rehabilitation; Ulnar neuropathies.

**Poster 73**

A Case of a Lesion of the Left Lower Trunk of the Brachial Plexus After Lifting Heavy Luggage. **Patient:** A 33-year-old right-hand dominant male gastroenterologist. **Case Description:** The patient was referred for electromyography and nerve conduction testing due to weakness and numbness of the left hand, which started after the patient lifted heavy luggage. He was unable to perform endoscopic procedures, which involved using his left hand. **Assessment/Results:** No gross deformity or atrophy of the left upper-extremity proximal muscles was noted, while mild atrophy of small muscles of the left hand was noted. Strength in the left hand flexors was 4/5 and in the extensors was 3/5. Muscle strength in the proximal muscle groups was 5/5. Right and left hand grips were 40.5kg (9lb) and 6.8kg (15lb), respectively. Range of motion actively and passively in all joints of left upper extremity was preserved. Sensory deficits in the left hand median, ulnar, and radial distribution were noted. Electrodagnostic studies revealed severe axonometric lesion of the lower trunk. **Discussion:** Our patient suffered from injury to the lower trunk of the brachial plexus. Partial recovery was seen gradually. The patient underwent outpatient rehabilitation and was eventually successful in resuming his practice by changing his method of performing endoscopy. **Conclusions:** Electrodagnostic studies after history and physical examination are helpful diagnostic tools to localize, determine extent of injury, and prognosticate the brachial plexus injuries, and should be considered early. **Key Words:** Brachial plexus; Electromyography; Rehabilitation.
Poster 74  
Comparison of Quantitative Sensory Testing and Conventional Nerve Conduction Study in Diabetic Patients. Reza S. Roghani (University of Social Welfare & Rehabilitation Sciences, Tehran, Iran); Ashin Adib; Ahmad Delbari, PhD(C).  
Disclosure: R.S. Roghani, None; A. Adib, None; A. Delbari, None.  
Objective: To evaluate diabetic patients by conventional nerve conduction studies (NCS) and current perception threshold (CPT), a quantitative sensory testing subtype, and to compare the test results.  
Design: Descriptive cross-sectional. Setting: PM&R clinics in 2 Iranian universities. Participants: 47 diabetic patients and 50 normal volunteers referred to our clinics consecutively. Interventions: Not applicable. Main Outcome Measures: Conventional NCS, CPT, and clinical examination. Results: Of 47 diabetic patients, 25 (53%) had abnormal NCS while 31 (66%) had abnormal CPT (P=.12), and 42 (89%) had some abnormalities in at least 1 of these tests. Of 9 patients who had less than a 1-year history of diabetes, only 1 (11%) had abnormal NCS, while 7 (77%) revealed abnormal CPT. Conclusions: CPT was not superior to NCS in the diagnosis of diabetic neuropathy or vice-versa but diagnostic sensitivity was increased if both were considered together. It seems as if CPT is more sensitive in the diagnosis of diabetic neuropathy in the early stages but more studies with more cases are necessary. Key Words: Diabetes mellitus; Diabetic neuropathies; Nerve conduction; Rehabilitation.  
Poster 75: Canceled.  
Poster 76  
Electromyography of Ulnar Neuropathy at Guyon’s Canal: A Case Report. Jessica Fuller-Hines, MD (Temple University Hospital, Philadelphia, PA); Ernesto Cruz, MD.  
Disclosure: J. Fuller-Hines, None; E. Cruz, None.  
Setting: Outpatient electromyography laboratory. Patient: A 31-year-old man with laceration of the right hand. Case Description: This patient with 7 years of dominant hand pain, weakness, and numbness of the palmar fifth and medial half of the fourth digit following trauma underwent electromyographic examination. Pertinent physical examination findings were visible healed lacerations on medial palm, finger abductor and adductor muscle weakness, atrophy of first dorsal interosseous (FDI) muscle, and a positive Froment sign. On nerve conduction studies, median sensory and motor nerves were normal in all tested parameters. The ulnar sensory nerve recording from the fifth digit and motor nerve recording from the abductor digitii minimi (ADM) with stimulation at the wrist, below the elbow, and above the elbow also had normal distal latencies, conduction velocities, and amplitudes. However, the ulnar motor nerve recording from the FDI stimulating at the wrist had attenuated amplitude and onset latency that was prolonged relative to ipsilateral recording at the ADM. On needle examination, the FDI and adductor pollicis muscles had fibrillation potentials and positive sharp waves with polyphasic motor unit potentials of increased amplitude and duration with a poor recruitment pattern. The remainder of the tested muscles including ADM and cervical paraspinals was normal. Assessment/Results: This patient has electromyographic evidence of an ulnar neuropathy affecting only the deep motor branch of the distal nerve. Discussion: Distal ulnar neuropathy should not be ruled out on the basis of standard ulnar motor and sensory studies recording from the ADM and fifth digit, respectively. Further investigation was clearly warranted in this patient with visible laceration scars, but other causes of ulnar neuropathy, such as repetitive compression in cyclists or ganglion cysts about Guyon’s canal, are not uncommon. Conclusions: Further electromyography study is indicated in patients with clinical symptoms of distal ulnar neuropathy. Key Words: Electromyography; Guyon syndrome; Rehabilitation; Ulnar neuropathies.  
Poster 77  
Normal Cervical Paraspinal Muscle Electromyography After Anterior Cervical Discectomy and Fusion: A Case Report. Kristina E. Hicks, MD (UMDNJ-New Jersey Medical School, Newark, NJ); Patrick M. Foye, MD.  
Disclosure: K.E. Hicks, None; P.M. Foye, None.  
Setting: Outpatient physiatric academic practice. Patients: Patients with a history of anterior cervical discectomy and fusion (ACDF), referred for electrodiagnostic testing. Case Descriptions: We present 5 patients who were referred for electromyography at various times after ACDF. Assessment/Results: In each case, needle electromyography of the cervical paraspinal muscles was normal, thus making it less likely that the patients’ symptoms were caused by any cervical radiculopathy. Meanwhile, in each case, electromyography and nerve conduction studies within the upper limbs were abnormal, leading to a diagnosis of brachial plexopathy in 1 case, ulnar neuropathy in 4 cases, and apparent median neuropathy at the wrist in 1 case. In each patient, the electrodiagnostic conclusion essentially fit well with the patient’s presenting symptoms and physical exam findings. In each case, the normal cervical paraspinal electromyography was a crucial portion of the testing. We believe this case series is the first to explicitly address the issue of normal cervical paraspinals after ACDF. Discussion: During needle electromyography, cervical paraspinal muscle abnormalities are often considered a hallmark finding in electrodiagnosis of cervical radiculopathy. However, such abnormalities have also been reported merely as a result of spinal surgery, thus decreasing the utility of paraspinal electromyographic testing in postoperative patients. However, newer, anterior approaches to cervical spine surgeries potentially spare the paraspinals from surgery-induced electromyographic abnormalities. Conclusions: Our results have important implications for any electromyographer evaluating upper-limb symptoms in a patient status post ACDF. Electromyographers should not erroneously assume that the postoperative status automatically causes paraspinals to be abnormal. Such flawed assumptions might mislead electromyographers into skipping paraspinal electromyographic testing. Conversely, our results emphasize the importance of including needle electromyography of the cervical paraspinals, even in patients status post ACDF. Key Words: Diskectomy; Electromyography; Radiculopathy; Rehabilitation.  
Poster 78  
Chronic Inflammatory Demyelinating Polyneuropathy With Axonal Involvement: A Case Report. Ali I. Khawaja, MD (Nassau University Medical Ctr, East Meadow, NY); Henry Sardar, DO; Vladimir Salomon, DO; Ajendra Sohal, MD; Jeffrey Perry, DO; Lyn Weiss, MD.  
Disclosure: A.I. Khawaja, None; H. Sardar, None; V. Salomon, None; A. Sohal, None; J. Perry, None; L. Weiss, None.  
Setting: Electromyography laboratory and outpatient rehabilitation unit. Patient: A 42-year-old woman. Case Description: The patient was referred for electromyographic and nerve conduction testing due to weakness and numbness of all 4 extremities. These symptoms developed and progressed over months. Assessment/Results: Strength in bilateral upper extremities was 3/5 proximally and 2/5 distally and strength in bilateral lower extremities was 4/5. There was gross atrophy of small muscles of the hands bilaterally. Sensation to touch and pain were spared in all extremities. Deep tendon reflexes were spared in all 4 extremities. On nerve conduction testing, bilateral median and ulnar and right peroneal motor responses showed increased latencies, decreased amplitudes dispersion, and decreased velocities. Sensory responses in the right tibial motor and sensory responses in the bilateral median, ulnar, and right sural nerves were unobtainable. Monopolar study showed evidence of denervation in upper- and lower-
extremity muscles. The diagnosis of severe segmental demyelinating and axonal sensory motor peripheral neuropathy was made. **Discussion:** Chronic relapsing polyneuropathy is characterized by slowly progressive symmetrical weakness and sensory dysfunction in the extremities. Although usually demyelinating in nature, this case clearly had an axonal component as well, as evidenced by the decreased compound muscle action potential and sensory nerve action potential amplitudes and abnormally spontaneous potentials on needle study. The exact etiology is unknown. **Conclusions:** After clinical assessment, electrodiagnostic studies are extremely helpful in diagnosing, localizing, and prognosticating. As with acute inflammatory demyelinating polyneuropathy, an axonal component has a poor prognosis. **Key Words:** Electromyography; Polyneuropathies; Rehabilitation.

**Poster 79**
**Anterior Interosseous Nerve Damage Presenting as Anterior Wrist Pain: A Case Report.** Andrew I. Gitkind, MD (Montefiore Medical Ctr, Bronx, NY); Ryul Kim, DO; Dennis D. Kim, MD. Disclosure: A.I. Gitkind, None; R. Kim, None; D.D. Kim, None.

**Setting:** A community-based private hospital. **Patient:** A 55-year-old man. **Case Description:** This patient presented for evaluation of left wrist pain, worse when in the neutral position or extension. Because of this, the patient chooses to keep his wrist in flexion. The patient’s anterior wrist pain began 7 months earlier, after an intravenous line infiltrated in his left forearm. Beginning with this event, the patient describes a continuous “deep pain inside” his left wrist. On physical examination, no muscle atrophy was noted of either hand. The only muscle weakness noted was that of pronation of the left forearm. He was also noted to have extension contracture of the interphalangeal joint of the left thumb. The sensory exam was within normal time limits, except for a slight decreased sensation to light touch on the tip of the left thumb. Nerve conduction tests and needle electromyography were performed on the bilateral upper extremities in order to localize any neuropathic involvement. **Assessment/Results:** Sensory nerve conduction studies (NCS) of the left median, radial, and ulnar nerve were all within normal time limits. Mixed NCS of the bilateral median nerves showed normative and symmetrical values. Motor NCS of the bilateral median, and bilateral anterior interosseous nerves were all within normal time limits. Needle electromyography revealed positive sharp waves and fibrillation potentials in both the left flexor pollicis longus and pronator quadratus. **Discussion:** Based on our electrodiagnostic findings, we concluded that our patient had suffered a partial nerve lesion to the left anterior interosseous nerve. **Conclusions:** Without any further evidence of local tissue damage, we conclude that this patient’s wrist pain was due to left anterior interosseous nerve damage, which has been described in the literature only once before. **Key Words:** Electromyography; Pain; Rehabilitation.

**Poster 80**
**Bilateral Meralgia Paresthetica Associated With Injection of the Thigh: A Case Report.** Myung Jae Yoo, MD (Montefiore Medical Ctr of Albert Einstein College of Medicine, Bronx, NY); Sylvia Fernandes, MD. Disclosure: M.J. Yoo, None; S. Fernandes, None.

**Setting:** Tertiary care hospital. **Patient:** A 32-year-old woman with numbness in the lateral aspects of both thighs. **Case Description:** The patient presented with complaints of numbness in the lateral aspects of both thighs for the past 4 months. She denied any back pain and weakness in the lower extremities (LE). Medical history included hepatitis C, for which she had been getting Interferon alfa-2b injections subcutaneously for the past 3 years. On examination, there was mild atrophy of subcutaneous tissue in the upper lateral aspects of both thighs where she was getting the injections. On sensory exam, she had hypoesthesia in the lateral aspects of both thighs. The muscle strength of the LE was normal bilaterally. The knee and ankle jerks were normoactive bilaterally. Straight-leg raise tests and Babinski signs were negative on both sides. **Assessment/Results:** Electrodiagnostic studies were limited secondary to unobtainable sensory responses of the lateral femoral cutaneous nerves (LFCN) on both sides due to technical difficulties. The bilateral tibial and peroneal nerve motor nerve conduction studies were within normal time limits. The sensory studies were within normative limits on the bilateral sural and saphenous nerves. Needle electromyography showed no abnormalities in the bilateral iliohypogastric, vastus medialis, gastrocnemius, tibialis anterior, and L1-5 paraspinal muscles. Magnetic resonance imaging of lumbar spines showed a diffuse mild disk bulge at L4-5 without evidence of neural foraminal narrowing or nerve root compression and lymphadenopathy or pelvic mass lesion. **Discussion:** Meralgia paresthetica is caused by entrapment of the LFCN at the inguinal ligament. In this case, the patient experienced sensory change in the lateral aspects of both thighs. **Conclusions:** To our knowledge, this is one of few reports demonstrating bilateral meralgia paresthetica associated with thigh injections. **Key Words:** Femoral nerve; Rehabilitation.

**Poster 81**
**The Influence of the Reference Electrode on Recording F Waves.** Nobushige Takahashi, MD (Higashisaitama National Hospital, Saitama, Japan); Satoru Mitsumasu, MD; Toshiki MorI, MD; Tomoyoshi Otsuka, MD. Disclosure: N. Takahashi, None; S. Mitsumasu, None; T. MorI, None; T. Otsuka, None.

**Objectives:** To demonstrate that many tibial F waves can be recorded with the tendon electrode and to determine the importance of the “reference” electrode in F-wave recording. **Design:** Experimental study. **Setting:** Electromyography laboratory. **Participants:** 4 healthy subjects. **Interventions:** Tibial and fibular F waves were recorded with the belly and tendon electrodes separately, using the opposite foot electrode as a reference site. **Main Outcome Measure:** F-wave persistence. **Results:** The mean tibial F-wave persistence was 51.5% with the belly electrode and 86.7% with the tendon electrode. A greater number of tibial F waves were recorded with the tendon electrode than with the belly electrode, while few fibular F waves were recorded with the tendon electrode. **Conclusions:** Many of the standard tibial F waves were recorded with the tendon “reference” electrode, and this phenomenon might be a clue to the difference of the F-wave persistence between the tibial and the fibular nerves. **Key Words:** Rehabilitation; Tibial nerve.
Musculoskeletal

Poster 82
Comparative Effects of Adenovirus Expressing Bone Morphogenetic Proteins and Sox9 on Matrix Accumulation by Bovine Anulus Fibrosus Cells: Implications for Anular Repair. Yejia Zhang, MD, PhD (Thomas Jefferson University, Philadelphia, PA); D. Greg Anderson, MD.

Disclosure: Y. Zhang, None; D.G. Anderson, None.

Objective: To compare the effects of recombinant adenoviral vectors expressing various bone morphogenetic proteins and Sox9 on extracellular matrix accumulation by bovine AF cells. Design: Adult bovine AF cells cultured in monolayer were transduced with adenoviral vectors expressing one of the human bone morphogenetic proteins and green fluorescence protein or Sox9 and green fluorescence protein (AdSox9), or green fluorescence protein alone (AdGFP). Setting: Wet lab. Participants: Not applicable. Interventions: Not applicable. Main Outcome Measures: Proteoglycan (PG) and collagen accumulation, and cell proliferation were measured 6 days after viral transduction. Results: Anulus fibrosus cells transduced with BMP-2, −3, −5, −7, −8, −12, −13, −14, −15, and Sox9 accumulated significantly more collagen than AF cells transduced with AdGFP (control). AF cells transduced with Ad-BMP-2, −4, −7, −10, −12, −13, and AdSox9 accumulated more PGs than AF cells transduced with AdGFP. Among the growth factors or transcription factors tested, AdBMP-2, −13, and Sox9 were the most effective in stimulating collagen accumulation (147%, 183%, and 158% increases, respectively), whereas Ad-BMP-2 and −13 were the most effective in stimulating PG accumulation (218% and 167% increases, respectively). Conclusions: This study, the first to compare the relative effectiveness of various BMPs and Sox9 on extracellular matrix accumulation by AF cells, could help to develop more efficacious approaches to anular repair that could be utilized by rehabilitation physicians. Key Words: Intervertebral disk; Rehabilitation; Treatment outcome.

Poster 83
Nephrogenic Systemic Fibrosis—A New Physiatric Challenge: A Case Report. Joan Sybell Petalcorin, MD (Kansas University Medical Ctr, Kansas City, KS); George Varghese, MD; Charles Kelly, MD.

Disclosure: J.S. Petalcorin, None; G. Varghese, None; C. Kelly, None.

Setting: Tertiary care hospital. Patient: A 48-year-old man with left arm pain and swelling. Case Description: The patient, with a history of diabetes (19y), hypertension, end-stage renal disease on hemodialysis, with a patent left upper-extremity arteriovenous fistula, neuropathy, and previous diabetic myonecrosis (1996) of the right quadriceps was admitted with left upper-extremity pain and swelling after a fall onto his left arm. Extensive work-up was unremarkable for thrombosis, abscess, liquefaction necrosis, fracture, osteomyelitis, and central venous stenosis, though magnetic resonance imaging was suggestive for an early-stage myonecrosis. Assessment/Results: The patient was seen by the orthopedic service and was not deemed a candidate for surgery. The patient required intravenous antibiotics, nerve blocks, and a high-dose patient-controlled analgesia pump for pain control. In rehabilitation, the patient’s pain subsided with careful titration of his medications and his swelling improved with gentle therapy. He was discharged home with 4 weeks of doxycycline and amoxicillin/clavulanate. Discussion: First described in 1965 and with less than 30 cases reported in the literature since, diabetic myonecrosis is an extremely rare complication of diabetes. Typical presentation consists of severe thigh pain; however, extremely rare cases can be seen in the upper extremity. Most commonly affected are muscles of the thigh, which can extend to the gastrocnemius. Its pathogenesis is unclear, but its presentation is a sign of underlying vascular disease. Strength and sensation are unaffected, though movement is limited secondary to pain. Short-term prognosis is excellent with strict glucose control, but long-term prognosis is poor due to high rates of recurrence. Most patients die within 5 years of diagnosis. Conclusions: Despite the uncommon presentation of diabetic myonecrosis in the upper extremity, the goal of rehabilitation is for gentle therapy with diabetic and pain management. Vigorous exercise during physical therapy may extend infarction and exacerbate vascular disease. Key Words: Rehabilitation.

Poster 85
Lower-Extremity Muscle Function in “At Risk” Elderly. Brian P. Gavin, BA (Spaulding Rehabilitation Hospital, Boston, MA); Lisa S. Krivickas, MD; Gomathi Krishnan, MS; Kieran Reid, MS; Roger A. Fielding, PhD; Walter R. Frontera, MD, PhD.

Disclosure: B.P. Gavin, None; L.S. Krivickas, None; G. Krishnan, None; K. Reid, None; R.A. Fielding, None; W.R. Frontera, None.

Objective: To compare single muscle fiber contractile properties in elderly persons “at risk for mobility disability” and age-matched healthy controls. Design: Cross-sectional study. Setting: Muscle physiology lab. Participants: 18 subjects (12 men, 6 women; mean imaging contrast agent gadolinium and the development of NSF is suggested as a strong possibility. The pathogenesis of the skin fibrosis is discussed. 3 other cases with similar clinical features were encountered in our clinic. Methods of rehabilitation management are presented. Conclusions: NSF results in progressive soft tissue and joint contractures, affecting the patient’s ADLs and mobility, making the rehabilitation a challenge. It is essential that physiatrists recognize this disorder when encountered. Should gadolinium exposure be proven to be a causative factor in the development of NSF, then physicians should be cautious in ordering imaging with contrast on end-stage renal patients. Key Words: Contracture; Fibrosis; Rehabilitation; Renal disease, end stage.
age, 74y), were classified by Short Physical Performance Battery score, an indicator of future mobility disability. A score of 9 or lower was considered “at risk” (n = 6) and of 10 or higher was considered healthy (n = 12). 

**Interventions:** Percutaneous biopsies were obtained from the vastus lateralis muscle. The cross-sectional area (CSA) of 339 chemically skinned single muscle fibers was measured followed by activation in Ca\(^{2+}\) solution. The slack test was used to determine maximal force, specific tension, and unloaded shortening velocity. A series of isometric contractions was performed to generate a power curve for each fiber, allowing measurement of peak and specific power. Myosin heavy chain (MHC) composition was determined using sodium dodecyl sulfate–polyacrylamide gel electrophoresis. 

**Main Outcome Measures:** CSA, maximal force, specific tension, unloaded shortening velocity, peak power, specific power, and MHC composition. 

**Results:** Type I muscle fibers from “at risk” subjects had a lower unloaded shortening velocity compared with healthy subjects (0.62FL/s vs 0.57FL/s; P = .016). There were no between-group differences in CSA, maximal force, specific tension, peak power, or specific power. Type IIa muscle fibers did not show significant differences between groups. 

**Conclusions:** Elderly people who are “at risk” for mobility disability have reduced single muscle fiber velocity. This may contribute to a decrease in whole muscle contractile velocity and power generation, which in turn may decrease ability to correct balance perturbations and increase the risk of falls. 

**Key Words:** Aging; Muscle fibers; Myosin, heavy chains; Rehabilitation.

**Poster 86** 

Local Biochemical Milieu Response to Microdialysis Needle Advancement in the Upper Trapezius Muscle in Normal, Latent, and Active Myofascial Trigger Points. Lynn Y. Nakamura, MD (NIH, Bethesda, MD); Jay P. Shah, MD; Jerome Danoff, PhD, PT; Lynn H. Gerber, MD; Sagar Parikh, BA; Terry Phillips, PhD, DSc. 

Disclosure: L.Y. Nakamura, None; J.P. Shah, None; J. Danoff, None; L.H. Gerber, None; S. Parikh, None; T. Phillips, None. 

**Objective:** To observe temporal changes of selected biochemical markers in response to microdialysis needle advancement (MNA).

**Design:** Prospective, controlled. 

**Setting:** Biomedical research hospital.

**Participants:** 9 subjects were equally distributed among 3 groups based on trapezius findings: normals (no neck pain or myofascial trigger points [MTP]); latents (no neck pain but MTP present); and actives (neck pain and MTP present).

**Intervention:** Samples were obtained at regular intervals for 9 minutes after MNA.

**Main Outcome Measures:** Intergroup and intragroup comparison of marker slopes post-MNA (5–9min) and at profile tail (10–14min). Selected markers include bradykinin, serotonin, nor-epinephrine, interleukin (IL)-1β, substance P (SP), calcitonin gene-related peptide (CGRP), tumor necrosis factor alpha (TNF-α), IL-6, IL-8, and IL-12. 

**Results:** Time-dependent profiles of each marker were characterized by a distinct curve. Levels peaked at approximately 5 minutes then declined, but not all markers returned to baseline. Post-MNA, each marker concentration, except IL-12, declined. There were intergroup slope differences between actives versus latents and normals for all markers except IL-6 and IL-8 (P < .05). For the profile tail, intergroup slope differences were found between actives versus latents and normals for bradykinin, serotonin, SP, CGRP, IL-1β, and TNF-α (P < .05). In actives, bradykinin and serotonin increased whereas other markers remained stable or continued to decline. 

**Conclusions:** Marker peaks temporally corresponded with MNA. The post-MNA marker decline suggests a possible biochemical basis for dry-needling MTPs. Intergroup differences post-MNA and at profile tail in actives differ biochemically from latents and normals. This is consistent with previous studies. Bradykinin, serotonin, and CGRP increased at profile tail in actives only, suggesting they may play a role in the maintenance of active MTPs. Additionally, the elevation in bradykinin suggests muscle injury may distinguish actives from latents and normals. Among cytokines, TNF-α peaked higher and declined slower in actives versus latents and normals, suggesting a greater role in myofascial pain. 

**Key Words:** Microdialysis; Myofascial pain syndromes; Rehabilitation; Trigger points, myofascial.

**Poster 87** 


Disclosure: K.A. Carneiro, None. 

**Setting:** Inpatient rehabilitation. 

**Patient:** A 39-year-old woman with postpartum pelvic injury. 

**Case Description:** The patient is a G1P2 female who acquired a 5-cm diastasis of the pubic symphysis during vaginal delivery of twins, complicated by mid-shoulder dystocia. The patient presented with severe back pain on postpartum day 0. The PM&R service was consulted on postpartum day 1 and directed orthopedic care. After pelvic radiographic views were obtained and diastasis made apparent, the orthopedics service was consulted. With failure of an orthosis to brace and stabilize the pubic separation, the patient was taken to surgery for open reduction and external fixation on postpartum day 4. The patient was transferred to our inpatient rehabilitation facility on postpartum day 9. 

**Assessment/Results:** The patient participated in an 8-day course of comprehensive physical and occupational rehabilitation therapies. The patient made significant functional gains, with a total discharge FIM score of 100 and a change in the total FIM score of 21. The overall FIM efficiency score was 12.5. The most significant changes occurred in locomotion and transfers. Hospital course was notable for active medical and nursing management of urinary retention and pain. 

**Discussion:** This is the first report, to our knowledge, of the occurrence of pelvic injury (pubic diastasis) following traumatic vaginal delivery of twins. This case report outlines the patient’s characteristics that may affect the outcomes of inpatient rehabilitation. 

**Conclusions:** Early interventions in inpatient rehabilitation in postpartum women with severe pubic diastasis can improve their overall functional status and the quality of life necessary in the care for their newborns. 

**Key Words:** External fixators; Pubic symphysis; Rehabilitation.

**Poster 88** 

Paper presentation.
Young adult New Zealand White rabbits. **Interventions:** Not applicable. **Main Outcome Measures:** Proteoglycan accumulation by the disk explants was assessed using the dimethylmethylene blue dye-binding method. **Results:** 1 month after injection, the explants injected with chondrocytes expressing Ad-hBMP-7 accumulated 49.2% ($P<.05$) more proteoglycans in the NP than those injected with chondrocytes transduced with AdGFP. **Conclusions:** We have successfully cultured rabbit disks with intact endplates for up to 2 months. We also have shown, for the first time, that chondrocytes transduced with Ad-hBMP-7 can survive in the disk explant where they stimulate matrix production by the NP. Because chondrocytes are widely available and phenotypically similar to disk cells, they are an attractive cell type for promoting disk repair. **Key Words:** Growth factors; Intervertebral disk; Rehabilitation; Treatment outcome.

**Poster 90**

**Rare Case of Tuberculosis of the Knee in an Elderly East-Indian Man Living in the United States: A Case Report. Jafar W. Siddiqui, MD (Rush University Medical Ctr, Chicago, IL); Christopher Reger, MD; Xuong K. Tang, DO.**

Disclosure: J.W. Siddiqui, None; C. Reger, None; X.K. Tang, None.

**Setting:** Tertiary care hospital. **Patient:** An 80-year-old East-Indian man with knee pain. **Case Description:** The patient, with medical history significant for degenerative joint disease, presented with atraumatic, progressive right knee pain, stiffness, and swelling refractory to conservative treatment. Initial workup was consistent with pigmented villonodular synovitis. **Assessment/Results:** The patient had normal chest radiographs and blood work. Magnetic resonance imaging showed highly proliferative synovial reaction with severe destructive arthropathy. He underwent resection arthroplasty, antibiotic spacer placement, and synovectomy. Acid-fast bacilli stains were negative by biopsy, but consistent with noncaseating granulomatous disease. Post-placement, and synovectomy. Acid-fast bacilli stains were negative by biopsy, but consistent with noncaseating granulomatous disease. Postplacement, and synovectomy. Acid-fast bacilli stains were negative by biopsy, but consistent with noncaseating granulomatous disease. Post-operatively, the patient was fitted with a knee immobilizer on touchdown weight-bearing status and a prolonged course of combination anti-tuberculosis (TB) chemotherapy medication. Patient subsequently underwent successful knee reimplantation. **Discussion:** TB is the number one cause of death and disability worldwide. Skeletal TB is not common and accounts for 1% of all cases of TB worldwide and is even rarer in the United States. It frequently involves the spine (50%), pelvis (12%), hip and femur (10%), and the knee and tibia (10%). Knee joint TB is an even rarer condition (0.1%) that is primarily observed in children and young adults in Southeast Asia and sub-Saharan Africa. It is usually monarticular and diagnostic imaging is made by biopsy. Clinically, these patients present with progressive pain and/or loss of joint function; the onset of symptoms is often insidious, occurring over weeks to months. Surgical intervention is warranted to drain large abscesses and/or to obtain synovial tissue for biopsy. A total knee arthroplasty is usually performed with combined pre- and postoperative chemotherapy when there is advanced disease process from loss of joint space and osseous architecture. **Conclusions:** Although rare, knee joint tuberculosis should be considered part of the differential diagnosis for synovial diseases in the absence of pulmonary TB. Once diagnosed, the mainstay of treatment is active-assisted non-weight-bearing exercises of the involved joint for successful return to premorbid functioning. **Key Words:** Knee; Rehabilitation; Tuberculosis.

**Poster 91: Paper presentation.**

**Poster 92: Paper presentation.**

**Poster 93**

**Neuroborreliosis Causing Symmetric Plexopathy: A Case Series. Joel See, MD (Tufts New England Med Ctr, Boston, MA); Matthew Johnson, DO; Ryan Stephenson, DO; Khyber Zaffar Khan, DO.**

Disclosure: J. See, None; M. Johnson, None; R. Stephenson, None; K. Zaffar Khan, None.

**Setting:** Acute rehabilitation hospital. **Patients:** 2 patients with severe focal weakness. **Case Descriptions:** These 2 patients were in their usual state of health until 6 weeks prior to admission. Each of the patients complained of headache and a mild fever for a few days that resolved without medical attention. There was approximately 1 week of quiescence for each patient. The first patient developed migratory shoulder pain over the next 3 weeks, with initial right shoulder discomfort that was treated with physical therapy. 2 weeks later his left shoulder pain was attributed to compensatory overuse from the prior shoulder pain. The second patient developed lumbosacral back pain as well as mild abdominal pain. In both of these cases, strength was relatively preserved until 4 weeks after the initial joint pains, prompting further workup. **Assessment/Results:** Both patients underwent thorough workup for their complaints, including magnetic resonance imaging early in the course and electrophysiologic testing later. The electromyography studies showed a plexopathy of the brachial plexus and lumbosacral plexus, respectively. Lyme serology studies returned positive in both cases, including immunoglobulin M assays that definitively demonstrated acute infection. A course of ceftriaxone was prescribed successfully for each patient; however, the return of muscle function required several months of rehabilitation. **Discussion:** These cases demonstrate an uncommon way neuroborreliosis can present. **Conclusions:** While shoulder and lower back pain are extremely common, the waxing and waning nature of the symptoms should prompt clinicians to suspect unusual causes such Lyme disease. The muscle weakness in these cases was rather abrupt, and early detection may lead to sparing of further decline. **Key Words:** Lyme disease; Rehabilitation.

**Poster 94**

**Lyme Radiculopathy: A Case Report. Jennifer Baima, MD (Brigham and Women’s Hospital/Spaulding Rehab Hospital, Boston, MA); Zacharia Isaac, MD.**

Disclosure: J. Baima, None; Z. Isaac, None.

**Setting:** Outpatient spine clinic. **Patient:** A 52-year-old man. **Case Description:** Mismatch between objective clinical findings and diagnostic imaging demonstrates an interesting clinical dilemma for the musculoskeletal physician. The patient presented with a history of psoriatic arthritis on methotrexate and remicade, with more than 4 weeks of neck pain, upper-back pain, and severe left arm pain. On physical exam, there was atrophy of the first dorsal interossei and the abductor pollicis brevis. **Assessment/Results:** Electromyography studies and clinical findings were consistent with left C8 radiculopathy. However, neuroimaging did not demonstrate left foraminal narrowing at C7-T1. While awaiting further diagnostic tests, the patient developed a target lesion over the left anterior thigh consistent with erythema migrans. He was evaluated in the emergency department and laboratory data were consistent with early Lyme infection. The patient’s remicade and methotrexate were discontinued. He was treated with a course of intravenous ceftriaxone with complete resolution of left upper-limb radicular pain. **Discussion:** Our patient had clinical evidence of Lyme neuropathy prior to developing erythema migrans. Classically, erythema migrans usually occurs before other manifestations of Lyme disease. Because early disseminated Lyme disease may also occur in the first month of infection, the radiculopathy may present prior to, concurrently with, or after the rash. Unfortunately,
there is insufficient evidence on the temporal course of erythema migrans in disseminated Lyme disease because adults often miss the tick bite and routine screening is discouraged. **Conclusions:** Lyme radiculopathy is an important consideration in patients presenting to outpatient spine clinics with radicular pain in the absence of foraminal compression on magnetic resonance imaging. **Key Words:** Lyme disease; Radiculopathy; Rehabilitation; Spine.

**Poster 95**

**Ultrasound-Guided Aspiration of a Right Shoulder Spinoglenoid Notch Cyst: A Case Report.** Jeffrey Payne, MD (Mayo Clinic College of Medicine, Rochester, MN); Stephen Wisniewski, MD; Jay Smith, MD.

Disclosure: J. Payne, None; S. Wisniewski, None; J. Smith, None.

**Jay Smith, MD.**

College of Medicine, Rochester, MN); Stephen Wisniewski, MD; Jay Smith, MD.

**Case Description:** The patient presented with a 6-week history of achy, nonradiating, posterior right shoulder pain. The pain primarily occurred with running and was limiting his training for an upcoming triathlon. Physical examination demonstrated mild infraspinatus atrophy, 3/5 strength with external rotation, and multidirectional laxity, which was most pronounced posteriorly at 3+. An ultrasound examination of the right shoulder demonstrated a large, well-defined 2.4×1.4×2.4cm simple cyst located in the spinoglenoid notch that deformed the overlying infraspinatus muscle. The cyst appeared to be arising from the posterior glenohumeral joint. Electromyography showed an acute to subacute right supraspinatus neuropathy distal to the branch to the supraspinatus. Because the patient was hoping to participate in a triathlon in 1.5 weeks, it was decided to attempt to aspirate the cyst. Therefore, using ultrasound guidance, an 18-gauge spinal needle was advanced from a lateral-to-medial approach and penetrated the cyst. Aspiration produced 3.5mL of typical ganglionic fluid, which resulted in an approximately 50% reduction in the size of the cyst. **Assessment/Results:** The patient was able to complete the triathlon and was not limited by shoulder pain. Magnetic resonance imaging was performed following the triathlon and showed a 2.5×0.9cm lobulated ganglion cyst in the spinoglenoid notch with a moderate-sized posterior labral tear. The patient subsequently underwent right shoulder arthroscopy with cyst decompression and posterior superior labral repair. **Discussion:** This case illustrates the use of musculoskeletal ultrasound for both diagnostic and interventional purposes in the shoulder. The use of ultrasound in the presented case helped to provide an accurate, timely diagnosis and treatment of a difficult clinical problem. **Conclusions:** Musculoskeletal ultrasound is a useful tool for both diagnostic and interventional purposes. **Key Words:** Aspiration; Rehabilitation; Ultrasound, interventional.

**Poster 96**

**Construct Validity of Biochemical Measurement for Muscle Injury.** William Parkinson, PhD (McMaster University, Hamilton, ON, Canada); Dinesh A. Kumbhare, MD, MSc; Brett Dunlop, MD.

Disclosure: W. Parkinson, None; D.A. Kumbhare, None; B. Dunlop, None.

**Objective:** To test the construct validity of circulating creatine kinase as a measure of muscle injury, using paraspinous muscle retraction in lumbar surgery as a model. **Design:** Repeated measures and measurement development. **Setting:** Physical medicine research laboratory and orthopedic surgery clinic. **Participants:** 18 subjects who underwent lumbar decompression surgery. **Interventions:** Not applicable. **Main Outcome Measures:** Surface area of muscle isolated and retracted (length of incision by muscle depth) and serum creatine kinase (CK) concentration, measured as the total CK and skeletal muscle isomer (CK/MM). Blood samples were obtained from the intravenous catheter during hospitalization and by venipuncture in the home after discharge. A baseline sample was taken in the preoperative waiting area, immediately after the operation, and then at 6, 12, 24, and 48 hours. Each subject’s highest CK concentration between 12 to 48 hours postsurgery was used as the biochemical injury response. **Results:** The correlation between CK muscle surface area was moderate ($r=.60$) and significant ($P<.01$). Correlations between surface area and CK at specific time points revealed minimal loss of association at 12 hours ($r=.57$) and 24 hours ($r=.58$) but weaker correlations at 6 hours ($r=.45$) and 48 hours ($r=.28$) postinjury. Analyses for proportions of each isoenzyme making up the total CK revealed that baseline and peak CK consisted almost exclusively of skeletal muscle CK (CK-MM), with minimal representation by heart muscle and brain. **Conclusions:** The findings provide support for the construct validity of serum CK as an index of skeletal muscle injury. Sampling at the peak maximizes valid measurement. **Key Words:** Creatine kinase; Muscles; Rehabilitation; Validity of results; Wounds and injuries.

**Poster 97**

**Coccydynia (Coccyx Pain) due to Dynamic Instability of the Tailbone: A Case Report.** Michael Rhee, MD (UMDNJ-Newark, Newark, NJ); Patrick M. Foye, MD; David Tung, MD.

Disclosure: M. Rhee, None; P.M. Foye, None; D. Tung, None.

**Setting:** Outpatient clinic. **Patient:** A 53-year-old woman with coccydynia (coccyx pain), worse with sitting. **Case Description:** The patient presented for physiatric pain management consultation for coccydynia. Previous work-up elsewhere focused on imaging studies (including magnetic resonance imaging) of the lumbosacral spine, ironically lacking any images that included the symptomatic tailbone. **Assessment/Results:** On consultation, the physiatrist ordered sacrococcygeal radiographs, specifically including coned-down lateral views of the coccyx in 3 positions: supine, standing, and seated. The supine and standing coccygeal radiographs appeared essentially within normal limits. However, the radiographs obtained with the patient seated (the position that reproduced her concordant pain) demonstrated a blatantly obvious posterior dislocation of the coccyx relative to the sacrum. In fact, in the seated position, approximately 75% of the coccygeal depth (in the anteroposterior dimension) had dislocated posterior to the posterior aspect of the distal sacrum. Thus, while seated, most of the coccyx had actually dislocated to a position behind the sacrum, rather than remaining inferior to the sacrum. These “stress” views documented pathology that would have been missed by traditional coccygeal imaging studies. The dynamic instability visualized from these studies corroborated her concordant symptoms. **Discussion:** The etiology of coccydynia is sometimes elusive. Objective findings, when demonstrated, can have significant medicolegal implications. Objective findings can also help reassure patients that their tailbone pain is not “all in their head,” as some patients have been told by their doctors. Such abnormalities can form a basis for patients discussing with the patient an individualized approach to the various treatment options for coccydynia. **Conclusions:** Diagnostic workup for coccydynia should often include adding coned-down lateral radiographs with the patient in the seated position. These seated views are particularly helpful in cases where more traditional radiographs have failed to document pathology that explains the patient’s symptoms. **Key Words:** Coccyx; Pain; Rehabilitation.
Poster 98
The Use of Computed Tomography Scan With 3-Dimensional Reconstructions to Identify Occult Bony Abnormalities Producing Chronic Pain: A Report of 2 Cases. Martin S. Tamler, MD; Adam T. Zierenberg, MD (William Beaumont Hospital, Royal Oak, MI). Disclosure: M.S. Tamler, None; A.T. Zierenberg, None.

Setting: Outpatient office. Patients: A 39-year-old woman with pain over the left posterior iliac crest and a 46-year-old man with right costochondral pain. Case Descriptions: The first patient had experienced 4 years of chronic left-sided low back pain following a left ilium bone graft harvest for a lumbar spinal fusion. The pain prevented her from sitting against the back of a chair. Magnetic resonance imaging (MRI) failed to show abnormality other than postoperative changes at that site. A computed tomography scan with 3-dimensional reconstructions (3D-CT) showed a “corticated osseous lesion” (7.6cm bony spicule) arising from the superior-posterior aspect of the left ilium corresponding to the location of the patient’s pain. An orthopedic surgeon was able to successfully excise the large bony growth. The second patient had chronic pain in the right anterior chest wall along the lower costal margin. The patient underwent extensive workup, including plain films, cardiac testing, cholescintigraphy, and abdomi- nal and thoracic CT with no identifiable abnormalities. 3D-CT showed an “ossific or calcific structure” protruding from the lower costal margin. This patient also underwent surgical excision of the bony spicule. Assessment/Results: Following surgical intervention both patients experienced significant long-term resolution of their chronic pain symptoms and were able to discontinue pain medication. Discussion: The use of MRI has become ubiquitous in identifying causes of pain. We identify 2 cases where MRI was found to be nondiagnostic. In both examples, 3D-CT was able to identify large occult bony spicules that would have otherwise been missed. In each instance, patients were identified to be surgical candidates, the large bony spicules were removed, and pain was completely resolved. Conclu- sions: CT scan with 3-dimensional reconstruction should be consid- ered as another diagnostic option for identification of bony sources of chronic pain. Key Words: Pain; Rehabilitation; Tomography scanners; x-ray computed.

Poster 99
Early Development of Postoperative Hematoma in Patients Receiving Fondaparinux Sodium for Prophylaxis Against Deep Vein Thrombosis: A Case Series. Robert E. Roberts III, MD (Temple University Hospital, Philadelphia, PA); Carmen A. Angles, MD. Disclosure: R.E. Roberts III, None; C.A. Angles, None.

Setting: Acute inpatient rehabilitation hospital. Patients: 3 patients admitted for inpatient rehabilitation following orthopedic surgery. Patient A was a 78-year-old man who underwent an elective right total hip arthroplasty. Patient B was an 81-year-old woman who underwent an elective right total knee arthroplasty. Patient C was a 50-year-old man who underwent an elective right total hip arthroplasty. Patients A and C had their procedures performed by the same surgeon, while patient B underwent surgery by a different surgeon at another facility. Case Descriptions: Patient A reported increased swelling and discomfort behind the right knee on rehabilitation day 1 (postoperative day 5). Patient B complained of pain and swelling in the right thigh on rehabilitation day 3 (postoperative day 6). Patient C developed uncomfortable swelling of the right lateral thigh on rehabili- tation day 2 (postoperative day 5). Assessment/Results: Ultrasound examinations were performed on all 3 patients. Patient A was found to have a hematoma in the right popliteal fossa. Patient B was found to have multiple hematomas in the right thigh. Patient C was found to have a small hematoma in the right thigh underlying his incision. Discussion: All 3 patients developed symptomatic postoperative hematomas while being treated with fondaparinux sodium during the first few days of their rehabilitation stay. Over the same time period, no postoperative hematomas were diagnosed in patients receiving other medication for deep venous thrombosis (DVT) prophylaxis. Conclusions: Treatment with fondaparinux sodium for prophylaxis of DVT following orthopedic surgery may increase the risk of postoperative hematoma formation, particularly soon after admission to rehabilitation. Key Words: Hematoma; Postoperative complications; Rehabilitation; Thromboembolism.

Poster 100
Adhesive Capsulitis Symptoms in a Patient With Intracapsular Shoulder Abscess: A Case Report. Sayed E. Wahezi (Montefiore Medical Ctr/Albert Einstein College of Medicine, Bronx, NY). Disclosure: S.E. Wahezi, None.

Setting: Tertiary care hospital. Patient: A 52-year-old man with spinal abscess. Case Description: The patient with a medical history of hypertension, diabetes mellitus, immunoglobulin G and A gammopathy, and methillicin-suspectible Staphylococcus aureus (MSSA) epidural spinal abscess in 1986, was diagnosed with acute MSSA subdural spinal abscess. He presented to the medical unit with right upper-extremity (RUE) weakness, headache, and fever. On day 20 of a 60-day course of intravenous nafcillin, he complained of worsening “stiffness” in his right shoulder. He did not have neck or hand pain, numbness, or constitutional symptoms. His shoulder was not erythe- metous, edematous, or warm or tender to palpation. On physical examination he had an active assist range of motion (ROM) of 60° in flexion, 30° in extension, and 30° in abduction, without pain. All rotator cuff muscle tests were negative. RUE strength was unchanged since day of admission. The left shoulder was normal. Radiographs of the shoulder and neck were negative. A T2-weighted magnetic reso- nance imaging of the right shoulder and brachial plexus displayed a high-intensity signal at the head of the humerus and rotator cuff tendons with a large loculated glenohumeral fluid collection, which extended to the subcoracoid space. Erythrocyte sedimentation rate was elevated (95mm/h), while C-reactive protein was normal (0.7). These results suggested chronic infectious versus chronic inflammatory eti- ology. Aspiration of the right shoulder was performed. Approximately 10mL of frank pus was obtained. Incision and drainage of the localized collection was performed the following day. He was observed 48 hours postoperatively, during which his strength and ROM consistently improved. Assessment/Results: At 2 weeks postoperatively, the pa- tient continued to demonstrate improvement of right shoulder ROM. Further developments will be discussed. Discussion: To our knowl- edge, this is the first reported case of a capsular infection that mim- icked adhesive capsulitis. Conclusions: In the proper setting, capsular infections can mimic adhesive capsulitis. Key Words: Adhesive cap- sulitis; Epidural abscess; Rehabilitation.

Poster 101
The Biochemical Response Post Microdialysis Needle Insertion in Active, Latent, and Absent Myofascial Trigger Points in the Upper Trapezius Muscle. Sagar S. Parikh, BA (National Institute of Health, Bethesda, MD); Jay P. Shah, MD; Jerome Danoff, PhD, PT; Lynn H. Gerber, MD; Lynn Y. Nakamura, MD; Terry Phillips, PhD, DSc. Disclosure: S.S. Parikh, None; J.P. Shah, None; J. Danoff, None; L.H. Gerber, None; L.Y. Nakamura, None; T. Phillips, None.

Objective: To observe temporal responses of selected biochemical markers post microdialysis needle insertion (PMNI) in the upper trapezius. Design: Prospective, controlled. Setting: Biomedical research hospital. Participants: 9 subjects were equally distributed into Arch Phys Med Rehabil Vol 88, September 2007
3 groups based on these findings in the trapezius: actives (painful and myofascial trigger points [MTP] present); latents (nonpainful but MTP present); and normals (no pain or MTP present). **Intervention:** Samples were obtained at regular intervals for 5 minutes PMNI. **Main Outcome Measures:** Intergroup and intragroup comparisons of marker slopes PMNI at specific intervals (1–2, 2–4, and 4–5 min). Selected markers include bradykinin, substance P, calcitonin gene-related peptide (CGRP), serotonin, norepinephrine, tumor necrosis factor alpha, interleukin-1β, interleukin-6, interleukin-8, and interleukin-12 (IL-12). **Results:** Time-dependent profiles of each marker were characterized by distinct curves. Marker curves peaked at approximately 5 minutes PMNI. For 1 to 2 minutes, bradykinin showed the greatest initial ascent for actives versus latents and normals (P < 0.01). All other marker curves remained flat. For 2 to 4 minutes, intergroup slope differences existed between actives versus latents and normals for all markers, except substance P and CGRP (P < 0.001). Intragroup slope differences existed in actives only (P < 0.03). All marker curves ascended in actives (except IL-12); latents and normals remained flat. For 4 to 5 minutes, significant intergroup slope difference existed between actives versus latents and normals for serotonin and all cytokines (P < 0.02). Intragroup differences existed for all cytokines in latents and normals (P < 0.03), and bradykinin and serotonin in normals only (P < 0.03). **Conclusions:** Marker curves display unique intergroup and intragroup time-dependent profiles PMNI. The earlier marker ascent in actives suggests that subjects with active MTPs are more responsive to noxious stimuli than latents or normals. In actives, all markers changed at varied times and rates, suggesting a complex interplay of biochemical reactions. Cytokines levels elevated faster and peaked higher in actives, suggesting a possible role in MTP symptomatology. **Key Words:** Microdialysis; Myofascial pain syndromes; Rehabilitation; Trigger points, myofascial.

**Poster 102**

**Retroperitoneal Hematoma as a Source of Hip Pain on a Rehabilitation Service: A Case Report.** Joseph P. Purcell, DO (NYU School of Medicine, New York, NY).

**Disclosure:** J.P. Purcell, None.

**Setting:** Acute inpatient rehabilitation hospital. **Patient:** An 81-year-old man with a history of atrial fibrillation on chronic warfarin therapy, prostate cancer, and spinal stenosis was admitted to an outside hospital for a congestive heart failure exacerbation. **Case Description:** His hospital course was significant for treatment of congestive heart failure and a mechanical fall. He was then transferred to an acute inpatient rehabilitation hospital with a recent diagnosis of chronic inflammatory demyelinating polyneuropathy. His transfer occurred prior to the generation of an official report of a left hip radiograph taken following the fall. On admission, he complained of left hip pain that radiated to his groin and improved while he was seated upright. **Assessment/Results:** Basic labs on transfer were normal with the exception of a subtherapeutic international normalization ratio (INR) for which he had been receiving treatment with enoxaparin. At this time, the official radiograph report from the outside hospital was received, revealing suspicion for a femoral neck fracture. Computed tomography of the hip was immediately obtained to view the femoral neck with greater resolution. It was negative for a fracture, though it revealed a 10x8 cm retroperitoneal hematoma. Admission labs then returned revealing a drop in hematocrit and a subtherapeutic INR. He became hypotensive and syncopated. He was stabilized and transferred to the medical hospital, and later underwent open laparotomy with evacuation of the retroperitoneal hematoma. **Discussion:** The sources of hip pain are numerous and not always benign in origin. If the differential diagnosis is not extensive and workup is not initiated in a timely manner, the consequences can be severe. **Conclusions:** The evaluation of hip pain requires an extensive differential diagnosis, especially in patients with significant medical comorbidities. **Key Words:** Hematoma; Hip; Rehabilitation.

**Poster 103**

**Thoracic Pain Secondary to a Spontaneous Sternal Fracture in a Young Cystic Fibrosis Patient: A Case Report.** Kaipo Pau, MD (Spaulding Rehabilitation Hospital/Harvard Medical School, Boston, MA); Yong-Tae Lee, MD; Darren C. Rosenberg, DO.

**Disclosure:** K. Pau, None; Y. Lee, None; D.C. Rosenberg, None.

**Setting:** Outpatient clinic. **Patient:** A 21-year-old right-handed man with cystic fibrosis (CF). **Case Description:** The patient presented to the clinic after having been evaluated for right posterior and medial shoulder pain, which started in October 2003. The patient had had multiple evaluations and treatment of the shoulder, including magnetic resonance imaging (MRI), physical therapy, and even an injection, with minimal improvement of his symptoms. On examination, the patient was noted to have thoracic levels T4–7 rotated to the right-hand side with overlying paraspinous muscle spasm and rib restriction on the left. It was also noted that there were active trigger points over the right thomboid region. A thoracic MRI revealed a mild thoracic spondylodiscus without impingement. A transforaminal epidural steroid injection was tried, without relief. He also underwent other treatments consisting of manual manipulation and a trial of tizanidine with minimal effect. **Assessment/Results:** Given the continuation of his symptoms despite treatment, a bone scan was ordered. The scan was found to have evidence of increased uptake indicative of a sternal fracture as well as a right rib fracture; despite having a recent normal bone density scan. **Discussion:** This is an unusual presentation of a spontaneous sternal fracture presenting as chronic thoracic pain in a young CF patient with normal bone density. **Conclusions:** It is important to have a good differential diagnosis when identifying the source of a patient’s pain. While a patient’s pain may present in a certain manner, the actual cause of the pain may be referred from another point. **Key Words:** Cystic fibrosis; Fractures, bone; Rehabilitation.

**Poster 104**

**Thoracic Arachnoid Cyst in a Young Man With Ehlers-Danlos Syndrome Presenting With Thoracolumbar Back Pain: A Case Report.** Franz J. Macedo, DO (University of Wisconsin, Middleton, WI); Bonnie Weigert, MD; Kelly Logan, DO.

**Disclosure:** F.J. Macedo, None; B. Weigert, None; K. Logan, None.

**Setting:** University hospital, outpatient clinic. **Patient:** A 24-year-old man with Ehlers-Danlos syndrome, back pain, and worsening gait. **Case Description:** The patient presented for evaluation of 10-year history of thoracic back pain with worsening gait. His pain was “stabbing,” worse from sit to stand, and associated with leg pain at night. He had difficulty walking, which he attributed to worsening equinovarus foot deformities and left ankle pain. Medical history included Ehlers-Danlos syndrome, radiographic evidence of left distal fibular fracture (subacute), and asthma. On examination, the skin had diffuse scarring. He had equinovarus foot deformities and left ankle pain with weight bearing. Lower extremities were hyperreflexic with an upgoing Babinski sign bilaterally. Flexion of his lumbar spine reproduced pain in the thoracolumbar spine. Thoracolumbar spine films showed mild disk degeneration at L3–5 and left scoliotic curve at T3-7 without fracture. Magnetic resonance imaging (MRI) of the lumbar spine was negative. MRI of the thoracic spine showed a T1-5 dorsal arachnoid cyst compressing the thoracic cord with myelomalacia distal to the lesion extending to T7. A thoracic myelogram showed dye filling the cyst, representing communication with subarachnoid...
space. **Assessment/Results:** History, examination, and diagnostic data all supported the diagnosis of thoracic dorsal arachnoid cyst with myelopathy. **Discussion:** Intradural arachnoid cysts of the spine are rare and have been commonly associated with arachnoiditis. In this case there is no known etiology. While there is no documented evidence, the connective tissue disorder (Ehlers-Danlos) may be a predisposing factor. **Conclusions:** This is a case of thoracic spinal arachnoid cyst of unknown etiology. When large enough, cysts of this type can cause back pain and myelopathy. Interventions include computed tomography—guided aspiration of the cyst or laminectomy with excision of the cyst wall. **Key Words:** Arachnoid cysts; Ehlers-Danlos syndrome; Myelopathy; Rehabilitation.

**Poster 105**

**Functional Capacity of Elderly People Living Alone in Their Homes Prior to the Acute Care Admission for a Hip Fracture: A Cohort Study of 2 Rehabilitation Settings.** Esther Pàgès, MD, PhD (Vall d’Hebron Hospitals, Barcelona, Spain); Ampar Cuxart, MD, PhD; Jordi Iborra, MD, PhD; Judith Sánchez Raya, MD; Ramón Arroyo, MD.

Disclosure: E. Pàgès, None; A. Cuxart, None; J. Iborra, None; J. Sánchez Raya, None; R. Arroyo, None.

**Objective:** To compare, in a prospective analysis, the functional outcome of 2 rehabilitation settings after discharge from the acute hospital, for elderly patients who were living alone in their homes before suffering a hip fracture. **Design:** Longitudinal design with prospectively collected data. **Setting:** Rehabilitation unit in level III trauma center. **Participants:** 215 patients aged 65 years and older admitted from their own home and living alone to a public tertiary university hospital with acute hip fracture diagnosis, who underwent rehabilitation at home or at a convalescent care unit between 2003 and 2006. **Intervention:** Rehabilitation at home or at a convalescent care unit. **Main Outcome Measures:** All patients were evaluated immediately after admission to the hospital and after rehabilitation discharge, using a specially designed questionnaire that included social, medical, functional, and orthopedic variables. The statistical analysis was done with SPSS, version 13, and an inferential bivariate analysis was applied. The level of statistical significance used was $P<.05$.

**Results:** No statistically significant differences (age, sex distribution, social support, comorbidities, mental status, previous functional level, type of fracture, surgical treatment) in either series were found. Patients discharged home with rehabilitation ambulated better (not able, 4.6% vs 2.1%; indoors with walker, 16.5% vs 34%; outdoors with crutches, 27.5% vs 23.4%; outdoors with crutches, 51.4% vs 40.4%; $P=.032$) with a lower mean number of physical therapy sessions (24 vs 51, $P<.01$) and a lower mean discharge time (61d vs 80d, $P<.01$) than patients discharged to a convalescent care unit. **Conclusions:** The home rehabilitation program presents great advantages by returning patients with hip fractures to their home environment, and may promote earlier functional independence. **Key Words:** Elderly; Hip fractures; Hospitals, convalescent; Rehabilitation.

**Poster 106**

**Clinically Occult Presentation of Femoral Neck Fracture on the Inpatient Rehabilitation Consult Service: A Case Report.** Annie Davidson, DO (NYU, New York, NY); Owen Kieran, MD.

Disclosure: A. Davidson, None; O. Kieran, None.

**Setting:** Tertiary teaching hospital. **Patient:** An 85-year-old man admitted to the medicine service for syncope workup after a fall. **Case Description:** The rehabilitation service was consulted for gait training for this patient, who had been ambulating without an assistive device on the unit the day before. After spending several hours on the bedpan overnight, the patient awoke unable to ambulate. There was no history of trauma or a fall from the bed. He had no complaints of pain and only admitted to vague left groin discomfort on review of systems. On physical exam, there was no swelling, and no shortening or external rotation of the lower extremities. He had 2/5 strength in left hip flexion, with no pain on direct palpation of the hip and negative left flexion, abduction, and external rotation test test. He stood with moderate assistance without complaints of pain although he would not completely extend his left hip. Plain films of the hip and pelvis were recommended. **Assessment/Results:** Radiographs revealed a minimally displaced subcapital fracture of the left femoral neck and osteoporotic bones. **Discussion:** Hip fractures in alert and oriented patients rarely have a subtle clinical presentation, although there are a few reports in the literature of initially undiagnosed hip fractures in the elderly. This case is unique in that although there is a possibility of the fracture occurring from the initial fall prior to admission, the ambulatory status of the patient suggests it was new. The physical exam was atypical, with no complaints of hip pain, no shortened and externally rotated lower extremity, and no swelling and no pain with active or passive movement. **Conclusions:** Despite having no history of new trauma and an atypical clinical presentation, the possibility of occult hip fracture cannot be excluded, especially in elderly, and likely osteoporotic patients. **Key Words:** Hip fractures; Rehabilitation.

**Poster 107**

**Sural Neuropathy After Prolotherapy for Lateral Ankle Instability: A Case Report.** William M. Jones, MD (American Sports Medicine Institute, Birmingham, AL); Robert B. Poczatek, MD; Tracy R. Ray, MD.

Disclosure: W.M. Jones, None; R.B. Poczatek, None; T.R. Ray, None.

**Setting:** Outpatient sports medicine clinic. **Patient:** A 22-year-old female college basketball player with chronic lateral instability of the left ankle. **Case Description:** The patient presented to our clinic 7 weeks after undergoing 6 prolotherapy sessions, performed at an outside facility over a 2-month period, for left ankle instability. Injections consisted of a 15% dextrose solution administered to the posterolateral ankle region. 1 week after her final treatment, she developed constant, lateral left foot and ankle numbness and paresthesias. She denied pain, swelling, motor weakness, skin abnormalities, or temperature changes. She denied trauma, alteration in activity level, or change in footwear. **Discussion:** Prolotherapy injections for ligamentous instability can cause neuropathy. In this case, the patient reports that prolotherapy improved her ankle stability. She had minimal improvement of her sensation. Incidentally, the neuropathy was more likely due to the sclerosing action of the dextrose solution. **Conclusions:** The patient was nontender with full, painless range of motion. Skin, motor, and vascular examinations were normal. **Assessment/Results:** The patient’s symptoms were closely monitored and did not interfere with her athletic performance. 4 months after onset, she developed hypoesthesias that gradually resolved. **Discussion:** When performing prolotherapy injections for ligamentous instability, the dextrose solution will commonly infiltrate the surrounding soft tissues, in addition to the intended ligaments. Given the 1-week interval between the final treatment and symptom onset, her sural neuropathy was more likely due to the sclerosing action of the dextrose than from needle trauma. **Conclusions:** Sural neuropathy due to the inflammatory action of dextrose is a potential complication when performing prolotherapy for lateral ankle injury. **Key Words:** Ankle; Injection; Rehabilitation; Sural nerve.
 Artículo 108
Caracterización de fragmentos de fibronectina en pacientes humanos con degeneración de la columna vertebral. Yefia Zhang, MD, PhD (Thomas Jefferson University, Philadelphia, PA); Mon-Li Chu, PhD; Alexander Vaccaro, MD; Todd Albert, MD; Alan Hilibrand, MD; D. Greg Anderson, MD.

Discusión: Y. Zhang, None; M. Chu, None; A. Vaccaro, None; T. Albert, None; A. Hilibrand, None; D.G. Anderson, None.

Objetivo: Para caracterizar los fragmentos de fibronectina en el hueso y ayudar a definir el papel de estos fragmentos en la degeneración de la columna vertebral. Diseño: Se compararon los fragmentos de fibronectina de 200 kDa a 25 kDa, que se identificaron en pacientes con degeneración de la columna vertebral. Los fragmentos de 200 kDa fueron los más grandes y se identificaron en pacientes con degeneración de la columna vertebral. Los fragmentos de 25 kDa fueron los más pequeños y se identificaron en pacientes con degeneración de la columna vertebral.

Resultados: No aplicable. Main Outcome Measures: No aplicables. Intervenciones: No aplicables. Presupuestos: No aplicables. Lenguaje de las palabras clave: Back pain; Fibronectin receptors; Intervertebral disk; Rehabilitation.

Poster 109
Osteomyelitis in the Femur and Sternum of an Adult Patient: A Case Report. Douglas Elwood, MD, MBA (NYU School of Medicine, New York, NY); Mark V. Ragucci, DO, MS.

Discusión: D. Elwood, None; M.V. Ragucci, None.

Setting: Tertiary care medical center. Patient: A 32-year-old woman with osteomyelitis of the femur and sternum. Case Description: This patient presented with a 1-month history of progressive leg pain, worsened with ambulation. She had no significant medical history with the exception of being 6 months postpartum and actively breast-feeding. Further questioning revealed that she developed an abscess in her right axilla approximately 2 months prior to presentation. On physical examination, she was tender to palpation on the right thigh and sternum. Her white blood cell count was 10.8, C-reactive protein was 45, and she was febrile. She had no intravenous drug history.

Assessment/Results: The patient was assessed for leg pain, with radiographs revealing a fusiform lucency of her distal femoral shaft. Computed tomography and magnetic resonance imaging confirmed the diagnosis of osteomyelitis of this area. Biopsy scan also located areas of enhancement on her ribs. She underwent cement and bone grafting in the affected limb and sternum. The patient completed a 6-week course of antibiotics and repeat exams for infection were negative. Medically and surgically stable, she was referred to the outpatient physical medicine and rehabilitation clinic for progressive ambulation and gait training. Discussion: Osteomyelitis of the femur is relatively common in children; however, in adults, this malady is rare, with few reported cases, especially in an otherwise healthy adult.

Conclusions: The differential for leg pain is large and covers numerous potential etiologies. History is paramount in elucidating a cause and may present a physiatrist with a challenging diagnosis. Therefore, it is imperative to rule out potential sources of pain and functional impairment before designing an effective treatment plan. Key Words: Femur; Osteomyelitis; Rehabilitation: Sternum.

Poster 110
Comparison of Serum Interleukin-6 and Creatine Kinase Concentrations Following Lumbar Decompression Surgery. Dinesh A. Kumbhare, MD, MSc (McMaster University, Hamilton, ON, Canada); William Parkinson, PhD; Brett Dunlop, MD; Carl Richards, PhD; Julian Mathoo, MD.

Discusión: D.A. Kumbhare, None; W. Parkinson, None; B. Dunlop, None; C. Richards, None; J. Mathoo, None.

Objetivo: To compare interleukin-6 (IL-6) and creatine kinase (CK) as indices of musculoskeletal injury created by lumbar decompression surgery, including concurrent validity, relative sensitivities, and relative time to peak. Diseño: Repeated measures and measurement evaluation. Setting: Orthopedic surgery clinic in a teaching hospital in Ontario, Canada. Participantes: 7 women and 5 men undergoing lumbar decompression surgery. Intervenciones: Not aplicables. Main Outcome Measures: Blood samples were taken in the preoperative waiting areas, immediately after surgery, at 6-hour intervals until discharge, and at 2, 4, and 6 to 7 days following surgery. CK was used to detect injury to muscle. IL-6 was used to detect combined injury to various structures, including muscle, bone, skin, and adipose tissue. Individual subject protein concentrations were plotted over time.

Resultados: There was a moderate correlation between the rise in IL-6 and rise in CK (Pearson r = .68, P < .05), amounting to 46% of the variance in CK explained. Based on the t test, comparisons of the concentration by time curves indicated IL-6 to be significantly elevated only at 6 hours (P < .05) whereas CK was significantly elevated at 6 (P < .05), 12 (P < .01), 24 (P < .01), and 48 hours (P < .05). Substantial individual variability in time to peak was characteristic of both IL-6 (range, 6–48h) and CK (range, 7–48h). Conclusion: IL-6 was less sensitive to muscle injury than CK in this model. The findings are consistent with tissue distributions of these proteins, and support the approach in which both proteins are measured to provide sensitivity to muscle and nonmuscle components of an injury. Variability in time to peak across subjects indicates a need for multiple serial measures within a broad time window to capture either biochemical responses. Key Words: Creatine kinase; Interleukin-6; Rehabilitation.
sures: Blood samples were taken 1 hour before surgery, immediately after surgery, at 6, 12, and 24 hours, and then at 24-hour intervals until discharge. The criterion for detectable muscle injury was a total CK peak 100% or greater than baseline. Results: 11 of 22 unilateral TKR patients had detectable muscle injury. 6 of 7 bilateral TKR patients had detectable muscle injury. Among unilateral patients with muscle injury, mean peak CK ± SD was 371±270U/L, which was elevated over the baseline (89±68U/L, P<0.01). In the 6 bilateral patients with muscle injury, mean peak CK was 339±146U/L and this was elevated over the baseline (69±52U/L, P<0.001). Mean time to peak CK was 28 hours. However, there were wide individual differences in peak timing (range, 9—69h). Conclusions: Unilateral TKR was associated with detectable muscle injury in 50% of cases. There was a trend toward higher incidence with bilateral TKR, but no higher injury severity. Individual differences in peak timing necessitate multiple serial measures to capture the biochemical injury response. Key Words: Creatine kinase; Knee replacement; Muscle injury; Rehabilitation.

Poster 112
Changes in Lumbar Intervertebral Disk Morphology Following Percutaneous Disk Decompression Using Coblation Technology. Matthew Smuck, MD (University of Michigan, Ann Arbor, MI); Joshua Levin, MD; Eric Zemper, PhD.
Disclosure: M. Smuck, research staff is funded (<10%) to assist with an Arthrocare-funded multicenter trial; J. Levin, None; E. Zemper, None.
Objective: To evaluate anatomic changes in disks treated with percutaneous disk decompression using coblation technology. Design: Retrospective comparison of pretreatment and post-treatment magnetic resonance imaging (MRI). Setting: University spine clinic. Participants: Records of 60 consecutively treated patients were reviewed. 15 subjects were identified with both pre and post-treatment MRIs. Interventions: 2 physicians independently reviewed all 30 MRI scans on a 20-in monitor using MagicView imaging software. Main Outcome Measures: Interval change in anteroposterior (AP) diameter of disk protrusions at the treatment levels and disk height at the treatment versus adjacent levels. Results: Post-treatment MRIs were obtained for: no improvement/presurgery evaluation (n=2), leg pain resolved/presurgical evaluation for low back pain (n=2), initial worsening of symptoms (n=2), initial improvement then return of usual radicular symptoms (n=7), new radicular symptoms (n=1), and new injury (n=1). MRI measurements by the 2 physicians demonstrated good correlation for disk height change (r=.89, P<.001) and for AP diameter change (r=.51, P=.051). Disk height was reduced by a mean of 0.48mm at treated levels (P=.001), and did not change significantly at untreated levels. Comparing treated disks with untreated disks, the reduction of disk height in treatment disks was significant (P<.001). AP diameter of disk protrusions were decreased in 6, unchanged in 6, and increased in 3 subjects. Overall the change in AP diameter of disk protrusions was not significant, from 4.74mm (range, 3.75—6.55mm) to 4.42mm (range, 2.55—7.95mm) (P=.114). Excluding the 3 subjects with re-herniations, the reduction in AP diameter of disk protrusions was significant (mean, 0.93mm; P<.001). Conclusions: MRI comparisons demonstrated a significant reduction in disk height and AP diameter of disk protrusions. Anatomic and histopathologic studies of percutaneous disk decompression using coblation technology have been performed on human cadavers and live animal models. This is the first in vivo human study to investigate anatomic changes following treatment. Key Words: Discectomy, percutaneous; Lumbar region; Magnetic resonance imaging; Rehabilitation.

Poster 113
Functional Capacity and Buschke’s Scleredema Adulorum Associated With Diabetes Mellitus: A Case Report. Esther Pagès, MD, PhD (Vall d’Hebron Hospital, Barcelona, Spain); Judith Sánchez Raya, MD; Ramón Arroyo, MD; Núria Jou, MD; Jordi Iborra, MD, PhD; Ampar Cuxart, MD, PhD.
Disclosure: E. Pagès, None; J. Sánchez Raya, None; R. Arroyo, None; N. Jou, None; J. Iborra, None; A. Cuxart, None.
Setting: Rehabilitation unit in a tertiary public hospital. Patient: A 52-year-old woman presented with Buschke’s scleredema adulorum associated with diabetes mellitus. Case Description: Patient with a 2-year history of scleredema adulorum type 3 and pulmonary hypertension as a systemic manifestation of the disease. She was referred to our rehabilitation unit because her functional capacity was getting worse, pain, a bilateral temporo-mandibular joint dysfunction, and important shoulder, elbow, and cervical spine range of motion (ROM) limitations that affected her activities of daily life and quality of life (QOL). Assessment/Results: Pain and functional capacity was assessed with a visual analog scale (VAS), the Constant Shoulder Scale, the Disability of the Arm, Shoulder and Hand (DASH) scoring system, and the 36-Item Short-Form Health Survey (SF-36). The patient was admitted to our unit in order to follow an intensive inpatient program of rehabilitation. After 4 weeks of daily treatment, the patient had lowered pain and improved functional capacity: VAS score improved from 7 to 5; right shoulder Constant scale score improved from 23 to 35; left shoulder Constant scale improved from 23 to 31; and the DASH score improved from 117 to 92. There was no change in SF-36 scores. Discussion: Buschke’s scleredema adulorum is a diffuse, nonpitting induration of the skin of unknown etiology. It typically begins on the face or head and spreads to other areas of the body. The condition might resolve spontaneously, usually within 2 years of onset. Although it usually is regarded as a benign, self-limited, skin disease, scleredema may be persistent, involve the viscera, and affect ROM and functional capacity. Conclusions: Management of scleredema is difficult, and therefore many treatment modalities have been used. Although the condition is rare, a multidisciplinary approach, including rehabilitation, is needed to maintain functional capacity and QOL. Key Words: Diabetes mellitus; Rehabilitation; Scleredema adulorum.

Poster 114
A Physiologic Approach to Persistent Osgood-Schlatter Disease in an Adult Woman: A Case Report. Gerard Dysico, MD; Krishna Parameswar, MD; Jonathan Clapp, MD (Rush University Hospital, Chicago, IL).
Disclosure: G. Dysico, None; K. Parameswar, None; J. Clapp, None.
Setting: Outpatient clinic. Patient: A 33-year-old former female volleyball player. Case Description: The woman presented to clinic with bilateral knee pain. She was diagnosed with bilateral Osgood-Schlatter disease (OSD) in her adolescence. Her adult medical history included a right knee arthroscopy and limited physical therapy for continued knee pain, including pain medications, bilateral knee braces, and solid rigid plastic foot orthoses. At presentation, she was being considered for a right hip—greater trochanteric osteotomy to further alleviate her knee pain. Our approach to the patient’s pain included a re-evaluation of her foot orthoses and a dedicated gait analysis to provide focused physical therapies to alleviate her knee pain without further surgery. Assessment/Results: After 7 months of aquatic therapy, the patient’s gait and pain had improved. Discussion: OSD is a proximal tibial tubercle osteochondrosis seen in adolescent athletes involved in jumping sports. It is considered a benign and self-limited condition treated primarily with conservative therapeutic measures. As the prevalence of OSD in girls increases (as female athletic participation increases in time), surgical correction prevails (according to a
review of the literature) for cases of persistent (ie, adult) OSD. Conclusions: Typically, OSD is managed surgically, but in this case a physiatric, nonsurgical approach focusing on gait and using orthotics, resulted in less pain and better gait mechanics. Key Words: Osteochondrosis; Osteotomy; Rehabilitation.

Poster 115
Complicated Case of Meralgia Paresthetica Caused by a Large Adenexal Cyst: A Case Report. Darren C. Rosenberg, DO (Harvard Medical School, Framingham, MA); Nicole P. Tomasino, DPT.
Disclosure: D.C. Rosenberg, None; N.P. Tomasino, None.
Setting: Outpatient rehabilitation center. Patient: A 43-year-old woman with unusual cause of meralgia paresthetica. Case Description: Patient had left lateral thigh and knee pain and paresthesias for 10 years. She had 6/10 throbbing pain and numbness in the left lateral thigh, and an inability to run or to sit on the floor. Magnetic resonance imaging (MRI) of the lumbar spine revealed slight facet arthropathy. The patient was treated for idiopathic band syndrome and muscular imbalance. Initial physical exam had a negative slump test and straight-leg raise (SLR). The pelvis was level; the Ober test and 90/90 were positive; the patient demonstrated decreased strength and stability of the bilateral hip musculature. Treatment consisted of 15 sessions of physical therapy. After 8 sessions, she had increased hip and knee muscle strength and flexibility, and slightly improved function, with increased ability to drive. Patient then presented with new onset of lower back pain, positive slump, and SLR test at 45°. The patient reported increased paresthesias in the left thigh and an increase in symptoms with menstruation. Assessment/Results: Pelvic MRI revealed a 7cm multilobulated cyst in the adnexal region of endometrial origin. She had a full abdominal hysterectomy, an appendectomy, and part of the bowel removed, secondary to severe endometriosis. The patient returned to her previous level of activity without pain. Discussion: Meralgia paresthetica is a pain syndrome and/or dysesthesia in the anterolateral thigh caused by entrapment of the lateral femoral cutaneous nerve. This case discusses a long-standing case of meralgia paresthetica caused by a large adnexal cyst causing prolonged pain and decreased function. Conclusions: A wide differential diagnosis when identifying the source of patients’ pain is important. Despite a 10-year history of symptoms, the patient failed to have appropriate imaging studies done. Consider pelvic MRI in patients with chronic left lower-extremity radiation despite normal lumbar imaging. Key Words: Cysts; Nerve compression syndromes; Pain; Rehabilitation.

Poster 116
Gout-Induced Arthropathy in a Knee Following Total Arthroplasty: A Case Report. Jeffrey S. Berger, DO (Temple University Hospital, Philadelphia, PA); Michael Weinik, DO.
Disclosure: J.S. Berger, None; M. Weinik, None.
Setting: Tertiary medical center. Patient: A 39-year-old man with a history of right total knee arthroplasty (TKA). Case Description: The patient presented to the emergency department with a 2-day history of progressively worsening right knee pain and swelling, along with fever and generalized malaise. There was no history of recent trauma, infection, or illness. Assessment/Results: Active knee range of motion was 10° to 70°, limited by exquisite pain. Radiographs identified the prosthesis to be in proper position without loosening. Knee aspirate was cloudy with 6900 white blood cells per/mm³ (97% polymorphonuclear leukocytes) and 3200 red blood cells. An exploratory arthrotomy failed to identify any prosthetic component loosening. A complete synovectomy was performed along with thorough irrigation and closure. Evaluation of joint aspirate after surgery identified a large number of monosodium urate crystals consistent with gout. Fluid culture was negative for aerobic, anaerobic, and fungal growth. Colchicine and indomethacin were initiated with rapid resolution of clinical symptoms. At discharge, the patient was ambulating independently with no assistive device and minimal pain. Discussion: Gout-induced arthropathy after TKA is a rare, yet likely underdiagnosed clinical entity, which is difficult to distinguish from infectious arthritis. Synovial fluid white blood cell counts less than 50,000 cells/mm³ generally favor an inflammatory process. However, septic arthritis must be definitively ruled out because infection mandates washout along with possible prosthesis removal and antibiotic spacer placement. Definitive diagnosis requires histologic identification of monosodium urate crystals in joint aspirate in conjunction with a negative culture and gram stain. Conclusions: Gout-induced arthropathy should be considered in patients with an acutely inflamed arthroplasty and synovial fluid aspirate should always be sent for crystal analysis. Accurate diagnosis is crucial to component retention and effective pharmacologic treatment. Key Words: Arthroplasty, replacement; Gout; Knee; Rehabilitation.

Poster 117
Three-Dimensional Translucent Models as a Tool in the Rehabilitation of a Patient With a Comminuted Pelvic Fracture: A Case Report. Vincent Codispoti, MD (Walter Reed Army Medical Ctr, Washington, DC); Brandon Goff, DO.
Disclosure: V. Codispoti, None; B. Goff, None.
Setting: Inpatient rehabilitation unit. Patient: A 39-year-old male U.S. Army soldier. Case Description: The patient was injured during Operation Iraqi Freedom when he sustained a gunshot wound to the left side of his pelvis. This resulted in comminuted pelvic and sacral fractures, rectal damage requiring colostomy, and a left lumbosacral plexopathy. Due to the complex nature of his pelvic and sacral fractures, the plan was to keep him non-weight bearing with complete bedrest to allow for nonoperative fracture healing. Serial imaging was followed throughout his hospitalization using radiography and computed tomography (CT) scanning. The CT scans were converted into 3-dimensional life-size models using stereo lithography rapid prototyping. These models were used to assess fracture healing and advancement of weight-bearing status. Assessment/Results: The patient underwent extensive physical and occupational therapy to improve his activities of daily living and overall strength, most notably in the left lower extremity. He became independent with a clean intermittent catheterization program due to lower motoneuron injury bladder. He required bedrest for a total of 13 weeks following his injury. Throughout this time, serial 3-dimensional models from stereo lithography rapid prototyping provided vital information about the healing process of his complex pelvic and sacral fractures. These models provided accurate information on callus formation and potential areas of poor healing, and also served as a useful tool for the patient to visualize the nature and extent of his injuries. Once callus formation was sufficient, as indicated on CT and 3-dimensional models, the patient was cleared for weight bearing. He began training using a tilt table for improved orthostasis and ultimately progressed to full weight bearing and ambulation. Conclusions: 3-dimensional modeling using stereo lithography rapid prototyping can be a valuable treatment planning and educational tool in the rehabilitation of patients with complex fractures. Key Words: Imaging, three-dimensional; Military personnel; Pelvic bones; Rehabilitation.
Sciatic Neuropathy Following Hip Arthroplasty: A Case Report. Keith M. D’Souza, MD (Marianjoy Rehabilitation Hospital, Wheaton, IL); Vasilios Stambolis, MD.

Disclosure: K.M. D’Souza, None; V. Stambolis, None.

Setting: Freestanding inpatient rehabilitation hospital. Patient: A 72-year-old man with diabetes mellitus. Case Description: The subject sustained a fall, resulting in right femoral neck fracture, and underwent right total hip arthroplasty (THA). Postoperatively, he developed ipsilateral foot drop. Assessment/Results: Following prolonged inpatient stay for multiple medical issues, the subject was transferred to our inpatient rehabilitation hospital. Electrodagnostic studies done 6 weeks following surgery noted severe sciatic neuropathy on the right side involving both the tibial and peroneal components, with underlying sensorimotor neuropathy likely secondary to diabetes. Discussion: In the past, neuropathies following THA have been reported to vary from 0.7% to 3%, with an almost equal incidence of peroneal versus sciatic neuropathy. Currently, the incidence of neuropathy following unilateral THA is 1% to 1.1% with up to 80% involving the peroneal branch of the sciatic nerve alone. Though sciatic neuropathy is rare, physiatrists should actively look for features suggesting these lesions. This is especially important in the first few days postoperatively, at which time corrective measures, including hematoma drainage and femur length shortening, may be undertaken with improved functional outcomes. Weakness of both ankle dorsiflexors and plantarflexors should be assessed. Plantarflexors are strong anti-gravity muscles and subtle weakness may not be picked up when the subject is supine. Additionally, nerves of diabetic patients may be more sensitive to operative compression and traction neuropathy. However, studies reviewing incidence of postoperative neuropathy in diabetic versus nondiabetic patients are currently unavailable. Conclusions: Sciatic neuropathy should be actively looked for postoperatively. Ankle plantarflexors should be assessed by having patients stand on their toes. High-risk patients, including those with diabetes, may benefit from preoperative electromyography to rule out neuropathy. Key Words: Arthroplasty; Diabetes mellitus; Femoral neck fractures; Rehabilitation; Sciatic neuropathy.

Poster 119
Rare Recurrent Left Femoral Shaft Stress Fractures in a 19-Year-old Female Collegiate Long-Distance Runner: A Case Report. Randy L. Calisoff, MD (Loyola University Medical Ctr, Maywood, IL); Andrea Quandt, MS-4; George E. Charuk, DO.

Disclosure: R.L. Calisoff, None; A. Quandt, None; G.E. Charuk, None.

Setting: University outpatient rehabilitation clinic. Patient: A 19-year-old female cross-country runner with a history of asthma. Case Description: The patient presented with 3 weeks of left-sided deep thigh pain, aggravated by activity and relieved by rest. Assessment/Results: Further history revealed 2 left femoral shaft stress fractures in 2004 and 2005. The patient’s medication history consisted of a 3-week course of 10mg of oral prednisone taken 3 months prior to her first stress fracture in 2004. Review of systems was negative for disordered eating, amenorrhea, and endocrine disorders. Physical examination showed tenderness to palpation at the middle third of her left femur. Magnetic resonance imaging showed a hyperintense signal within the proximal three fourths of the left femoral diaphysis, consistent with a stress fracture. The patient was advised to refrain from running and was prescribed hydrotherapy with water walking as tolerated for 8 weeks. Discussion: A stress fracture is a partial or complete fracture of bone resulting from its inability to withstand stress applied in a rhythmic repeated, subthreshold manner. Femoral stress fractures are rare, as they represent only 5% of all stress fractures and involve the femoral neck, condyles, or shaft. Fractures involving the femoral shaft have been reported to be the least common of all femoral stress fractures. Furthermore, an extensive literature search revealed only 1 previously published case of a recurrent stress fracture involving the shaft of the femur on the same side. Conclusions: Recurrent unilateral stress fractures involving the femoral shaft are exceedingly rare. Although previous research has identified several medical and biomechanical risk factors for developing a stress fracture, the risk factors for developing recurrent femoral shaft stress fractures on the same side are unclear, suggesting the need for future studies to identify these predisposing factors. Key Words: Femur; Fractures; stress; Rehabilitation.
denervation of the right nasalis or frontalis was found. **Discussion:** The structural integrity of the zygoma allows for normal facial width and prominence of the cheek. Fractures of the zygomatic complex frequently result in complications such as trismus, diplopia, enophthalmos, and sensory disturbances in the infraorbital nerve distribution. The fifth and seventh cranial nerves also traverse through this region of the mid-face. As evidenced by this case, these nerves are also prone to damage from a zygomatic complex fracture. **Conclusions:** The clinician should be aware of the potential for nerve damage following zygoma fracture. Branches of the fifth and seventh cranial nerves must be dissected carefully during repair of zygoma fractures to prevent complications of facial paresthesia and paresis. **Key Words:** Facial palsy; Rehabilitation; Zygomatic fracture.

**Poster 122**

Greater Trochanteric Pain Syndrome Unmasked After Lumbar Spinal Injections: A Case Series. Binod Shah, MD (Montefiore Medical Ctr, Bronx, NY).

**Setting:** Tertiary care hospital. **Patients:** 3 patients with radicular low back pain (LBP). **Case Description:** 3 patients each presented with LBP radiating to the lower extremity, which correlated with pathology identified on magnetic resonance imaging. After the appropriate spinal injection was performed for each patient, the back pain was alleviated but the patients soon after complained of severe lateral hip pain, with maximum tenderness of the greater trochanter. 2 patients complained of pain immediately following spinal injection and one the following day. All 3 patients experienced full pain relief with injection of the greater trochanteric bursa. **Assessment/Results:** To the best of our knowledge, these are the first reported cases of greater trochanteric pain syndrome (GTPS) unmasked by spinal injection. **Discussion:** A broad range of musculoskeletal conditions present as LBP or sciatica, one of which is GTPS, an inflammation of the trochanteric bursa. 20% of patients referred to spine specialists for LBP in fact have GTPS. This entity may not be obvious, and it is important to maintain a high index of suspicion for GTPS before considering invasive and costly spinal procedures. **Conclusions:** These are the first reported cases of GTPS unmasked soon after spinal injection and they highlight the importance of GTPS in the differential diagnosis of LBP or sciatica, particularly when spinal procedures are being considered. **Key Words:** Acute greater trochanteric pain syndrome; Injection, spinal; Rehabilitation.

**Poster 123**

Patrolman’s Ankle: Determining a Physiatric Approach to Deltoid Ligament Injury: A Case Report. Joshua Reimer, MD (UMDNJ, Newark, NJ); Todd P. Stitik, MD; Patrick M. Foye, MD.

**Disclosure:** J. Reimer, None; T.P. Stitik, None; P.M. Foye, None. **Setting:** Outpatient physiatric academic practice. **Patient:** A 34-year-old police officer. **Case Description:** A 34-year-old man presented with progressively worsening swelling, pain, and tenderness of the medial ankle, with resultant limping, following a 1.2m (4ft) fall onto his everted right ankle while in pursuit of a suspect. Radiographs revealed no fracture. Magnetic resonance imaging demonstrated an intrasubstance tear deltoid ligament, without any evidence of posterior tibial tendon pathology. **Assessment/Results:** The patient was diagnosed with an intrasubstance tear of the deltoid ligament. Treatment included oral anti-inflammatory, an ankle AirCast splint, and temporary work restrictions. At follow-up, he still had slight limitation of passive inversion due to pain, without any evidence of ankle instability or ligamentous laxity. The support brace was discontinued, range of motion activities and strengthening of ankle plantarflexors and invertors were begun. Full work activities were gradually resumed. **Discussion:** Despite the abundance of surgical publications detailing operative management of deltoid ligament tear, there is no literature outlining nonsurgical treatments. Although medial ankle sprains are far less common than lateral ankle sprains, the sequelae of secondary posterior tibial tendon dysfunction and chronic medial instability suggest the need for further research into nonsurgical treatments specific to this injury. While the treatment closely resembled that for a lateral ankle sprain, perhaps this was not the optimal approach. Because the structures of the medial ankle serve a critical role in establishing the medial arch of the foot and limiting excessive pronation, a physiatric approach needs to be developed to address the optimal management approach to the medial ankle injury. **Conclusions:** No literature currently exists describing a conservative physiatric approach to deltoid ligament sprain. Evidence-based studies are needed to understand the ideal approach to restoring function and minimizing symptoms after these medial ankle injuries. **Key Words:** Ankle; Ligaments; Rehabilitation; Sports medicine.

**Poster 124**

Deep Venous Thrombosis Masquerading as Neurogenic Claudication: A Case Report. Roseanna Jackson-Parekh, MD (UMDNJ, Newark, NJ); Patrick M. Foye, MD; Todd P. Stitik, MD.

**Disclosure:** R. Jackson-Parekh, None; P.M. Foye, None; T.P. Stitik, None. **Setting:** Outpatient physiatric practice. **Patient:** A 70-year-old male neurologist. **Case Description:** A 70-year-old male neurologist was referred to physiatry by an orthopedist, requesting nonsurgical management of neurogenic claudication. The patient complained of anterolateral left calf pain that was worse with ambulation. The orthopedist had obtained lumbar magnetic resonance imaging (MRI), which showed severe spinal stenosis at L3-4 and moderate spinal stenosis at L4-5. But physiatric physical exam revealed tenderness to palpation of the left proximal calf and the symptoms were not exacerbated by lumbar sacral extension. Also, there were no motor, sensory, or reflex deficits. He was sent for lower-extremity Dopplers to rule out a deep venous thrombosis (DVT). The Dopplers revealed an acute left popliteal DVT. **Assessment/Results:** A left lower-extremity DVT was diagnosed as the cause of his presenting symptoms. He was treated with anticoagulation, with an excellent outcome. **Discussion:** As physiatrists become increasingly specialized, we must remember that life-threatening medical conditions may present similarly to common musculoskeletal and neurologic conditions. The case also excellently illustrates the importance of performing a careful history and physical exam, rather than relying primarily on diagnostic testing such as MRI. Specifically, in this case, an orthopedist and a neurologist had assumed, based on MRI findings, that the symptoms were due to spinal stenosis. Failure to properly diagnose the DVT could have led to an unnecessary spine surgery or, more acutely, could have led to life-threatening complications of an untreated DVT. **Conclusions:** Life-threatening medical conditions such as DVT can masquerade as common musculoskeletal and neurologic conditions seen in the outpatient physiatry setting. A careful history and physical exam is crucial prior to attributing symptoms to abnormalities found on MRI. **Key Words:** Physical medicine; Rehabilitation; Spinal stenosis; Venous thrombosis.

**Poster 125**

Treatment of Plantar Fasciitis With Extracorporeal High-Energy Shock Wave Therapy: Our Experience With 35 Patients. José A. Pereira (Hospital São João, Porto, Portugal); Francisco Pires; Manuela Ribeiro; Fernando Parada.

**Disclosure:** J.A. Pereira, None; F. Pires, None; M. Ribeiro, None; F. Parada, None.
Objective: To test the hypothesis that high-energy extracorporeal shock wave therapy (ESWT) solely is an effective treatment for plantar fasciitis in our patient population, contributing to improving quality of life. Design: Self-controlled prospective study. Setting: Rehabilitation clinic. Participants: 35 subjects (9 men, 26 women; age range, between 3rd and 8th decades of life) with a diagnosis of plantar fasciitis longer than 6 months, who were submitted before to other forms of conservative management of plantar fasciitis with no success, and who were not submitted to other forms of treatment during our study. Interventions: We performed 3 sessions, with a 2-week interval between each, of high-energy ESWT to the calcaneal area of greater pain, with no anesthesia. Main Outcome Measures: We assessed pain (scale range, 0–10), walking time without pain (<5 min, 5–20 min, >20 min), and problems in buying shoes (yes, no) before the first session (t0) and 3 months after the last session (t1). Results: We found a major therapeutic effect, with statistical significance ($P < .05$), using the nonparametric Wilcoxon signed-rank test, when comparing the measurements of $t_1$ and $t_2$ for the pain scale (scale range, 0–10) and walking time without pain, and also using the chi-square test for difficulty in buying shoes. Conclusions: High-energy ESWT is safe and a good option for the treatment of plantar fasciitis and should be considered prior to other options such as corticoid infiltration, when available. Key Words: Fasciitis; High-energy shock waves; Rehabilitation.

Poster 126
Right Shoulder Plexiform Neurofibroma Mimicking Rotator Cuff Tendonitis: A Case Report. Ali I. Khawaja, MD (Nassau University Medical Ctr, East Meadow, NY); Vladimir Salomon, DO; Sarah Sheikh, SPT; Ajendra Sohal, MD; Lynn Weiss, MD. Disclosure: A.I. Khawaja, None; V. Salomon, None; S. Sheikh, None; A. Sohal, None; L. Weiss, None.
Setting: Outpatient rehabilitation unit. Patient: A 47-year-old woman. Case Description: The patient had a medical history of neurofibromatosis and was referred for right shoulder pain, which progressed over months. Assessment/Results: The patient complained of shoulder pain that was achy, variable in intensity, and aggravated by overhead activities, relieved by rest and analgesics, and did not radiate. Physical examination revealed generalized neurofibromatosis, a mobile palpable mass anterior to the shoulder, and no skin color changes. Supraspinatus impingement sign was positive on the right side. Strength in bilateral upper extremities was 5/5 proximally and distally, and there was no restriction on range of motion in either arms. A computed tomography scan of the right shoulder showed an ill defined soft tissue mass. Further evaluation with magnetic resonance imaging showed an infiltrative mass lesion anterior to the right shoulder, consistent with a plexiform neurofibroma. Discussion: The neurofibromatoses are a group of genetically distinct but related disorders of the nervous system that cause tumors to grow around nerves. The tumor begins in the myelin sheath and often spreads into adjacent areas. The type of tumor that develops depends on its location in the body and the kind of cells involved. The most common tumors are neurofibromas, which develop in the tissue surrounding peripheral nerves. Most tumors are noncancerous, although occasionally they become cancerous over time. Conclusions: In patients with suspected rotator cuff tendinitis, the existence of a palpable mass should raise the suspicion of neurofibromas. A thorough workup should be done to rule out any other cause of mass, including cancer. Key Words: Neurofibroma, plexiform; Neurofibromatosis; Rehabilitation.

Poster 127
Distribution and Patterns of Injuries in Swimmers. Janna Friedly, MD (University of Washington, Seattle, WA); Andrew Cole, MD; Eagleton Richard, PT, ATC; Marion McGregor, BS. Disclosure: J. Friedly, None; A. Cole, None; E. Richard, None; M. McGregor, None.
Objective: To determine the frequency and distribution of injuries in swimmers. Design: Anonymous, written survey of swimmers. Setting: Surveys administered during practices in the 1995–1996 season. Participants: 335 swimmers on 7 swim teams within the United States, including junior high school (n=1), high school (n=1), divisions I (n=1), II (n=1), and III (n=2) collegiate, and master’s level (n=1) teams. Interventions: Not applicable. Main Outcome Measure: Injuries within the previous year. Results: 335 participants completed the survey (completion rate, 84%). 52.8% of swimmers sustained at least 1 injury, with 302 different injuries reported. The most common injuries were shoulder injuries (32% of total number of injuries) followed by back (n=60 [20%]), knee (n=34 [11%]), and elbow (n=21 [7%]). The majority of swimmers reported having sustained more than 1 injury (70%). Swimmers with shoulder injuries were more likely than not to also have a spine ($P=.004$) or a knee injury ($P=.006$). There was a statistically higher incidence of shoulder injuries among female swimmers ($P=.047$), but all other injuries were comparable between sexes. 60% of swimmers in the least and most conditioned groups reported injuries versus 45% in the moderately conditioned category ($P=.014$). Spine injuries were more common in the least conditioned swimmers (33% vs 16%, $P=.008$). There were no significant differences in shoulder or knee injuries based on conditioning level. Conclusions: Swimming injuries are extremely common in competitive swimmers, with more than half reporting significant injuries within the previous year. The most common injuries sustained are shoulder, followed by back and knee injuries. The overall incidence of injury is directly related to level of conditioning, with the most and least conditioned being more likely to sustain any injury. The type of injury is also related to the swimmer’s level of conditioning, with back injuries being less common in the most conditioned. Key Words: Injuries; Rehabilitation; Swimming.

Poster 128
Ultrasonic Guided Sacroiliac Joint Injection in Pregnancy: A Case Series. Mark-Friedrich B. Hurdle, MD (Mayo Clinic, Rochester, MN); Ryan McHugh, MD; Wade Schwendemann, MD; Christina Psimos, BS; Jay Smith, MD. Disclosure: M.B. Hurdle, None; R. McHugh, None; W. Schwendemann, None; C. Psimos, None; J. Smith, None.
Setting: Tertiary care medical center. Patients: 4 parturients who failed conservative management (warm/cold compresses, nonsteroidal anti-inflammatory drugs, bedrest, physical therapy) were referred to the pain clinic for back and buttock pain. All were greater than 14 weeks in gestation, had a body mass index greater than 35kg/m², and had no contraindications to intra-articular injections. Their history and physical examinations pointed toward sacroiliac joint pain. Case Descriptions: Ultrasonic-guided sacroiliac joint (SIJ) injections were performed on all 4 patients with a 22-gauge needle inserted in the joint space delivering 6mg of betamethasone in 2mL of 1% lidocaine. Assessment/Results: Using the numeric rating scale (range, 0–10), patient pain scores decreased by more than 3 points by the fourth week after the injection and no analgesic supplementation was needed. None of the parturients had delivered at time of submission. Discussion: About 50% of women will suffer from some form of pelvic pain during pregnancy. SIJ laxity has been reported to account for 77% of reported pelvic pain. The severity of pain has been shown to be related to increased gestational and maternal age. Our case series shows that...
SIJ injections can greatly benefit the patient for up to 1 month. Corticosteroids have long been used in the obstetric population, particularly with comorbidities of asthma, inflammatory bowel disease, and systemic lupus erythematosus, without fetal abnormalities. **Conclusions:** Ultrasound appears to be an effective and safe imaging method for SIJ injection. The technology is an excellent alternative to fluoroscopy or unguided SIJ injections in pregnant women. Additional studies to evaluate the efficacy of SIJ injections in pregnant women are needed. **Key Words:** Pain; Pregnancy; Rehabilitation; Sacroiliac joint; Ultrasonomography.

**Poster 129**

**Correlations of Impairments and Functional Limitations in Hutchinson-Gilford Progeria.** Monique B. Perry, MD (National Institutes of Health, Bethesda, MD); Wendy J. Introne, MD; Melissa Merideth, MD; Gloria P. Furst, MPH; William A. Gahl, MD, PhD; Lynn H. Gerber, MD.

Disclosure: M.B. Perry, None; W.J. Introne, None; M. Merideth, None; G.P. Furst, None; W.A. Gahl, None; L.H. Gerber, None.

**Objective:** To describe impairments, physical function, and their correlations in patients with Hutchinson-Gilford progeria, a premature aging syndrome. **Design:** Prospective longitudinal descriptive study.

**Setting:** Biomedical research facility.

**Participants:** 15 subjects with Hutchinson-Gilford progeria (7 male, 8 female; age range, 18mo to 16y; mean, 6.6y).

**Interventions:** Not applicable. **Main Outcome Measures:** The Child Health Assessment Questionnaire (CHAQ), a measure of activities of daily living (ADLs), and health status, history, and physical examination, including joint range of motion (ROM) (clinically significant at least 15° or 20%), Schober test, grip strength, and distance traveled in a 6-minute walk.

**Results:** The CHAQ identified 1 subject with no functional limitations, 5 with mild, 7 with moderate, and 2 with severe limitations. The percentage of patients who had clinically significant loss of ROM in the lower extremity was 67% for hip flexion, 69% for hip flexion contracture, 43% for knee extension, and 58% for total ankle ROM. The percentage of patients with abnormal upper-extremity ROM was 20% for shoulder abduction, 29% for shoulder external rotation, and 73% for wrist flexion. The CHAQ correlated inversely with hip flexion contracture (r = - .60, p = .05), knee extension (r = - .56, p = .05), wrist flexion (r = - .55, p = .05), shoulder abduction (r = - .69, p = .05), and grip strength (r = - .69, p = .05). The distance traveled on the 6-minute walk correlated with ankle plantar flexion (r = .83, p = .05), total degrees of ankle ROM (r = .80, p = .05), and hip flexion contracture (more involved side) (r = .74, p = .05). **Conclusions:** Hutchinson-Gilford progeria is a chronic, multisystem disease involving the cardiovascular and musculoskeletal system associated with impairment in ROM and functional limitations. Prevention of loss of ROM, principally hip and knee flexion contracture, shoulder abduction and wrist flexion, may prevent loss of ADL function. Furthermore, preserving grip strength may prevent loss of ADL function. Prevention of loss of ROM, particularly ankle plantarflexion and hip extension, may prevent loss in ambulation. **Key Words:** Progeria; Rehabilitation.

**Poster 130**

**Trends in Surgical Management and Rehabilitation of Femoral Neck Fractures in the United States.** Nitin B. Jain, MD, MSPH (Newton-Wellesley Hospital, Boston, MA); Elena Losina, PhD; Daniel M. Ward, MD; Mitchel B. Harris, MD; Ricardo Pietrobon, MD, PhD; Jeffrey N. Katz, MD, MS.

Disclosure: N.B. Jain, None; E. Losina, None; D.M. Ward, None; M.B. Harris, None; R. Pietrobon, None; J.N. Katz, None.

**Objective:** To examine trends over the last decade in utilization of the 3 most frequently performed procedures for femoral neck fractures (open reduction and internal fixation [ORIF], total hip arthroplasty [THA], hemiarthroplasty) and in the use of inpatient rehabilitation following these procedures. **Design:** Retrospective cross-sectional analysis. **Setting:** Not provided. **Participants:** Closed femoral neck fracture cases managed surgically (n = 162,257) were extracted from the 1990–2001 nationwide inpatient samples. Trends were estimated over 3 time periods (1990–93 [period I], 1994–97 [period II], 1998–2001 [period III]). **Interventions:** Not applicable. **Main Outcome Measures:** Utilization of ORIF, THA, and hemiarthroplasty, and use of rehabilitation following these procedures. **Results:** The proportion of patients discharged to rehabilitation facilities after surgery increased from 78.7% in period I to 90.4% in period III. The utilization of hemiarthroplasty increased from 67.8% in period I to 75.3% in period III (P < 0.001). In the same period, the use of THA decreased from 11.6% to 6.6%. **Conclusions:** The increase in utilization of hemiarthroplasty over the last decade conforms with recent evidence that arthroplasty has better outcomes as compared with ORIF. This trend, coupled with increased use of inpatient rehabilitation following surgery for femoral neck fracture, indicates that rehabilitation facilities should anticipate increased demand for services focused on improving functional outcomes of patients with hemiarthroplasty and preventing arthroplasty-specific postoperative complications. The decrease in use of THA is contrary to what might be expected from evidence showing better outcomes with THA. The reasons for this declining utilization of THA, and its impact on short- and long-term patient outcomes after rehabilitation need to be evaluated. **Key Words:** Arthroplasty; Hip fractures; Rehabilitation.

**Poster 131**

**Bilateral Hip Avascular Necrosis Masked by Chronic Lumbar Radiculopathy and Unilateral Sacroilits.** A Case Report. Enzo L. Abad, DO (University of Miami - Miller School of Medicine/Jackson Memorial Hospital, Miami, FL); Andrew L. Sherman, MD, MS.

Disclosure: E.L. Abad, None; A.L. Sherman, None.

**Setting:** University academic center multidisciplinary spine institute. **Patient:** A 60-year-old woman with chronic buttock and leg pain. **Case Description:** This patient presented initially after an acute exacerbation of her chronic pain and left buttock pain. Physical examination revealed local sacroiliac tenderness, no neurologic deficits, and normal motion of the hip joints. Lumbar magnetic resonance imaging (MRI) revealed L5-S1 foraminal stenosis due to disk degeneration and chronic bi-foraminal herniation. Conservative treatment with physical therapy worsened the symptoms. The pain now radiated to the left groin, posterior and anterior thigh, and lateral leg. Examination revealed abnormal left flexion, abduction, and external rotation and straight-leg raise. Treatment consisted of 2 left sacroiliac joint injections and an L5-S1 transfemoral epidural. On follow-up, the buttock and leg pain resolved, but the left groin pain radiating to the anterior thigh increased. Examination now revealed a negative straight-leg raise, but pain with left hip motion. **Assessment/Results:** Hip radiographs were negative but MRI revealed bilateral avascular necrosis (AVN) of the hip joints. The patient was referred to an orthopedic surgeon. Although offered core decompression surgery, the patient elected further conservative treatment with observation and physical therapy. **Discussion:** Physicians accept AVN as a complication of systemic, but not local, steroid therapy. The symptoms of groin and thigh pain became more severe after the radiculopathy and sacroiliac pain resolved. Continued assessment after successful treatment of the painful radiculopathy led to further testing that revealed the more serious condition of AVN. This case reaffirms that because multiple symptoms can exist in the same patient, re-examination after all interventions is essential. **Conclusions:** Clinicians must remain vigi-
Compartment pressures were obtained pre- and post-exercise with both needles simultaneously, using a handheld compartment pressure measurement device. Results: The 18-gauge needle had a mean measurement ± SD of 25.09 ± 12.83mmHg compared with a mean of 26.75 ± 14.7mmHg for the 25-gauge injectable electromyography needle. The difference of 1.65 ± 5.5mmHg was statistically significant (P < .05). The Pearson correlation coefficient was .93 (2-tailed, P < .01). Conclusions: The compartment pressures measured correlated highly and the differences were not clinically relevant. Our findings support the use of the 25-gauge electromyography needle as an alternative to the larger 18-gauge needle for measuring compartment pressures. Key Words: Compartment syndromes; Needles; Rehabilitation.

Poster 133
Using Structural Deformity to Facilitate Gain in Function: A Case Report. Amit Bansal, DO (Rusk Institute of Rehabilitation Medicine, New York, NY); Alex Moroz, MD; Maribeth DeTorto, PT, MS, DPT. Disclosure: A. Bansal, None; A. Moroz, None; M. DeTorto, None.

Setting: Acute inpatient rehabilitation. Patient: An 88-year-old woman with severe fixed S-shaped thoracolumbar scoliotic curve who sustained an acute right proximal tibia and fibula fracture and left distal femur fracture. The patient was admitted for gait and transfer training with weight-bearing status of toe touch on the right leg and as tolerated on the left. Case Description: After falling and sustaining multiple fractures, this patient was admitted to acute rehabilitation. Goals on admission were improving gait and transfer training and decreasing her burden of care. Initially she required the assistance of 2 people to perform sit-to-stand and stand-to-pivot transfers. The goal was to decrease the level of assistance required for safe functional mobility to 1 person while maintaining weight-bearing status. Assessment/Results: Slideboard transfers were incorporated to facilitate functional mobility and to decrease this patient’s burden of care. This technique required moderate assist of 2 people when transferring to the left; however, slideboard transfers to the right required moderate assist of 1 person because she was already fixed in optimal slideboard transfer position secondary to her scoliotic curve. Discussion: The ability to incorporate slideboards with the patient’s scoliotic structural curve decreased the assistance required for functional mobility from 2 to 1 person, which decreased the burden of care, allowing a home discharge. By taking advantage of existing conditions, physiatrists may augment overall care. In this case, the burden of care and length of stay were decreased, ultimately leading to community discharge rather than to a facility. Conclusions: Careful functional physical examination and maximal use of existing structural deficits to the patient’s advantage during transfer training greatly affect the course of therapy. It is therefore imperative to consider the complete clinical and functional presentation prior to implementing a therapeutic plan of care. Key Words: Rehabilitation; Scoliosis; Spinal curvatures.

Poster 134: Canceled.

Poster 135
Role of Intra-Articular Hyaluronic Acid in Management of Periarthritis Shoulder: An Indian Experience. Naman Goel, MD (All India Institute of Medical Sciences, New Delhi, India); S.L. Yadav, MD, DNB; U. Singh, DPMR, DNB; Nitin Kukkar, MS (orthopedics); Sonia Vishwajit, MBBS. Disclosure: N. Goel, None; S.L. Yadav, None; U. Singh, None; N. Kukkar, None; S. Vishwajit, None.

Objective: To evaluate the efficacy of hyaluronic acid in the management of periarthritis shoulder. Design: Prospective study. Setting: Tertiary care center. Participants: 60 patients with periarthritis shoulder. Interventions: Patients were enrolled and randomized in 2 groups: group A (n=30) received a 5-week treatment that included 5 intra-articular hyaluronic acid injections in the affected shoulder joint by posterior approach 1 week apart, daily nonsteroidal anti-inflammatory drugs, alternate day local ultrasonic therapy, and a structured supervised rehabilitation program. Group B was the control group (n=30) and was given the same regimen for 5 weeks but without the intra-articular hyaluronic acid. Main Outcome Measures: Parameters used for evaluation were: 10cm visual analog scale for pain, Shoulder Pain and Disability Index for functional improvement, goniometry and hand behind back scale for range of motion (ROM), a structured questionnaire for quality of life assessment, and activities of daily living charting. Outcomes were checked at 0 weeks, after 5 weeks, and a follow-up assessment was done after 3 and 6 months. Results: The mean reduction in pain ± SD was 7.75 ± 2.58 (on a 10-cm scale) compared with 4.42 ± 2.96 for the control group. Using a Wilcoxon sum rating test there was significant difference (P = .021) in pain reduction between injection and control group. Joint ROM and functional improvement tended to be more effectively improved, but did not achieve statistical significance. Conclusions: The group treated with intra-articular hyaluronic acid had a significantly greater reduction in pain compared with the control group. Although the clinical improvement was impressive, due to the small sample size we could not show statistically significant improvement in all the variables that tended to suggest that effect was more than simply analgesic. Intra-articular hyaluronic acid may be a useful adjunct to treatment of periarthritis shoulder. Key Words: Arthritis; Hyaluronic acid; Rehabilitation; Shoulder.

Poster 136
Groin Injuries Correlated With Greatest Loss in Ranking and Income in Professional Bull Riders. Mary G. Bryant, MD (UVA Health System, Charlottesville, VA); Heather L. Powell, MD; Laura W. Lee, MD, MBA. Disclosure: M.G. Bryant, None; H.L. Powell, None; L.W. Lee, None.

Objective: To determine the type of injury sustained by professional bull riders (PBR) that correlated with the most missed events.
Poster 137

Pulmonary Embolism in a Patient With Quadriceps and Patella Tendon Rupture Repair With Long Leg Cast: A Case Report.
Andrew K. Ankamah, MD (UMDNJ - New Jersey Medical School, Newark, NJ); Vipul Shah, MD; Aoop Shah.

Setting: Outpatient musculoskeletal physical medicine and rehabilitation (PM&R) practice. Patient: A 56-year-old man with left patella and right quadriceps tendon rupture repair, complicated by massive pulmonary embolism (PE). Case Description: He slipped and fell while playing golf. 1 week later, he reinjured both knees when he fell after his crutches slipped. Radiographs showed thickening of quadriceps tendon of the right knee and patella alta of the left knee. Magnetic resonance imaging (MRI) of the right knee showed complete tear of quadriceps tendon, partial tear of the anterior cruciate ligament, partial tear of the medial collateral ligament, and contusions of the quadriceps. Left knee MRI showed complete patella tendon tear. He underwent repair of the patella and quadriceps tendons. He had bilateral long-leg cast. He received the prophylactic enoxaparin (Lovenox). PM&R was consulted to evaluate for gait training. Right long-leg cast was changed to long-leg cast postoperatively. He was discharged to a rehabilitation hospital where he developed acute shortness of breath. Labs showed high D-dimers. Computed tomography angiogram revealed massive bilateral PE involving his bilateral lower lobes. Discussion: Early gait training of patients with quadriceps and patella tendon rupture is important to prevent the development of deep venous thrombosis (DVT) and PE. Knee immobilizers can provide effective knee protection and still allow for relatively early ambulation training. Conclusions: Patients with patella and quadriceps tendon rupture who wear a long-leg cast postoperatively have increased risk of developing DVT and PE. Long-leg casts should be avoided; instead, a knee immobilizer should be recommended to allow early and effective gait training. Key Words: Patella; Rehabilitation.

Poster 138

“Dojo Toe”: The Physiatric Approach to Toe Fractures in Martial Artists—A Case Report. Roseanna Jackson-Parekh, MD (UMDNJ, Newark, NJ); Patrick Foye, MD

Setting: Outpatient physiatric academic practice. Patient: A 38-year-old male martial artist. Case Description: A 38-year-old man presented with pain, swelling, and ecchymosis at the right fifth toe. The prior day at the jujitsu dojo, he had been flipped over the shoulder of a martial arts student who was inadvertently standing on the patient’s toe at the time, resulting in immediate pain at that site. Imaging studies revealed a complex, comminuted fracture of the fifth middle phalanx, with articular involvement. Assessment/Results: The patient was diagnosed with a comminuted fifth toe fracture. Treatment included oral anti-inflammatories, a postoperative (stiff-soled) shoe, and temporary restrictions from full engagement in martial arts. After 6 weeks, his pain had completely resolved and he was medically cleared to resume full activities, including martial arts. Discussion: As physiatrists become increasingly involved in treating athletic injuries, it is important to understand the evaluation and management of various fractures. This case, for which we coined the term “dojo toe,” emphasizes the increased incidence of toe fractures in martial artists. Because physiatrists focus on functional outcomes, it was important in this case to address eventual clearance to return to athletic activities, including martial arts. Clearance for martial arts took into consideration that the sport involves physical contact and stresses associated with repeated kicking and flips. The patient reported being extremely satisfied with his medical care and he had no long-term difficulties or symptoms. Conclusions: Musculoskeletal physiatrists can successfully and nonsurgically treat toe fractures in martial artists, with good outcomes both symptomatically and functionally. Key Words: Fracture fixation; Physical medicine; Rehabilitation; Sports medicine.

Poster 139

Colchicine-Induced Myopathy: A Case Report. Scott Davidoff, MD (Temple University, Philadelphia, PA); Ernesto Cruz, MD.

Setting: University hospital. Patient: A 53-year-old man with lower-extremity pain and weakness. Case Description: The patient presented with progressive muscle pain in his proximal lower extremities over 5 days. He was unable to get out of bed for 2 days due to weakness. 1 week prior, he was started on colchicine for an acute gout attack in his right ankle and knee. The patient also reported anorexia for 2 weeks due to an upper-respiratory illness. He exhibited symmetrical 2/5 strength in the hip flexors and quadriceps and 5/5 in his ankles. Palpation revealed tenderness in his quadriceps, hamstrings, and calves. He was unable to stand due to pain and weakness. Laboratory results were significant for a creatine phosphokinase (CPK) over 30,000. His creatinine was elevated at 3.4. Assessment/Results: When myopathy and acute renal failure were diagnosed, colchicine was discontinued. As the creatinine and CPK trended down, his muscular pain decreased. After 2 weeks, his proximal lower-extremity strength improved to 4+/5, and muscle palpation became less tender. He progressed to a minimal assistance level for sit-to-stand transfer and began ambulating with a rolling walker. His progress was then limited by a recurrence of polyarticular gout. Electromyography was refused. Discussion: This patient was clinically diagnosed with myopathy secondary to colchicine toxicity. Renal failure was due to dehydration. Toxic levels of colchicine uncommonly cause a myopathy due to...
disruption of the microtubule system. His proximal weakness and muscle tenderness correlated. Therapy focused on mild resistive exercises to prevent disuse atrophy while avoiding further muscle damage. As gout treatment was restricted to steroids, recurrence was a limiting factor in recovery. **Conclusions:** Myopathy due to colchicine toxicity in the setting of gout and acute renal failure is a challenging rehabilitation presentation. **Key Words:** Colchicine; Myopathy; Rehabilitation.

Poster 140

Opioid Use Following Lumbar Epidural Steroid Injections in the Veteran Population. Janna Friedly, MD (University of Washington, Seattle, WA); Isuta Nishio, MD, PhD.

Disclosure: J. Friedly, None; I. Nishio, None.

**Objective:** To evaluate whether use of epidural steroid injections (ESI) is associated with decreased subsequent opioid use in the veteran population. **Design:** We reviewed national Veteran Administration (VA) administrative data from 2001 to 2003 to determine use of ESI for low back pain (LBP) and its relationship to opioid use. Opioid use was determined by examining VA pharmacy data for 6 months before and after an ESI. **Setting:** U.S. VA administrative data. **Participants:** Administrative data for veterans undergoing lumbar ESLs between 2001 and 2003. **Interventions:** Not applicable. **Main Outcome Measure:** Opioid use. **Results:** Between 2001 and 2003, 13,741 VA patients underwent an ESI for LBP and a total of 25,733 injections were performed. The majority of patients were using opioids in the 6 months prior to their ESI (64%), as well as after their ESI (67%). Opioid use did not decrease in this patient population in the 6 months following an ESI. 38% of patients not on opioids before the ESI were prescribed opioids afterward whereas only 16% of people on opioids before the ESI stopped using opioids afterward. Patients receiving opioids before their ESI were more likely to stay on them after ESI (P<.000). Patients not receiving opioids before were more likely not to be taking them after ESI (P<.000). **Conclusions:** The majority of VA patients receiving ESI for LBP are also using opioid medications. Contrary to our hypothesis, opioid use did not decrease in the 6 months after ESI in this population and over a third of patients who were not taking opioids prior to the ESI received them afterward. These findings are concerning and suggest that ESIs are not reducing opioid use in this population of veterans. **Key Words:** Injections, epidural; Low back pain; Opioids; Rehabilitation.

Poster 141

Case Report: Debilitating Sweet’s Syndrome in an Acute Rehabilitation Setting. Douglas Elwood, MD, MBA (NYU School of Medicine, New York, NY); Ira Rashbaum, MD; Dong Ma, MD.

Disclosure: D. Elwood, None; I. Rashbaum, None; D. Ma, None.

**Setting:** Tertiary care medical center. **Patient:** A 73-year-old man with Sweet’s syndrome. **Case Description:** This patient presented with a history of Sweet’s syndrome, ulcerotic colitis, and polymyalgia rheumatica. He was admitted to the hospital with increasing bloody diarrhea, abdominal pain, and severe diffuse joint and muscle pains, negatively affecting his gait and activities of daily living. His initial erythrocyte sedimentation rate and C-reactive protein were both 140. **Assessment/Results:** His acute flare was treated successfully with intravenous infliximab (Remicade), steroids, and cyclosporine, with resolution of his abdominal pain and diarrhea. His musculoskeletal symptoms persisted and he was admitted for acute inpatient rehabilitation. He reported upper- and lower-extremity impairment secondary to debilitating arthralgias and weakness limiting his mobility and function. Additionally, idiopathic demyelinating peripheral polynuropathy was confirmed electrophysiologically. Complicating his case further was unilateral hearing loss. **Discussion:** Sweet’s syndrome, or acute febrile neutrophilic dermatosis, is an extremely rare extraintestinal manifestation of ulcerative colitis and other inflammatory and hematologic diseases that may result in severe polyarticular pain. When coupled with polymyalgia rheumatica and peripheral polyneuropathy, significant functional disability occurs. **Conclusions:** Though rare, Sweet’s syndrome may be severe enough to warrant acute inpatient rehabilitation. The combination of this disorder with polymyalgia rheumatica and peripheral neuropathy is uncommon and may have a cumulative effect of aggregating their physical manifestations. Sweet’s syndrome has been associated in 1 case report with peripheral neuropathy thought due to use of thalidomide. It is essential to control ulcerative colitis and other predisposing conditions effectively to avoid severe exacerbations. With judicious use of steroids and rehabilitation therapy, these patients may return close to their baseline and regain most of their functional abilities. **Key Words:** Peripheral neuropathies; Polymyalgia rheumatica; Rehabilitation; Sweet’s syndrome.

Poster 142

Bilateral Efficacy of Local Corticosteroid Injection in a Prima-gravid Patient With Asymmetric Temporal Development of Carpal Tunnel Syndrome in the 2 Hands. Peter Yonclas, MD; Eric L. Altschuler, MD, PhD (UMDNJ, Newark, NJ).

Disclosure: P. Yonclas, None; E.L. Altschuler, None.

**Setting:** Academic medical center. **Patient:** A 35-year-old woman in the third trimester of her first pregnancy. **Case Description:** The patient had no significant medical history. Chief complaint was pain in her right hand and arm significant at all times of day, sufficiently severe to make getting to sleep difficult. She also noted numbness in the first 3 fingers of the right hand. Exam was consistent with right carpal tunnel syndrome (CTS). Splinting did not significantly decrease pain. The patient opted against a trial of oral medications, however, she did allow a local steroid and anesthetic injection. **Assessment/Results:** She noted immediate and complete relief of pain and numbness, and had ability to fall asleep that night and subsequently without difficulty. Some weeks later, she presented with similar symptoms in her left hand. Exam was consistent with CTS. A steroid and local anesthetic injection was performed. Again, the patient noted immediate relief of pain and numbness and the ability to fall asleep without difficulty. A healthy baby was delivered at term without complication. Mother and baby are doing well. There has been no recurrence of CTS symptoms. **Discussion:** Pregnancy increases the risk of developing CTS through an incompletely understood mechanism. Local steroid injection often has efficacy for a few months in CTS—long enough to last until parturition, when the symptoms of CTS typically resolve. Our case not only illustrates the utility of local steroid injection in CTS in pregnancy, but also raises the interesting question of why the CTS developed in an asymmetric temporal fashion in the 2 hands. **Conclusions:** Local corticosteroid injection is safe and effective in CTS in pregnancy. A full understanding of how and why pregnancy so frequently induces often de novo CTS may lead to a better understanding of the pathogenesis of CTS, and merits further study. **Key Words:** Carpal tunnel syndrome; Corticosteroid injection; Pregnancy; Rehabilitation.

Poster 143

Peroneal Nerve Injury and Foot Drop Following Tibia and Fibula Fracture: A Case Report. Anupam Sinha, DO (Nassau University Medical Ctr, East Meadow, NY); Lyn Weiss, MD.

Disclosure: A. Sinha, None; L. Weiss, None.

**Setting:** Outpatient rehabilitation clinic. **Patient:** A 27-year-old man. **Case Description:** A patient with no significant medical history was a
restrained driver involved in a motor vehicle collision. The patient sustained a displaced left midshaft fibula fracture and a displaced left distal tibia fracture. Assessment/Results: The patient underwent intramedullary rodding of the left tibia fracture, realignment of the fibula, and short-leg cast placement. On removal of the cast, the patient was noted to have left foot weakness, and the patient was referred for electrodiagnostic studies. Electromyography and nerve conduction studies showed a neurometabolic lesion of the left peroneal nerve and an axonometric lesion of the left tibial nerve at the level of the knee. Discussion: We report a unique case of a tibia and fibula fracture with associated peroneal and tibial nerve palsies. Conclusions: The clinician should be aware of the potential for nerve damage following displaced tibia and fibula fractures. An appropriate follow-up plan, including electrodiagnostic workup, should be instituted following repair of such fractures with resulting neurologic deficit. Key Words: Fibula; Fracture; Peroneal nerve; Rehabilitation; Tibia.

Poster 144
Brachial Plexus Injury Following Humerus Fracture and Repair: A Case Report. Anupam Sinha, DO (Nassau University Medical Ctr, East Meadow, NY); Walter Gaudino, MD; Lyn Weiss, MD. Disclosure: A. Sinha, None; W. Gaudino, None; L. Weiss, None. Setting: Outpatient rehabilitation clinic. Patient: A 32-year-old man. Case Description: A patient with no significant medical history was involved in a motorcycle crash and sustained multiple injuries. Imaging studies revealed a subarachnoid hemorrhage and multiple fractures, including a comminuted fracture of the right humeral shaft with involvement of the radial nerve. Assessment/Results: The patient underwent open reduction and internal fixation of the right humerus, along with right radial nerve grafting and repair. Physical examination revealed sensation loss along the areas of the right upper arm, forearm, and hand, with inability to extend the right wrist and abduct the right shoulder. Electromyography and nerve conduction studies showed evidence of a combined right radial and axillary nerve injury at the level of the humeral head. Discussion: Most closed axillary nerve injuries occur in association with a glenohumeral dislocation and/or fracture of the surgical neck of the humerus. Radial nerve injuries occur in up to 18% of humeral shaft fractures. We present a case where both the radial and axillary nerves were damaged with a humeral shaft fracture. Conclusions: The clinician should be aware of the potential for nerve damage following a humerus fracture. Patients presenting with arm weakness or paresthesia following a humerus fracture and/or repair should undergo electrodiagnostic studies to evaluate for brachial plexus injury. Key Words: Brachial plexus; Rehabilitation.

Poster 145
Physiatric Management of Severe Cervical Spondylosis and Spinal Cord Compression With Impaired Balance and Gait: A Case Report. Andrew K. Ankamah, MD (UMDNJ - New Jersey Medical School, Newark, NJ); Rex Ma, MD; Richard Dentico, MD; Celestine Nnaeto, BS. Disclosure: A.K. Ankamah, None; R. Ma, None; R. Dentico, None; C. Nnaeto, None. Setting: Outpatient musculoskeletal physical medicine and rehabilitation practice. Patient: An 82-year-old man with gait and balance impairment. Case Description: The patient presented with complaints of gait and balance difficulties when ambulating during that previous 12 months. He denied dizziness, vertigo, paresthesias, pain, visual deficits, and bowel or bladder incontinence. He denied falling, although on 1 occasion he lost his balance and almost fell on top of hot cooking gas. His symptoms were exacerbated when he increased his walking speed. On examination, manual muscle testing was 5/5 in the bilateral upper and lower extremities. Sensation was intact in all dermatomes. Reflexes were 2+ at the biceps, triceps, and patella, but were absent at the ankle bilaterally. The Romberg test was grossly positive. Cerebellar function tests were intact. He had significant difficulty when asked to walk in a straight line. Computed tomography scan of the brain showed atrophy and an old infarct in the left basal ganglia. There was no acute pathology. Magnetic resonance imaging (MRI) showed severe multilevel degenerative spondylosis with significant spinal cord compression of C2-7 (chronic Smorl’s node) and C6-7. There was central canal stenosis at C2-3. Comprehensive physical therapy program with emphasis on gait, balance, and proprioception exercises was initiated. Assessment/Results: He returned 1 month later with 90% improvement of his symptoms, despite his significant initial gait and balance deficits, as well as MRI findings consistent with severe cervical spondylosis complicated by spinal cord compression. Discussion: Cervical spondylosis can lead to spinal cord compression at the cervical level, especially involving C1, C2, and C3. MRI should be obtained to delineate the degree of the cord compression. Early and comprehensive physical therapy is necessary to improve function. Conclusions: Severe cervical spondylosis with spinal cord compression complicated with gait and balance impairment can be effectively managed by physiatrists without the need for surgical intervention. Key Words: Gait; Rehabilitation; Spondylolisthesis.

Poster 146: Canceled.

Poster 147
Acute Low Back Pain With Right Lower-Extremity Paresthesia in a 24-Year-Old Man After a Snowboarding Fall: A Case Report. Steve M. Aydin, DO (UMDNJ-Kessler Institutes for Rehabilitation, Newark, NJ). Disclosure: S.M. Aydin, None. Setting: Musculoskeletal clinic. Patient: A 24-year-old man. Case Description: The patient presented with acute onset of low back pain (LBP) for 4 weeks. The pain was dull-achy and like a band across the lower lumbar spine. The patient also developed numbness and tingling in the right leg down to his lateral toes 3 weeks after the onset of the LBP. The patient was an active snowboarder and admitted having a fall where he landed on his belly and his spine bent backward. Deep tendon reflex at the right Achilles’ was 2+. Muscle strength testing was 5−/5 for the right extensor hallucis longus. He had a positive straight-leg raise test on the right. Magnetic resonance imaging (MRI) of the lumbar spine showed grade I retrolisthesis of the L5 vertebrate on S1 and broad-based disk herniation of the L5-S1 disk. Radiographs showed grade I spondylolisthesis and bilateral pars reticularis fractures. Electrodiagnostics showed increased insertional activity in the right gastrocnemius and lumbar paraspinal muscles. Assessment/Results: An L5 on S1 spondylolisthesis, with an underlying S1 radiculopathy on the right. The patient underwent physical therapy, with resolution of LBP and mild improvement of the right lower-extremity paresthesias. Discussion: The presentation of a hyperextension injury followed by the acute onset of LBP will often include the differential diagnosis a pars fracture. Often, a series of lumbar radiographs are done initially to determine pathology. Given the presentation of a radicular type of presentation, LBP with radiating paresthesia, an MRI resulted in the initial evaluation. This was an atypical presentation of a bilateral pars reticular fracture, due to its radicular presentation. Conclusions: S1 radiculopathy presentation with LBP should also include a differential diagnosis of spondylolisthesis, especially in a younger athlete participating in sports with increased risk of lumbar spine hyperextension. Key Words: Lumbar manipulation; Radiculopathy; Rehabilitation; Spondylolisthesis; Sports.
Other Rehabilitation Topics

Poster 148
Muscle Oxygenation and Recovery From Calf Desaturation in Peripheral Arterial Disease. Arash Asher, MD (UCLA/VA, Los Angeles, CA); Norman Banks, MD, MS; John Tin, MD; Anthony Rivera, MD; Stephen F. Figoni, PhD; Charles F. Kunkel, MD, MS. Disclosure: A. Asher, None; N. Banks, None; J. Tin, None; A. Rivera, None; S.F. Figoni, None; C.F. Kunkel, None.

Objective: To compare calf oxygen recovery times of subjects with peripheral arterial disease (PAD) to controls without PAD. Design: Cross-sectional matched-pairs comparisons. Setting: Outpatient rehabilitation clinic at a tertiary care medical center. Participants: 13 PAD subjects with stage 2a calf claudication and 13 control subjects without PAD, matched on age, sex, and ethnicity. Interventions: Not applicable. Main Outcome Measures: T50 and T100 are the times to 50% and 100% recovery of muscle tissue saturation (StO2) following exercise that causes oxyhemoglobin desaturation. Repeated-measures analysis of variance of StO2 were used to compare T50 and T100 in both groups during treadmill and calf exercise testing protocols. Results: During the treadmill protocol, T50 in the PAD group was significantly (P<.05) longer compared with controls (PAD treadmill, 2.8 ± 2.4min vs control treadmill, 0.4 ± 0.3min). During the calf protocol, T50 in the PAD group did not differ significantly from controls (PAD calf, 1.7 ± 1.1min vs control calf, 0.8 ± 0.6min). During the treadmill and calf protocols, T100 in the PAD group was significantly longer than controls (PAD treadmill, 6.5 ± 2.9min vs control treadmill, 1.4 ± 0.9min; PAD calf, 5.4 ± 2.2min vs control calf, 3.0 ± 1.5min). Conclusions: PAD disturbs the recovery kinetics of StO2. Using a noninvasive tissue oxygen monitor to determine StO2, T50, and T100 may provide a viable tool for the diagnosis of PAD. Key Words: Exercise; Oxygen; Rehabilitation; Vascular diseases, peripheral.

Poster 149
Pregabalin Monotherapy for Relief of Symptoms of Fibromyalgia Syndrome: Analysis of 2 Double-Blind, Randomized, Controlled Trials. I. Jon Russell, MD (University of Texas Health Science Ctr, San Antonio, TX); Lesley M. Arnold, MD; W. Rachel Duan, PhD; Hana Florian, PhD; James P. Young Jr, MS; Susan Martin, MPH. Disclosure: I.J. Russell, research grants from Pfizer Inc; consulting fees from Pfizer Inc; L.M. Arnold, research grants from Pfizer Inc; consulting fees from Pfizer Inc; W.R. Duan, stock/options in Pfizer Inc; full-time employee of Pfizer Global R&D; H. Florian, stock/options in Pfizer Inc; full-time employee of Pfizer Global R&D; J.P. Young Jr, stock/options in Pfizer Inc; full-time employee of Pfizer Global R&D; S. Martin, stock/options in Pfizer Inc; full-time employee of Pfizer Global R&D.

Objective: To provide additional insight into the efficacy and safety of pregabalin as treatment of fibromyalgia, using a pooled analysis of 2 trials. Design: Double-blind, placebo-controlled, parallel-group. Setting: Primary-care and specialty centers. Participants: Patients meeting 1990 American College of Rheumatology criteria for fibromyalgia plus a pain visual analog scale score of ≥40mm (scale range, 0–100mm) and a mean pain scale of ≥4 (numeric rating scale range, 0–10). 91% were white, 94% were women, mean age was 49 years, and baseline mean pain score was 6.9. Intervention: Pregabalin given at 300, 450, or 600mg/d twice daily or placebo for 13 to 14 weeks. Main Outcome Measures: Endpoint mean pain score, Fibromyalgia Impact Questionnaire (FIQ), and Patient Global Impression of Change (PGIC). Results: 1493 patients were randomized, 368 to pregabalin 300mg/d; 373 to 450mg/d; 378 to 600mg/d; and 374 to placebo. Differences from placebo in change from baseline to endpoint in mean pain score were: 300mg/d group, −.55 (P=.000); 450mg/d group, −.71 (P<.001); and 600mg/d group, −.82 (P<.001). Treatment effect sizes increased almost linearly from the 300mg/d group to the 450mg/d group to the 600mg/d group. Mean differences from placebo in total FIQ score at endpoint were: 300mg/d group, −2.47 (P=.070); 450mg/d group, −3.43 (P=.011); and 600mg/d group, −3.05 (P=.024). A significantly greater proportion of pregabalin patients reported clinically meaningful improvement on the PGIC: 300mg/d group, 38% (P=.000); 450mg/d group, 44% (P<.001); 600mg/d group, 45% (P<.001); and placebo, 29%. Most adverse effects (AEs) were mild-to-moderate and tended to resolve with continued treatment. The most common treatment-emergent AEs among pregabalin-treated patients were dizziness (300mg/d group, 31%; 450mg/d group, 41%; 600mg/d group, 45%; placebo, 8%), somnolence (18%; 22%; 25%; 5%, respectively), and weight gain (11%; 11%; 14%; 2%, respectively). Among pregabalin patients, 18%, 22%, and 29% of the 300mg/d, 450mg/d, and 600mg/d groups, respectively, discontinued because of AEs compared with 11% of placebo patients. Conclusions: In this pooled analysis of about 1500 patients with fibromyalgia, pregabalin at 300, 450, and 600mg/d was associated with robust efficacy for pain relief. Pregabalin was also associated with significant improvement in total FIQ score (at 450 and 600mg/d) and in PGIC (all dosages). Key Words: Fibromyalgia; Pain; Rehabilitation.

Poster 150
Effect of Once-Yearly Infusion of 5mg of Zoledronic Acid in Postmenopausal Women With Osteoporosis: The HORIZON-Pivotal Fracture Trial. Meryl S. LeBoff, MD (Harvard Medical School, Boston, MA); Dennis Black, MD; Pierre Delmas, MD; Richard Eastell, MD; Ian Reid, MD; Steve Cummings, MD. Disclosure: M.S. LeBoff, Amgen; Novartis; Abbott; Proctor & Gamble; Lilly; D. Black, Novartis; P. Delmas, Novartis; R. Eastell, Novartis; I. Reid, Novartis; S. Cummings, Novartis.

Objective: To evaluate once-yearly 5mg of zoledronic acid (ZOL) to decrease fracture risk in women with postmenopausal osteoporosis (PMO). Design: Multinational, 3-year, randomized, double-blind, placebo-controlled trial. Setting: 240 clinical centers in 27 countries. Participants: 7736 women with PMO (age range, 65–89y). Intervention: Once-yearly 5mg infusion of ZOL. Main Outcome Measure: New morphometric vertebral fractures and hip fractures at 3 years. Results: A 5mg treatment of ZOL resulted in significant relative risk reductions in morphometric vertebral fracture of 70% versus placebo (3.3% vs 10.9%; 95% confidence interval (CI), 62%–76% and in hip fracture of 41% versus placebo (1.4% vs 2.5%; 95% CI, 17%–58%). Secondary endpoints, nonvertebral (excluding finger, toe, facial), clinical vertebral, and any clinical fracture (including nonvertebral, hip, clinical vertebral), were significantly reduced by 25%, 77%, and 33% (all P<.001), respectively. Bone mineral density increased significantly in ZOL versus placebo at total hip (6.0%), lumbar spine (6.7%), and femoral neck (5.0%) (P<.001). While transient increases in serum creatinine ≥0.5mg/dL over preinfusion levels were seen in a small fraction (1.3%) of patients on 5mg of ZOL, no cumulative impact on renal function was demonstrable. Hypocalcemia (serum calcium, <2.075mmol/L) was observed in 2.3% of patients. Virtually all events occurred after first infusion of ZOL, and all were asymptomatic and transient. Adverse events occurring ≤3 days after infusion were more frequent after first infusion (44.7% ZOL vs 14.7% placebo) but declined markedly on subsequent infusions. There were more atrial fibrillation–serious adverse events in ZOL versus placebo (1.3% vs 0.5%). 2 cases of osteonecrosis of the jaw (1 in placebo, 1 in ZOL) were identified after adjudication; both resolved with antibiotic therapy and debridement. Conclusions: Once-yearly infusion of 5mg of ZOL over 3 years achieves highly significant decreases in vertebral, hip, and other fracture risk and is generally safe and well tolerated.
Key Words: Hip fractures; Postmenopausal osteoporosis; Rehabilitation; Spinal fractures.

Poster 151
Uncovering Differences in the Meaning of Functional Recovery: A Comparison of Patients and Clinicians. Margaret G. Stineman, MD (University of Pennsylvania, Philadelphia, PA); Pamela M. Rist; Greg Maislin, MS, MA; Jibby E. Kurichi, MPH.

Disclosure: M.G. Stineman, None; P.M. Rist, None; G. Maislin, None; J.E. Kurichi, None.

Objective: To show differences between the relative value patients and clinicians assign to various functional abilities. Design: Applying the emerging technique of recovery preference exploration, patients and rehabilitation clinicians expressed optimal patterns of recovery from the imagined state of complete disability in the 18 items of the FIM instrument. The procedure yielded utilities demonstrating the relative value of 1 activity according to the remaining 17 on a scale from 0 to 1. Due to the non-normalcy of the utility distributions, median utilities were used to contrast values between patients and clinicians.

Setting: An inpatient rehabilitation facility. Participants: 79 patients with acutely disabling neurologic, musculoskeletal, or medically complex conditions, and 93 clinicians, including physicians, medical school students, nurses, physical therapists, a recreational therapist, occupational therapists, psychologists, and social workers.

Intervention: Recovery preference exploration. Main Outcome Measure: Quantitative utilities for 18 functional activities. Results: The most valued FIM item for patients was eating (median utility, 13; Q1 [or 25th percentile], 0.05; Q3 [75th percentile], 0.50) followed by bathing (median, 0.10; Q1 = 0.05; Q3 = 0.14). With the exception of bowel management, patients’ median utilities for the physical FIM items were greater than the clinicians’. In comparison, the clinicians consistently assigned greater value to the cognitive FIM items. Expression (median, 0.36; Q1 = 0.24; Q3 = 0.58) and comprehension (median, 0.26; Q1 = 0.11; Q3 = 0.51) were the functional abilities most valued by clinicians. There was almost no correlation between patient and clinician utilities. Conclusions: Strong differences in preference for functional recovery may relate to the context of patients’ real-life experiences of acute dependency associated with their severe illnesses or injuries. In contrast, clinicians may have more academic concepts of functionality. Key Words: Health priorities; Patient-centered care; Quality of life; Rehabilitation.

Poster 152
Implications of Functional Outcome on Survival Among Amputees. Margaret G. Stineman, MD (University of Pennsylvania, Philadelphia, PA); Janet A. Prvu-Bettger, ScD; Jibby E. Kurichi, MPH; Barbara E. Bates, MD; Richard N. Ross, MS; Greg Maislin, MS, MA.

Disclosure: M.G. Stineman, None; J.A. Prvu-Bettger, None; J.E. Kurichi, None; B.E. Bates, None; R.N. Ross, None; G. Maislin, None.

Objective: To determine the degree to which higher grades of physical independence achieved by the conclusion of rehabilitation of postsurgical amputation of the lower limb(s) is associated with improved likelihood of up to 1-year survival. Design: A retrospective cohort analysis using Cox proportional hazards regression was applied to estimate the likelihood of survival up to 1 year, removing the effects of age, sex, marital status, amputation level, bilateral versus unilateral amputation, amputation etiologies, and comorbidities. The analysis was stratified by the achievement of 6 grades of physical independence by the completion of either generalized consultative or specialized comprehensive rehabilitation. Adjusted Kaplan-Meier survival curves were obtained to plot associations between each grade and survival up to 1 year. Grade 1 represented complete dependence, grade 6 complete independence, and grades 2 through 5 intermediate levels of independence across 13 functional items measuring activities of daily living and mobility. Setting: 125 Veteran Affairs medical centers. Participants: 3242 veterans who underwent surgical amputation of the lower limbs between October 1, 2002, and September 30, 2004. Interventions: Not applicable. Main Outcome Measure: All-cause mortality up to 1 year. Results: The adjusted expected likelihood of survival up to 1 year postsurgery for patients who were at grades 1, 2, 3, 4, 5, and 6 was 68.8% (95% CI, 63.8%–72.4%), 90.2% (95% CI, 85.8%–94.9%), 91.4% (95% CI, 88.4%–94.5%), 94.6% (95% CI, 91.9%–97.4%), 94.0% (95% CI, 92.0%–96.1%), and 98.3% (95% CI, 97.0%–99.6%), respectively. Perioperative sepsis and greater comorbidity were associated with reduced survival (both \( P = .000 \)). Conclusions: Achievement of even low levels of physical independence compared with complete dependency markedly improved survival rates. Survival for patients who achieved grades 2 and 3 and grades 4 and 5 appeared similar, with further improved prognosis for those who achieved grade 6. Key Words: Amputation; Forecasting; Rehabilitation; Survival.

Poster 153
Cryptococcal Meningitis in a Rehabilitation Setting. Jonathan Clapp, MD (Rush University Hospital, Chicago, IL); Merrie Viscarra, DO.

Disclosure: J. Clapp, None; M. Viscarra, None.

Setting: Inpatient rehabilitation. Patient: A 53-year-old man. Case Description: The patient, who had no medical history or history of immunosuppression, presented with progressive low back pain and lower-extremity weakness for 1 month prior to admission. He was admitted with progressive weakness and sensory deficits to the bilateral lower extremities secondary to cryptococcal meningitis involving the conus medullaris, cauda equina, and lumbar nerve roots. The patient was treated with dexamethasone (Decadron), flucytosine (Ancobon), and amphotericin B (Ambisome), and serial lumbar taps. On admission to rehabilitation, he was taking 400mg of fluconazole oral daily for long-term treatment. Assessment/Results: Previously, he was independent with mobility and activities of daily living. On admission to rehabilitation, he needed supervision with rolling, minimal assistance with supine to sit, moderate assistance with wheelchair-to-bed transfers, supervision with wheelchair mobility, and was not able to ambulate. After 1 month in rehabilitation, his gait improved to minimal assistance, using a left knee-ankle-foot orthotic and a right ankle-foot orthotic. He was at a modified assistance level going up and down a 10.2-cm (4-in) curb and minimal assistance with transfers. In occupational therapy, he required minimal assistance with tub transfers using a tub bench, minimal assistance with lower-extremity dressing, and with wheelchair-to-mat transfers. Discussion: Cryptococcal meningitis typically presents in immunocompromised patients with symptoms including headache, fever, nausea, vomiting, stiff neck, photophobia, mental status changes, and hallucinations. Presentations of lower-extremity weakness and paresthesias are rare among even immunocompromised patients. Conclusions: This case is interesting because of the paucity of cases of cryptococcal meningitis in non-immunocompromised patients, and presentations with focal lower-extremity weakness and paresthesias due to involvement of the conus medullaris, cauda equina, and lumbar nerve roots. This case also illustrates the benefits of rehabilitation in this situation.

patient’s recovery. **Key Words:** Cryptococcal meningitis; Rehabilitation.

Poster 154
**Rare Case of Central Nervous System Nocardiosis in an Immunosuppressed Cadaveric Renal Transplant Patient: A Case Report.** Erik C. Marsiglia, DO (Rush University Medical Ctr, Chicago, IL); Christopher Reger, MD.

Disclosure: E.C. Marsiglia, None; C.D. Reger, None.

**Setting:** Tertiary care hospital. **Patient:** A 40-year-old man with cadaveric renal transplant. **Case Description:** The patient had a cadaveric renal transplant performed after having end-stage renal disease from uncontrolled diabetes and hypertension. After 1 month of immunosuppressive therapy, he presented with mental status changes and falls. A noncontrast computed tomography of the brain was normal; however, his cerebrospinal fluid contained *Cryptococcus neoformans* and fluconazole was started. **Assessment/Results:** After his cryptococcal infection, the patient had functional and cognitive decline. He required comprehensive inpatient rehabilitation and had improved. 10 months post-transplant, he was readmitted for seizure disorder and found with imaging to have a superior right front lobe cystic lesion. He underwent a craniotomy and abscess removal. Pathology confirmed *Nocardia farcinica* infection and trimethoprim-sulfamethoxazole was started. Within 1 week, the patient had another seizure episode, and his antibiotic was changed for presumed resistance. Nonetheless, follow-up imaging noted a growing left parietal lesion requiring another craniotomy. Following each craniotomy, he participated in physical therapy and was able to be discharged with an improvement in his functional status. **Discussion:** Nocardiosis is a rare gram-positive aerobic bacterial opportunistic infection affecting 500 to 1000 patients per year in the United States. One third of infections affect the central nervous system, and few involve renal transplant recipients. Of the several known species, *Farcinica* is less often implicated but is more likely to show resistance to usual antibiotic regimens. Despite repeated infections and surgeries, this patient was able to maintain a high level of function because of rehabilitation. **Conclusions:** Functional decline may initially occur in the immunosuppressed patient with neurologic infection. However, this case demonstrates that with aggressive anti-biotic therapy, surgery, and a comprehensive rehabilitation program, a satisfactory outcome was achieved in this complex and medically challenging patient. **Key Words:** Immunosuppression; Nocardia; Rehabilitation.

Poster 155
**Calf Muscle Oxygenation During Treadmill and Calf Exercise in Peripheral Arterial Disease.** Erika Sarem, MD (VA Greater Los Angeles Healthcare System, Los Angeles, CA); Stephen F. Figoni, PhD; Charles F. Kunkel, MD; Roy B. Hooks Jr, BS; Jeanneuse B. Elghanayan, BS; Oscar U. Sarem, MD, PhD.

Disclosure: E. Sarem, None; S.F. Figoni, None; C.F. Kunkel, None; R.B. Hooks Jr, None; J.B. Elghanayan, None; O.U. Sarem, None.

**Objective:** To compare calf muscle oxygenation during treadmill and calf exercise in patients with critical illness polyneuropathy. **Participants:** Patients With Critical Illness Polyneuropathy. Iordanca D. Anica, MD (William Beaumont Hospital, Royal Oak, MI); Ronald S. Taylor, MD.

Disclosure: I.D. Anica, None; R.S. Taylor, None.

**Objective:** To compare functional outcomes of critical illness polyneuropathy (CIP) patients in an inpatient rehabilitation unit with those of patients admitted with acute cerebrovascular accident (CVA). **Design:** Retrospective, chart review study. **Setting:** Inpatient rehabilitation unit in a 1050-bed tertiary care hospital. **Participants:** 151 patients with CIP and 152 patients with acute CVA admitted to our inpatient rehabilitation unit during 2006. The patient populations were similar in size and mean age (age, 72.14y vs 69.98y). **Interventions:** Not applicable. **Main Outcome Measures:** FIM instrument change, FIM change per day, length of stay (LOS), and discharge destination. **Results:** CIP patients had a shorter mean LOS (11.27d vs 13.77d). FIM change per day was similar in each group (1.01 for CIP vs 1.06 for CVA). Both groups had equivalent rates of discharges to home (62.91% vs 59.48%). Discharges to extended care facilities were higher in the CVA group (40 patients vs 15 patients), whereas transfers to the medical floor were higher in the CIP group (41 patients vs 21 patients). Analysis of comorbidities showed higher incidence of renal disease, chronic obstructive pulmonary disease, and decubiti in the CIP group, whereas hypertension and hyperlipidemia were higher in the CVA group. Diabetes mellitus, coronary artery disease, and other comorbidities were roughly similar. **Conclusions:** Our study indicates that patients with CIP experience similar improvement and discharge destination to that of patients with CVA and therefore represent an appropriate group of patients to be treated in an inpatient rehabilitation unit. **Key Words:** Cerebral stroke; Critical illness; Polyneuropathies; Rehabilitation; Treatment outcome.

Poster 157
**Bilateral Flaccid Paralysis Secondary to West Nile Virus Infection: A Case Report.** Qamar Khan, DO (Rush University Medical Ctr, Chicago, IL); Sri Muthukrishnan, MD.

Disclosure: Q. Khan, None; S. Muthukrishnan, None.

**Setting:** Tertiary care hospital. **Patient:** A 53-year-old man with hypertension was admitted with fevers, chills, rash, and acute bilateral exercise baseline and nadir during exercise; initial (ICT) and maximal (MCT) claudication times (in minutes); and StO2 values at ICT and MCT (PAD only). **Results:** 2×2 repeated-measures analysis of variance revealed that StO2 baseline and nadir values in the PAD group were significantly (*P<.05*) lower than in the control group during both treadmill and calf exercise tests (StO2 baseline: treadmill, 89%±6% vs 81%±13%; calf, 90%±6% vs 79%±16%; StO2 nadir: treadmill, 10%±13% vs 43%±23%; calf, 24%±26% vs 62%±19%). Paired *t* tests indicated that in PAD subjects’ ICT, StO2 at ICT, and MCT during treadmill tests did not differ significantly from values during calf tests (treadmill ICT, 2.4±0.9min vs calf ICT, 1.9±0.2min; treadmill StO2 at ICT, 20%±19% vs calf StO2 at ICT, 37%±30%; treadmill MCT, 7.0±3.6min vs calf MCT, 5.9±2.2min). Mean StO2 at MCT was significantly lower during the treadmill test (treadmill, 15%±14% vs calf, 35.1%±29.6%). **Conclusions:** StO2 baseline and nadir responses differ significantly between groups of PAD and controls for either type of test. Compared with treadmill exercise, calf exercise has the advantages of (1) being relatively independent of walking and cardiopulmonary impairment and (2) eliciting similar StO2 and exercise responses. **Key Words:** Exercise; Oxygen; Peripheral vascular diseases; Rehabilitation.
lower-extremity weakness. **Case Description:** On presentation, a lumbar puncture was performed that showed pleocytosis with lymphocytic predominance and elevated protein concentration. After progression of his symptoms to acute flaccid paralysis and onset of urinary retention, magnetic resonance imaging of the thoracic and lumbar spine were obtained that found contrast enhancement around the conus, with increased central cord signal on T2 imaging, suggesting an inflammatory or infectious process. Electromyography was suggestive of a lumbosacral motor neuropathy or polyradiculopathy. Viral culture of the cerebrospinal fluid was positive for West Nile virus (WNV) and the patient was diagnosed with WNV myelitis. **Assessment/Results:** Given the patient’s symptoms and decreased mobility, physiatry was consulted and he was admitted to the acute rehabilitation floor. On admission, the patient was at a moderate-to-maximum assistance level for transfers and bed mobility. The patient increased his overall strength and on completion of the rehabilitation program he was independent in activities of daily living, ambulating with a right knee-ankle-foot orthotic and a left ankle-foot orthotic and a rolling walker up to 45 m (150 ft), and was able to negotiate stairs at a supervised level. **Conclusions:** Encephalitis and meningitis are more common manifestations of the WNV infections than the acute flaccid paralysis syndrome. The acute flaccid paralysis syndrome is preceded by encephalitis, a rash, and typically produces an asymmetric myelitis with long-term functional outcomes demonstrating that most will have incomplete recovery of limb strength resulting in profound residual deficits. As WNV infections in the United States rise, comprehensive rehabilitation should be considered for those with this condition to provide the best opportunity to improve functional mobility and quality of life. **Key Words:** Myelitis; Paralysis; Rehabilitation; West Nile virus.

**Poster 158**

**Availability of Teaching Skills Improvement Programs in U.S. Physical Medicine and Rehabilitation Academic Programs.** Ann-Marie Thomas, MD (Spaulding Rehab/Harvard Med, Boston, MA; Stacy Bishop, DO).

**Disclosure:** A. Thomas, None; S. Bishop, None.

**Objective:** To determine the prevalence and characteristics of teaching skills improvement programs (TSIPs) in academic PM&R programs. **Design:** A 23-item questionnaire was emailed and faxed to the 65 PM&R residency program directors in October 2004 and again in March 2005. Information requested included demographics, whether or not there was a TSIP, and the characteristics of any TSIP. **Setting:** U.S. PM&R residency programs. **Participants:** Residency program directors. **Interventions:** Not applicable. **Main Outcome Measures:** Not applicable. **Results:** 63% (n = 41) completed the survey of which 17% (n = 7) had a TSIP. The TSIPs were offered 1 to 2 times per year, with 1 to 2 hours of instruction per offering; 57% of the TSIPs were during working hours. 86% of the TSIPs had mandatory attendance and 50% included other specialties. The department chair or other teaching staff provided the instruction in 50% of the TSIPs. The most common topic covered was evaluation and feedback and the most frequent instructional method was group discussion. 50% provided post-program assessments and 57% offered later reinforcement of teaching skills. Resident evaluation of faculty teaching skills occurred in 92.7% of the residency programs that responded. **Conclusions:** Few TSIPs exist in academic PM&R programs. Further evaluation is needed to determine the most effective characteristics of TSIPs. **Key Words:** Rehabilitation; Teaching.

**Poster 159**

**Cognitive Demand Affects Functional Mobility in Multiple Sclerosis.** Seema R. Khurana, DO (University of Miami, Miami, FL); George H. Kraft, MD; Melissa J. Cline, BS; Alyssa M. DiGiacomo, MPH; Rohini V. Wadhwani, BS; James D. Bowen, MD.

**Disclosure:** S.R. Khurana, None; G.H. Kraft, None; M.J. Cline, None; A.M. DiGiacomo, None; R.V. Wadhwani, None; J.D. Bowen, None.

**Objective:** To analyze the effects of cognitive distractions on ambulation in people with multiple sclerosis (MS). **Design:** Prospective case-control study. **Setting:** MS clinic. **Participants:** 100 ambulatory Expanded Disability Status Scale score < 6.0 community-dwelling adults (53 with MS, 57 age- and sex-matched controls) were enrolled. **Interventions:** 2 ambulation measures were used: the Timed Up & Go (TUG) test and a 100-foot walking test. These measures were performed under 3 conditions: no cognitive task; a simple cognitive task: reciting the alphabet; and a more difficult cognitive task: counting backward by 3. In addition, subjects counted backward by 3 while seated and completed the Paced Auditory Serial Addition Test. **Main Outcome Measures:** The time taken to complete each of the tests and the subjects’ accuracy. **Results:** In MS subjects and controls, both simple and complex cognitive tasks adversely affect motor performance. MS subjects showed trends toward greater differences in speed between the TUG alone and the TUG with the alphabet (P = .04). The MS group performed 81% to 92% worse, respectively, when performing a cognitive task along with the motor task than with the motor task alone. **Conclusions:** Cognitive challenge does impair speed of motor behavior in MS. The complexity of the cognitive task may not matter, but more importantly, the 2 tasks are being performed simultaneously. This study is relevant to MS because it addresses the interplay between 2 areas that are commonly affected by MS: cognition and motor function. The results allow us to better understand the impact of distraction on common motor functions. **Key Words:** Cognition; Multiple sclerosis; Rehabilitation; Walking.

**Poster 160**

**Lumbar Diskogenic Pain: A Review of Minimal Invasive Treatment Modality.** Hany R. Nosir, MD (Advanced Pain Management, Milwaukee, WI).

**Disclosure:** H.R. Nosir, None.

**Objective:** To understand the role of minimal invasive treatment in lumbar diskogenic pain, including thermal collagen modification treatment, biologic photodynamic-photochemical disk repair, and disk cell transplantation. **Data Sources:** Systematic review of the medical and surgical literature regarding minimal invasive therapy in lumbar diskogenic pain. 40 research and clinical reports published between 2000 and 2006 were reviewed for lumbar degenerative disk disease, minimal invasive therapy, and treatment outcomes. **Study Selection:** A systematic review of all available studies based on Cochrane Collaboration evidence review criteria and meta-analysis of minimal invasive interventions in lumbar diskogenic pain. Case series, cost-effectiveness analysis, randomized trials, and prospective studies were reviewed. **Data Extraction:** The literature on the minimal invasive therapy in disk disease is limited to short clinical follow-ups. The success rates reported in different studies vary from 65% to 70% of excellent or good results. **Data Synthesis:** Minimal invasive intradiscal treatment has shown promising results with regard to pain relief, increased level of functioning, and improved quality of life. **Conclusions:** Minimal invasive disk modalities provide an alternative for lumbar diskogenic pain, with fewer long-term side effects. However, more clinical studies and basic science research are necessary to improve the clinical efficacy of these techniques. **Key Words:** Intervertebral disk; Rehabilitation.

Disclosure: H.R. Nosir, None.

Objective: To evaluate whether needle tip anterior scalene muscle (ASM) insertion under fluoroscopy can be better performed using a nerve stimulator. Design: Under fluoroscopic guidance, an insulated nerve stimulator needle was inserted into the belly of the ASM. An Omnipaque contrast was injected inside the muscle. Nerve stimulation was performed to make sure that the needle tip was not in the brachial plexus, confirming the needle placement only in the muscle. Local anesthetic was injected and amount of pain relief was documented after the block. Setting: Private practice. Participants: 10 cases with positive thoracic outlet syndrome (TOS) stress maneuvers. Intervention: Fluoroscopically guided nerve stimulator ASM anesthetic relaxation in TOS. Main Outcome Measures: There were no cases with somatic or sympathetic block. Results: The 10 cases with positive TOS stress maneuvers had complete pain relief after the block. Conclusions: The use of nerve stimulator guided fluoroscopy is a simple reliable technique to provide precise needle tip placement in ASM relaxation in diagnosing TOS. Key Words: Rehabilitation; Thoracic outlet syndrome.

Changes in Bladder Function After Initiation of Intrathecal Baclofen in Patients With Supraspinal Spasticity: A Report of 2 Cases. David M. Kanter, MD (SUNY Upstate Medical University, Syracuse, NY); Claudine T. Ward, MD; Margaret A. Turk, MD.

Disclosure: D.M. Kanter, None; C.T. Ward, None; M.A. Turk, None.

Setting: Tertiary care hospital. Patients: 2 female patients, ages 30 and 15 years, with spastic quadriplegia, one due to cerebral palsy and one due to traumatic brain injury. Case Descriptions: Both patients have had pumps placed for intrathecal baclofen (ITB) administration to manage spasticity, had not had urinary problems associated with oral baclofen, and had a change in urinary status following ITB administration. Urodynamic studies were performed to assist with urinary management after pump implantation due to new onset urinary retention. Both had stable urinary management with infrequent urinary tract infections (UTIs). Assessment/Results: Urinary management prior to pump implantation was timed voiding with episodes of urinary incontinence, with low post void residuals. Both patients had frequent UTIs and urinary retention after pump implantation. Urodynamic studies showed detrusor sphincter dyssynergia with normal bladder compliance and poorly contracting detrusor. Intermittent catheterization was initiated, although it was not continued long term. Discussion: There are reports of the positive and negative effects of ITB on spinal-mediated neurogenic bladders. However, there are fewer reports about patients with supraspinal spasticity receiving ITB, and none reporting urodynamics. There are several mechanisms for urinary dysfunction, and ITB may have variable effects on some of them. In the patients reported here, new onset urinary retention may be a factor in a decreased micturition reflex, resulting in normal detrusor compliance but ineffective detrusor contraction. There appeared to be little ITB effect on pelvic floor muscle activity. Conclusions: Urinary function can change following initiation of ITB in patients with supraspinal spasticity. Documentation of urinary function preimplant is important for long-term management, and urinary function should be monitored after ITB initiation. Urodynamics are useful for diagnosis and treatment if bladder function changes occur. Key Words: Baclofen; Muscle spasticity; Rehabilitation.

Comparison of the Functional Walking Levels Before Orthopedic Surgery and After Rehabilitation in Patients With Cerebral Palsy. Luis M. Rodrigues, MD (Associação de Assistência à Criança Deficiente, São Paulo, Brazil); Fernando M. Rocco; Gláucia S. Oliveira-Alonso; Alice C. Ramos.

Disclosure: L.M. Rodrigues, None; F.M. Rocco, None; G.S. Oliveira-Alonso, None; A.C. Ramos, None.

Objective: To comparatively assess functional walking levels in patients with cerebral palsy prior to orthopedic surgery and after rehabilitation treatment, because children with late diagnosis often have musculoskeletal deformities when they start attending rehabilitation centers and this impairs the correct determination of functional classification and walking prognosis. Design: Retrospective review of medical records. Setting: Rehabilitation center in Brazil. Participants: 20 patients hospitalized for rehabilitation after orthopedic surgery who met the following criteria: (1) incapable of functional gait before surgery; (2) underwent surgery in order to improve gait; and (3) had 6 or more months of progress after being discharged from inpatient rehabilitation. Interventions: Functional gait status was determined at 3 intervals: before surgery, at discharge from inpatient hospitalization (orthopedic surgery plus rehabilitation), and 6 or more months after discharge, using the Gillette Functional Assessment Questionnaire (FAQ). Main Outcome Measures: Data were assessed by Friedman analysis of variance by ranks and complemented by the multiple comparisons test. Results: Before orthopedic surgery, 65% of the patients were FAQ1 (cannot take any steps), 20% were FAQ2 (can do some steps with help), and 15% were FAQ3 (gait during therapy). The general comparison of functional gait status in the 3 intervals was significant (P<.001). FAQ values at discharge presented improvement when compared with those before surgery. Only 2 patients did not present changes in their functional status and 2 were unable to walk. Current FAQ was better than preoperative FAQ and was practically the same as FAQ at discharge. 4 patients did not maintain the gains during hospitalization. Conclusions: Functional gait standard improved when the all treatment was finished and the gains remained during hospitalization; the functional walking status remained unchanged for only 2 patients. Key Words: Cerebral palsy; Gait; Orthopedics; Rehabilitation.

Delayed Symptomatic Cerebral Vasospasm After Partial Meningioma Resection: A Case Report. Heather L. Powell, MD (University of Virginia, Charlottesville, VA); Fred Terry, DO; Mary G. Bryant, MD.

Disclosure: H.L. Powell, None; F. Terry, None; M.G. Bryant, None.

Setting: Academic tertiary care hospital and acute inpatient rehabilitation hospital. Patient: A 48-year-old woman with a large left petroclival meningioma underwent left retrosigmoid craniotomy with partial tumor resection complicated by subarachnoid hemorrhage (SAH). Case Description: The patient was admitted to our acute inpatient rehabilitation hospital on postoperative day 8 for physical, occupational, and speech-language therapy directed at lower cranial nerve dysfunction and mild right-sided hemiparesis. She participated well until postoperative day 13, when she complained of severe headache and new left-sided weakness. She was transferred to the emergency department, where computed tomography (CT) revealed no acute changes and resolving SAH. Magnetic resonance imaging and magnetic resonance angiography with diffusion-weighted imaging, obtained to evaluate for ischemic phenomena, revealed significant focal stenosis of the right M1 segment and multiple areas of focal stenosis in the left M1, bilateral A2 segments and the right posterior cerebral artery. The diagnosis of cerebral vasospasm was confirmed by
CT angiogram and she was treated with nimodipine, vasopressors, intravenous fluids, and steroids. **Assessment/Results:** Her symptoms improved immediately following initiation of systemic hypertension. After 2 weeks in the acute care facility, she was readmitted to acute inpatient rehabilitation, and finally discharged home on postoperative day 56. **Discussion:** Delayed symptomatic cerebral vasospasm related to SAH following tumor surgery is a rare clinical sequela with potentially devastating complications. If recognized early and treatment initiated, permanent neurologic morbidity and mortality may be averted. **Conclusions:** Treatment methods, including calcium channel blockade, hypertension, hemodilution, hypervolemia, and arterial dilation for proximal disease, have shown arbitrary levels of effectiveness but remain the mainstay of vasospasm therapy. In this particular case, the administration of nimodipine and increasing blood pressure to maintain cerebral blood flow resulted in an excellent recovery of neurologic function. It is important that inpatient physiatrists recognize the possible delayed complications of brain tumor resection. **Key Words:** Cerebral vasospasm; Meningioma; Rehabilitation.

**Poster 165**

**Pregnancy Outcomes Among Women With Physical Disabilities Seen in an Integrated Care Clinic.** Christina M. Sawhney, MD (Northwestern University, McGaw Medical School, Chicago, IL); Kristi Kirschner, MD; Cassing Hammond, MD; Eileen Murphy, MD; Lena Shahbandar, MD; Joan Le, MD. Disclosure: C.M. Sawhney, None; K. Kirschner, None; C. Hammond, None; E. Murphy, None; L. Shahbandar, None; J. Le, None.

**Objectives:** To determine obstetric and disability-related pregnancy complications among physically disabled women seen by an integrated-care team and to evaluate their pregnancy outcomes. **Design:** Retrospective chart review. **Setting:** Rehabilitation hospital outpatient interdisciplinary clinic. **Participants:** 36 physically disabled subjects were identified with pregnancies confirmed by urine and serum human chorionic gonadotropin or ultrasound from 755 charts reviewed. Clinic, therapy, and labor and delivery charts were reviewed from pregnancy diagnosis to 6-week postpartum or pregnancy termination. The interdisciplinary team included obstetrics and gynecology, physical therapy, physical, occupational, and speech therapy, anesthesiology, pulmonology, and social work. **Interventions:** Not applicable. **Main Outcome Measures:** Disability Rating Scale and FIM instrument. **Results:** 45 pregnancies were documented in 36 subjects (mean age, 26y; range, 17–40y); 35 unplanned pregnancies with 11 elective abortions performed; 1 spontaneous abortion; 2 intrauterine fetal demise (IUFD); 1 spontaneous abortion; 2 intrauterine fetal demise (IUFD); 12.1% required assisted delivery, and 97.8% delivered under Cesarean section, 12.1% required assisted delivery, and 97.8% delivered under epidural anesthesia. 21.2% of mothers attempted breastfeeding. Obstetric and disability-related complications were reported according to type and level of disability. Further obstetric complications included: urosepsis with IUFD, cocaine abuse with IUFD, uterine atony, retained placenta, chorioamnionitis, pre-eclampsia, pylephlebitis, and multiple uterine tract infections. Disability-related complications included: autonomic dysreflexia, muscle fatigue impairing swallowing function, respiratory distress requiring ventilator support, increased spasticity, hospitalization for pain management, adjustments to wheelchair seating and positioning, change in bladder management, and functional status decline requiring increased physical assistance with body habitus changes. **Conclusions:** Disabled women can successfully experience pregnancy and childbirth with proper measures for identification, prevention, and management of obstetric and disability-related complications through comprehensive interdisciplinary care. **Key Words:** People with disabilities; Pregnancy; Rehabilitation.

**Poster 166**

**Femoral Pseudoaneurysm After Total Hip Arthroplasty: A Case Report.** Asim S. Oty, MD (Montefiore Medical Ctr/Albert Einstein College of Medicine, Bronx, NY); Stanley F. Wainapel, MD. Disclosure: A.S. Oty, None; S.F. Wainapel, None.

**Setting:** Academic teaching hospital. **Patient:** An 80-year-old woman. **Case Description:** This patient presented with advanced degenerative joint disease prior to admission to the hospital for intratable right hip pain after suffering a fall. Admission physical exam was remarkable for tenderness of the right hip. Strength and range of motion were limited in the right lower extremity, secondary to pain at the lateral thigh down to the knee. There was no evidence of obvious fracture or misalignment on the admission right hip radiographs, but magnetic resonance imaging showed diffuse marrow edema within the right femoral head and neck consistent with a fracture of indeterminate age. After discussion of conservative treatment versus hip replacement along with its risks, she opted for right total hip arthroplasty (THA). Postoperatively she was stabilized and transferred for subacute rehabilitation, but on postoperative day 11 she developed right anterior groin pain. Palpation of the area did not reveal pulsation. The next day she was noted to have persistent hip pain with anemia leading to a blood transfusion and ultrasound evaluation. **Assessment/Results:** Ultrasound of the right groin showed a false aneurysm, necessitating transfer back to the university medical center where an angiogram showed a 4×4×2cm pseudoaneurysm anterior to the hip joint, which was repaired. She was managed postoperatively and on vascular surgery postoperative day 9 she was discharged to a rehabilitation hospital with no further complications. **Discussion:** Vascular injuries are rare complications after the commonly performed THA procedure. Of these injuries, femoral pseudoaneurysm is among the most common injuries. **Conclusions:** This case illustrates the importance of considering vascular injury early in the course of care after THA, and why physiatrists should be alert to its potential occurrence in post-THA patients admitted for inpatient rehabilitation. **Key Words:** Aneurysm; Arthroplasty; Rehabilitation.

**Poster 167**

**Susac Syndrome in a Young Female: A Unique Case and Rehabilitation Perspective.** Peter Bailey, MD (Mayo Clinic, Rochester, MN); Kenley D. Schmidt, MD. Disclosure: P. Bailey, None; K.D. Schmidt, None.

**Setting:** Academic medical center. **Patient:** A 19-year-old woman with Susac syndrome. **Case Description:** The patient developed acute onset of severe headache 3 weeks prior to presentation. Over the following weeks, she continued to have headaches that did not respond to oral pain medications prescribed by multiple providers. Subsequently, she developed abnormal behavior and presented to an outside hospital where a workup, including magnetic resonance imaging (MRI) of the brain, revealed multiple areas of ischemia in the bilateral cerebral hemispheres and a lesion in the posterior aspect of the corpus callosum. During her course she began to develop blurred vision, hearing loss, and ataxia. **Assessment/Results:** It was felt that she may have Susac syndrome and was, therefore, started on intravenous steroids and intravenous immunoglobulin (IVIG) and transferred to our facility for further evaluation and treatment. Examination on admission revealed a healthy appearing young woman who was completely deaf, had bilateral branch retinal artery occlusions, mildly impaired cognition, and an ataxic gait. Repeat MRI of the brain showed multiple areas of ischemia in the bilateral cerebral hemispheres and progression...
of the lesion involving the corpus callosum. MRI of the spine showed no lesions. Audiometry revealed severe bilateral sensorineural hearing loss. With continuation of steroid treatment and IVIG the patient showed improvements in cognition, but remained deaf and had a mild ataxia at the time of dismissal. Discussion: Susac syndrome is an exceedingly rare clinical triad of encephalopathy, branch retinal artery occlusions, and deafness. It is likely underdiagnosed and at times misdiagnosed as multiple sclerosis. It is typically self-limited and standard treatment involves steroids and either IVIG or plasma exchange. Presenting symptoms are variable and, like the patient presented, present unique rehabilitation challenges. Key Words: Ataxia; Deafness; Rehabilitation.

Poster 168
Use of Complementary and Alternative Therapies by Physiatric Attending and Resident Physicians and Their Recommendations to Patients: A Survey at an Academic Rehabilitation Center, Kevin Wang, MD (RUSK Institute of Rehabilitation Medicine, NYU, New York, NY).

Objective: To identify the use of complementary and alternative therapies by physiatrists and their recommendations to patients. Design: Survey. Setting: Academic rehabilitation center. Participants: PM&R resident and attending staff. Interventions: Not applicable. Main Outcome Measures: Personal use and recommendation to patients of complementary and alternative therapies. Results: A total of 22 attendings and 34 residents completed the survey. There were 36 respondents who had a personal experience with some form of complementary and alternative therapy. 52 physiatrists had recommended the use of such therapies to their patients. Massage and acupuncture were the most frequently used for personal well-being, as well as the most frequently recommended to patients. Other therapies reported were herbal therapy, osteopathic manipulation, electromagnetic therapy, chiropractic therapy, and Jin Shin Jitsu. Conclusions: Use of complementary and alternative therapies for personal well-being among physiatrists at an academic rehabilitation center is greater than that estimated for the general population. In addition, 92% (52/56) of these physicians recommended the use of some form of complementary and alternative medicine to patients. These data suggest that physiatrists are accepting of complementary and alternative medicine and are major advocates for such therapies. Key Words: Alternative medicine; Complementary therapies; Physiatry; Rehabilitation.

Poster 169
A Practical Algorithm for Decannulation in an Inpatient Rehabilitation Setting, Mary F. Musso, DO (University of Michigan, Grand Rapids, MD); Manoj Mithal, MBBS, PhD; Thomas D. Polisoto, MD.

Disclosure: M.F. Musso, None; M. Mithal, None; T.D. Polisoto, None.

Objective: To develop an algorithm for downsizing tracheostomy tubes and decannulation in an inpatient rehabilitation setting. Design: Systematic review of available literature. Setting: Inpatient rehabilitation. Participants: Not provided. Interventions: Not applicable. Main Outcome Measure: Successful decannulation described as stable pulse oximetry and vital signs for 24 hours. Results: The process of decannulation is initiated once patients are able to control secretions and have stable pulse oximetry for 24 hours. Decannulation should start with downsizing to a smaller tube such as a number 7 or 6; subsequently, vital signs should be monitored every 4 hours for 24 hours. After this, capping trials can be initiated. Patients should be initially capped for 2 hours on and 2 hours off with pulse oximetry monitored every 4 hours. When the patient tolerates this, proceed to 24 hours, capping with pulse oximetry monitored every 4 hours. If capping is successful, downsize to a smaller tracheal tube such as a number 5 or 4 and repeat the capping procedure. If the patient tolerates capping with the smaller tube, decannulation should be performed. On decannulation, the tracheostomy site should be loosely covered to help patients phonate and vital signs and pulse oximetry monitored every 4 hours for 24 hours. One should be prepared to reestablish the airway if desaturation arises. If the patient’s vital signs and pulse oximetry remain stable over 24 hours, successful decannulation has been established. Conclusions: Managing tracheotomies and decannulating inpatients is an essential skill for physiatrists. In the absence of clear guidelines, this can be challenging because failed decannulation can result in interruption of patients’ rehabilitation programs. This algorithm, based on a systematic review of current evidence, outlines a practical and step-by-step method for downsizing and eventually decannulating patients in an inpatient rehabilitation setting. Utilizing this protocol will minimize the risk of failed decannulation and its associated risks. Key Words: Decannulation; Inpatient rehabilitation; Rehabilitation.

Poster 170
Cadmium Toxicity From Moonshine Abuse Causing Myopathy and Peripheral Neuropathy: A Case Report, Jonathan P. French, MD (UVA Health System, Charlottesville, VA); Mary G. Bryant, MD.

Disclosure: J.P. French, None; M.G. Bryant, None.

Setting: Academic tertiary care hospital. Patient: A 46-year-old woman with a history of alcohol abuse, hypertension, and thalamic stroke. Case Description: The patient presented with a 2-week history of progressive bilateral lower-extremity (LE) weakness leading to inability to ambulate. Per family, the patient had been on a 6-week drinking binge with little food intake. On admission, the patient was in acute renal failure, with metabolic disarray, and had a urinary tract infection. On manual muscle testing (MMT), her proximal LE strength was 1/5mm with decreased sensation to vibration in both LEs. She received fluid, vitamins, and electrolyte repletion. She had confusion and disorientation, which cleared during her hospitalization. At discharge, her MMT showed 2/5 proximal in both LE strength. She was discharged to an acute inpatient rehabilitation hospital. Assessment/Results: Brain magnetic resonance imaging showed an old thalamic stroke. Nerve conduction (NCS) and electromyography studies showed axonal sensorimotor peripheral neuropathy, with repeat NCS and electromyography testing also showing positive for myopathy. Labs including human immunodeficiency virus, hepatitis C, liver function tests, thyroid-stimulating hormone, Reiter protein reagin, hemoglobin A1C, vitamin B12, folate, coagulation, and rheumatologic studies and arsenic, mercury, and lead levels were all negative or within normal limits. Urine cadmium level, however, was 14.8 (<3). Sural nerve biopsy showed chronic degeneration of the entire axonal-myelin unit with vascular changes. Quadriceps muscle biopsy showed chronic severe myopathic changes without evidence of inflammation, vasculitis, or denervation. Discussion: Heavy metal–associated peripheral neuropathy is well documented. Lead-associated myopathy has been described in monkeys. Cadmium has been shown to cause neurocognitive impairment in humans but previously has not been associated with myopathy. Moonshine, home-distilled alcohol, is a common source of heavy-metal toxicity in the southern United States. Conclusions: It is important for physiatrists, when diagnosing peripheral neuropathy or myopathy, to include heavy metal and cadmium toxicity in their differential diagnosis. Key Words: Alcohol drinking; Myopathies; Polyneuropathies; Rehabilitation.
Poster 171
Vibration-Induced Neural Plasticity in a Participant With Dysafferentation Syndrome: A Case Study. Dennis E. Enix, DC, MBA (Logan University, Chesterfield, MO); Kristan J. Giggey, DC. Disclosure: D.E. Enix, None; K.J. Giggey, None.

Setting: University research division’s biomechanics laboratory.

Patient: A healthy consenting 22-year-old woman who was 2 years posturgery for repair of a comminuted fracture of the left tibia and fibula. After 3 months of physical therapy, the patient continued to report tenderness and occasional discomfort. Case Description: Proprioception error of the knee was determined by ipsilateral passive and active joint position sense testing. Muscle reaction time and movement velocity were recorded on the NeuroCom Balance Master device. Muscle changes were determined by stimulation of the peroneal nerve and measuring the area and amplitude of the F wave and area of the M waves. Gastrocnemius and tibialis anterior muscle activation were evaluated with surface electromyography during submaximal contraction. The participant received whole body vibration therapy at 30Hz to the unaffected right extremity for 12 nonconsecutive days. Assessment/Results: A 75% decrease in a proprioceptive error was noted. Reaction time and movement velocity increased by 44% and 114%, respectively. Electrophysiologic testing showed a 51% increase in F waves and a 32% increase in M waves. Surface electromyography showed a significant decrease in muscle activation during submaximal contraction. Discussion: Neuroplasticity is the functional basis of motor conditioning. This training-dependent model of motor plasticity describes changes in both cortical reorganization patterns and functional changes in neuronal or synaptic morphology. Peripheral stimulation of mechanoreceptors is known to cause increased dendritic arborization and long-term potentiation or depression of synapses. Decreased afferent input from mechanoreceptors creates dysafferen- tation affecting both joint angle position sense and balance. Conclu- sions: Specific vibrational frequencies used to stimulate peripheral mechanoreceptors may enhance motor cortical plasticity and increase dendritic arborization through increased afferent bombardment of the central nervous system. Key Words: Neuronal plasticity; Propriocep- tion; Rehabilitation.

Poster 172
Neurologic Deficits as Initial Presentation for Sarcoidosis: A Case Report. Qamar Khan, DO (Rush University Medical Ctr, Chicago, IL); Christopher Reger, MD. Disclosure: Q. Khan, None; C. Reger, None.

Setting: Tertiary care hospital.

Patient: A 38-year-old man with hypertension, noninsulin-dependent diabetes mellitus, and dyslipidemia was admitted for left-sided facial numbness and weakness, diplopia, dysphagia, paresthesias, and muscle weakness. Case Description: At initial presentation, magnetic resonance imaging (MRI) of the brain and spine were performed with unremarkable findings. After progression of symptoms he received a lumbar puncture that revealed high-dose steroids. On admission the patient should be considered to provide the best possibility of improving function mobility to premorbid status. Key Words: Multiple sclerosis; Obesity; Rehabilitation; Sarcoidosis.

Poster 173
The Prevalence of Overweight and Obesity in Veterans With Multiple Sclerosis. Seema R. Khurana, DO (University of Miami, Miami, FL); Rohini V. Wadhwani, BS; Alyssa M. DiGiacomo, MPH; James D. Bowen, MD; Aaron P. Turner, PhD; Jodie K. Haselkorn, MD, MPH. Disclosure: S.R. Khurana, None; R.V. Wadhwani, None; A.M. DiGia- como, None; J.D. Bowen, None; A.P. Turner, None; J.K. Haselkorn, None.

Objective: To estimate the prevalence of overweight and obesity in veterans with multiple sclerosis (MS) enrolled in the Veterans Health Administration (VHA), compared with sex-specific published rates for the U.S. population, veterans receiving outpatient care at Veterans Affairs (VA) medical facilities, and male veterans in the VHA with spinal cord injury (SCI). Design: Retrospective study. Setting: VA health system. Participants: 3917 veterans with MS enrolled in the VHA were identified by linking the VA MS Centers of Excellence Data Repository to the VA Office of Quality and Performance 1999 Large Health Survey and the Survey of Healthcare Experiences of Patients (2002–2004). Interventions: Not applicable. Main Outcome Measures: Body mass index (BMI) was calculated from self-reported weights and heights. Subjects were then classified into 4 weight categories based on Center for Disease Control and Prevention guidelines: underweight (BMI <18.5kg/m²), normal weight (BMI range, 18.5 to ≤24kg/m²), overweight (BMI range, 25 to ≤29kg/m²), and obese (BMI ≥30kg/m²). Results: The proportion of men with MS (n = 3373) in the 4 weight classifications was: 2.3% underweight, 35.1% normal weight, 43.7% overweight, and 19% obese. The proportion of women with MS (n = 515) in each weight class was: 4.8% underweight, 42.5% normal weight, 28.6% overweight, and 24.1% obese. By comparison, the proportion of men who were overweight and obese was 39.7% and 27.5%, respectively, for the U.S. population, 40.1% and 32.9% for veterans, and finally 38.7% and 27.2% for SCI. Conclusion: Overall, people with MS enrolled in VHA appear to have similar rates of being overweight as other populations and slightly decreased rates of obesity. Key Words: Multiple sclerosis; Obesity; Rehabilitation; Veterans.

Poster 174
Parkinson’s Patient With Significant Functional Gains Following Acupuncture: A Case Report. Kenneth A. Powell, DO (Temple University Hospital, Philadelphia, PA); Philip Stevens, DO. Disclosure: K.A. Powell, None; P. Stevens, None.

Setting: Outpatient alternative medicine clinic.

Patient: A 74-year-old man presented with chief complaint of low back pain (LBP). Case floor after treatment with high-dose steroids. On admission the patient was at a minimal assistance level for transfers, ambulation, and stairs. On completion of the rehabilitation program he was independent in activities of daily living, ambulating with a rolling walker up to 54m (180ft), and able to negotiate stairs at a supervised level. Conclusions: Neurologic complications make up about 5% of those patients known to have diagnosed sarcoidosis. Many disease processes have similar presenting symptoms, thus neurologic symptoms like the presenting manifestation of sarcoidosis is an unusual and rare occurrence and therefore difficult to diagnose. Once diagnosis and treatment is initi- ated, comprehensive rehabilitation with appropriate therapy services should be considered to provide the best possibility of improving function mobility to premorbid status. Key Words: Muscle weakness; Rehabilitation; Sarcoidosis.
Description: The patient had LBP pain secondary to spinal stenosis. Medical history included Parkinson’s disease. Computed axial tomography scan of the lumbar spine revealed spinal stenosis at L3-4 and L4-5, with herniated nucleus pulposus at L5-S1. Clinical examination revealed festinating gait with single-point cane at a contact guard-minimum assistance level. Activities of daily living required minimum assistance to don and doff shoes and socks and to button shirts. Transfers and bed mobility were also at minimum assistance. The patient had a monotone voice and was not driving on initial presentation. He presented for acupuncture treatments to relieve new onset LBP.

Assessment/Results: Treatment with Jue Yin-Shao Yang initiated on February 10, 2004. Points included triple heater 5, master of the heart 3, kidney 3, liver 3, and gallbladder 41. Additional points included governor vessel 20, governor vessel 24.5, gallbladder 1, liver 14, and spleen 6. He had 1 treatment a week for 10 weeks. At the November 12, 2004 follow-up appointment, his functional status was reassessed and significant improvement had occurred. He was pain free, independent with activities of daily living, and had a nonfestinating independent gait without use of an assistive device. The December 15, 2004 follow-up included increased walking pace, improved voice quality, and driving a car. There were no changes in medical management or medication alterations during the acupuncture treatments.

Discussion: This is a case of the use of acupuncture for treatment of LBP with additional points used for whole body treatment that resulted in significant functional improvements and resolution of pain.

Conclusions: Acupuncture may be of benefit in the treatment of Parkinson’s sequelae. Key Words: Acupuncture; Low back pain; Parkinson disease; Rehabilitation.

Poster 175
Impaired Renal Function on Admission to Acute Rehabilitation.
Joel B. See, MD; (Tufts New England Med Ctr, Boston, MA); Ryan Stephenson, DO; (Tufts Johnson, DO; Khyber Zaffarkhan, DO.
Disclosure: J.B. See, None; R. Stephenson, None; M. Johnson, None; K. Zaffarkhan, None.

Objective: To analyze the estimated glomerular filtration rate (GFR) of a selection of patients admitted to acute inpatient rehabilitation. Design: Observational study. Setting: Acute inpatient rehabilitation. Participants: 51 patients admitted to the general inpatient rehabilitation service without preexisting mention of impaired renal function. Interventions: Review of the medical records to gather initial laboratory data from an outside acute hospital and admission labs from the rehabilitation hospital. Using the Devine formula, ideal body weight was calculated for each patient. Serum creatinine values were obtained from the discharge paperwork from the acute care hospital and from our own facility from lab work taken within 48 hours of admission. Main Outcome Measures: The Cockcroft-Gault formula was used to calculate the creatinine clearance of each patient on admission to the rehabilitation hospital and on initial presentation to the acute care facility. This was used as an estimate of the GFR and by convention, a value of 50mL/min was deemed significant for impaired renal function. Results: Of the 51 charts reviewed, 31.4% (n=16) had impaired renal function on admission. Of these patients, 12 were women and 4 were men. The average age of the impaired group was 78.8 years compared with the overall mean age of 73.5 years. The admitting diagnosis of the impaired patients was mixed; however, 5 of the 16 had a primary admitting diagnosis of cerebrovascular accident. Length of stay at the acute care facility prior to rehabilitation admission averaged 9.2 days overall and 9.8 days for the affected group. Conclusions: This study demonstrates that impaired renal function may be overlooked in patients admitted to acute rehabilitation. Age and female sex were strong predictors of impaired renal function. Proposed future study includes more specific testing to verify these findings. Key Words: Rehabilitation.

Poster 176
Jose Urquidez, MD (Medical College of Wisconsin, Milwaukee, WI); Terry Walton, MS, OTR; John McGuire, MD.
Disclosure: J. Urquidez, None; T. Walton, None; J. McGuire, has received research support unrelated to this report and is on the speaker’s bureau for Allergan (Botox) and Bioness (NESS H200).

Setting: Tertiary care hospital. Patients: 5 chronic stroke patients (age range, 29–78y) and 1 traumatic brain injury (TBI) patient (age, 19y). The stroke patients were 1.7 to 10 years poststroke and the TBI patient was 10.5 years postinjury. 3 patients had spastic left hemiparesis and 3 had spastic right hemiparesis. All patients were limited by increased tone of their finger flexors (Ashworth Scale score, 2–4/4).

Case Descriptions: Each stroke patient’s finger flexor spasticity was managed with injections of 50 to 175U of botulinum toxin type A (BTX-A) (Botox) every 3 to 4 months (number of treatment sessions, 5–23) before combined treatment with functional electric stimulation (FES). Treatment with FES involved the use of a custom-fitted neuromechanotherapy, the NESS H200. The device stimulated finger flexors and extensors, allowing the patient to perform grasp and release exercises. Weekly use ranged from 5 to 21 hours a week for 6 to 22 months while receiving BTX-A injections every 3 to 4 months. Assessment/Results: All patients reported a greater reduction in spasticity and increased passive range of motion after combined treatment of FES and BTX-A than with chemodenervation alone. They also had improved gross motor function while using the device and 3 patients reported an increase in gross motor function when not wearing the device. 3 stroke patients had a 25% to 40% decrease in the dose of BTX-A after 8 to 12 months of combined treatment. Discussion: This case series illustrates the potential benefits of combined treatment of FES and chemodenervation in the management of upper-extremity spasticity versus chemodenervation alone. Conclusions: FES may enhance the effectiveness of chemodenervation with BTX-A and reduce the doses needed to manage upper-extremity spasticity. A randomized double-blind placebo controlled trial is planned to further define these effects. Key Words: Botulinum toxin type A; Electric stimulation; Muscle spasticity; Rehabilitation.

Poster 177
Use of the Siebens Domain Management Model to Document Use of the 6 Association of American Medical Colleges Core Competencies in Graduate Medical Education.
Mary G. Bryant, MD (UVA Health System, Charlottesville, VA); Alan P. Alfano, MD; Hilary C. Siebens, MD.
Disclosure: M.G. Bryant, None; A.P. Alfano, None; H.C. Siebens, None.

Setting: PM&R residency program. Program: Improving documentation of the use of the 6 Association of American Medical Colleges (AAMC) core competencies in PM&R residency education.

Program Description: The Siebens Domain Management Model (SDMM), operationalizes the biopsychosocial model and improves rehabilitation care through better organization of medical information. The model organizes medical information into 4 domains: medical/surgical issues, mental status/emotions/coping, physical function, and the patient’s living environment. These domains are then reflected in the medical documentation, including history and physical examinations, daily progress notes, and discharge summaries. The SDMM...
works for both acute inpatient medical and rehabilitation hospitals, and helps with the transition of the patient to outpatient care. **Assessment/Results:** It is possible to document a resident’s mastery of the 6 core competencies by analysis of their performance over time at family and team meetings, on their medical documentation and physical examinations, and through their prescription of therapies and medication. The SDMM helps residents organize information that is critical to optimal patient care. **Discussion:** Process improvements for medical documentation are especially needed at academic medical centers for several reasons. First, the Accreditation Council for Graduate Medical Education has limited resident duty hours. Residents now have less time to complete their work and documentation and dictations must be concise. Second, AAMC has devised 6 core competencies for all medical specialties for residency education: patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice. Residency training programs are required to devise methods to measure the acquisition of skills by their residents. **Conclusions:** Use of the SDMM improves care processes, the transfer of medical information between different health care providers and sites of care, and improves the training of resident physicians and allows for the measurement of skills developed over the course of residency training. **Key Words:** Education, medical; Rehabilitation.

**Poster 178**

**Multiple-Limb Amputations Following Septic Embolism Secondary to Bacterial Endocarditis: A Case Report.** Sepideh Haghpahan, MD (MetroHealth Rehabilitation Institute of Ohio/CWRU, Cleveland, OH); Gregory Nemunaitis, MD; Melvin S. Mejia, MD. Disclosure: S. Haghpahan, None; G. Nemunaitis, None; M.S. Mejia, None.

**Setting:** Tertiary care rehabilitation facility. **Patient:** A 55-year-old man with a history of intravenous substance use who presented with a change in mental status and was diagnosed with infective endocarditis. **Case Description:** The patient presented to a medical center after being found down in his home with mental status changes, myoglobinuria, respiratory insufficiency, and septic shock. Workup revealed gram positive cocci in 4/4 bottles, acute renal failure, and endocarditis. Patient was subsequently intubated and had a chest tube placed for a spontaneous pneumothorax on day 1. On day 2, the patient was noted to have acrocyanosis of both hands. Anticoagulation was withheld due to thrombocytopenia and gastrointestinal bleeding. On day 10, an inferior vena cava filter was placed due to bilateral lower-extremity deep venous thrombosis. Progression of the cyanosis of the hands and feet was noted. On day 14, a right wrist disarticulation was done due to extensive gangrene of all the digits of the right hand extending into the metacarpals. On days 22 and 24, the patient underwent bilateral transiliac amputations secondary to gangrene of the feet. **Discussion:** Following an extensive review of the literature, this is the first reported case, to our knowledge, that resulted in amputations of 3 limbs as a consequence of infective endocarditis. **Conclusions:** Current guidelines do not include a recommendation for amputation in the management of infective endocarditis. **Key Words:** Acrocyanosis; Embolism; Gangrene; Septic.

**Poster 179**

**Diagnostic Difficulties Posed by Myasthenia Gravis–Related Dysphagia in a Stroke Patient: A Case Report.** Peng Zhao, MD (Albert Einstein College of Medicine/Montefiore Medical Ctr, Bronx, NY); Miriam Segal, MD. Disclosure: P. Zhao, None; M. Segal, None.

**Setting:** Acute rehabilitation facility. **Patient:** An 81-year-old man with a history of myasthenia gravis (MG) on pyridostigmine, presented for rehabilitation following cerebellar and pontine stroke. **Case Description:** On the morning of hospital day 1, fiberoptic endoscopic evaluation of swallowing demonstrated aspiration of all liquids. The patient underwent multidisciplinary rehabilitation and demonstrated significant functional improvement. In the afternoon of hospital day 20, a modified barium swallow study (MBS) was performed with anticipation of improvement, but unexpectedly demonstrated silent aspiration of all materials. A repeat brain magnetic resonance imaging showed no changes. MBS was repeated twice more, once in the morning, then after the pyridostigmine dose and once after the dose had been increased from 60 to 90mg. Each test demonstrated aspiration of all materials and progressive pharyngeal muscle weakness. Electrodiagnosis with repetitive nerve stimulation was negative (although the patient was on pyridostigmine at the time). A clinical diagnosis was made of MG exacerbation. **Assessment/Results:** The symptoms failed to improve with steroids and the patient required gastrostomy tube placement for nutritional support. **Discussion:** Dysphagia is a common symptom in MG, occurring in 15% to 40% of patients. While it is uncommon for dysphagia to be the sole manifestation of MG, such cases have been reported. In the elderly in particular, MG is more likely to present with bulbar muscle weakness, which can be a source of diagnostic confusion when comorbid conditions are present, as in this case. In addition, hospitalization for stroke can invoke various triggers of MG such as infection, changes in medications (antibiotics in particular), as well as physical and emotional stress. **Conclusions:** Clinicians should be aware of the possibility of MG-related dysphagia in the elderly, even patients with stroke-related dysphagia, especially in patients with a history of MG. **Key Words:** Cerebrovascular accident; Deglutition disorders; Myasthenia gravis; Rehabilitation.

**Poster 180**

**A Novel Treatment Method of Persistent Dysphagia in Stroke Patients by Reconstructed Conduit From the Anterior Mouth: A Case Report.** Wen-hsuan Hou, MD (E-Da Hospital and I-Shou University, Kaohsiung, Taiwan); I-Ru Chen, MD; Ting-Chou Tsai, MD. Disclosure: W. Hou, None; I. Chen, None; T. Tsai, None.

**Setting:** A university hospital. **Patient:** A 55-year-old man with severe dysphagia following an episode of paramedian pons ischemic stroke. **Case Description:** He was fed initially through a nasogastric tube, then a percutaneous endoscopic gastrostomy tube while undergoing swallowing rehabilitation programs for 13 months without any evidence of improvement. He was unable to propel the food bolus to the cervical esophagus and was unable to avoid choking and aspiration. A modified barium swallow revealed an absence of swallowing reflex and severe piriform sinus stasis with aspiration. After evaluation by our speech-language pathologist, physiatrist, and neurologist, the patient was treated with a free jejunal flap by microsurgery to divert food from the anterior mouth to the cervical esophagus. **Assessment/Results:** Although the flap underwent partial loss, this was reconstructed with a tubed deltopectoral flap and following a revision procedure for stricture, the patient’s diet was advanced to a regular diet. At 13-month follow-up, the patient was able to eat safely and efficiently with increasing body weight, and reported complete...
satisfaction with the procedure. Discussion: We performed such an invasive procedure for this patient because patients with brainstem lesions or bilateral hemisphere lesions may progress slowly and hence require gastrostomy for long periods. Cricopharyngeal myotomy is only indicated in patients with pharyngeal dysphagia that is associated with a defective opening of the upper esophageal sphincter but with adequate laryngeal and hyoid elevation and tongue and pharyngeal propulsion. There is also a novel diagnostic and therapeutic method that involves injecting botulinum toxin transcutaneously or transorally with the aid of an endoscope, but the technique and dosage are still immature. Conclusions: The application of this diversion technique to treat patients with a medical disease (ie, stroke) is a significant step toward resuming oral feedings in this group of patients. Key Words: Dysphagia; Microsurgery; Rehabilitation; Stroke.

Poster 181
Rehabilitation of Neuromyelitis Optica (Devic’s syndrome); 3 Case Reports. Adam L. Schreiber, DO, MA (Thomas Jefferson University, Philadelphia, PA); Guy W. Fried, MD; Christopher S. Formal, MD; Bryan X. DeSouza, MD.
Disclosure: A.L. Schreiber, None; G.W. Fried, None; C.S. Formal, None; B.X. DeSouza, None.
Setting: Acute rehabilitation hospital. Patients: 3 women in their forties with a diagnosis of neuromyelitis optica (NMO). Case Descriptions: 3 patients diagnosed with relapsing NMO were admitted to rehabilitation with severe functional deficits from baseline. Assessment/Results: After a course of 1 to 1.5 months of acute rehabilitation, patients improved in the FIM categories of feeding, bathing, dressing, and comprehension. The FIM subsets of sphincter control and locomotion showed no improvement. Discussion: NMO is a central nervous system demyelinating disease distinct from multiple sclerosis (MS). NMO is characterized by optic neuritis, myelitis, and at least 2 of 3 criteria: a longitudinally extensive cord lesion, magnetic resonance imaging (MRI) findings that are not diagnostic for MS, and neuromyelitis optica immunoglobulin G seropositivity. NMO is poorly described in rehabilitation literature. This is most likely due to its low incidence and prevalence as well as an evolving understanding of the clinicopathologic features that set it apart from MS. With emerging neurologic therapies, physiatrists must optimize rehabilitation to minimize complications and improve quality of life. This is even more pertinent with NMO versus MS because of the severe sequelae that occur after an acute episode. The NMO patient’s rehabilitation must be adapted due to its progressive nature and risk of relapse. Although the 3 patients did not return to pre-relapse functionality, they improved their function. By our account, functional gains can be expected through comprehensive rehabilitation. Conclusions: Although rehabilitation of MS is well reported in the literature, the rehabilitation of NMO is not. This is because NMO has been lumped together with MS. Now neurologic literature distinguishes MS from NMO. As newer neurologic treatments become available, we must optimize rehabilitation to prevent complications and maximize recovery of function. In our patient series, functional gains can be made by a comprehensive rehabilitation program. Key Words: Multiple sclerosis; Neuromyelitis optica; Rehabilitation.

Poster 182
Disclosure: R.O. Stephenson, None.
Setting: Tertiary care hospital. Patient: A 61-year-old woman with a 20-year history of multiple sclerosis (MS). Case Description: This patient, with a long history of relapsing remitting MS, presented emergently with a temperature of 31.1°C, bradycardia, and respiratory failure requiring mechanical ventilation. She had developed gradual onset weakness and fatigue 4 weeks prior to presentation, followed by confusion and difficulty walking for 1 week. On admission she was diagnosed with syndrome of inappropriate antidiuretic hormone secretion (SIADH) and given empiric corticosteroids for the clinical picture of adrenal insufficiency; her cortisol level and cort-stim tests later revealed no adrenal dysfunction. Assessment/Results: Magnetic resonance imaging (MRI) of the brain showed no new abnormalities and no thalamic or hypothalamic lesions. She improved clinically without specific intervention and returned home without recurrence, to date. Discussion: MS is a centrally demyelinating disease with often amorphous characteristics and unusual complications. Hypothermia has been observed infrequently, but must be recognized and evaluated promptly because it may signal or trigger a cascade of serious medical issues including SIADH, infection, and death. Core temperature regulation is a highly complex and strictly controlled process of the central nervous system. The hypothalamic preoptic nucleus is the major central thermoregulatory center and is in close proximity to paraventricular and supraoptic nuclei responsible for antidiuretic hormone control. There have been very few cases of hypothermia associated with MS reported in the literature. The majority of patients were either stuporous or comatose during the episode, and outcomes ranged from complete resolution to death. In 1 patient with no hypothalamic lesions on MRI, postmortem histologic analysis revealed plaques throughout the hypothalamus. Conclusions: In our patient with both hypothermia and SIADH, there likely were active lesions in the posterior hypothalamus below the threshold of MRI detection. The corticosteroids errantly given for adrenal insufficiency probably led to the remission of symptoms. Key Words: Multiple sclerosis; Rehabilitation.

Poster 183
Postoperative Visual Loss Following Spine Surgery: A Case Series. Eric W. Aschenbrenner, MD (Mayo Clinic, Rochester, MN); William S. Craig, MD; Kurtis M. Hoppe, MD.
Disclosure: E.W. Aschenbrenner, None; W.S. Craig, None; K.M. Hoppe, None.
Setting: Tertiary care academic medical center. Patients: 3 patients, ages 63, 66, and 73 years old, with posterior ischemic optic neuropathy following multilevel laminectomies with fusion. Case Descriptions: Case 1 was a man with previous laminectomies from L3 to S1 with intractable back pain who developed a pseudarthrosis. He subsequently underwent elective decompression revision with bilateral laminoforaminotomy at L2-3, revision fusion from L2 to S1, and instrumentation from L2 to S1. Following surgery, the patient could not see. Case 2 was a woman with spinal stenosis, neurogenic claudication, and back pain who underwent elective L1 through L5 decompressive laminectomies and fusion, and L3 to L5 foraminotomies with spinal instrumentation. The patient could not see after surgery. Case 3 was a man with a persistent left-sided radiculopathy who had previous posterior decompression at L3 through S1 levels who elected for an L5-S1 laminectomy and T11 to S2 instrumented fusion. After surgery, he noted a brief loss of vision with resolution but reduced visual acuity in his right eye. Consultation with ophthalmology provided a diagnosis of posterior ischemic optic neuropathy in all 3 cases. Assessment/Results: No significant improvement was noted in vision in all 3 cases at a minimum of 9 months postsurgery. Discussion: Posterior ischemic optic neuropathy can be a complication following spinal surgery. Various degrees of vision loss have been noted in the literature. All involved in rehabilitation of these patients must be
Caval occlusion should be considered in patients with IVC filters and bolytics, thrombectomy, and systemic anticoagulation. Thrombi can occur acutely. In addition to the significant risk of pulmonary embolus, changes in lower-extremity weakness can be profound and occur within hours. Treatment options include local thrombolytics, thrombectomy, and systemic anticoagulation. Conclusions: Caval occlusion should be considered in patients with IVC filters and worsening lower-limb edema. The decision to anticoagulate in patients with known hemorrhage and hypercoagulability should be determined by weighing risks and benefits of each. Because rehabilitation patients often include those with both vena cava filters and relative contraindications to anticoagulation, physiatrists should recognize this rare but serious complication and be aware of treatment options. Key Words: Edema; Rehabilitation; Thrombosis; Vena cava filters.

Poster 184
Acute Onset of Bilateral Lower-Extremity Swelling due to Inferior Vena Cava Occlusion and Filter Thrombosis in a Woman With Subarachnoid Hemorrhage: A Case Report. Madhu K. Mehta, MD (University of North Carolina, Chapel Hill, NC); Lisa Blankenship, MD; Sara Ashley McCowen, MD. Disclosure: M.K. Mehta, None; L. Blankenship, None; S.A. McCowen, None.

Setting: Tertiary care hospital. Patient: A 65-year-old woman with subarachnoid hemorrhage (SAH) and inferior vena cava (IVC) filter for deep venous thrombosis. Case Description: The patient was admitted to the rehabilitation unit for right-sided weakness from an SAH sustained during clip ligation of a previously embolized anterior cerebral artery aneurysm. She was not anticoagulated secondary to her bleed despite a known left common femoral vein thrombosis. An IVC filter was placed. Examination revealed moderate pitting edema through the left thigh. Overnight she developed acute, severe worsening of her lower-extremity edema extending bilaterally, with cooling and mottling of both lower limbs. A computed tomography venogram revealed extensive thrombi, extending from the IVC filter through the pelvic venous structures and into both lower extremities. She was not a candidate for thrombolitics, given her recent neurosurgical procedure. Given that the benefits of anticoagulation now outweighed the risks, she was started on systemic anticoagulation and edema control (elevation, compression, decongestive massage). Assessment/Results: With systemic anticoagulation and edema management, overall volume decreased. Discussion: IVC filter and subsequent vena cava obstruction is a rare but potentially serious complication. In patients with known clot burden, development of extensive extension of thrombi can occur acutely. In addition to the significant risk of pulmonary embolus, changes in lower-extremity weakness can be profound and occur within hours. Treatment options include local thrombolitics, thrombectomy, and systemic anticoagulation. Conclusions: Cognizant of their unique rehabilitation needs. Conclusions: Visual loss can be a complication of spinal surgery. Although there is no defined incidence of this complication, it is important to counsel patients regarding this potential adverse outcome. An interdisciplinary approach is necessary when acute visual loss occurs in this setting. Key Words: Laminectomy; Optic neuropathy, ischemic; Rehabilitation.

Poster 185
A Phase 1 Safety Study of Intradiskal Osteogenic Protein-1 Injection in Patients With Lumbar Degenerative Disk Disease. Timothy T. Davis, MD (The Spine Institute, Santa Monica, CA); Hyun Bae, MD; Michael Sikorsky, MD; Jeffrey Fischgrund, MD. Disclosure: T.T. Davis, None; H. Bae, None; M. Sikorsky, None; J. Fischgrund, Consulting agreement. FDA device/drug status: Lyophilized OP-1 (rhBMP-7) (investigational new drug: Not Approved).

Objective: To assess the safety and tolerability of ascending doses of epototermin alpha (OP-1) when injected into intervertebral disks. Design: A phase 1, multicenter, randomized, double-blind, placebo-controlled, dose escalation trial of 4 doses of OP-1 (0.1, 0.5, 1.0 or 2.0mg) injected intradiskally. Setting: Not provided. Participants: Patients with symptomatic single-level degenerative disk disease confirmed by provocative diskogram were randomized 3 to 1 to receive OP-1 or placebo. Up to 32 patients in 4 cohorts of 8 patients were treated. Intervention: Patients were injected on day 1 with OP-1 or placebo, with follow-up visits at 1, 2, 6, 12, 26, 52, and 104 weeks for assessment. Descriptive statistics will be presented by treatment group and pooled across all OP-1 doses. Data from patients treated with OP-1 will be compared with data from patients treated with placebo. Main Outcome Measures: Safety was measured by adverse events, changes in physical and neurologic exams, laboratory evaluations, and antibody formation. Efficacy was assessed by changes in intervertebral disk height and magnetic resonance imaging signal intensity, Oswestry Disability Index, visual analog scale for pain, and 36-Item Short-Form Health Survey scores. Results: As of January 15, 2007, 12 patients had been treated (8 in cohort 1, 4 in cohort 2). No safety issues or adverse events were identified. Conclusions: Early findings of intradiskal injection of OP-1 have been tolerated well. Efficacy evaluations will be available at time of presentation. Key Words: Intervertebral disk; Rehabilitation.
Pain Rehabilitation

Poster 186

Alcock’s Syndrome Causing Pudendal Neuralgia: A Case Report.
Jeffrey R. Conly, MD (University of Pennsylvania, Philadelphia, PA); Richard Salcido, MD.

Disclosure: J.R. Conly, None; R. Salcido, None.

Setting: Outpatient pain management clinic. Patient: A 50-year-old man with insidious onset of pelvic pain. Case Description: The patient presented with a 9-month history of progressive bilateral ischiatic pain radiating to the buttocks, low back, and posterior thighs. His pain was exacerbated by prolonged sitting, improved with standing, and completely relieved by sitting on a toilet seat. Physical exam findings were remarkable for increased pain with lumbar extension, and tenderness on rectal examination with palpation of the distal rectal wall. Magnetic resonance imaging studies of the pelvis revealed normal anatomy of the pudendal nerve. Nerve conduction studies (NCS) and electromyography performed 11 months postonset of symptoms showed marked abnormalities in the left pudendal nerve, suggestive of entrapment. Needle electrodiagnostic findings to the left external anal sphincter indicated axonal loss with incomplete reinnervation. The patient was subsequently started on a neuropathic and opiate pain regimen, and pressure-relief cushioning. The patient is being considered for image-guided pudendal nerve block and will be followed again in a few months for improvement. Assessment/Results: Clinical history, along with NCS and electromyography studies, detected a pudendal nerve entrapment, rather than lumbosacral radiculopathy, sacroiliac dysfunction, or piriformis syndrome, as the likely cause of dysesthetic pelvic pain. This has implications for therapeutic interventions and functional outcome. Discussion: This case highlights the importance of a physiatrist’s evaluation, including electromyography studies, for the workup of Alcock’s canal syndrome, which has been likened to other peripheral entrapment neuropathies. This is a rare entrapment syndrome causing significant functional impairment and should be a consideration in patients presenting with pelvic pain. Conclusions: This case report illustrates the importance of electrodiagnostic studies, patient history, and a high level of clinical suspicion in the diagnosis and management of Alcock’s canal syndrome and resultant pudendal neuralgia. Key Words: Electromyography; Nerve conduction; Neuralgia; Rehabilitation.


Poster 188

Pain Reproduction and Acute Pain Relief With Transforaminal Injections Do Not Predict 2-Week or 2-Month Pain or Functional Outcomes. Pam Hansen, MD (University of Utah, Salt Lake City, UT); Stuart Willick, MD; Richard Kendall, DO.

Disclosure: P. Hansen, None; S. Willick, None; R. Kendall, None.

Objectives: To determine if reproduction of usual radicular pain during an epidural steroid injection (ESI) predicts pain relief or functional improvement and to assess if acute pain relief postinjection predicts longer-term pain relief or functional improvement. Design: Prospective cohort study. Setting: University clinic. Participants: 81 patients with single-level radicular pain referred for a transforaminal ESI. Interventions: Subjects completed baseline questionnaires with a visual analog scale (VAS) to assess baseline pain and the Roland-Morris Disability Questionnaire (RMDQ) for disability prior to the procedure. Pain reproduction was documented during the procedure on a 4-point scale. VAS was obtained 15 minutes postprocedure. VAS and RMDQ data were obtained at 2 weeks and 2 months by mailed questionnaires. Main Outcome Measures: VAS and RMDQ. Results: There was a significant difference in change in pain at 15 minutes postprocedure (P = .01) between those with pain reproduction and those without pain reproduction (34.5 vs 48.5). Pain reproduction scores did not have a significant effect on VAS or RMDQ at 2 weeks (P = .55, P = .86) or 2 months (P = .53, P = .99). There was no significant difference in VAS or RMDQ at 2 weeks (P = .38, P = .85) or 2 months (P = .59, P = .85) between those who had pain reduction and those without pain reduction at 15 minutes. Conclusions: Similar or exact pain reproduction of one’s usual radicular pattern during a transforaminal ESI appears to predict a poorer VAS outcome at 15 minutes postprocedure but does not predict longer-term outcomes, based on changes in VAS or RMDQ. Changes in VAS 15 minutes postinjection do not appear to be predictive of VAS and RMDQ outcomes at 2 weeks or 2 months postprocedure. Key Words: Injections, epidural; Radiculopathy; Rehabilitation.

Poster 189

Duloxetine as an Effective Treatment for Improving Painful Physical Symptoms and Functioning Associated With Generalized Anxiety Disorder. Christer Allgulander, MD; Hannu Koponen, MD; Janelle Erickson, PhD; Susan Ball, PhD; Jerry Hall, MD (Eli Lilly, Indianapolis, IN); James Russell, MD.

Disclosure: C. Allgulander, Boehringer Ingelheim; H. Koponen, Boehringer Ingelheim; J. Erickson, Eli Lilly & Co; S. Ball, Eli Lilly & Co; J. Hall, Eli Lilly & C; J. Russell, Eli Lilly & Co.

Objective: To examine the efficacy and safety of duloxetine, a serotonin and norepinephrine reuptake-inhibitor, for treatment of painful physical symptoms and functioning in generalized anxiety disorder (GAD). Design: A 9-week, double-blind study. Setting: Psychiatrists at university and clinical trial research sites. Participants: Adult outpatients with GAD. Interventions: Subjects were randomized to 60mg/d of duloxetine (DLX-60mg) (n = 168), 120mg/d of duloxetine (DLX-120mg) (n = 170), or placebo (n = 175). Main Outcome Measures: Visual analog scales for pain, Sheehan Disability Scale (SDS), Quality of Life Enjoyment and Satisfaction Questionnaire—Short Form (Q-LES-Q-SF), and EuroQol-5D. Results: Compared with placebo, both DLX groups demonstrated significantly greater reduction in ratings for each pain item: overall pain (P < .02), headaches (P < .05), back pain (P < .001), shoulder pain (P < .01), interference due to pain (P < .02), and pain during waking hours (P < .001). The DLX groups also demonstrated greater improvement compared with placebo in all domains of the SDS (P < .001), in Q-LES-Q-SF total score (P < .001), EuroQol index (P < .01), and health state scores (P < .001). Conclusions: Within patients with GAD, who were not selected for the occurrence of pain, treatment with 60mg and 120mg of duloxetine once daily resulted in significant improvement in painful physical symptoms. Duloxetine also enhanced patients’ quality of life and overall functioning. Key Words: Antidepressants; Anxiety disorder; Pain; Rehabilitation.

Poster 190

Fistulous Communication Between Right and Left L4-5 Zygapophyseal Joints During Arthrography: A Case Report. Chi-Tsai Tang, MD (University of Michigan, Ann Arbor, MI); Matthew Smuck, MD.

Disclosure: C. Tang, None; M. Smuck, None.

Setting: University spine center. Patient: A 63-year-old woman with a 7-month history of right low back pain and leg numbness. Magnetic resonance imaging showed a right L4-5 zygapophyseal joint synovial cyst. Case Description: Examination revealed right L5
weakness, positive straight-leg raise test, and pain over the sacroiliac joint (SIJ). Reflexes and sensation were normal. Initial treatment with physical therapy and acetaminophen provided minimal relief. Next, a right L5-S1 transforaminal epidural steroid injection and SIJ injection produced full relief. Within 2 months her symptoms returned. The right L5-S1 transforaminal injection was repeated along with a right L4-5 zygapophysial joint injection and percutaneous puncture of the cyst. To puncture the cyst, an arthrogram was produced. After injecting 2mL contrast, the cyst began to fill. Concurrently, a small stream of contrast was observed moving horizontally toward the midline. Next, the contrast in the cyst disappeared. An additional 3mL contrast was injected, again filling the cyst. This time, the contrast crossed the midline and produced a contralateral zygapophysial joint arthrogram. Multplanar fluoroscopy confirmed the fistulous communication crossed the midline through the ligamentum flavum. Finally, the cyst was punctured by a transforaminal approach. **Assessment/Results:** At the 2-week follow-up, she reported complete relief and return to normal activities. Her examination was normal. She remained asymptomatic, 6 months after her initial visit. **Discussion:** Some authors have proposed using high-volume injections of saline to rupture zygapophysial joint synovial cysts. As this case demonstrates, there is no guarantee the saline will cause the cyst to rupture and may actually flow elsewhere. **Conclusions:** This is the first time a communication between left and right lumbar zygapophysial joints has been reported. It may be unique to this patient, or it may be more common but unnoticed since small quantities of contrast are typically used in zygapophysial joint injections. **Key Words:** Fluoroscopy; Injections; Rehabilitation; Spine.

Poster 191

**Efficacy, Safety, and Tolerability of Fentanyl Buccal Tablet in Opioid-Tolerant Patients With Chronic Cancer Pain and Breakthrough Pain.** Neal Slatkin, MD (City of Hope National Medical Ctr, Duarte, CA); Fang Xie, PhD; John Messina, PharmD.

**Disclosure:** N. Slatkin, Employee of City of Hope Medical Group (California Cancer Specialists Medical Group); Consultant for Endo Pharmaceuticals, 2006; KV Pharmaceuticals, 2006; Valeant Pharmaceuticals, 2006; GW Pharmaceuticals, 2006; McMahon Publishing, 2007; Cephalon, 2006; Speakers bureau for Pfizer, Cephalon, Orthobiotech; F. Xie, Full-time employee of Cephalon; J. Messina, Full-time employee of Cephalon.

**Objective:** To evaluate the efficacy and safety of a fentanyl buccal tablet (FBT) for the management of breakthrough pain in opioid-tolerant patients with chronic cancer pain. **Design:** Double-blind, randomized, placebo-controlled study. **Setting:** 30 centers in the United States. **Participants:** 129 enrolled patients; 70% (87/125) identified an effective FBT dose (100, 200, 400, 600, or 800µg) during initial open-label dose titration. **Interventions:** Patients self-administered prespecified sequences of 10 tablets (7 FBT, 3 placebo). **Main Outcome Measures:** Pain intensity and pain intensity differences from 5 to 120 minutes postdose; summed pain intensity differences at 60 minutes (SPIPD60; primary efficacy measure); pain relief; episodes with ≥33% and ≥50% improvement in pain intensity; global medication performance; supplemental opioid usage; and adverse events (AEs). **Results:** SPIPD60 significantly favored FBT versus placebo (mean ± SEM, 9.7±0.6 vs 4.9±0.5; P < .001). There were significant differences between FBT and placebo in pain intensity differences (mean, 0.9±0.1 vs 0.5±0.1) and pain relief (0.8±0.1 vs 0.6±0.1) at 10 minutes and at all time points through 2 hours (P < .001). There were ≥33% and ≥50% improvements in pain intensity in a larger proportion of episodes following FBT versus placebo from 10 minutes (16% vs 10% and 7% vs 4%; P < .05) through 2 hours (74% vs 38% and 66% vs 28%; P < .001). Ratings of global medication performance were superior for FBT versus placebo at 60 and 120 minutes (P < .001). Supplemental opioids were required for approximately 3 times as many breakthrough pain episodes following placebo as FBT. AEs were typical for opioids: nausea (13%), dizziness (11%), fatigue (8%), constipation (6%), and vomiting (6%). Application site-related AEs occurred in 12 patients (10%). Total of 11 (9%) of 125 patients had ≥1 serious AE (unlikely or not related to study drug). **Conclusions:** FBT was effective and well tolerated in the management of breakthrough pain in opioid-tolerant patients with cancer-related chronic pain; onset of analgesia occurred 10 minutes postdose with effects lasting through 2 hours. **Key Words:** Fentanyl; Pain; Rehabilitation; Safety; Self efficacy.

Poster 192

**Treatment of Cerebrospinal Fluid Leakage-Induced Headache by Thoracic Transforaminal Epidural Blood Patch: A Case Report.** Yuting Xiong, MD, PhD (Pain Management Associates of Connecticut, Stamford, CT); Amory Fiore, MD.

**Disclosure:** Y. Xiong, None; A. Fiore, None.

**Setting:** Private pain management office and surgery center. **Patient:** A 51-year-old white man with intractable headache. **Case Description:** The patient developed severe headache without any prior trauma or injury on October 13, 2006. Standing aggravated his headache while laying flat alleviated some of his headache symptom. Nuclear medicine scan indicated cerebrospinal fluid (CSF) leakage. Subsequent computed tomography myelogram of cervicothoracic spine showed dilatation of right C7, bilateral C8 (left > right), and right T1 nerve root sleeves, as well as abnormal collection of contrast within the right T1-2 neural foramen. The patient underwent right paramedian T1-2 interlaminar epidural blood patch with 12mL of autologous blood. Unfortunately, this procedure provided no headache relief. He was then prescribed fentanyl patches and oxycodone (Roxicodone). 2 weeks later, he received a right T1-2 transforaminal epidural blood patch with 6mL of autologous blood via a 22-gauge, 3.5-in spinal needle. **Assessment/Result:** The patient reported 100% headache relief following the right T1-2 transforaminal epidural blood patch procedure. He remained headache-free at follow-up 3 weeks after the injection. He was not taking any pain medication. **Discussion:** To our knowledge, this is the first report of thoracic transforaminal epidural blood patch used to treat headache secondary to CSF leakage at nerve root sleeve. Although the etiology of his CSF leakage at the nerve root sleeve is of interest to study, it is also interesting that the patient did not respond to the epidural blood patch through a paramedian interlaminar approach. The transforaminal approach probably provided better seal of the hole in the nerve root sleeve with a blood clot than the interlaminar epidural blood patch did in this case. **Conclusions:** Transforaminal epidural blood patch is a choice for treating the headache induced by CSF leakage at the nerve root sleeve. **Key Words:** Blood patch, epidural; Cerebrospinal fluid; Headache; Injections, epidural; Rehabilitation.

Poster 193

**Percutaneous Diagnosis and Treatment of Fungal Diskitis With Osteomyelitis: A Case Report.** Brad Goodman, MD (Alabama Orthopedic, Spine and Sports Associates and University of Missouri-Columbia, Birmingham, AL); Srinivas Erragolla, MD; Matt Bayazitoglu, MD; Srinivas Mallempati, MD; Zenko Hrynkiw, MD; David Innis, MD.

**Disclosure:** B. Goodman, None; S. Erragolla, None; M. Bayazitoglu, None; S. Mallempati, None; Z. Hrynkiw, None; D. Innis, None.

**Setting:** Community hospital. **Patient:** A 65-year-old man with a history of bladder cancer and reconstruction was admitted with pro-

gressive back pain. **Case Description:** 3 months prior to admission, the patient had a gradual onset of low back pain following urologic stent placement and antibiotic therapy. He was diagnosed as having degenerative disk disease at L1-2 following numerous imaging studies and orthopedic referral. Physical therapy and epidural block did not relieve his pain. He was admitted to the hospital due to worsening pain that prohibited ambulation. The patient noted a 13.5kg (30lb) weight loss but denied bowel and bladder incontinence or fever and chills. Magnetic resonance imaging (MRI) on admission demonstrated significant spinal stenosis at L1-2, edema of the L1-2 disk space, and destruction of the L1 and L2 vertebrae. Differential diagnosis included metastatic tumor versus osteomyelitis. **Assessments/Results:** The initial plan by a neurosurgeon was open surgical decompression. On review with an interventional physiatrist, a less invasive fluoroscopically guided percutaneous approach was performed. Using Kyphon biopsy devices, traditional spinal injection approaches were utilized to biopsy the L1 and L2 vertebrae and decompress the L1-2 disk. Cultures grew *Candida albicans*, and the patient was treated with intravenous fluconazole for 4 weeks, followed by oral therapy. Postoperatively and at follow-up visits, the patient was pain free. Follow-up MRI at 9 months revealed fusion of the L1-2 vertebrae and excellent decompression of the spinal canal. **Discussion:** This case illustrates the value of a cooperative, team approach among surgeons and interventional pain physicians. The patient’s pain and fungal infection were treated without an open surgery. **Conclusions:** Fungal osteomyelitis and diskitis are uncommon yet treatable causes of low back pain. Modern minimally invasive techniques using fluoroscopy may assist both with diagnosis and treatment, while decreasing morbidity and mortality when compared to traditional open surgeries. **Key Words:** Discitis; Diskectomy, percutaneous; Low back pain; Rehabilitation.

**Poster 194**
**Single Insertion for Multiple Injections: A Safer and Less Painful Technique for Concomitant Facet Joint and Transforaminal Epidural Injections.** Matthew Smuck, MD; Matthew J. McGehee, MD (University of Michigan, Ann Arbor, MI); Robert P. Farhat, DO; Adil Ali, MD.

Disclosure: M. Smuck, None; M.J. McGehee, None; R.P. Farhat, None; A. Ali, None.

**Objective:** To examine the effects of a novel injection technique on procedure time, radiation exposure, anesthetic use, and intra-procedure pain. **Design:** Prospective randomized controlled study. **Setting:** University spine clinic. **Participants:** 8 patients scheduled for symmetric bilateral lumbar facet joint and adjacent transfemoral epidural steroid injections. **Interventions:** Participants received injections by a “traditional” technique on 1 side, and a single needle for multiple injections (SIMI) technique on the contralateral side. All were blinded to the technique. Traditional technique involves needles placed independently for each injection, beginning with the epidural injection and ending with the facet injection. SIMI technique uses a single needle and a single insertion site to first perform the epidural injection, then withdraw and redirect the needle to the ipsilateral facet after adjusting the c-arm to a favorable view. One nonblinded physician (>5y experience) performed every injection. Injections started on the right, alternating between traditional and SIMI technique to begin. **Main Outcome Measures:** An independent third party recorded procedure time, fluoroscopy time, and needles used. The treating physician recorded volume of local anesthetic and intraprocedure pain on a 10-point verbal analog scale (VAS). **Results:** The SIMI technique reduced procedure time by 25% (mean, 148±42s vs 207±89s; *P*<.05) and fluoroscopy time by 37% (14.6±3.3s vs 23.1±11.8s; *P*<.05). The SIMI technique used 33% less local anesthetic (mean, 1.0±0.3mL vs 1.6±0.3mL; *P*<.01) and half as many needles (P<.01). Last, VAS scores were lower for the SIMI technique (mean, 5.9±1.9 vs 7.6±2.7; *P*:>.05). **Conclusions:** The SIMI technique was less painful and safer than traditional techniques when performing concomitant facet joint and transforaminal epidural injections. **Key Words:** Fluoroscopy; Injections; Pain; Rehabilitation.

**Poster 195**
**The Effect of Repeated Treatment of Botulinum Toxin Type A on Poststroke, Spasticity-Related Pain: A Subgroup Analysis of Patients in a 12-Month Trial.** Elie Elovic, MD (Kessler Medical Rehabilitation Research and Education Corp, West Orange, NJ); Allison Brashear, MD; Darryl Kaelin, MD; Jingyu Liu, PhD; Amanda M. VanDenburgh, PhD; Frederick Beddingfield III, MD, PhD; et al.

Disclosure: E. Elovic, Allergan, Merz; Solstice; A. Brashear, Ovation, Merz, Ipsen, Allergan, Elan, Solstice; D. Kaelin, Allergan, Medtronic; Solstice, Cephalon; Pfizer; J. Liu, Allergan; A.M. VanDenburgh, Al-lergan; F. Beddingfield III, Allergan.

**Objective:** To evaluate the efficacy and safety of repeated botulinum toxin type A (BTX-A) (Botox) treatment of focal upper-limb poststroke spasticity in reducing pain frequency and intensity. **Design:** Multicenter, open-label, repeated dose study. **Setting:** 35 clinical sites in North America. **Participants:** Patients with upper-limb poststroke spasticity were enrolled in a 12-month study of BTX-A (N=279). A post hoc subgroup analysis of 73 patients (mean age, 56.8y; 56.2% women) who scored ≥2 on the pain component of the 4-point Disability Assessment Scale (DAS; 0 [no pain] to 3 [severe pain]) at baseline was performed. **Interventions:** Patients received up to 5 treatments of 200 to 400U of BTX-A in the elbow, wrist, finger, and/or thumb flexors of the affected limb. Successive treatments were administered at least 12 weeks after the previous injection. Patients were assessed every 6 weeks for 12 months. **Main Outcome Measures:** Change from baseline in pain frequency (0 [none of the time] to 4 [all of the time]), pain intensity (0 [no pain] to 10 [pain as bad as it can be]), DAS (pain domain), and muscle tone (Ashworth Scale) following BTX-A treatment. Adverse events (AEs) were documented. **Results:** Pain frequency, DAS (pain domain), and muscle tone were significantly reduced from baseline at all time points (P≤.05) after BTX-A treatment. Mean DAS pain reductions ranged from 0.9 to 1.1. Average pain intensity was significantly reduced from baseline at all time points (P≤.05), except week 54. Mild-to-moderate treatment-related AEs were reported in 6.8% (5/73) of patients. **Conclusions:** Repeated BTX-A treatment was well tolerated and resulted in a significant decrease in pain frequency and intensity in spastic upper limbs. **Key Words:** Botulinum toxin type A; Pain; Rehabilitation.

**Poster 196**
**Internet Use in Patients With Chronic Pain.** Leonid M. Shinchuk, MD (Spaulding Rehabilitation Hospital, Boston, MA); Virginia Czarnowski, RN; Alec L. Meleger, MD.

Disclosure: L.M. Shinchuk, None; V. Czarnowski, None; A.L. Me-leger, None.

**Objective:** To evaluate access and utilization by patients with chronic pain of related medical information (PRMI) available on the internet. **Design:** Cross-sectional survey study. **Setting:** Outpatient pain rehabilitation center. **Participants:** 60 chronic pain patients. Mean age was 47.6±10.0 years, 46.7% were men, 53.3% were...
women, 93.3% were high school graduates, 33.3% were college graduates, 75.0% were unemployed, and 56.7% were on disability. **Interventions:** Self-administered survey of access, utilization, and attitudes toward PRMI available on the Internet. **Main Outcome Measures:** Prevalence of Internet and PRMI access, patients’ satisfaction with relevancy and reliability of PRMI, and interest in the future Internet use to obtain PRMI. **Results:** 51 (85%) patients had access to the Internet; of those, 94.1% were able to connect from home. 39 (65%) patients used the Internet to obtain PRMI; of those, 61.5% reported no difficulty in finding the information; 64.1% and 69.2% felt that the information was relevant and reliable, respectively. Only 56.4% of patients ever shared the information found on the Internet with their physician. 94.5% of patients who currently obtain PRMI online and 47.6% of patients with and without Internet access, who currently do not obtain PRMI online, plan to search the Internet for PRMI in the future. 28.3% of patients had ever been encouraged by their physician to conduct a condition-related online search. **Conclusions:** A significant number of patients use the Internet to obtain PRMI, while many of the current nonusers plan to do so in the future. Even though multiple previous reports question the quality of medical information available on the Internet, most of the patients feel confident in its reliability and many choose not to share that information with their physicians. Physicians must acknowledge the growing importance of Internet-based health information, and be prepared to entertain questions and assist patients in evaluating the quality of online PRMI. **Key Words:** Consumer information (publication type); Internet; Pain; Rehabilitation.

Poster 197

Is Opioid Use a Factor in Response to Epidural Steroid Injection for Radicular Low Back Pain? Navjeet Boparai, MD (Stanford, Palo Alto, CA); Dexter Wong, MD; Binh Luu, MD; Esther Kim, MD; Edgar Han, MD; Raj Mitra, MD.

Disclosure: N. Boparai, None; D. Wong, None; B. Luu, None; E. Kim, None; E. Han, None; R. Mitra, None.

**Objective:** To determine the predictive value of opioid use in the response to epidural steroid injection. **Design:** Retrospective chart review. **Setting:** University hospital outpatient clinic. **Participants:** 53 consecutive patients who received a transformaminal epidural steroid injection for diagnosis of radiculopathy seen over 2 years. Mean age was 48 years, with 28 men and 25 women. 19 of the 53 patients were using opioids at the time of the injection. **Intervention:** Each patient underwent a fluoroscopically guided transformaminal epidural injection with 3 mL solution of 2 mL of 80 mg of triamcinolone and 1 mL of 1% lidocaine. Needle placement was confirmed by injecting 0.5 mL of Omnipaque 240 contrast dye. **Main Outcome Measure:** A positive response to the injection was defined as the absolute change between pre- and postinjection visual analog scale (VAS) scores. **Results:** 74% of patients on opioids had improved VAS scores after injections, while 71% of patients without opioids had improvement. Using the analysis of variance F test, there was no significant relationship between concurrent opioid use and a lack of response to epidural steroid injections ($P = .066$). **Conclusions:** Our study indicates that fluoroscopically guided epidural steroid injection is an effective treatment for radicular low back pain in patients using opioids. Opioids can induce central sensitization, and may affect the clinical response to epidural steroid injections, however, these results demonstrate that current opioid use should not be a deterrent to epidural steroid injection. This study is limited by a low power and larger studies would be beneficial. **Key Words:** Analgesics, opioids; Anesthetics; Injections; Pain; Rehabilitation.

Poster 198

An Interdisciplinary Approach to Complex Pain Management in a Burn Patient With a Cerebrovascular Accident: A Case Report. Satinderpaul S. Satia, MD (University of South Florida, Tampa, FL); Gail Latlief, DO; Hung Tran, MD; Glenn Curtiss, PhD; Maulik Bhalani, MD; Steven Scott, DO.

Disclosure: S.S. Satia, None; G. Latlief, None; H. Tran, None; G. Curtiss, None; M. Bhalani, None; S. Scott, None.

**Setting:** Veterans Affairs hospital polytrauma center. **Patient:** A 23-year-old active duty soldier exposed to a blast from an improvised explosive device. **Case Description:** This patient sustained 45% total body surface area burns involving his face, neck, torso, bilateral upper extremities (BUE), buttocks, and legs. Medical complications included compartment syndrome of the abdomen and legs, anemia, hypercalcemia, sepsis, and seizures. After initial extubation, workup also revealed left middle cerebral arterial stroke. He underwent fasciotomies of the bilateral lower extremities with resection of the anterior compartments; escharotomies of the BUE with left thumb amputation; excision and extensive skin grafting of the elbows and legs; and split thickness skin graft to left thumb stump. Because of his burns, he developed thick contracture bands in the left axilla and underwent splitting and Z-plasty. Furthermore, he developed heterotopic ossification at the bilateral elbows. **Assessment/Results:** On presentation to the rehabilitation unit, he had bilateral foot drop secondary to the fasciotomies, right hemiparesis, expressive aphasia, and he was awake lying in a fetal position due to pain. He experienced different types of pain symptoms, including somatic, neuropathic, and sympathetic, which were exacerbated by his spasticity. His pain management consisted of an interdisciplinary approach from psychiatry, neurology, and anesthesiology. 9 months after daily physical, occupational, and neuropsychologic therapies, opioids, anesthetics, and medications for spasticity (eg, morphine, hydromorphone, oxycodone, transdermal fentanyl, gabapentin, baclofen, ketamine), and a stellate ganglion block, he was discharged with acetaminophen for pain control and ambulated with minimal assistance. **Discussion:** In light of his stroke and pain symptoms, he required a combination of physical modalities, pain medications, and interventional procedures. This collaborative approach exemplifies the management of pain in relation to his cognitive and functional deficits. **Conclusions:** Pain management requires an interdisciplinary approach to maximize function in complex patients. **Key Words:** Burns; Cerebrovascular accident; Pain; Rehabilitation.

Poster 199

Age, Sex, and Previous Opioid Use Do Not Affect Clinical Responses to Oxymorphone Extended Release in a Diverse Population of Chronic Low Back Pain Patients. Suna Barlas, PhD (Endo Pharmaceuticals, Chadds Ford, PA); Errol Gould, PhD; Beverly A. Jones, PhD.

Disclosure: S. Barlas, Endo Pharmaceuticals; E. Gould, Endo Pharmaceuticals; B.A. Jones, Endo Pharmaceuticals.

**Objective:** To determine whether age, sex, or previous opioid use affects efficacy of oxymorphone extended release (ER) for the treatment of chronic low back pain (CLBP). **Design:** Two 12-week, double-blind, randomized, placebo-controlled trials were conducted: 1 each in opioid-naive and -experienced patients. **Setting:** Multidisciplinary pain centers in the United States. **Participants:** Adults with moderate to severe CLBP for ≥3 months. **Interventions:** Patients underwent open-label titration and/or conversion to a stable dose of oxymorphone ER that reduced pain intensity to ≤40mm on a 100-mm visual analog scale (VAS) on 3 of 5 consecutive days. Stabilized patients were then randomized to either continue their stabilized dose.

of oxymorphone ER or receive placebo. Rescue medication was available. **Main Outcome Measures:** Pain intensity and adverse events (AEs). **Results:** Overall, 63% (174/278) of men, 59% (174/297) of women, 63% of patients younger than 65 years (312/495), and 45% of patients ≥65 years (36/80) successfully completed titration. The majority of opioid-naïve (63% [205/325]) and opioid-experienced (57% [143/250]) patients were successfully titrated, and discontinuations due to AEs were low in both groups (18.1%, 18.7%, respectively). Throughout the double-blind period, oxymorphone ER–treated patients experienced significantly lower mean VAS scores than placebo patients: least squares means ranged from 9.8 to 14.2 mm (P < .001). Efficacy was not affected by age (P = .504), sex (P = .086), or previous opioid use (P = .130). More placebo patients experienced severe AEs (2.3% vs 0.6%) while more oxymorphone ER patients experienced mild or moderate AEs (25.1% vs 14.0%). **Conclusions:** The majority of this diverse population of CLBP patients was titrated to a well-tolerated, efficacious dose of oxymorphone ER. Oxymorphone ER patients experienced significantly greater decreases in VAS scores over 12 weeks of the double-blind period. Neither age, sex, nor previous opioid use affected the efficacy of oxymorphone ER. **Key Words:** Analgesics, opioid; Low back pain; Rehabilitation.

**Poster 200**

**Evaluation of the Safety and Efficacy of a 5% Lidocaine Patch Compared With Trigger Point Injections (of 0.1% Lidocaine) in Patients With Low Back Pain After Nonoperated Injury: A Prospective, Randomized, Controlled Study.** Michael G. Jenson, MS, PA-C, CPP (Pain Care Associates of Oklahoma, Tulsa, OK); Raymond F. Sorensen, DO; Suna Barlas, PhD; Arnold R. Gammaitoni, PharmD; Beverly Jones, PhD; Errol M. Gould, PhD.

**Disclosure:** M.G. Jenson, Endo Pharmaceuticals; R.F. Sorensen, Endo Pharmaceuticals; A.R. Gammaitoni, Endo Pharmaceuticals; B. Jones, Endo Pharmaceuticals; E.M. Gould, Endo Pharmaceuticals.

**Objectives:** To evaluate the safety and efficacy of the 5% lidocaine patch (Lidoderm) compared with trigger point injections (TPIs) using 0.1% lidocaine in patients with continued low back pain after injury without surgical intervention. **Design:** Prospective, randomized, parallel, active-controlled study. **Setting:** Pain clinic. **Participants:** 40 patients (age range, 18–80y), with clinical diagnosis of lower back pain after prior injury primarily due to a muscular process, were randomized at baseline to TPI (n = 20) or 5% patch (n = 20) groups. **Intervention:** Patients received either 1 set of 4 to 6 TPIs at the first office visit or 4 to 6 5% patches (changed daily for 4wk) at the trigger sites. **Main Outcome Measures:** Treatment effects on pain were assessed at baseline (week 0) and in some cases at weeks 2 and 4 with visual analog scale, patient’s subjective response to treatment, McGill Pain Questionnaire Short-Form (MPQ-SF), Ashworth Scale, and algometer readings of trigger points (in kilograms). **Results:** 38 patients completed the study: 1 TPI patient discontinued due to a 6-month absence and 1 5% patch patient due to rash. The 5% patch group reported significantly greater reductions in VAS (39mm vs 16mm), MPQ-SF (7 vs 3), and Ashworth Scale (2.2 vs 0.8) scores compared with the TPI group, in addition to marked improvement (5 vs 2.6) in algometer readings. Overall patient subjective response in terms of percentage improvement was overwhelmingly in favor of the 5% patch; 84% of patch patients reported moderate or better pain relief compared with only 21% of TPI patients. **Conclusions:** The 5% lidocaine patch provided significantly greater improvements compared with TPIs in all of the scales measured in this study associated with assessing the level of pain. The 5% lidocaine patch may be a potentially beneficial, noninvasive alternative therapy to TPI for myofascial pain syndrome. **Key Words:** Analgesics; Myofascial pain syndromes; Rehabilitation; Trigger points, myofascial.

**Poster 201**

**The Efficacy of Suprascapular Nerve Block in Treating Shoulder Pain.** David Ben-Aviv, MD (Stanford University Hospital, Palo Alto, CA); Navjeet Boparai, MD; Dexter Wong, MD; Binh Luu, MD; Esther Kim, MD; Raj Mitra, MD.

**Disclosure:** D. Ben-Aviv, None; N. Boparai, None; D. Wong, None; B. Luu, None; E. Kim, None; R. Mitra, None.

**Objective:** To determine the efficacy of suprascapular nerve block in treating rotator cuff tendonitis unresolved by conservative measures. **Design:** Retrospective chart review. **Setting:** University hospital outpatient clinic. **Participants:** 43 consecutive patients with a diagnosis of rotator cuff tendonitis were reviewed from 2004 to 2007, 8 of whom received a suprascapular nerve block. Of those injected, 7 of 8 patients were women, with ages ranging from 43 to 59 years (mean age, 50y). **Intervention:** Each patient received 5mL of 1% lidocaine in the region near the spine of the scapula surrounding the suprascapular nerve. **Main Outcome Measures:** Preinjection verbal analog scale (VAS) and postinjection VAS at 3-week follow-up were documented. A positive response to the injection was defined as at least a 50% improvement between the pre- and postinjection VAS. **Results:** 7 of 8 patients experienced greater than 50% pain relief. The exact binomial analysis demonstrated that the effect of the suprascapular nerve block on treating pain was P < .07 when using greater than 50% relief in pain as an endpoint. When using the t test to examine the absolute change in VAS, the results indicated a P < .01. **Conclusions:** Our study indicates that suprascapular nerve blocks were effective in the treatment of rotator cuff tendonitis. Although the P value was less than .07 when considering greater than 50% relief, 88% of the patients injected had significant pain relief and analysis was limited by the small sample size. Suprascapular nerve block may be a safer alternative than injections involving steroid exposure. **Key Words:** Nerve block; Rehabilitation; Rotator cuff; Shoulder pain.

**Poster 202**

**Atlanto-Axial Joint as a Source of Headache in Congenital Atlanto-Occipital Fusion.** Omar H. El Abd, MD (Spaulding Rehabilitation Hospital, Wellesley, MA).

**Disclosure:** O.H. El Abd, None.

**Setting:** Tertiary referral hospital. **Patient:** A 40-year-old woman with persistent right-sided headache. **Case Description:** The patient was evaluated for predominantly right-sided occipital, temporal, frontal headache, and neck pain. The symptoms started spontaneously and persisted for 3 years. Nonsteroidal anti-inflammatory drugs and a regimen of physical therapy failed to improve her condition. Imaging studies demonstrated fusion of occiput and C1. **Assessment/Result:** A diagnostic right C1-2 facet joint injection was performed with a positive result. Therapeutic right C1-2 facet joint injections relieved the neck pain and headache for 1 year. **Discussion:** Neck pain and headache are among the most frequently reported symptoms from C1-2 facet arthropathy. C1-2 facet arthropathy may be an underdiagnosed source of neck pain and headache due to technical difficulties in diagnosis. In this case, the diagnosis was suspected. We successfully employed a fluoroscopically guided intra-articular C1-2 injection for both diagnostic and therapeutic purposes. The improvement of symptoms for 1 year in duration further confirms the diagnosis. **Conclusions:** This case illustrates the importance of considering the upper cervical facet joints and particularly the C1-2 facet joint as a cause of headache. To our knowledge, this is the first reported case of congenital occipital-fusion with headache believed to emanate from C1-2 facet arthropathy. **Key Words:** Facet joint; Headache; Rehabilitation.
Conclusions: weakness or pain since the procedure and has returned to normal dorsiflexor group on the right side. The patient has continued without therapy and, 6 weeks later, had only trace weakness of the ankle (Depo-Medrol) and lidocaine. He then began a course of physical guided right L5 selective nerve root block with methylprednisolone. Electrodiagnostic studies confirmed the diagnosis of postherpetic right 

resonance imaging of the lumbar spine revealed mild degenerative foot drop requiring use of a molded ankle-foot orthosis. Magnetic 

man with herpetic rash involving the L5 dermatome. This case demonstrates that selective nerve root block can be an effective treatment for this condition. 

Key Words: Herpes zoster; Muscle weakness; Radiculopathy; Rehabilitation.

Poster 205


Disclosure: L. Kamen, Allergan.

Setting: Office-based rehabilitation pain medicine practice. Patients: 3 patients who had undergone multiple surgeries for treatment of post-traumatic knee arthrosis were identified with elements of neuropathic pain in and around the operated knee joints. Case Descriptions: Trials of several classes of analgesics and adjunctive medications, injections, and physical therapies over 10 years have failed to substantially alleviate pain. Intra-articular injections of 100U of botulinum toxin type A (BTX-A) were performed via a subpatellar approach. Assessment/Results: Reduction of visual analog scale of pain, range of motion, skin turgor, medication use, and activity tolerance were assessed for efficacy of intervention. Discussion: Rationale for the use of intra-articular BTX-A includes blockade of nociceptor excytosis from the peripheral terminal fibers responsible for pain. Additional mechanisms have been proposed regarding interruption of peripheral and central sensitization pain. BTX-A has been studied extensively with regard to safety, although little is known about its intra-articular effects. Conclusions: Neuropathic pain, contracture, and persistent difficulty walking were all addressed in a positive way with intra-articular BTX-A. Objective and functional outcomes along with longevity of benefit have been documented. Although the precise mechanism of action is unknown, these results have been replicated in several independent trials. Future studies with larger cohorts and validation techniques are warranted to justify this procedure. Key Words: Botulinum toxin type A; Pain; Rehabilitation.

Poster 206

Use of Botulinum Toxin Type A for Treatment of Chronic Low Back Pain After Lumbar Fusion: A Case Report. Adam Berliner, DO (Jackson Memorial Hospital, Miami, FL); Andrew Sherman, MD.

Disclosure: A. Berliner, None; A. Sherman, None.

Setting: University-based multidisciplinary tertiary spine center. Patient: A 35-year-old man with chronic low back pain (LBP). Case Description: While unloading boxes, this patient developed severe LBP and numbness radiating down the right lower extremity. While conservative treatment failed, he ultimately underwent 4 lumbar surgeries, including an L4-5 fusion. He presented to our center with severe lumbar pain; disabled from work and leisure activities. Spine imaging demonstrated adequate L4-5 fusion and normal adjacent lumbar disk morphology. Exam revealed direct myofascial tenderness and a normal neurologic exam. Treatments consisting of physical therapy, zygapophyseal injections, and epidural steroid injections provided temporary relief. Despite large doses of opioid medications and high self-motivation, the patient was still disabled. Therefore, treatment with botulinum toxin type A (BTX-A) was initiated. 200U of BTX-A was injected into 8 separate sites in the lumbar paraspinal muscles from L2 to L5 bilaterally. Assessment/Results: The patient reported significant pain reduction by the second week following administration of BTX-A. He returned to work full-time and required much lower doses of opioid medications. 6 months later he still reported significant relief, but he had more episodic spasms. The procedure was repeated with 150U of BTX-A bilaterally. He continued to work full-time and started a spine exercise program. At his 6-month follow-up, he reported sustained relief and did not require a third injection. Discus-
sion: Several recent published studies have demonstrated promising results after BTX-A injection to lumbar paraspinal muscles in persons with chronic LBP. Pain relief occurs due to a combination of mechanisms. No study, however, addresses the specific treatment of LBP in patients who underwent previous lumbar surgery. Conclusions: BTX-A may be a viable treatment option in patients with recurrent LBP following spine surgery. Key Words: Botulinum toxin type A; Low back pain; Rehabilitation; Treatment outcome.

Poster 207
Interpretation of Contrast Dispersal Patterns by Experienced and Inexperienced Interventional Physiatrists. Zachary I. Abbott, DO (University of Michigan, Ann Arbor, MI); Matthew Smuck, MD. Disclosure: Z.I. Abbott, None; M. Smuck, None.

Objective: To determine how accurately inexperienced interventional physiatrists interpret transforaminal epidural contrast dispersal patterns. Design: Prospective comparative study. Setting: University spine center. Participants: 2 experienced interventional physiatrists with more than 5 years experience, and 3 pain fellows with 6 months of experience. Intervention: Each participant independently interpreted 100 images showing contrast dispersal patterns from cervical and lumbar transforaminal epidural injections performed by another physician. All images were obtained after an injection of 0.5mL of contrast, half during contrast injection and half 1 second after contrast injection. The “true” contrast dispersal pattern was determined under live fluoroscopy during the injection and classified by any or all of 3 potential contrast patterns: epidural, nonepidural, and/or vascular. Participants were told to assume 0.5mL of contrast injection in each image, and to describe each image with any or all of the 3 potential contrast patterns. Main Outcome Measures: Variance in agreement with the “true” contrast patterns between inexperienced and experienced participants. Results: Inexperienced participants correctly identified epidural contrast patterns in 76% versus 94% for the experienced participants (P=.01). Not surprisingly, accuracy for all participants was low in identifying vascular patterns on these static images. Experienced participants did slightly better but the difference was not significant: 73% accuracy for the experienced and 68% for the inexperienced (P=.18). Overall, the inexperienced participants were in exact agreement with the “true” pattern in 52% of the images, whereas experienced participants were in exact agreement in 70% (P=.03). Conclusions: Even with 6 months of intensive experience, trainees are significantly less accurate than experienced physicians in correctly interpreting contrast dispersal patterns from transforaminal epidural injections. In light of the potential consequences of such errors, these procedures should be performed by physicians with more than 6 months of intensive training. The competency of interventional spine trainees should be a topic of further examination. Key Words: Fluoroscopy; Injections; Rehabilitation; Spine.

Poster 208
Treatment of Thoracic Facet Osteoarthritis With a 5% Lidocaine Patch: A Case Report. Hoylond Hong, MD (Stanford, Palo Alto, CA); Lance Cheung, MD; Edgar Han, DO; Raj Mitra, MD. Disclosure: H. Hong, None; L. Cheung, None; E. Han, None; R. Mitra, None.

Setting: Tertiary care academic medical center. Patient: A 74-year-old man with thoracic facet joint osteoarthritis. Case Description: The patient presented with chronic mid thoracic anterior radiating back pain, quality described as burning, aggravated by physical activity including walking, and relieved by heat, ice, and massage therapy. Physical examination revealed intact strength and sensation in all upper and lower myotomes; reflexes that were +2 and symmetric at biceps, triceps, and brachioradialis; and negative Hoffman and Spurling signs. Palpation revealed right rhomboid major and latissimus dorsi tenderness, with focal tenderness over T5-6 facet joints. Radiographs revealed facet osteoarthritis on T5-6 and T6-7 and magnetic resonance imaging showed T6-7 disk protrusion without foraminal narrowing. The patient’s initial treatments included nonsteroidal anti-inflammatory drugs, physical therapy, and thoracic facet steroid injections without any relief of the mid back pain. The patient was prescribed 5% lidocaine patches (Lidoderm), with instructions to apply them to the affected area for 12 hours on and 12 hours off. Assessment/Results: At 4 weeks, the patient reported significant pain relief with numeric pain scores before and after lidocaine patch of 7/10 and 0/10, respectively. The patient reported no unfavorable side effects and further conveyed improved function in daily activities and movement. Discussion: The U.S. Food and Drug Administration approved Lidoderm for postherpetic neuralgia. No published studies exist for thoracic facet osteoarthritis treatment with the lidocaine patch. The lidocaine patch provided more pain relief for thoracic joint osteoarthritis than analgesics and other physical interventions. Conclusions: Conservative medical management for thoracic joint osteoarthritis is limited to oral medications, physical therapy, and thoracic facet steroid injections. Lidocaine patch may provide a safe alternative for pain relief as monotherapy or in combination with other treatments. Key Words: Lidocaine; Rehabilitation.

Poster 209
Painful Scar Following a Radical Neck Dissection Successfully Treated With Botulinum Toxin Type B Subcutaneous Injection: A Case Report. Jerry J. Pryde Jr, MD, MPH (Cedars Sinai Medical Ctr, Los Angeles, CA). Disclosure: J.J. Pryde, Solstice Neurosciences Inc; Allergan Inc.

Setting: Outpatient clinic. Patient: A 29-year-old woman with recurrent and persistent squamous cell carcinoma of the right lateral neck who had undergone surgery in July 2005 (laryngoscopy, esophagoscopy, right partial glossectomy, right modified radical neck dissection, cranial nerve dissection) and June 2006 (right radical neck dissection, right partial thyroidectomy, laryngoscopy). Case Description: She presented with chronic pain and numbness in the right shoulder and neck and severe surgical scar pain. She was unable to take oral pain medications secondary to side effects. On examination, she was diagnosed with myofascial neck pain secondary to radical dissection and severe surgical scar pain. She was fearful and depressed about chronic pain and loss of function. Moderate short-term pain relief was obtained following trigger point injections. We decided to treat her with botulinum toxin type B (BTX-B) to lengthen the duration of effect. She received BTX-B (total, 5000U); 2500U intramuscularly to the right trapezius, 1250U intramuscularly to the right levator scapulae, and 1250U subcutaneously around the incision site. Assessment/Results: 2 weeks after BTX-B injection, the patient reported 65% improvement in neck pain and 70% improvement in scar pain with no adverse events. At this visit, she was much happier and no longer crying with pain. She continued to report upper thoracic pain where she did not receive BTX-B. Discussion: This is the first report in the literature of BTX-B successfully utilized subcutaneously for the treatment of severe pain associated with cervical surgical scars. BTX-B may represent a new tool in the armamentarium for the treatment of severe scar pain. Conclusions: Further research is needed to understand the role that BTX-B may play in the treatment of severe pain associated with surgical scars. Key Words: Botulinum toxins; Myofascial pain syndromes; Pain; Rehabilitation.
Post 210
Fluoroscopically Guided Versus Blind Steroid Injections for Chronic Iliolumbar Syndrome: Case Control Study. John C. Keel, MD (Walton Rehabilitation Hospital, Augusta, GA).
Disclosures: J.C. Keel, None.

Setting: Interventional pain clinic and fluoroscopy suite. Patients: All patients in the preceding year receiving injections of the iliolumbar ligament were included, in order to study differences in outcome in those receiving fluoroscopically guided injections. A total of 6 were identified retrospectively. 3 had "blind" injections and 3 had fluoroscopically guided injections. Case Descriptions: Each group consisted of 2 women and 1 man with back pain for 1 year or more, with matched preinjection average severity on verbal numeric rating scale (VNRS) score of 7.7. All were obese except 1 in the fluoroscopy group. Assessment/Results: The blind group received injections using surface landmarks corresponding with the iliolumbar ligament insertion on the iliac crest. Fluoroscopically guided injections were performed using lumbar transverse processes and iliac crest to identify bony attachments of the iliolumbar ligament. All patients in the fluoroscopy group improved, with average postinjection VNRS score of 4.7 at average follow-up of 15.7 days. Blind injections had average postinjection VNRS score of 8.7 at average follow-up of 21.3 days. Discussion: Low back pain related to structures in the multifidus triangle has long been recognized by several names, such as iliolumbar syndrome, iliac crest syndrome, and others. There are several potential anatomic sources of pain: the highly innervated iliolumbar ligament is under mechanical stress at its iliac insertion. The iliolumbar ligament insertion is adjacent to dorsal rami of L1-2, the superior sacroiliac joint, and attachments of quadratus lumborum and erector spinae muscles. Injections directed at the iliolumbar ligament insertion may place medication in a way to affect any or all of these closely spaced structures. Fluoroscopy may guide injections of the iliolumbar ligament insertion by better identification of its bony attachments. Surface landmarks may not be reliable in patients with obesity. Conclusions: Fluoroscopy improves the accuracy of injection of the iliolumbar ligament insertion, which leads to better outcomes in low back pain due to iliolumbar syndrome. Key Words: Back pain; Fluoroscopy; Rehabilitation.

Poster 211
Injection of Botulinum Toxin as a Treatment for Superficial Peroneal Nerve Entrapment Caused by Muscle Hernia: A Case Report. Myung Jae Yoo, MD (Montefiore Medical Ctr of Albert Einstein College of Medicine, Bronx, NY); Dennis Kim, MD; Jeffrey Lee, DO; Moo Yeon Oh-Park, MD.
Disclosures: M.J. Yoo, None; D. Kim, None; J. Lee, None; M. Oh-Park, None.

Setting: Foot clinic of university hospital. Patients: A 79-year-old woman with pain in the lower leg and dorsum of the foot. Case Description: The patient presented with insidious onset of pain radiating from the anterodistal lower leg to the dorsum of right foot for the past 5 weeks. Pain was exacerbated with activities and relieved by rest. Her medical history included noninsulin-dependent diabetes mellitus for the past 22 years. Physical examination revealed a tender bulge of soft tissue 8cm above the lateral malleolus. Sensation to light touch was reduced on the distal anterolateral aspect of the lower leg and dorsum of the foot sparing the first web space. Her Tinel sign was positive when tapping over the soft tissue bulge, reproducing the symptoms. Remaining neurologic examination was not significant. Ultrasonographic evaluation of the lower leg showed herniation of peroneal muscle and exiting superficial peroneal nerve through fascial defect. Electromyography confirmed the soft tissue bulge as being the skeletal muscle. Assessment/Results: The patient was diagnosed with entrapment of superficial peroneal nerve secondary to muscle herniation. Diagnostic injection of lidocaine under ultrasonographic guidance near the superficial peroneal nerve alleviated the symptoms completely. She returned to the clinic 2 weeks later with complaint of residual pain and tenderness. 20U of botulinum toxin (Botox) were injected into the herniated muscle under ultrasonographic and electromyographic guidance. 1 week after the injection, the patient reported complete resolution of her symptoms. Discussion: Entrapment of superficial peroneal nerve due to muscle herniation through fascial defect of the lateral compartment has been previously described. This is, however, the first report of treating this condition with botulinum toxin. Conclusions: In this case, investigators showed that botulinum toxin can be utilized in the treatment of entrapment of the superficial peroneal nerve due to muscle herniation under the guidance of ultrasonography and electromyography. Key Words: Botulinum toxins; Entrapment neuropathies; Peroneal neuropathy; Rehabilitation.

Poster 212
Clinical Correlations With Number of Vertebral Levels Fused in Patients With Chronic Low Back Pain. Ralph A. Crisostomo, MD (Mayo Clinic, Rochester, MN); W. Michael Hooten, MD; Jennifer L. Kerkvliet, MA; Cynthia O. Townsend, PhD.
Disclosures: R.A. Crisostomo, None; W.M. Hooten, None; J.L. Kerkvliet, None; C.O. Townsend, None.

Objective: To investigate clinical characteristics and multidisciplinary rehabilitation outcomes for chronic low back pain (LBP) patients based on number of lumbar levels fused. Design: Retrospective pre- and post-treatment study. Setting: Tertiary care center. Participants: 111 patients with disabling LBP and prior history of lumbar fusion, admitted to a multidisciplinary pain rehabilitation program from January 2000 to April 2006. Interventions: Intensive, outpatient-based, multidisciplinary rehabilitation with analgesic medication withdrawal. Main Outcome Measures: The Multidimensional Pain Inventory, Center for Epidemiologic Studies—Depression Scale, catastrophizing subscale of the Coping Strategies Questionnaire, and opioid medication usage. Results: 46 patients had 1 level fused, 41 patients had 2 levels fused, 15 patients had 3 levels fused, 6 patients had 4 levels fused, and 3 patients had 6 levels fused. Age (r=0.35, P=.000), years of education (r=.29, P=.002), and duration of symptoms (r=.29, P=.002) correlated positively with number of levels fused. Other admission and dismissal measures did not correlate significantly with number of levels fused. To correct for multiple comparisons, statistical significance was determined at P<.0025. Conclusions: Of patients with history of lumbar fusion admitted to a multidisciplinary rehabilitation program for chronic disabling back pain, older, more educated patients with greater duration of symptoms were more likely to have more lumbar levels fused. Rehabilitation outcome measures were not associated with number of levels fused. Key Words: Back pain; Rehabilitation; Spinal fusion.

Poster 213
Relief Through Botulinum Neurotoxin Injection for Postoperative Chronic Myofascial Pain. Xuong K. Tang, DO (Rush University Medical Ctr, Chicago, IL); Thomas Pang, MD; Jafar W. Siddiqui, MD; Hoang Vu, DO.
Disclosures: X.K. Tang, None; T. Pang, None; J.W. Siddiqui, None; H. Vu, None.

Setting: Tertiary care hospital. Patients: A 29-year-old man with chronic shoulder pain. Case Description: The patient had a medical history significant for multiple shoulder repairs, now with persistent burning pain in his left trapezius, levator scapulae, and rhomboids.
since his last surgery. A physical therapist and active tri-athlete, the patient had been self-treating with his own therapy regimen. The patient has had 2 sets of traditional trigger point injections (TPI) with minimal relief. Assessment/Results: On examination, the patient exhibited a forward flexed c-spine and protracted shoulders with noticeable tightness and palpable painful bands in the bilateral pectoralis and upper trapezius muscles (left > right). He had restricted scapulo-humeral rhythm on the left and required the use of his trapezius and scapula for arm abduction. Neurologically, the patient was normo-reflexive symmetrically. He failed several conventional modalities (stretching, deep-tissue massage, muscle energy technique, ultrasound, electric stimulation, TPI). Physical therapy was, therefore, focused on scapular stabilization exercises. After receiving 2 series of botulinum neurotoxin injections to the pectoralis muscles, he had great shoulder pain relief with improved range of motion in his glenohumeral and scapulothoracic rhythm. Discussion: The pathophysiology of myofascial pain is not well understood. Research suggests both a peripheral sensitization of the mechanosensitive afferent nerves associated with dysfunctional motor endplates as well as a central sensitization of the dorsal horn neurons within the spinal cord. Recently, the use of botulinum neurotoxin has been implemented to treat myofascial pain. Treatment is targeted at the peripheral sensitization, which indirectly treats the central sensitization. Botulinum neurotoxin works at the neuromuscular junction to inhibit the release of acetylcholine and other neuropeptides responsible for sensitization. To date, the U.S. Food and Drug Administration (FDA) has approved indications for botulinum neurotoxin that include strabismus, blepharospasms, hyperhidrosis, and cervical dystonia. Conclusions: Although there is no FDA indication for use of botulinum toxin for treatment of muscular and myofascial pain, it has been shown to be of great utility. Key Words: Botulinum toxins; Myofascial pain; Rehabilitation.

Poster 214
The Role of Computerized Infrared Imaging as an Objective Assessment Tool in Diagnosing Complex Regional Pain Syndrome and Facilitating Its Treatment: A Case Series. Jeffrey Cohen, MD (Rusk Institute of Rehabilitation Medicine, NY, NY); Laura Downing, BS; Mathew H. Lee, MD.

Disclosure: J. Cohen, None; L. Downing, None; M.H. Lee, None.

Setting: Tertiary care center. Patients: 3 patients presenting with persisting extremity pain secondary to trauma. Case Descriptions: The first patient sustained trauma to his left ankle when his wheelchair struck a door. He presented with a 23-month history of persistent, burning left ankle and foot pain, paresthesias, swelling, tenderness to palpation, and limited range of motion. The second patient presented with a 15-month history of persistent, burning left hand, wrist and arm pain, and hypersensitivity to touch following an explosion. The third patient fractured his left hip and sustained severe trauma to his pelvic region in a motor vehicle collision. He presented with a 33-month history of sharp, intermittent pain in his left leg and left foot, paresthesias, and cold sensations in his left leg. In each patient, standard radiographic studies were unrevealing. In addition, each patient had been treated with several therapeutic interventions (medications, injections, therapy) with no significant clinical improvement. Computerized infrared imaging (CII) was performed on each patient to rule out complex regional pain syndrome (CRPS). Assessment/Results: Data from CII revealed significant heat asymmetry (>1.0°C cooler in the affected extremity vs the contralateral extremity) in each patient. This was useful in making the diagnosis of CRPS in each case. Discussion: The findings on CII were helpful in guiding further management decisions in this group of patients who were not responding to treatment. CII is a sensitive, noninvasive test that objectively documents cutaneous temperature patterns, which reflect the underlying physio-logic state of the sympathetic nervous system. Pain fibers are closely associated with sympathetic nervous system fibers. Conclusions: CII is a potentially valuable objective tool in the evaluation of patients with persisting extremity pain and suspected CRPS who are not responding to treatment. Key Words: Diagnostic imaging; Pain; Pain syndromes, regional complex; Rehabilitation.

Poster 215
The Use of Compression Garments in the Treatment of Allodynia: A Case Series. Alicia A. Hillman, MD (Mayo Clinic, Rochester, MN); Mark F. Hurdle, MD; Rusty A. Moore, DO.

Disclosure: A.A. Hillman, None; M.F. Hurdle, None; R.A. Moore, None.

Setting: Tertiary medical center. Patients: 3 patients with neuropathic pain. Case Descriptions: Patient A was a 44-year-old woman status post radiotherapy for low grade astrocytoma involving the dorsal left C6-7 spinal cord who complained of progressive left arm, hand, and bilateral feet pain characterized as allodynia to light touch, and severe cold intolerance despite pharmacotherapy. Patient B was a 56-year-old man with a history of cervical spinal cord injury status post cervical decompression and fusion with instrumentation at C4-5 who presented with burning pain and allodynia in his upper extremities despite pharmacotherapy. Patient C was a 43-year-old woman status post cervical decompression for cervical myelopathy who presented with bilateral upper-extremity pain characterized as throbbing, worse with light touch and cool temperatures, despite pharmacotherapy. Assessment/Results: Each patient was thought to have neuropathic pain with a component of allodynia. A trial of compression garments at 20 to 30mmHg, to be worn as needed for pain, was prescribed for each patient to mediate or modify the component of allodynia. Discussion: Neuropathic pain is defined as pain due to dysfunction of the nervous system in the absence of ongoing tissue damage. It is a debilitating disorder often resistant to pharmacotherapy. Allodynia is a common feature of neuropathic pain and patients often report subjective relief with external pressure to the allodynic area. We report on a series of patients who were given a trial of compression garments for relief of neuropathic pain with an alldynic component. Possible mechanisms include stimulation of large-diameter peripheral afferent nerves that may blunt the signal of smaller-fiber afferent nerves. Conclusions: External compression achieved with compression garments can be considered an adjunct to the treatment of neuropathic pain with an alldynic component. Key Words: Nerve pain; Paresthesia; Rehabilitation; Stockings, compressions.

Poster 216
Relevance of Motor Performance and Psychologic Tests to Low Back Pain Assessment Based on the Brief ICF Core Sets. Birgit Paul, PhD; Christoph Leitner, MD; Sonja Zehetmayer, PhD; Erich Vanecek, PhD; Gerald R. Ebenbichler, MD (Clinics of Physical Medicine & Rehabilitation, MUV, Vienna, Austria).

Disclosure: B. Paul, None; C. Leitner, None; S. Zehetmayer, None; E. Vanecek, None; G.R. Ebenbichler, None.

Objective: To identify those clinical tests that most expediently examine the body functional categories “muscle function” and “emotional function” of the Brief ICF Core Sets (International Classification of Disability and Health [2001]) for chronic low back pain (CLBP).

Design: Case-control study. Setting: Outpatient department of physical medicine and rehabilitation. Participants: 32 consecutive CLBP patients and 19 nonathletic healthy controls, matched in age, body mass index, and sex. Interventions: Not applicable. Main Outcome

Measures: Following a comprehensive standardized clinical examination, all patients and controls underwent extensive objective muscle function tests that measured trunk muscle strength, endurance, and postural performance. Assessment of the category “emotional function” included the Symptom Checklist—90—Revised, the Beck Depression Inventory, the Fear-Avoidance Beliefs Questionnaire (FABQ-D), and body experience (Borg Category Ratio Scales about exertion, tension, fear of harm and [re-]injury). Results: A series of logistic regression analyses that included the significant and clinically relevant muscle function and emotional and cognitive functional variables revealed back muscle endurance and somatization to explain 50% of the between group variances. Furthermore, the variables Sensory Organization Test (SOT) composite score and FABQ were the strongest predictors of disablement in CLBP. Conclusions: In the Brief ICF Core Set for CLBP, the category “muscle function” would be best examined by back muscle endurance tests whereas that of “emotional function” by tests that examine somatization. Furthermore, both the SOT and the FABQ would, in addition to the muscle endurance and somatization tests, optimize the clinical relevance of the 2 ICF categories for CLBP. Key Words: Emotions; Low back pain; Muscles; Rehabilitation; Rehabilitation outcome.

Poster 217
Costotransverse Articulation Injections for Treatment of Posterior Shoulder Girdle Pain: A Case Report. Kathryn T. Gollotto, DO (Temple University Hospital, Philadelphia, PA); Michael Weinik, DO.
Disclosure: K.T. Gollotto, None; M. Weinik, None.
Setting: Outpatient PM&R clinic. Patient: A 37-year-old woman with shoulder girdle pain. Case Description: The patient, with a medical history of central nervous system glioma, neurofibromatosis, and thoracic scoliosis requiring fusion of C7 and T1, presented with chronic right posterior shoulder girdle and interscapular pain following a traction injury at work. On examination, she had tenderness over the right medial scapular border, C2 to C7 costotransverse articulations, and paraspinal musculature. There were also 3+/5 strength deficits noted in the right biceps and flexor digitorum indices and bilateral triceps. Imaging revealed cervical spine degenerative disk disease and dextroscoliosis of the thoracic spine. Shoulder radiographs were negative for any pathology. Electromyography showed C6 and C7 radiculopathy. Her shoulder girdle pain failed to respond to conventional therapies, including physical therapy and a subacromial bursa lidocaine injection. She subsequently underwent fluoroscopically guided injections of the right T3, T4, and T5 costotransverse articulations with 0.5mL of betamethasone (Celestone Soluspan) and 0.5mL of 1% lidocaine at each level. Assessment/Results: Following the costotransverse articulation injections, the patient noted complete resolution of her right posterior shoulder girdle pain at her follow-up interviews 2 years out. Discussion: The costotransverse articulation is a synovial joint with limited excursion secondary to a fibrous capsule and 3 costotransverse ligaments. It is innervated by ventral rami of the spinal nerve. When ribs undergo structural dysfunction, thoracic stability is compromised and nonphysiologic motion patterns incur. These aberrant movements irritate the ventral rami and generate localized discomfort. Conclusions: This case illustrates that the costotransverse articulation can serve as a myofascial pain generator and should be taken into consideration when a patient has thoracic discomfort. Further studies to evaluate the effectiveness of costotransverse articulation injections would be of benefit. Key Words: Injections, intra-articular; Myofascial pain syndromes; Rehabilitation.

Poster 218
Pulsed Radiofrequency in the Treatment of Radicular Pain: A Cross-Sectional Observational Study of Efficacy. Matthew H. Kalter, MD (Ctr for Pain Medicine and Rehabilitation, Annapolis, MD); Brian S. Kahan, MD; Richard J. Genato, MD.
Disclosure: M.H. Kalter, None; B.S. Kahan, None; R.J. Genato, None.
Objective: To test the efficacy of pulsed radiofrequency on the dorsal root ganglion in patients with radicular pain. Design: Cross-sectional observational study. Setting: Private institution. Participants: 18 subjects found to have radicular symptoms with nerve root compression (11 lumbar, 5 cervical, 1 thoracic, 1 sacral). Interventions: Pulsed radiofrequency was performed on 18 subjects at the cervical, thoracic, lumbar, and sacral levels corresponding to each subject’s symptoms and magnetic resonance imaging changes. The intensity of the first perceived sensory stimulation at 50Hz was noted for each subject to ensure proper placement of the radiofrequency probe. Main Outcome Measure: Subjects reported of their pain scores on a scale of 0 to 10. Results: Subjects were asked to report their pain scores both before and 3 weeks after pulsed radiofrequency. 8 (44%) of 18 subjects reported an improvement of at least 2 points. 4 (36%) of 11 subjects with lumbar complaints and 3 (60%) of 5 with cervical complaints reported improvement of at least 2 points. The subject with the sacral complaints reported a 2-point improvement whereas the subject with the thoracic complaints did not respond. Of the subjects who perceived sensory stimulations at intensities of 0.5V or less, 6 (55%) of 11 reported improvement of at least 2 points whereas 2 (29%) of 7 subjects first perceived sensory stimulations at intensities greater than 0.5V. Conclusions: Pulsed radiofrequency of the dorsal root ganglion provides a safe treatment alternative for patients who suffer from radicular pain. The intensity of the first perceived sensory stimulation seems to correlate with the subject’s response to the treatment. Long-term follow-up investigational studies with sham controls are recommended. Key Words: Radiculopathy; Rehabilitation.

Poster 219
Does Income Level Influence Complementary Medicine Use With Chronic Low Back Pain? David Berbrayer, MD, FRCP(C (University of Toronto, Thornhill, ON, Canada). Disclosure: D. Berbrayer, None.
Objectives: To examine low back pain (LBP) patients treated either medically or surgically and to determine whether their use of complementary and alternative medicine (CAM) was related to their household income. Design: Not provided. Setting: Recruitment was from a university tertiary back clinic of a physiatrist and orthopedic surgeon. Participants: A total of 19 patients were surveyed, including 12 who received medical treatment and who received surgical treatment for their chronic LBP (CLBP). Interventions: Not applicable. Main Outcomes Measures: CLBP was defined as pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds. Furthermore, the pain must have lasted 3 months or longer in the past 2 years, and was not attributable to cauda equina syndrome, infection, sciatica, stenosis, spinal deformity, or spinal fracture. A validated CAM questionnaire was used and income level was generated from a government survey. Results: 8 (67%) of 12 of medically treated patients and 5 (71%) of 7 of surgically treated patients tried CAM for a total of 13 (68%) of 19. By chi-square analysis, the number of medically versus surgically treated patients who had tried or not tried CAM did not differ. Furthermore, chi-square analysis also revealed that there was no difference between income levels as to whether subjects had tried CAM or not. Conclusions: Surgical patients used more CAM “mind body and spirit” and “diet and nutrition” than medical patients. Medical patients used more CAM.
“manual healing” techniques. Medical patients perceived transient improvement with CAM more than surgical patients. Level of income was not a factor in whether CLBP patients used CAM. **Key Words:** Complementary therapies; Income; Low back pain; Rehabilitation.

**Poster 220**

**Treatment for Low Back Pain in a Patient With Myasthenia Gravis:** A Case Report. Jeffrey E. Oken, MD (Marianjoy Rehabilitation Hospital, Oakbrook Terrace, IL); Jeanne Wilson, MD. Disclosure: J.E. Oken, None; J. Wilson, None.

**Setting:** Outpatient pain clinic. **Patient:** A 47-year-old white woman with low back pain (LBP) and history of myasthenia gravis (MG). **Case Description:** The patient presented to clinic with a 2- to 3-year history of LBP. Pain was insidious in onset and was described as sharp pain with “spasms” in her lower lumbar area. Housecleaning, lifting, pulling, pushing, or too much walking exacerbated her pain. The patient had a 20-year history of MG and was being treated with pyridostigmine (Mestinon). The patient was prescribed physical therapy 2 times a week for 4 weeks for strengthening, flexibility, and home exercise program. No restrictions were placed on therapy secondary to MG. **Assessment/Results:** The patient returned to clinic when 4 weeks of therapy was completed. **Discussion:** MG is a disorder of neuromuscular function characterized by weakness and abnormal fatigability of skeletal muscles. Weakness becomes progressively worse with activity and may be alleviated by rest. Strengthening has not been extensively studied in MG patients. Literature varies with regard to instructions relating to activity. There is a paucity of medical literature addressing biomechanic LBP in MG patients. Some studies advise patients to avoid any form of exercise, while others advise patients to remain as active as they can be. **Conclusions:** Physiatrists do not necessarily have to restrict therapies because of MG. Participation and efficacy of therapies may depend on the severity of the disease and the type of therapy prescribed. **Key Words:** Low back pain; Myasthenia gravis; Rehabilitation.

**Poster 221**

**Use of Epidural Steroid Injections in the Management of Arachnoiditis Following Subarachnoid Hemorrhage: A Case Report.** Waqas A. Quraishi, MD (North Shore-LIJ Health System, New Hyde Park, NY); Barry C. Root, MD; John Stamatos, MD. Disclosure: W.A. Quraishi, None; B.C. Root, None; J. Stamatos, None.

**Setting:** Tertiary care hospital. **Patient:** A 68-year-old man with arachnoiditis following subarachnoid hemorrhage (SAH). **Case Description:** The patient was admitted after workup for an excruciating headache revealed a Hunt and Hess grade 1 prepontine SAH. Post-bleed day 3, he complained of intractable lumbar pain radiating down the posterior left leg. Further radiologic studies revealed no acute bleeding and/or vascular abnormalities. The patient was discharged on post-bleed day 7, with oral pain medication and outpatient follow-up. 2 days later, he presented with continued symptoms. Based on his history and physical examination, arachnoiditis was diagnosed, and 2 caudal epidural steroid injections were performed 1 month apart. **Assessment/Results:** 2 weeks postinjection 1, the patient had partial resolution of symptoms with a near-resolution of symptoms postinjection 2. **Discussion:** Arachnoiditis is a rare, painful, underdiagnosed condition most commonly arising from epidural injections, blood, surgery, infections, and trauma. In SAH, blood becomes a chemical irritant and can cause inflammation of the arachnoid layer surrounding the spinal cord, manifesting frequently as burning sensations, sharp pains in the lower back, legs, and feet, numbness, and tingling. Persistent inflammation leads to scarring and fibrosis, causing adhesive arachnoiditis, a debilitating condition with chronic and treatment-refractory sequelae. The rationale behind the injections was: (1) to provide acute symptomatic relief and (2) to curtail the inflammatory process that could develop into adhesive arachnoiditis. The epidural steroid injection is a well-documented cause of arachnoiditis. Its therapeutic value in managing arachnoiditis, however, has not been widely reported. **Conclusions:** Though extremely rare, arachnoiditis is a serious and painful condition. Early diagnosis and management can minimize debility and maximize recovery. The oft-implicated epidural steroid injection holds merit as an efficacious treatment modality for arachnoiditis. **Key Words:** Arachnoiditis; Injections, epidural; Low back pain; Rehabilitation.

**Poster 222**

**Nonsurgical Treatment of Lumbar Spinal Stenosis: A Pilot Study.** Ng Vuong, MD (GLAVAHS/UCLA, Los Angeles, CA); Shirley Chi, MD; Bao Nguyen, MD; Ron Brizzie, DO; Sanjog Pangarkar, MD; Agnes Wallbom, MD. Disclosure: N. Vuong, None; S. Chi, None; B. Nguyen, None; R. Brizzie, None; S. Pangarkar, None; A. Wallbom, None.

**Objective:** To investigate changes in treadmill walking time and self-reported symptoms following therapeutic exercise, epidural steroid injections (ESI), and/or educational materials in subjects with symptomatic lumbar spinal stenosis. **Design:** Randomized controlled trial. **Setting:** PM&R clinic. **Participants:** 20 subjects randomly assigned to 1 of 4 treatment groups. **Interventions:** Group 1 received a translaminar ESI; group 2, physical therapy (PT); group 3, ESI and PT; and group 4 (control group), educational materials. **Main Outcome Measures:** Treadmill walking time, visual analog scale, Quebec Back Pain Disability Scale, Roland-Morris Disability Questionnaire, and the Swiss Spinal Stenosis Questionnaire. **Results:** Increased walking time after interventions, increased self-reported function, decreased pain, and greater improvement was found in those receiving a combination PT and ESI versus controls. **Conclusions:** Subjects with lumbar spinal stenosis receiving therapeutic exercise and ESI (group 3) had increased walking time and improved pain and function. **Key Words:** Injections, epidural; Rehabilitation; Spinal stenosis.

**Poster 223**

**Low Back Pain With Bilateral Gluteal Pain Due to Vascular Claudication: A Case Report.** Nandita Keole, MD (University of Florida, Gainesville, FL); Joseph Ferraro, MD. Disclosure: N. Keole, None; J. Ferraro, None.

**Setting:** Outpatient spine care clinic in university setting. **Patient:** A 79-year-old man with low back and bilateral hip pain. **Case Description:** A self-referred patient presented with a 4-month history of low back pain and worsening bilateral gluteal pain, right worse than left. It was associated with walking and was relieved with rest. The patient was concerned more about numbness in the gluteal region than pain, which seemed to occur especially after walking about 30m (100ft). In addition, he had a surgical history of stent placement in his left leg, due to arterial stenosis. The patient was sent for an abdominal aortic arteriogram to evaluate for iliac artery disease. The arteriogram revealed bilateral iliac disease with 75% to 85% stenosis of the right common iliac artery. **Assessment/Results:** The patient had total resolution of symptoms in the right gluteal region on stent placement in the right iliac artery. **Discussion:** Back pain with bilateral gluteal pain is often a presenting symptom of spinal stenosis and vascular etiology can get overlooked. **Conclusions:** As rehabilitation physicians we often receive referrals with back and leg pain in order to rule out...
lumbar spine disease, but similar symptoms can occur with proximal artery disease. **Key Words:** Intermittent claudication; Pain; Rehabilitation.

**Poster 224**
The Predictive Value of Radiographic Evidence of Lumbar Spine Foraminal Stenosis for Response to Lumbar Transforaminal Epidural Steroid Injections. Edgar Han, DO (Stanford University Hospital and Clinics, Stanford, CA); Navjeet Boparai, MD; Binh Luu, MD; Esther Kim, MD; Dexter Wong, MD; Raj Mitra, MD. Disclosure: E. Han, None; N. Boparai, None; B. Luu, None; E. Kim, None; D. Wong, None; R. Mitra, None.

**Objective:** To determine if radiographic evidence of lumbar spine foraminal stenosis adversely affects the clinical response to lumbar transforaminal epidural steroid injections for treatment of radicular low back pain (LBP).

**Design:** Retrospective chart review.

**Setting:** University hospital outpatient clinic. **Participants:** 53 consecutive patients (28 men, 25 women; average age, 48y) diagnosed with radicular LBP seen in our interventional spine clinic from 2004 to 2005.

**Interventions:** Every patient in the study underwent a fluoroscopically guided procedure using a 3.5-in 25-gauge needle directed to the lumbar spine foramen. Contrast dye was injected to confirm placement, and a 3-mL solution of 80mg of triamcinolone and 1mL of 1% lidocaine without epinephrine was injected in slow increments. Pre- and postinjection visual analog scale (VAS) scores were documented on the day of the procedure.

**Main Outcome Measures:** Presence or absence of lumbar foraminal stenosis was ascertained by review of the preprocedure lumbar magnetic resonance imaging. Positive response to the injection was defined as at least a 50% improvement between the pre- and postinjection VAS. **Results:** No statistically significant relationships were found between positive radiographic findings of lumbar foraminal stenosis and a positive clinical response to lumbar transforaminal epidural steroid injection (Fisher exact test, $P=0.539$; ANOVA, F test, $P=0.572$). **Conclusions:** Our results suggest that radiographic findings of lumbar spine foraminal stenosis may not be a positive predictor for a patient’s positive clinical response to a lumbar transforaminal epidural steroid injection. Our findings also suggest that the presence of lumbar foraminal stenosis should not be a deterrent for lumbar transforaminal epidural steroid injections. Interestingly, even severe foraminal stenosis did not decrease clinical response to transforaminal steroid injections. **Key Words:** Fluoroscopy; Injections, epidural; Low back pain; Radiculopathy; Rehabilitation.

**Poster 225**
Step-Down Treatment of Opioid Dependent Chronic Pain Syndromes Incorporating Cognitive Behavioral Strategies With Buprenorphine: A Case Series. Georgia K. Tettlow, MD (Thomas Jefferson University Hospital/Magee Rehabilitation Hospital, Philadelphia, PA); Leonard Kamen, DO. Disclosure: G.K. Tettlow, None; L. Kamen, None.

**Setting:** Office-based pain medicine practice. **Program:** Cognitive strategies and buprenorphine as a step-down treatment in opioid-dependent chronic pain. **Program Description:** Patients selected had established opioid-dependent chronic nonmalignant pain from a variety of spinal or surgical management interventions. Buprenorphine doses of 8 to 24mg sublingual were utilized to reduce withdrawal symptoms associated with high-dose opioids. Medication changes were applied in concert with office-based cognitive behavioral techniques (CBTs) and an individualized physical exercise (IPE) program. CBTs included: education about a multidimensional view of pain, identification of pain-eliciting and pain-aggravating thoughts, emotions and behaviors, and identification and modification of maladaptive cognition. Cognitive restructuring, exercise, physical therapy, and gradual downward titration of buprenorphine facilitated transition to lower potency but equally effective analogesics and/or nonopioid adjuvant agents for residual pain. **Assessment/Results:** Of a total 29 chronic nonmalignant pain patients on high-dose opioids completing induction of buprenorphine, 55% successfully transitioned to complete opioid withdrawal or maintenance on lower-dose buprenorphine. Visual analog scale scores were substantially reduced or unchanged despite dramatic reduction or complete withdrawal of high-dose opioids. **Discussion:** Hyperalgesia and amplification of chronic nonmalignant pain is often ineffectively addressed by increasing doses of high-dose opioids in a futile attempt to avoid drug tolerance and address pseudo-addiction. A system of office-based cognitive behavioral strategies, physical and medical management strategies designed to sustain effective pain management while stepping down high-dose opioids, is presented in this multicase study. The advantages to both the patient and practitioner of breaking the cycle of chronic pain and challenging prescription logistics related to opioid hyperalgesia are illustrated. **Conclusions:** Step-down treatment of high-dose opioids utilizing elements of CBT, an IPE, and buprenorphine appears effective and well accepted by a majority of those selected to participate in this combined pain management approach to a difficult but common problem. **Key Words:** Analgesics, opioid; Buprenorphine; Pain; Rehabilitation.

**Poster 226**
Improvement of Phantom Limb Pain With Pregabalin: A Case Study. Kristen E. Cardamone, DO (New York Presbyterian Hospital of Columbia and Cornell, New York, NY); Ellen Babinsky, DO; Michael O’Dell, MD. Disclosure: K.E. Cardamone, None; E. Babinsky, None; M. O’Dell, None.

**Setting:** Hospital-based acute inpatient rehabilitation unit. **Patient:** A 24-year-old man with status post multiple medical trauma from a motor vehicle collision, including left hip disarticulation. **Case Description:** The patient was admitted to inpatient rehabilitation with persistent shooting, burning, and gnawing pain at the former site of foot and ankle. Breakthrough medications further sedated him and participation in therapy was nearly impossible. Pain treatment was changed from gabapentin to pregabalin for better phantom pain control. Gabapentin was gradually tapered over the course of at least a week and daily pregabalin was administered in divided doses, starting at 300mg and titrated to 600mg. **Results/Assessment:** Sedation was a limiting factor during the crossover period of coadministration of both medications. As phantom limb pain decreased with initial pregabalin dosing, the fentanyl patch and hydromorphone were tapered, which reduced sedation problems. He was able to tolerate the target daily dose of 600mg without sedation and achieved good phantom pain control even after cessation of gabapentin. At discharge, he reported occasional but tolerable phantom pain and required only pregabalin and acetaminophen/oxycodone for breakthrough pain. **Discussion:** Phantom limb pain is usually a temporary complaint following amputations; however, it can be quite problematic for patients. Available manual and pharmacologic options are variably effective. New approaches are needed. **Conclusions:** As demonstrated in this case study phantom limb pain was very effectively managed with pregabalin titrated to individual patient needs. Further clinical study is needed to...
fully establish efficacy. **Key Words:** Neuralgia; Phantom limb; Rehabilitation.

**Poster 227**

**Duloxetine-Induced Hyponatremia: A Case Report.** Diana A. Kurmen Figueroa, MD (Mayo Clinic, Rochester, MN).

**Disclosure:** D.A. Kurmen Figueroa, None.

**Setting:** Outpatient spine clinic. **Patient:** A 77-year-old man. **Case Description:** A 77-year-old man whose medical history was significant for hypertension, history of melanoma, history of obstructive pulmonary disease, and vascular disease. He presented to the clinic with a 5-month history of severe L2-3 and L3-4 neuropathic pain. He was unsuccessfully treated for neuropathic pain with agents including tramadol, diclofenac sodium/misoprostol, and pregabalin. Duloxetine was started at a dosage of 20mg at bedtime. 5 days later, he was admitted to the local hospital for an acute onset of non-specific symptoms of anorexia, nausea, lethargy, and muscle weakness. The laboratory test results showed hyponatremia of 113mmol/L, plasma osmolality of 271mOsm/kg, urine osmolality of 396mOsm/kg, and a urinary sodium of 142mOsm/L. Other causes of the syndrome of inappropriate antidiuretic hormone secretion (SIADH) were ruled out. After discontinuing the medication and fluid restriction in the hospital, he had a serum sodium of 130mmol/L, 6 days later, symptoms resolved and he had full functional recovery. **Discussion:** SIADH is a common side effect of the old selective serotonin reuptake inhibitors. By comparison, a 48-year-old woman was admitted to the hospital for acute severe headache, and on psychiatric evaluation was diagnosed with depression and administered 30mg of duloxetine twice daily. 2 days later, she developed 2 generalized seizures, was afibrile, comatose, and her pupils were dilated and sluggishly reactive. Blood analysis revealed serum sodium level of 103mEq/L and a blood urea nitrogen of 6mg/dL. The patient was diagnosed with SIADH that resolved after duloxetine was discontinued. **Conclusions:** The signs and symptoms of hyponatremia depend on the rapidity with which the serum sodium concentration declines, as well as on its absolute level. Very young and very old patients typically develop symptoms with lesser decreases in the serum sodium level. **Key Words:** Duloxetine; Rehabilitation.

**Poster 228**

**Using Intradiskal Pulsed Radiofrequency Ablation for Diskogenic Low Back Pain: A Case Report.** Curt J. Winnie, MD (Mayo Clinic, Rochester, MN); Jefferey M. Tiede, MD.

**Disclosure:** C.J. Winnie, None; J.M. Tiede, None.

**Setting:** Pain clinic. **Patient:** A 35-year-old woman with severe lower back pain (LBP). **Case Description:** Our patient presented with a 6-month history of severe LBP that increased with sitting, bending forward, and ambulation, and was relieved lying supine. Lumbar magnetic resonance imaging revealed a high-intensity zone at L4-5 with a broad-based central disc bulge. Physical examination was significant for pain exacerbation with forward flexion. The patient subsequently underwent a series of injections, including an L5-S1 epidural steroid injection, bilateral L5-S1 facet joint injections, and bilateral sacroiliac joint injections, as well as several weeks of physical therapy, with no relief of symptoms. **Assessment/Results:** Subsequent discography at the L4-5 disk was markedly positive for the production of severe pain consistent with her typical symptoms as compared with control disks at L3-4 and L5-S1. Next, the L4-5 disk was treated with intradiskal pulsed radiofrequency (PRF) ablation for a total duration of 20 minutes with the following parameters: 2ms, 2Hz, and temperature of less than 42°C. The patient tolerated the procedure well and there were no complications. **Discussion:** Traditionally, spinal fusion was the only treatment option for diskogenic back pain that had failed to respond to conservative treatment. However, nonoperative treatments have more recently been introduced. While intradiskal electrothermal therapy (IDET) has been the mainstay of nonoperative treatment, this procedure is associated with prolonged recovery and significant postprocedural pain. In addition, although safer than spinal fusion, IDET carries some inherent risk. Although the true efficacy of intradiskal PRF ablation is still unknown, it appears to have less postprocedural discomfort, a quicker recovery, and less inherent risk than IDET. **Conclusions:** When available, intradiskal PRF ablation may be considered as an alternative to IDET for nonoperative treatment of diskogenic LBP. **Key Words:** Low back pain; Rehabilitation.

**Pediatrics**

**Poster 229**

**Relationship Between Health-Related Quality of Life, Spasticity, and Function in Children With Cerebral Palsy Undergoing Intra-thecal Baclofen Therapy.** Rita N. Ayyangar, MD (University of Michigan, Ann Arbor, MI); Hugh J. Garton, MD; Enebak Lindsay; Margaret Fox, RN.

**Disclosure:** R.N. Ayyangar, Medtronic: Investigator-initiated proposal; H.J. Garton, None; E. Lindsay, None; M. Fox, None.

**Objective:** To examine the relationship between health-related quality of life (HRQOL), spasticity, and function in children with cerebral palsy (CP) undergoing intrathecal baclofen (ITB) therapy (Lioresal). **Design:** Longitudinal cohort study. **Setting:** Tertiary care facility. **Participants:** 28 children (15 boys) with CP (Gross Motor Function Classification System levels: V, n = 23; IV, n = 2; III, n = 3), aged 4 to 20 years (mean, 12.5y), who were receiving chronic ITB therapy. **Interventions:** Bivariate correlation analyses between Modified Ashworth Scale (MAS) and functional measures were performed at baseline and follow-up with a majority at 1 year (n = 17). A Bonferroni-adjusted P value of .004 was accepted as significant. Mixed-model analysis, accounting for the small sample size and missing data, was used to correlate MAS and measures of function with HRQOL measured by the Child Health Questionnaire (CHQ). **Main Outcome Measures:** The CHQ, MAS, Gross Motor Function Measure (GMFM), and select scales of the Pediatric Evaluation of Disability Inventory (PEDI). **Results:** At 1 year, mean improvement in upper-limb MAS score was .58±.71, while lower-limb MAS score improved by 1.03±1.28. No significant differences were noted in CHQ or its subscales. Correlations between improved MAS scores and changes in CHQ were not statistically significant. Strong inverse correlations were noted with upper-limb MAS and GMFM, FIM, PEDI self-care, PEDI mobility, PEDI caregiver self-care, and PEDI caregiver mobility (all P < .004). Lower-limb tone correlations were not statistically significant. Similarly, while total CHQ appeared generally to correlate with reduced spasticity and caregiver assistance (lower-limb MAS, PEDI caregiver mobility, PEDI caregiver self-care, all P < .01), these did not meet our prespecified P value for significance. **Conclusions:** These results support a relationship between tone and function and possibly HRQOL among a group of children with CP receiving ITB therapy. Lower levels of upper-limb spasticity versus lower-limb spasticity correlated with better function and demonstrated a strong relationship to functional status and need for caregiver assistance. Therefore, the effects of upper-limb spasticity reduction on function and HRQOL should be further explored. **Key Words:** Baclofen; Quality of life; Rehabilitation.
Prolonged, Severe Intrathecal Baclofen Withdrawal Syndrome: A Case Report. Colby R. Hansen, MD (University of Utah Health Sciences Ctr, Salt Lake City, UT); Judith L. Gooch, MD; Teresa Such-Neibar, DO.

Disclosure: C.R. Hansen, None; J.L. Gooch, None; T. Such-Neibar, None.

Setting: Tertiary care children’s hospital. Patient: An 11-year-old girl with spastic quadriplegic cerebral palsy managed with a baclofen pump. Case Description: The patient developed an infected pump and subsequent meningitis, prompting the removal of her pump and catheter. She subsequently developed a severe, prolonged baclofen withdrawal syndrome marked by increased spasticity, agitation, hypertension, and tachycardia that lasted nearly 2 months, requiring intensive care unit care and continuous intravenous sedation with benzodiazepines and opiates. Assessment/Results: Her pump was eventually replaced on hospital day 56 and within 24 hours her symptoms dramatically improved. She was eventually weaned off sedating medications and returned to baseline functional status. Discussion: Intrathecal baclofen (ITB) withdrawal is a well-recognized complication when drug delivery is disrupted for any reason. ITB withdrawal varies widely in its severity and poses the very real possibility of death if not promptly managed. Cases of withdrawal lasting greater than 1 or 2 weeks, however, are sparse. This case represents the first pediatric case, to our knowledge, of a prolonged, severe withdrawal from ITB. In addition, the literature to date has not discussed the potential role for opiates in managing baclofen withdrawal, yet a growing body of literature is examining the interplay between opiates and GABA B pathways. Conclusions: ITB withdrawal can persist well beyond the usual expected course of 1 to 2 weeks. Opiates may have a potential role in managing severe baclofen withdrawal. Reinstitution of ITB should be considered the definitive therapy for ITB withdrawal. Key Words: Baclofen; Cerebral palsy; Rehabilitation; Substance withdrawal syndrome.

Botulinum Toxin Type A for Tongue Protrusion and Extrusion Disorder: A Case Report. Satish Mahajan, MD; Eugenio Montes-terio, MD; Jenny Andrus, MD (Virginia Commonwealth University, Richmond, VA); Colleen Wunderlich, MD, MSc.

Disclosure: S. Mahajan, None; E. Montasterio, None; J. Andrus, None; C. Wunderlich, None.

Setting: Pediatric long-term care facility. Patient: A 17-year-old woman with spastic quadriplegic cerebral palsy (CP). Case Description: Patient had severe oral ulceration at the tongue base with secondary dysphagia due to tongue protrusion. Treatment required both dental and otolaryngology surgical interventions and prolonged course of medication. Botulinum toxin injection was performed to decrease aberrant tongue movements. 200U of botulinum toxin type A (BTX-A) was injected into the genioglossus muscle in 2 sites (100U each), using a bilateral paramedian submandibular approach. Assessment/Results: Nursing and medical staff noted a 50% decrease in the aberrant tongue movements, with less protrusion and extrusion of the tongue. Effect lasted approximately 3 months. The ulcer has not returned to date. The patient has been more comfortable and tolerant of oral care. Discussion: BTX-A has been used successfully in a number of head and neck conditions, including cervical, spasmodic, oromandibular, and lingual dystonias, as well as bruxism, blepharospasm, hemifacial spasm, and sialorrhea. However, review of the literature shows only several case reports and a small series of patients with tongue protrusion dystonia secondary to Meige’s syndrome, oromandibu-lar, or tardive dyskinesia that have been treated successfully with botulinum toxin injection into the genioglossus. No one to date has reportedly used BTX-A to decrease tongue protrusion and extrusion in children with CP. Conclusions: The use of BTX-A to control tongue protrusion and extrusion disorders in CP may be warranted to prevent secondary complications such as Riga-Fede disease. Key Words: Botulinum toxins; Cerebral palsy; Oral ulcer; Rehabilitation.

Improvement of Pediatric Nonalcoholic Fatty Liver Disease by Diet and Physical Exercise: A Case Report. Osamu Ito, MD, PhD (Tohoku University School of Medicine, Sendai, Japan); Yoshikazu Muroya, MD; Nobuyoshi Mori, MD; Makoto Nagasaka, MD, PhD; Masayuki Kanazawa, MD, PhD; Masahiro Kohzuki, MD, PhD.

Disclosure: O. Ito, None; Y. Muroya, None; N. Mori, None; M. Nagasaka, None; M. Kanazawa, None; M. Kohzuki, None.

Setting: University hospital. Patient: A 9-year-old boy with obesity and hypertransaminasemia. Case Description: On admission, his height, body weight, and body mass index (BMI) were 149cm, 93kg, and 41.99kg/m², respectively. Blood pressure was normal. Serum alanine and aspartate transaminases and lactate dehydrogenase were 144, 244, and 370U/L, respectively. Levels of serum triglyceride and low- and high-density lipoprotein cholesterol were in the normative range. Oral glucose tolerance test showed normal glucose tolerance. The value of the homeostatic model assessment was 3.8, which indicated insulin resistance. Plain computer tomography (CT) showed thick subcutaneous fat, low CT densities of the liver, and normal sizes of visceral fat and pancreas. Assessment/Results: He was admitted for 40 days to undergo a diet of 1900kcal and physical exercise with bicycle ergometer (at 15W for 20min/d, 4d/wk) and walking (10,000 steps/d, 7d/wk), and he followed the diet and physical exercise at home for 12 months. After 12 months, BMI decreased to 35kg/m², and levels of serum liver enzymes normalized, as did CT densities of the liver. Discussion: Nonalcoholic fatty liver disease (NAFLD) is a series of diseases from asymptomatic steatosis with or without elevated transaminase to cirrhosis with complications of liver failure and hepatocellular carcinoma. Parallel to the increasing prevalence of obesity, NAFLD has become common and potentially serious even in children. There are few reports regarding the effect of therapeutic intervention on pediatric NAFLD. Conclusions: Therapeutic intervention with diet and physical exercise has beneficial effects in pediatric NAFLD. Key Words: Exercise, physical; Fatty liver; Obesity; Rehabilitation.

Orthoses and Conditioning in a Patient With Pompe’s Disease: A Case Report. Lainie Holman, MD (Cincinnati Children’s Hospital Medical Ctr, Yellow Springs, OH); Linda Michaud, MD, PT; Diane E. Von Stein, MD; Nancy Leslie, MD; Deborah Guebard, PT.

Disclosure: L. Holman, None; L. Michaud, None; D.E. Von Stein, None; N. Leslie, None; D. Guebard, None.

Setting: Pediatric tertiary care hospital. Patient: A 5-year-old girl with late infant Pompe’s disease (glycogen storage disease II). Case Description: This child presented at age 4 months with hypotonia and cardiomegaly. Deficiency of alpha-glucosidase in muscle confirmed a diagnosis of Pompe’s disease. At age 3, her cardiomyopathy and ventilation were stable and she could scoot on her bottom but could not ambulate. Enzyme replacement therapy...
(ERT) was begun at age 3.5 years with aglucosidase alfa infusions every other week. After 1 year, she was demonstrating increasing motor function and decreasing heart dysfunction. Efforts to ambulate were limited by hip extension of −70° bilaterally; popliteal angles were 45°. Computed tomography of her hips showed shallow acetabulae with mild posterior subluxation and valgus orientation of the femurs. Rather than undertake major hip reconstruction in this patient with cardiomyopathy, femoral neck osteotomies were done to improve hip extension, along with hamstring lengthenings. Customized hip-knee-ankle-foot orthoses (HKAFOs) were prescribed for ambulation, as well as postoperative trunk and lower-extremity strengthening inclusive of electric stimulation and aquatic therapy. **Assessment/Results:** 1 year after surgery, the patient ambulated more than 12m (40ft) with HKAFOs and a walker with minimal to stand-by assistance, and could stand with forearm crutches. **Discussion:** The natural history of infantile Pompe’s disease typically involves progressive weakness, with early death due to cardiomyopathy and/or respiratory failure. Children who respond to ERT present new management issues, particularly related to future motor development. To our knowledge, orthopedic intervention followed by subsequent rehabilitation and orthoses has not been previously undertaken to address lower-extremity function in Pompe’s disease. **Conclusions:** As emerging therapies become available for children with previously fatal diagnoses, previously unencountered morbidity presents novel challenges in pediatric rehabilitation that require a creative and adaptive therapeutic approach. **Key Words:** Pediatrics; Pompe disease; Rehabilitation.

**Poster 234**

White Matter Damage Following Pediatric Brain Injury as Assessed Using Diffusion Tensor Imaging, Weihong Yuan, PhD; Shari L. Wade, PhD; Nicolay C. Walz, PhD; Scott Holland, PhD; Prasanna Karunanayaka, PhD; Linda J. Michaud, MD (Cincinnati Children’s Hosp Med Ctr, Cincinnati, OH). Disclosure: W. Yuan, None; S.L. Wade, None; N.C. Walz, None; S. Holland, None; P. Karunanayaka, None; L.J. Michaud, None.

**Objectives:** To examine the sensitivity of diffusion tensor magnetic resonance imaging (MRI/DTI), which characterizes the directional properties of water diffusion in white matter tracts providing evidence about the integrity of the underlying tissue structure, in measuring changes sensitive to changes in the neural substrate of language in young children not necessarily rule out the possibility of future ambulation. **Key Words:** Diffusion tensor magnetic resonance imaging, Pediatric rehabilitation.

**Poster 235**

Return to Ambulation After Bilateral Hammstring and Heel Cord Releases and Comprehensive Rehabilitation in an Adolescent With Duchenne Muscular Dystrophy: A Case Report. Micah W. Baird, MD (Cincinnati Children’s Hospital and Medical Center, Cincinnati, OH); Mary A. McMahon, MD; David W. Pruit, MD; Brenda Wong, MD; Tweek T. Do, MD; Amy Meyer, BSPT; et al. Disclosure: M.W. Baird, None; M.A. McMahon, None; D.W. Pruit, None; B. Wong, None; T.T. Do, None; A. Meyer, None.

**Objective:** Return to ambulation after bilateral hammstring and heel cord releases. **Setting:** Tertiary care pediatric hospital. **Patient:** A 17-year-old young man with Duchenne muscular dystrophy (DMD). **Case Description:** The patient’s history was also notable for prolonged steroid therapy and significant short stature. At the age of 16 he developed progressive bilateral ankle plantarflexion and hamstring contractures associated with severe muscle weakness (proximal muscle strength 2/5 in his lower extremities) leading to the loss of ambulation. 9 months later he underwent bilateral hamstring and heel cord releases, followed by comprehensive inpatient rehabilitation. He was fit with bilateral ischial weight-bearing knee-ankle-foot orthoses (KAFO) and began gait training. On discharge from the rehabilitation unit, he was walking 45m (150ft) with stand-by assistance using KAFOs and a posterior walker. **Assessment/Results:** On evaluation 2 months after discharge from the hospital, the patient demonstrated continued functional improvement. He was standing or walking 4 hours daily using his KAFOs without an assistive device. He performed all activities of daily living except bathing and meal preparation with minimal assistance to supervision. **Discussion:** Boys with DMD typically lose the ability to ambulate between the ages of 8 and 12 years. This patient is unique because he maintained the ability to walk up to age 16 years and was able to regain ambulation after not walking for a prolonged period. The unusual success in this patient is thought to be due to many factors, including early steroid therapy, ischial weight-bearing KAFOs, his short stature, the patent and family’s extreme motivation, and the input from a team of professionals with significant knowledge about DMD. **Conclusions:** Prolonged ambulation is possible in boys with DMD who are of short stature and motivated to ambulate. Additionally, a period of nonambulation does not necessarily rule out the possibility of future ambulation. **Key Words:** Duchenene, Pediatrics; Rehabilitation.

**Poster 236**

Abnormalities in Language Circuity in Children With Traumatic Brain Injury: A Functional Magnetic Resonance Imaging Study. Prasanna Karunanayaka, PhD; Scott Holland, PhD; Weihong Yuan, PhD; Mekibib Altaye, PhD; Blaise Jones, MD; Linda J. Michaud, MD (Cincinnati Children’s Hosp Med Ctr, Cincinnati, OH); et al. Disclosure: P. Karunanayaka, None; S. Holland, None; W. Yuan, None; M. Altaye, None; B. Jones, None; L.J. Michaud, None.

**Objectives:** To determine whether functional MRI (fMRI) is sensitive to changes in the neural substrate of language in young children following traumatic brain injury (TBI) and to evaluate associations of blood oxygen level dependent (BOLD) activation with performance on language-specific neuropsychologic tests. **Design:** Cohort comparison. **Setting:** Tertiary children’s hospital and research foundation. **Participants:** 8 children with TBI (age range, 6–9y) and a comparison
group of 9 children with orthopedic injuries (age range, 6—9y).

Interventions: Not applicable. Main Outcome Measures: fMRI study of covert verb generation, NEPSY verbal fluency scores, and Differential Ability Scale (DAS) verbal intelligence quotient (IQ) scores.

Results: fMRI of the verb generation task revealed significantly different BOLD signal activation in perisylvian language areas between the groups of children with TBI and orthopedic injuries. Some regions of higher activation intensity were observed in the orthopedic injuries group (P < .001) and other regions of higher intensity in the TBI group (P < .02). Associations were significant in the combined group of TBI and orthopedic injuries subjects between BOLD signal activation and NEPSY verbal fluency scores (P < .05) and DAS verbal IQ scores (P < .01). Within the TBI group, children with lower Glasgow Coma Scale scores showed greater deficits on neuropsychologic indices and greater differences in the areas of fMRI activation (P < .005).

Conclusions: This study suggests that children with TBI have significantly different brain activation patterns in language circuitry as compared with children with orthopedic injuries. Our study demonstrates the feasibility and potential utility of fMRI as a means of quantifying changes associated with language deficits in future pediatric TBI studies, including studies of rehabilitative interventions.

Key Words: Brain injuries; Child; Magnetic resonance imaging; functional; Rehabilitation.

Poster 237
Oral Baclofen Prescribing Practices in the Treatment of Pediatric Hypertonia. Sharon Gohari, MD (Rehabilitation Institute of Chicago, Chicago, IL); Karin Baker, MD; Sarina Pasricha, BA; Deborah Gaebler-Spira, MD.

Disclosure: S. Gohari, None; K. Baker, None; S. Pasricha, None; D. Gaebler-Spira, None.

Objective: To define typical prescribing practices and parameters for using oral baclofen to treat pediatric hypertonia. Design: Cross-sectional survey; level of evidence, 5. Setting: Online surveys forwarded to practitioners listed on the AAPM&R Pediatrics Special Interest Group and AACPDF listservs. Participants: Respondents identified themselves as 1 or more of the following: pediatrics, pediatric neurology, adult and/or pediatric physical medicine and rehabilitation, orthopedic surgery, neurodevelopmental disabilities, developmental-behavioral pediatrics, nurse practitioner, and other.

Interventions: Not applicable. Main Outcome Measures: Respondents completed a secure, on-line survey consisting of 29 questions. Key questions addressed population dynamics, maintenance and tapering strategies, use in sleep and/or comfort, adverse reactions, efficacy measures, benefits, long-term use, and differences in treatment strategies for adult and pediatric patients. Responses were analyzed and entered into a single spreadsheet by a single recorder and analyzed via descriptive statistics. Results: 142 surveys were completed. Key findings included: 98.58% of respondents treated pediatric hypertonia in their practices, of which 83.33% prescribed oral baclofen. 57% of respondents treated adult hypertonia, and approximately 30% applied similar treatment strategies to adults and children. 93% of respondents found that baclofen was beneficial in the treatment of hypertonia and over 80% felt that baclofen was beneficial over a long period of time.

Conclusions: The survey demonstrated that the majority of respondents who treat pediatric hypertonia found use of oral baclofen to be efficacious, with benefits including improved function, sleep, and pain relief. The results of this study provide insight into current practice parameters for oral baclofen use in pediatric hypertonia, and will assist in future research and dosing standards. Key Words: Baclofen; Cerebral palsy; Muscle hypertonia; Rehabilitation.

Poster 238
Rehabilitation of Hemiparesis, Neglect, Mutism, and Dysphagia Following Hemispherectomy for the Treatment of Intractable Seizures: A Case Report. Alicia B. Feldman, MD (University of Colorado Health SciencesCtr, Denver, CO); Susan Apkon, MD.

Disclosure: A. B. Feldman, None; S. Apkon, None.

Setting: Tertiary care pediatric hospital. Patient: A 12-year-old girl with intractable seizures. Case Description: The patient is a 12-year-old girl with a history of Sturge-Weber syndrome and intractable seizures. Prior to admission, the patient was ambulatory and independent in all activities of daily living (ADLs). After undergoing a functional hemispherectomy involving primarily the right parietal and temporal lobes, the patient developed a dense left hemiparesis, left visual field neglect, mutism, and dysphagia. She was not ambulatory and was totally dependent in all ADLs. Once medically stable, the patient participated in an intensive interdisciplinary inpatient rehabilitation program, including physical, occupational, and speech therapies. Assessment/Results: This patient made improvements in all areas of gross motor, adaptive skills, and communication. At discharge, the patient had gained strength in her left lower extremity and was able to ambulate 1.5m (5ft) with contact guard assistance while wearing a left ankle-foot orthosis. She had no active movement in her left upper extremity. She required moderate assistance with dressing. She was communicating in 6 to 8 word sentences. The patient was transitioning from nasogastric feeds to a mechanical soft diet with thin liquids. The patient’s left neglect improved. Her memory and attentional skills returned to baseline. Her length of stay on the rehabilitation service was 31 days. Discussion: Hemispherectomy for the treatment of intractable seizures is being done with increasing frequency in the pediatric population. Impairments following surgery can be significant and impact function. Participation in a comprehensive interdisciplinary rehabilitation program may be an important part of the recovery process for this group of children. Conclusions: Children who undergo hemispherectomy for the treatment of intractable seizures can have post-operative impairments, including hemiparesis, neglect, mutism, and dysphagia, which improve with multidisciplinary rehabilitation.

Key Words: Pediatrics; Rehabilitation; Seizures.

Poster 239
Transitioning Adolescents Toward Adulthood: A Program to Set Goals and Overcome Barriers to Independence. Kristin Balfanz-Vertiz, MSW (Schwab Rehabilitation Hospital, Chicago, IL); Kimberly M. Taylor, MA; Citlaly R. Gomez, BS; Michelle Gittler, MD.

Disclosure: K. Balfanz-Vertiz, None; K.M. Taylor, None; C.R. Gomez, None; M. Gittler, None.

Setting: Rehabilitation hospital located in a low-income, urban neighborhood. Program: Making Tracks to Transitions (Transitions) is a program designed to assist youth with disabilities as they transition to adulthood. Program Description: The location of Transitions within a hospital makes it different from other transitional programs in that a primary emphasis is placed on medical issues, including decreasing independence in setting appointments, asking questions of doctors, and ordering supplies. However, the program also focuses on increasing independent living skills and bolstering psychosocial development. When people are enrolled in the Transitions program, assessments are completed with the young adult and his/her family. Age-appropriate goals are set, with an emphasis on the youth’s priorities. In addition to one-on-one case management, youth are encouraged to participate in educational workshops and recreational outings. These activities teach new skills and encourage social networking between youth who face similar life challenges. Assessment/Results: On enrollment in the
Transitions program, only half of the participants have been enrolled in school, although none have diplomas. They all live in inaccessible homes and have not been able to get the equipment they need to exit their homes independently. Other issues include transportation, sexuality, self-image, and a general lack of community resources. We discuss how these participants have set age-appropriate goals for themselves and created plans for overcoming barriers to their goals.

Discussion: As well as program methodology and execution, we present case studies of program participants. Conclusions: We demonstrate how a hospital can play a key role in assisting youth in gaining the skills and knowledge they need to function as independent adults. Key Words: Adolescence; Disabled persons; Rehabilitation; Social class.

Poster 240
Spina Bifida With Severe Scoliosis and Grade 5 Retrolisthesis With Minimal Neurologic Deficits or Pain: A Case Report. Scott Horn, DO (University of North Carolina, Chapel Hill, NC); Joshua Alexander, MD; Edmund Campion, MD.

Disclosure: S. Horn, None; J. Alexander, None; E. Campion, None.

Setting: Tertiary care hospital. Patient: A 3-year-old boy with lumbar spina bifida. Case Description: The boy presented to a spina bifida clinic for follow-up. The patient has a history of tethered cord lipomyelomeningocele with lumbar lamiectomies and release of tethered cord performed at 8 months of age. He was very active and age-appropriate in gross and fine motor function skills. Physical exam findings revealed 5/5 muscle strength testing in all lower extremities except 4+/5 in the tibialis anterior and peroneals. Mild claw-toe deformity and excessive supination were present. Gait was smooth with and without supramalleolar orthosis. Assessment/Results: Lumbar magnetic resonance imaging showed marked lumbar kyphosis identified from the L1 to L4 vertebrae, measuring approximately 56°. The L3 vertebral body demonstrated greater than 100% retrolisthesis relative to the L4 vertebral body. There was severe canal stenosis at the L3 vertebrae, with obliteration of the canal. The pediatric rehabilitation team worked with orthopedic surgery, neurosurgery, and urology. Given the patient’s excellent motor exam, despite the severe retrolisthesis, it was decided surgery was not urgently indicated. The team worked with orthopedic surgery, neurosurgery, and urology. The L3 vertebral body demonstrated greater than 100% retrolisthesis relative to the L4 vertebral body. There was severe canal stenosis at the L3 vertebrae, with obliteration of the canal. The pediatric rehabilitation team worked with orthopedic surgery, neurosurgery, and urology. Given the patient’s excellent motor exam, despite the severe retrolisthesis, it was decided surgery was not urgently indicated. The team decided to repeat urodynamic studies to make sure there had been no change from baseline with subsequent bladder involvement. The patient has continued to progress appropriately in all his milestones and we anticipate beginning bowel and bladder programs on his return to clinic if there is no evidence of worsening urodynamic studies. Discussion: While patients with spina bifida are known to have increased incidence of spondylolisthesis, this is a rare case in which such severe retrolisthesis is noted with very mild deficits. Conclusions: It is possible to have lumbar spina bifida and grade 5 retrolisthesis with very mild neurologic involvement. Guidelines may need to be adjusted for when surgery in this patient population is appropriate. Key Words: Pediatrics; Rehabilitation; Spondylolisthesis.

Poster 241
The Role of Salivary Gland and the Botulinum Toxin Injections in Reducing the Frequency of Aspiration Pneumonia in Children With the CHARGE Association: A Case Report. Nilusha T. Fernando, DO (Temple University Hospital, Philadelphia, PA); Heakyung Kim, MD.

Disclosure: N.T. Fernando, None; H. Kim, None.

Setting: Tertiary care facility. Patient: A 2-year-old boy with a history of the CHARGE association (coloboma, heart defects, atresia [choanal], retardation of growth and neurodevelopment, genitourinary abnormalities and ear abnormalities). Case Description: We describe a case of a child with the CHARGE association. He had a history of numerous hospitalizations for aspiration pneumonia prior to trials of botulinum toxin type A injections to the salivary glands. Assessment/Results: Following the intervention, the frequency of acute care admissions for pneumonia dramatically decreased. Significantly decreased frequency of suction and cough were reported. He was able to be off anticholinergics for his drooling. Discussion: The CHARGE association is a multisystem syndrome with a wide range of clinical manifestations. Respiratory abnormalities, although not represented in the acronym, can cause significant morbidity and mortality in these patients. Children with this disorder are often at high risk for aspiration and swallowing problems, and aspiration has been implicated as the most common cause of mortality in this population. Conclusions: Aspiration and its resultant respiratory complications are a common cause of hospitalizations and death in children with the CHARGE association. The use of botulinum toxin targeting the salivary glands may represent a useful measure in reducing the morbidity and mortality associated with the respiratory complications of this disease. Key Words: Aspiration pneumonia; Botulinum toxins; Rehabilitation; Salivary glands.

Poster 242
Child Abuse Screening in Pediatric Feeding Dysfunction Clinics: A Case Report. Chirag A. Patel, MD (Pitt County Memorial Hospital, Greenville, NC); George W. Crowl, MD; Daniel Moore, MD.

Disclosure: C.A. Patel, None; G.W. Crowl, None; D. Moore, Consultant for Blue Cross Blue Shield of North Carolina.

Setting: Pediatric feeding dysfunction clinic. Patient: A 3-month-old girl with poor feeding. Case Description: The patient was born at 32 weeks of gestation, and her medical history included gastroesophageal reflux disease and gastrointestinal dysmotility. She was being treated with erythromycin, metoclopramide, and lansoprazole. At presentation to the feeding clinic, the patient had been receiving formula feeds by feeding pump. Her weight had increased by 1757g since her birth. Review of systems questions posed to the patient’s mother revealed absence of choking, vomiting, frequent reflux, constipation, diarrhea, infection, motor and speech skill delays, fractures, and skin breakdown. On examination, the patient was noted to have difficulty sustaining a tight seal with her mouth on the bottle nipple. Swallow study showed consistent penetration with thinner liquids. Recommendations for a wider nipple and thickened formula were made, and the patient was scheduled for evaluation of gastrostomy tube placement. 2 weeks later, the patient presented to a local hospital and required transfer to a tertiary pediatric hospital. Radiologic imaging and exam were significant for bilateral subacute subdural hematomas, right frontal scalp swelling, rib fractures of multiple ages, and right retinal hemorrhages. The patient displayed impairments in age-appropriate and age-adjusted fine and gross motor skills, intellect, and development. Assessment/Results: The patient was diagnosed with severe traumatic brain injury secondary to nonaccidental trauma. She was treated in the pediatric rehabilitation unit and improved. Discussion: This case illustrates that multiple independent child abuse risk factors, such as the stress of parenting and situations involving handicapped children, are likely to be seen in settings such as pediatric feeding clinics. Conclusions: Patients may be better served in feeding clinics by the routine screening of caretakers for signs of increased risk of child abuse. Key Words: Child abuse; Feeding behavior; Rehabilitation.

Poster 243

Development of Autonomic Dysreflexia in a Teenager With Mid-Thoracic Level Myelomeningocele: A Case Report. David W. Pruitt, MD (Cincinnati Children’s Hospital Medical Ctr, Cincinnati, OH).

Setting: Tertiary care pediatric hospital. Patient: An 11-year-old boy with mid-thoracic level myelomeningocele. Case Description: The patient presented to the emergency room with intermittent, worsening episodes of diaphoresis and piloerection above his level of injury, facial flushing, and mild elevation in blood pressure in the month prior to evaluation. Symptoms did not correlate with positioning or timing of catheterizations. Urinalysis and culture revealed infection with Pseudomonas aeruginosa and the patient started treatment with appropriate antibiotics with subsequent resolution of symptoms. The patient had not exhibited similar symptomatology with prior urinary tract infections. Assessment/Results: Magnetic resonance imaging (MRI) of his cervical and thoracic spine was obtained to evaluate for the presence of anatomic changes in his lesional level, which could have potentiated the presence of autonomic dysflexia with noxious stimuli. MRI revealed significant kyphosis with angulation between T7 and T8 and significant narrowing of the thecal sac at this level. In addition, the area of wedging included a large intramedullary cystic lesion with near effacement of cerebrospinal fluid surrounding the lesion. Discussion: Changes in neurologic examination or function, including new autonomic dysreflexia, are clues to evaluate patients for changes in spinal cord involvement. Close monitoring and potential evacuation are options in the management of syrinx formation. Education of the patient and family about evaluation for causes as well as treatment of autonomic dysreflexia are essential in optimizing clinical care. Treatment of noxious stimuli, including syringomyelia, will often alleviate dysreflexic symptoms, but these symptoms can recur with future stimuli. Conclusions: Presentation of new symptomatology suggestive of autonomic dysreflexia in thoracic level myelomeningocele patients should elicit an evaluation for potential causes of ascending neurologic level of involvement. Key Words: Autonomic dysreflexia; Myelomeningocele; Pediatrics; Rehabilitation.

Poster 244

Lymphedema Therapy in Klippel-Trénaunay Syndrome: A Case Report. Alicia A. Hillman, MD (Mayo Clinic, Rochester, MN); Kenley D. Schmidt, MD

Setting: Tertiary medical center. Patient: A 17-month-old girl born with an edematous left leg. Case Description: The patient was found to have an enlarged left leg during a third trimester ultrasound. This finding persisted to the time of birth. At 12 months, she developed a clear drainage from her left leg and cellulitis. The patient was referred at 17 months of age for lymphedema consultation for persistent limb edema. Assessment/Results: On exam, the patient was a healthy 17-month-old child who was friendly and playful. She was an intelligent child and had met her milestones on target. Her left leg was markedly larger than her right throughout, measuring a mean 8cm difference in circumference. Superficial venous vascular malformations were noted, but no port wine stains. There were no further signs of cellulitis. No neurologic abnormalities were present. Scanogram showed a 1.7cm leg-length discrepancy, left longer than right. Magnetic resonance imaging demonstrated extensive vascular malformations present in the subcutaneous tissue and less extensively into deep muscle compartments of the left leg without obvious extensive involvement of the hip, knee, or ankle. She was diagnosed with Klippel-Trénaunay syndrome (KTS). For lymphedema control, she was fitted with a thigh-high compression stocking with a waist attachment. Heel lift was recommended for leg-length discrepancy. Discussion: KTS is a congenital anomaly characterized by unilateral limb overgrowth, venous varicosities, and capillary malformations. 95% of cases involve the lower extremity. Hypertrophy of the extremities can be extreme, requiring amputations. Lymphatic involvement can affect wound healing. Treatment is targeted at symptom management as well as maximizing and maintaining function. Physiatriac referral can provide patients with effective conservative measures. Conclusions: KTS poses relevant clinical challenges to the physiatrist, including lymphedema management, leg-length assessment with modifications, gait analysis, and presurgical counseling. Key Words: Klippel-Trénaunay-Weber syndrome; Lymphedema; Rehabilitation; Stockings, compression.

Poster 245

Prevalence of Low Back Pain in 7542 School Children Between 13 and 15 Years. Stefano Masiero, MD (University of Padova, Padova, Italy); Andrea Celia, MD; Diego Sarto, MD; Elena Carraro, MD; Mario Ermani, MD; Marco Ortolani, MD.

Disclosure: S. Masiero, None; A. Celia, None; D. Sarto, None; E. Carraro, None; M. Ermani, None; M. Ortolani, None.

Objective: To analyze the prevalence of low back pain (LBP) in adolescent subjects. Design: Screening program with questionnaire interview. Setting: Secondary school in Padova, Italy. Participants: 7542 adolescent subjects (3777 boys, 3765 girls; age range, 13–15y; average age, 14.8±1.1y). Interventions: Not applicable. Main Outcome Measures: Prevalence of LBP and correlated factors. Results: 1180 subjects (15.6%) (429 boys, 751 girls) reported 1 or more episodes of LBP; of these, 324 (27.3%) requested further medical investigation. LBP was more frequent in girls (P<.000) and in subjects with familiarity with this problem (P<.000), with long sedentary periods during the day (P=.003), and who lacked regular sports activities (P<.000). In the subjects who practiced sports, aerobics activities correlated with LBP (P=.000), but no significant correlations were found with volleyball, basketball, soccer, and swimming, or with length of training (number hours per week) (P range, .323–.063). No significant correlation was found with height, weight, body mass index, smoking, or degree of academic gratification (P range, .323–.063). Conclusions: LBP is a frequent event in the adolescent population, particularly among girls. Key Words: Adolescence; Low back pain; Mass screening; Rehabilitation.

Poster 246

The Falling Young Female Athlete: A Unique Presentation of Peripheral Neuropathy in a Patient With Benign Hypergammaglobulinemia of Waldenström. Ai Mukai, MD (Rehabilitation Institute of Chicago, Chicago, IL); Christina Marciniak, MD; Charles Sisung, MD.

Disclosure: A. Mukai, None; C. Marciniak, None; C. Sisung, None.

Setting: Outpatient electrodiagnostic laboratory. Patient: A 17-year-old woman with benign Waldenström’s hypergammaglobulinemic purpura. Case Description: A 17-year-old woman with history of benign hypergammaglobulinemia of Waldenström presented to pediatric physiatry for evaluation of chronic pain. She reported multiple falls during athletic activities, lower-limb rashes, and feet numbness precipitated by cold for several months. Hypergammaglobulinemia of Waldenström’s had been diagnosed about 18 months previously, when she developed a rash in her bilateral lower extremities associated with elevated immunoglobulin G level. Prednisone decreased pain but not falls or numbness. She was referred for electrodiagnostic studies by the
pediatric physiatrist, where her right lower-limb strength was 4+/5 and left lower-limb strength was normal. Muscle stretch reflexes were brisk but symmetrical at the bilateral patellae, medial hamstrings, and Achilles’. Dorsal pedal pulses were diminished in the right foot. She also had multiple scabs on her feet, which she said were from ice skates. On nerve conduction studies, bilateral lower-limb sensory nerve responses were absent, while lower-limb motor conduction velocities were slowed. Temporal dispersion and probable conduction block in the right peroneal nerve were noted. Findings were thought to be most consistent with an acquired distal demyelinating greater than axonal neuropathy, though occasional spontaneous activity in the distal lower limb demonstrated some evidence of axonal involvement as well. Discussion: Hypergammaglobulinemia of Waldenström’s is a polyclonal gammopathy resulting in nonthrombocytopenic purpura in activities that increase venous pressure. Treatment is often not required and neuropathy has not been described. Conclusions: Benign hypergammaglobulinemia of Waldenström’s is an unusual immune complex disorder. To our knowledge, this is the only reported case of neuropathy in this context and thus not initially suspected despite its effects on mobility and function. Early and appropriate assessment, as well as electrodiagnostic testing can guide treatment. Key Words: Electrodiagnosis; Hypergammaglobulinemia; Pediatrics; Polynuropathies; Rehabilitation.

Poster 247
Delayed Onset Choreic Movement in Cerebral Palsy. Jin Young Kang, MD (Asan Medical Ctr, Seoul, Republic of Korea); Jung Hwan Lee, MD; In Young Sung, MD.
Disclosure: J.Y. Kang, None; J.H. Lee, None; I.Y. Sung, None.
Setting: Tertiary care hospital. Patient: An 8-year-old boy with cerebral palsy (CP) presenting with newly developed choreic movement. Case Description: He had been treated for jaundice with hyperbilirubinemia in the neonatal intensive care unit for 2 weeks after birth. Gross motor milestone was delayed and he was unable to walk independently until 27 months old. As well, he showed abnormal involuntary movement when performing purposeful movements. He visited the department of rehabilitation medicine at 4 years of age, where he was diagnosed with a mixed type of spastic hemiplegic and dyskinetic type of CP. With rehabilitation treatment, his functionality was much improved in that he could walk independently, although dystonic movement intermittently manifested. No neurologic or clinical deterioration had appeared until choreic movement developed in the right lower extremity at 7 years of age. He was unable to walk even with assistive devices, as choreic movement was aggravated. Brain magnetic resonance imaging, electroencephalography, and genetic studies were performed but revealed no significant findings. Brain positron emission tomography showed decreased metabolic activity in the posterior putamen of both sides. Assessment/Result: After taking intensive rehabilitation treatment with administration of inolanzapin and clonazepam, he was able to stand and walk with a walker. Discussion: CP is commonly considered as a static encephalopathy. As patients get older, involuntary movements that have not been present at a younger age can be developed after stabilization of early clinical manifestations. This occurred without any additional brain lesion and was explained by aberrant and tardive myelinization subsequent to perinatal cerebral insult. Conclusions: Delayed-onset choreic movement in a child diagnosed with a mixed type of CP earlier could be well controlled by rehabilitation treatment with medications. He regained the functional ability to walk with an assistive device. Key Words: Cerebral palsy; Chorea; Rehabilitation.

Poster 248
Spasticity Treatment Services in Patients With Cerebral Palsy in the United States. Maria A. Ocasio-Silva, MD (Medical College of Wisconsin, Milwaukee, WI); Elizabeth A. Moberg-Wolff, MD; Timothy R. Dillingham, MD; J. Bradford Rice, MA.
Disclosure: M.A. Ocasio-Silva, None; E.A. Moberg-Wolff, None; T.R. Dillingham, None; J.B. Rice, None.
Objective: To identify patterns of spasticity diagnoses and treatment provisions in patients with cerebral palsy (CP) in the United States. Design: Cross-sectional study. Setting: Not applicable. Participants: Privately insured persons in the United States during 1998 with diagnosis of CP in the MarketScan Commercial Claims & Encounters Database (MED-STAT Group). Interventions: Not applicable. Main Outcome Measures: The scope and characteristics of spasticity diagnoses and treatment in CP patients were evaluated by exploring the Market Scan Database, utilizing CPT and ICD-9 codes commonly used in these conditions. Spasticity encounters were characterized by analyzing the data about diagnosis of CP or related symptoms, and orthopedic, botulinum toxin or phenol injections, and/or intrathecal baclofen (ITB) pump procedures. Results: Around 41,000 spasticity diagnoses-related claims were identified. 2710 of those claims were from patients with a diagnosis of any type of CP. Of these, 65% of claims were from patients less than 18 years. The main spasticity-related symptom in CP patients was spasm of muscle (14.2%), followed by hip subluxation (10.6%). The main procedure done in these patients was botulin toxin or phenol injection (10.4%), followed by tendon lengthenings (4.5% hip adductor, 4.2% hamstring, 4.2% heelcord). Adults (those >21y) encompassed 35% of the patients identified, but received fewer treatment procedures, including orthopedic (1.3%), botulin toxin or phenol injections (1.4%), and ITB pumps (1.0%). Conclusions: The relatively small proportion of spasticity treatments received by adult CP patients raises concerns about underservice and quality of care of these patients. These findings reflect the state of care in 1998, at the time when spasticity management was just beginning to become widespread. Future studies should examine contemporary management for these persons to further our knowledge regarding access to care. Key Words: Adult; Cerebral palsy; Muscle spasticity; Pediatrics; Rehabilitation.

Poster 249
Use of Botulinum Toxin Type A in Birth Brachial Plexus Palsy: A Case Series. Linda J. Michaud, MD (Cincinnati Children’s Hosp Med Ctr, Cincinnati, OH); Charles T. Mehlm, DO; Susan L. Foad, MPH; Kevin P. Yakuboff, MD.
Disclosure: L.J. Michaud, None; C.T. Mehlm, None; S.L. Foad, None; K.P. Yakuboff, None.
Setting: Tertiary children’s hospital. Patients: Case series of 16 consecutive children with birth brachial plexus palsies (BBPP) injected with botulinum toxin type A (BTX-A). Case Descriptions: 16 cases of children with BBPP were retrospectively reviewed for outcomes following BTX-A injections to address individualized goals at the shoulder or elbow. Measures before and 1 to 2 months after injections were individualized for patient-specific indications for injection, including Mallet classification for active shoulder movement, passive shoulder external rotation range of motion (ROM), active biceps brachii strength, passive elbow extension ROM, parent reports of satisfaction (1–10 scale), and changes in function or pain. Age, indications, surgical histories, injection sites and doses, postinjection therapy programs, and outcomes of 16 cases are described. Assessment/Results: Muscles in 9 shoulders and 7 elbows were injected. At the shoulder, for unbalanced strong internal rotation force, 7 children had pectoralis major and latisimus dorsi injections and 2 children who had undergone surgical transfer of their latisimus dorsi muscles had only pectoralis major injections. At the elbow, 5 triceps were...
injected to reduce co-contractions and to facilitate motor learning. In 1 of these children, a gracilis free flap had been performed to create a neobiceps and another had undergone primary nerve reconstruction. 2 children received injections to the biceps to facilitate stretching of elbow flexion contractures. 13 of 16 children improved postinjections. Factors were identified that were associated with positive responses. Discussion: While not typically used in conditions affecting the lower motoneuron, BTX-A injections can be used safely and effectively in children with BBPP. Conclusions: BTX-A injections can be beneficial in children with BBPP to address muscle imbalance, to reduce co-contractions, or adjunctively for motor learning or casting to decrease contractures. Key Words: Botulinum toxin type A; Brachial plexus; Child; Rehabilitation.

Poster 250
Intrathecal Baclofen Dosing in Pediatric Patients With Cerebral Palsy. Margaret Carmody, BS; Elizabeth A. Moberg-Wolff, MD (Medical College of Wisconsin, Brookfield, WI).
Disclosure: M. Carmody, None; E.A. Moberg-Wolff, Medtronic Neurological.

Objective: To identify longitudinal dosing patterns for intrathecal baclofen (ITB) in pediatric patients with quadriplegic cerebral palsy (CP). Design: Retrospective chart review over a 10-year period. Setting: Tertiary care pediatric PM&R clinic. Participants: 138 patients under the age of 21, who had an implanted ITB pump for at least 6 months. Interventions: Not applicable. Main Outcome Measures: Charts were reviewed for sex, age, diagnosis, date of implant, baclofen concentration, baclofen dosage and dosing pattern at each clinic visit, and medical or surgical information that may have affected the patient’s overall spasticity, pump dosing, or pump function. 1 practitioner evaluated all patients and made the majority of dosing changes, based on family, patient, therapist, and clinical needs. Each patient’s information was plotted graphically as a function of dosage versus time. Results: Initial dosing patterns indicated a stabilization in dose within 6 months after implant for the majority of patients. Significant deviations (>20%) from this dose or continued increases in dosage without plateau often indicated an ineffective delivery system or significant medical issues impacting the patient’s tone. Several abnormal patterns were identified. Ranges of what were felt to be an effective dose varied widely within this patient population. Conclusions: Overall, effective doses varied greatly in quadriplegic CP patients. Recognizing “effective” versus “ineffective” dosing patterns may prove a valuable tool in early detection of ITB delivery system malfunctions. Key Words: Baclofen; Cerebral palsy; Muscle spasticity; Pediatrics; Rehabilitation.
Physiatric Therapeutics

Poster 251
Improved Swallowing After a Trial of Electric Stimulation in Patient With Myasthenia Gravis: A Case Report. Stacey Miller-Smith, MD (NJMS/Kessler Residency, Newark, NJ); Peter Won, MD; Kate Bracken, MACC-SLP.

Setting: Acute inpatient rehabilitation center. Patient: A 75-year-old woman with myasthenia gravis (MG). Case Description: The patient had a 3-month history of progressively worsening weakness of primarily bulbar muscles and was diagnosed with MG via positive anti-acetylcholine receptor antibodies and a positive Tensilon test. Initial fiberoptic endoscopic evaluation of swallowing with sensory testing (FEEST) revealed severe oropharyngeal phase dysphagia characterized by delayed swallow initiation, pharyngeal pooling with retesting (FEEST) revealed severe oropharyngeal phase dysphagia characterized by delayed swallow initiation, pharyngeal pooling with retesting (FEEST) revealed severe oropharyngeal phase dysphagia characterized by delayed swallow initiation, pharyngeal pooling with retesting.

Discussion: MG is clinically characterized by pathologic fatigue with repetitive muscular contraction. While it may seem counterintuitive to apply electric stimulation to improve muscular function, the patient’s dysphagia improved after 6 sessions and continued to improve over the following several months. She was advanced to and tolerated a dysphagia diet after only 1 month of treatment. Conclusions: While some of the patient’s improvements in dysphagia may have been the natural remission of her disease, electric stimulation (with caution to avoid fatigue) as a treatment modality for dysphagia may have been the natural remission of her disease, electric stimulation (with caution to avoid fatigue) as a treatment modality for dysphagia may have been the natural remission of her disease, electric stimulation (with caution to avoid fatigue) as a treatment modality for dysphagia may have been the natural remission of her disease, electric stimulation (with caution to avoid fatigue) as a treatment modality for dysphagia may have been the natural remission of her disease, electric stimulation (with caution to avoid fatigue) as a treatment modality for dysphagia may have been the natural remission of her disease, electric stimulation (with caution to avoid fatigue) as a treatment modality for dysphagia may have been the natural remission of her disease, electric stimulation (with caution to avoid fatigue) as a treatment modality for dysphagia may have been the natural remission of her disease, electric stimulation (with caution to avoid fatigue) as a treatment modality for dysphagia.

Key Words: Dysphagia; Myasthenia gravis; Rehabilitation; Stimulation, electric.

Poster 252
Intervertebral Disk Cells Respond to Different Magnitudes of Tensile Stress With Alterations in Gene Expression. Gwendolyn Sowa, MD, PhD; Joao Paulo Coelho, MS; Christina Iucu, MS; Helga Georgescu, BS; Alan Chu, MD (Univ of Pittsburgh, Pittsburgh, PA); James Kang, MD.

Disclosure: G. Sowa, None; J.P. Coelho, None; C. Iucu, None; H. Georgescu, None; A. Chu, None; J. Kang, None.

Objective: To investigate the threshold at which mechanical forces can have both reparative and traumatic effects on the spine. Design: Controlled in vitro study of rabbit annulus fibrosus cells. Setting: Not provided. Animals: Rabbits. Interventions: Rabbit fibrochondrocytes from the annulus fibrosus were cultured in the presence or absence of an inflammatory stimulus (1ng/mL interleukin-1β). Cells were then exposed to tensile stress at 3% (low), 6% (moderate), and 18% (high), with frequencies of either 0.1Hz (low) or 0.5Hz (high), and compared with unstressed cells. Main Outcome Measures: After 4 hours, the messenger ribonucleic acid expression of inducible catabolic mediators of inflammation and matrix degradation as well as structural proteins were measured by quantitative real-time polymerase chain reaction and compared with control cells. Results: Low magnitudes and frequencies of tensile strain resulted in down-regulation of catabolic mediators and modest stimulation of structural proteins. However, low of this protective effect was observed at a higher frequency and magnitude. In examining the ratio of matrix metalloproteases to their endogenous inhibitors, which provides information about the catabolic balance within the cell, a more favorable response was again seen at low frequencies and moderate levels of strain. Conclusions: These data suggest an anti-inflammatory and protective effect of moderate tensile stress at low frequencies. This effect is lost at higher magnitudes or frequencies. These in vitro data confirm that a biochemical mechanism contributes to the threshold response of the tissues to various levels of mechanical strain. This may help to explain the beneficial effects of motion-based therapies, as well as the destructive effect of traumatic levels of stress. Further studies are needed to determine how these forces correspond with those experienced through different movements of the lumbar spine. Key Words: Inflammation; Intervertebral disk; Rehabilitation; Stress, mechanical.

Poster 253
Iontophoresis Using Acetic Acid for the Treatment of Shoulder Pain due to Osteophytic Spurring at the Acromioclavicular Joint. Bruce E. Porter, MD (Mississippi Physical Medicine and Rehabilitation and Pain Management Ctr, Tupelo, MS).

Disclosure: B.E. Porter, None.

Objective: To determine if iontophoresis using acetic acid will result in radiographic evidence of diminished osteophytic spurring at the acromioclavicular joint, and in the area of the coracoclavicular and the coracoacromial ligaments, with resultant decreased subjective pain in the area of the shoulder and increased pain-free range of motion (ROM) and function of the shoulder joint in subject patients. Design: Intervention study. Setting: Outpatient clinical physiatry and pain management practice. Participants: Selected patients with symptomatic shoulder pain, bilateral or unilateral, with radiographic evidence of osteophytic spurring in the area of the acromioclavicular joint and/or the area of the coracoclavicular and the coracoacromial ligaments. Intervention: Iontophoresis with 5% acetic acid 3 times per week for 4 to 12 weeks, over the area of the affected symptomatic shoulder joint. Main Outcome Measures: Interval radiographic, physical examination, and subjective questionnaire data were gathered to determine if there was a reduction or elimination of the spurring and if it correlated with a decrease in physical examination findings and subjective complaints with resultant increased shoulder joint function. Results: Preliminary data indicate that this intervention does reduce osteophytic spurring in the area of the acromioclavicular joint, however, other shoulder joint pathology must be accounted for when attempting to determine if this intervention alone could be expected to successfully result in decreased shoulder pain with increased ROM and function at the shoulder joint. Conclusions: The intervention will continue in order to determine whether sufficient evidence exists to make recommendations for protocol-based nonsurgical treatment guidelines for the treatment of symptomatic osteophytic spurring of the acromioclavicular joint, with iontophoresis and acetic acid, in order to decrease pain and improve shoulder function. Key Words: Acromioclavicular joint; Iontophoresis; Pain; Rehabilitation.

Poster 254
Resolution of Persistent Hiccups After Cervical Manipulation: A Case Report. Terrence R. McNamara, DO (Mayo Clinic, Rochester, MN); Jeffrey R. Basford, MD, PhD; David C. Weber, MD.

Disclosure: T.R. McNamara, None; J.R. Basford, None; D.C. Weber, None.

Setting: Tertiary care hospital. Patient: A 44-year-old man with a right middle cerebral artery ischemic stroke. Case Description: The patient was admitted following the sudden onset of left hemiparesis. Imaging was compatible with cardioembolic occlusion and he under-
went successful angiographic clot retrieval. The patient’s initial course was uneventful and he was transferred to our rehabilitation unit on hospital day 9. 2 days later, he noted the onset of prolonged bouts of hiccups that were not associated with new neurologic findings. Chest radiographs did not reveal aspiration pneumonitis or other causes of diaphragm irritation. Trials of baclofen, chlorpromazine, and metoclopramide were unsuccessful and resulted in sedation that impaired his ability to participate in therapy. Assessment/Results: Neurologic examination was stable. There were segmental cervical motion restrictions and tenderness to palpation over the right C3, 4, and 5 transverse processes. There was muscular hypertonicity and tenderness in the right scalenes and bilateral suboccipital musculature. The patient agreed to a trial of cervical manipulation using muscle energy, myofascial release, and counterstrain techniques. He noted complete resolution of his hiccups within 1 hour of treatment, which persisted until hiccups reoccurred following a transesophageal echocardiogram (TEE) 10 days later. Re-examination revealed findings similar to those at previous visits. In addition, medications used for hiccups may be limited by unacceptable side effects. This patient’s hiccups resolved after manipulation despite being refractory to extensive medication trials, and again resolved with manipulation following a recurrence after a TEE. Conclusions: Although further investigation is necessary, spinal manipulation may have potential in the conservative treatment of intractable hiccups. Key Words: Hiccup; Manipulation, spinal; Rehabilitation.

Poster 255
Botulinum Toxin Type B Treatment in Multiple Sclerosis Patients With Lower-Extremity Adductor Spasticity: Results of a Double-Blind, Placebo-Controlled, Safety Study. Eric J. Pappert, MD (Univ of Texas Health Sci Ctr, San Antonio, TX).

Disclosure: E.J. Pappert, Solstice Neurosciences; Teva, Ovation, Eisai; Schwarz, Novartis.

Objective: To evaluate the safety of botulinum toxin type B (BXT-B) in the treatment of lower-limb adductor spasticity in subjects with multiple sclerosis (MS). Design: Double-blind, placebo-controlled, single-treatment, sequential dose escalation safety study. Setting: Outpatient clinics. Participants: Subjects had clinically definite MS with bilateral lower-limb adductor spasticity (duration, >6mo). Intervention: Subjects were randomized in a 1 to 1 ratio to receive BXT-B (1 of 5 successive doses [25,000U, 30,000U, 35,000U, 40,000U, 45,000U]) or placebo. Main Outcome Measures: Subjects were assessed at baseline, 2 and 4 weeks, and every 4 weeks thereafter (up to 16wk), primarily for safety (treatment-emergent adverse events [AEs]). Prior to the randomization of subjects to the next dose level, safety data were assessed for the first 4 weeks after the administration of each dose. Secondary outcomes assessed the utility of efficacy measures in the evaluation of MS-related lower-extremity adductor spasticity. Results: 24 subjects (14 women) were randomized (25,000U [n=5]; 30,000U [n=5]; 35,000U [n=5]; 40,000U [n=5]; placebo [n=4]). 19 of 24 subjects completed the trial. All 24 subjects experienced at least 1 AE. The greatest proportion of AEs was reported in the higher-dose treatment groups (35,000U, 40,000U). The most frequent AEs in the BXT-B groups were dry mouth (n=11), dysphagia (n=7), and constipation (n=4). The majority of AEs were considered mild or moderate in severity. 2 serious AEs were considered treatment-related (weight loss [35,000U], urinary retention [40,000U]). Safety assessments resulted in the decision not to proceed with the 45,000U group. The small sample size limited observations regarding effects of BXT-B for secondary efficacy measures. Conclusions: Safety data suggest a starting dose of 30,000U could be safely utilized in the treatment of lower-limb adductor spasticity. Additional studies are warranted to evaluate efficacy. Key Words: Botulinum toxins; Multiple sclerosis; Muscle spasticity; Rehabilitation.

Poster 256
Efficacy and Safety of Repeated High-Dose Botulinum Toxin Therapy for Poststroke Spastic Hypertonia: Preliminary Observations. Gerard E. Francisco, MD (University of Texas Health Science Ctr, Houston, TX); Justin K. Smith, MD.

Disclosure: G.E. Francisco, Allergan; J.K. Smith, None.

Objective: To document the clinical efficacy and safety of repeated injections of high botulinum toxin type A (BTX-A) dose (>800U per treatment session) in poststroke spastic hypertonia. Design: Retrospective. Setting: 2 spasticity clinics affiliated with 2 major medical schools. Participants: Stroke survivors with functionally limiting spastic hypertonia. Intervention: BTX-A (Botox) injections to hypertonic upper- and/or lower-limb muscles. Main Outcome Measures: Ashworth Scale for muscle tone and symptom checklist for adverse events. Results: The records of 36 stroke patients treated by a single injector with BTX-A between 1998 and 2005 were reviewed. All were over 16 years of age at the time of first injection and had no exposure to other botulinum toxin serotypes or were treated with other neurolytic agents (eg, phenol). Throughout the entire treatment period, each subject received 300 to 900U per session as clinically indicated, but was injected with 800 to 900U of BTX-A on at least 2 occasions. Clinical outcome data were collected between 6 to 8 weeks postinjection. There was a significant decrease in Ashworth score in the injected muscle groups. Many subjects did not need high doses of BTX-A when injections had to be repeated, suggesting that a sustained treatment effect beyond the clinically expected duration of efficacy (3–4mo). Only 3 adverse events with high probability of resulting from BTX-A were reported in 2 patients (5.5%): mild transient weakness and fatigue that lasted 2 weeks. Neither event required medical intervention. Conclusions: Results of this preliminary investigation suggest that repeated injections of high doses of BTX-A (>800U) are effective in decreasing muscle tone. It also appears safe, with only 5.5% of the subjects reporting mild and transient adverse events. However, these results should be interpreted cautiously due to the retrospective nature of this study. Key Words: Botulinum toxins; Cerebrovascular accident; Muscle spasticity; Rehabilitation.

Poster 257
A Longitudinal Look at Intrathecal Baclofen Dosing. Elizabeth A. Moberg-Wolff, MD (Medical College of Wisconsin, Brookfield, WI); Maria A. Ocasio-Silva, MD; Mary Elizabeth Nelson, APNP.

Disclosure: E.A. Moberg-Wolff, Medtronic Neurological; M.A. Ocasio-Silva, None; M.E. Nelson, None.

Objective: To identify longitudinal dosing patterns for intrathecal baclofen (ITB) in patients with varying diagnoses. Design: 5-year retrospective chart review. Setting: Tertiary care hospital outpatient PM&R clinic. Participants: 135 patients (age range, 15–76y) who had an implanted ITB pump for at least 6 months. Diagnoses include spinal cord etiology (n=46), cerebral palsy (n=32), multiple sclerosis (n=26), brain injury (n=22), stroke (n=5), and miscellaneous (n=4). Interventions: Not applicable. Main Outcome Measures: Charts were reviewed for sex, age, diagnosis, date of implant, baclofen concentration, baclofen dosage and dosing pattern at each clinic visit, catheter tip level, and medical or surgical information that may have affected the patient’s overall spasticity, pump dosing, or pump function. Dosing changes were made based on family, patient, therapist, and clinical needs. Each patient’s information was plotted graphically as a function of dosage versus time. Results: Initial dosing patterns...
were dependent on number of clinic visits as well as diagnosis. A stabilization in dose occurred in patients without progressive disease typically within 6 months of implant. Complex dosing was utilized in 28% of patients. Significant deviations (>20%) from this dose or continued increases in dosage without plateau often indicated an ineffective delivery system or significant medical issues impacting the patient’s tone. Several abnormal patterns were identified. Range of “effective dose” varied widely within patient populations. Conclusions: While maintenance doses varied greatly depending on patient diagnosis, effective dosing patterns could be identified. Recognizing “effective” versus “ineffective” dosing patterns may prove to be a valuable tool in early detection of ITB delivery system malfunctions.

Key Words: Baclofen; Cerebral palsy; Muscle spasticity; Rehabilitation; Spinal cord injuries.

Practice Management

Poster 258
Influence of Comorbidities on Inpatient Rehabilitation Outcomes Following Total Joint Arthroplasty. Kevin R. Vincent, MD, PhD (University of Florida, Gainesville, FL); Heather K. Vincent, PhD.

Disclosure: K.R. Vincent, None; H.K. Vincent, None.

Objective: To examine the relationships of the type and number of comorbidities on major inpatient rehabilitation outcomes following total joint replacement. Design: A retrospective, exploratory study.

Setting: 15 independent inpatient rehabilitation facilities along the U.S. east coast. Participants: Patients admitted for inpatient rehabilitation following total knee arthroplasty (TKA) (N=15,506) or total hip arthroplasty (THA) (N=8210). TKA and THA were 87.8% primary surgeries and 35.2% of the patients were women. THAs were 98.2% primary surgeries and 31.9% of the patients were women. Bilateral surgeries comprised 12.2% and 2.4% of TKA and THA groups, respectively. Interventions: Not applicable. Main Outcome Measures: Length of stay (LOS), rehabilitation facility charges, and FIM instrument efficiency. Results: TKA and THA had a mean comorbidity number of 6.8±1.9 and 6.9±1.9, respectively. Regression analyses adjusted for age, sex, and revision status were performed on each outcome variable for all patients, and patients separated by joint. Hypertension was a consistent predictor among all joint replacement patients for the 3 main outcomes (all P<.001). Comorbidity number and cellulitis were significant predictors of FIM efficiency and LOS (P<.05). Anxiety was a predictor of LOS and total charges (P<.05). Some comorbidities predicted outcomes in TKA but not THA (deep venous thromboses, neuropathy), while other comorbidities predict THA but not TKA (hypothyroid, chronic obstructive pulmonary disease, dementia) (all P<.05). Bilateral status added predictive ability to all regression models of main outcome measures. Conclusions: Main rehabilitation outcomes can all be predicted by the presence of hypertension. TKA and THA outcomes can differentially be predicted by various comorbidities, most of which are related to compromised mobility or aerobic and muscular endurance. The presence of bilateral status also strengthens the predictive ability of regression models for LOS, total charges, and FIM efficiency. Key Words: Arthroplasty; Comorbidity; Rehabilitation.

Poster 259
Influence of Obesity on Inpatient Rehabilitation Outcomes Following Total Hip Arthroplasty: A Retrospective Review of 1947 Patients. Kevin R. Vincent, MD, PhD (University of Florida, Gainesville, FL); Heather K. Vincent, PhD.

Disclosure: K.R. Vincent, None; H.K. Vincent, None.

Objective: To examine whether obesity affects inpatient rehabilitation outcomes following total hip arthroplasty (THA). Design: Retrospective, exploratory study. Setting: 25 independent U.S. east coast inpatient rehabilitation hospitals. Participants: Medical records of patients who underwent THA were used in this analysis (patients were admitted from 2002–2005; N=1947; age, 70.1±10.6y). Patient records were stratified into 4 brackets based on body mass index (BMI): nonobese (<25kg/m²), overweight (25–30kg/m²), moderate obesity (30–39.9kg/m²), and morbid obesity (≥40kg/m²). All patients completed an interdisciplinary inpatient rehabilitation program post-THA.

Interventions: Not applicable. Main Outcome Measures: FIM instrument scores, length of stay (LOS), FIM efficiency scores, hospital charges, and discharge disposition location. Results: FIM change from admission to discharge was lowest in the ≥40kg/m² group (54.8% vs 56.2%–58.3%; P<.05). Improvements in walking and specific transfers were lowest in the ≥40kg/m² group (P<.01). However, FIM efficiency and LOS were curvilinearly related to BMI (P<.05). Such that patients in the BMI range of 25 to 39.9kg/m² demonstrated better scores on these measures than those with a BMI of <25kg/m² and ≥40kg/m² (all P<.05). Total hospital charges were highest in the <25kg/m² BMI bracket ($15,125) compared with those in the 25 to 29.9kg/m² and 30 to 39.9kg/m² bracket ($13,608–$13,850, P<.05); these same patterns occurred for physical and occupational therapy charges. Pharmacy charges were highest in the ≥40kg/m² group (P<.001). Non-home-bound discharge disposition rates were lowest in the BMI bracket <25kg/m² than in the remaining brackets (11.6% vs 4.6%–6%). Conclusions: Patients at the extreme ends of the BMI spectrum may have either more comorbidities or an older age, both of which delay functional improvements. Overall, morbidly obese patients can achieve physical improvements, but at a lower efficiency and greater LOS. Key Words: Arthroplasty; Hip; Obesity; Rehabilitation; Treatment outcome.

Poster 260

Disclosure: R.S. Kaplan, None.

Setting: Private practice performing impairment evaluation services for a multistate area. Program: Workers’ compensation, personal injury, Social Security Disability, and private disability insurance.

Program Description: Physiatrists serve an important societal role when assessing patients for the purpose of advising governments, insurers, and other entities regarding a patient’s impairment and/or disability status. These evaluations raise important ethical issues distinct from those of a treating physician relationship. A review of impairment evaluation case examples from multiple states affords a window into considering the administrative and regulatory scheme in a region that may influence practice patterns and patient expectations and, most significantly, clinical and functional outcomes. Review of such cases raises important ethical questions for physiatrists to consider as a profession.

Assessment/Results: Comparison of impairment evaluation patterns across regional boundaries raises ethical questions about this aspect of physiatry practice. This study is a case series comparing illustrative examples of how a treating physician or disability-evaluating physician may be influenced by the statutory scheme in a given state. Discussion: Questions raised by comparing impairment evaluation schemes in various states include: (1) Can disability evaluation induce an iatrogenic disability? (2) What obligation does a physician have to report to governmental authorities a patient who is unsafe to drive? (3) What effect do treatment preapproval requirements have in delaying work injury treatment and inducing a vocational disability? (4) What effect does an “approved condition” workers’ compensation system have on practice patterns for those patients?

Conclusions: Impairment evaluation and disability evaluation repre-
sent an evolving field of physiatry practice with unique ethical considerations worthy of discussion by the physiatry community. **Key Words:** Disability evaluation; Ethics; Rehabilitation.

**Poster 261**

Multicenter Examination of the Center for Medicare Services Eligibility Criteria in Total Joint Arthroplasty. Kevin R. Vincent, MD, PhD (University of Florida, Gainesville, FL); Heather K. Vincent, PhD.

Disclosure: K.R. Vincent, None; H.K. Vincent, None.

**Objective:** To analyze inpatient rehabilitation outcomes in total joint arthroplasty (TJA) patients using 2004 Center for Medicare Services (CMS) 75% rule criteria for eligibility for inpatient rehabilitation. **Design:** A multicenter, retrospective study using a patient sample from independent inpatient rehabilitation facilities, conducted from September 15, 2005, to September 30, 2006. All patients had either primary or revision TJA and were directly admitted for inpatient rehabilitation postacute care. **Setting:** 15 independent inpatient rehabilitation facilities along the U.S. east coast. **Participants:** 23,274 men and women, separated into 3 comparison pairs as based on the CMS eligibility criteria: (1) unilateral or bilateral arthroplasty surgeries, (2) age bracket younger than 85 years or ≥85 years, or (3) body mass index (BMI) <50kg/m² or ≥50kg/m². All patients underwent a comprehensive rehabilitation program that included physical and occupational therapies for 3h/d. **Interventions:** Not applicable. **Main Outcome Measures:** Main outcomes were inpatient rehabilitation length of stay (LOS), FIM instrument scores (total, motor, and cognitive FIM and subscores), FIM efficiency, hospital charges, and discharge disposition location. **Results:** Bilateral demonstrated lower admission and discharge FIM scores (P<.001) but similar changes in FIM scores compared with unilateral (P>.05). TJAs with BMI of ≥50kg/m² had similar admission and discharge FIM motor scores compared with BMI of <50kg/m² (P>.05). TJA patients ≥85 years had lower admission FIM scores, a longer LOS (10.3d vs 13.7d), and higher total charges than TKA patients <85 years (P<.05). TJA patients ≥85 years had lower total FIM, FIM motor, and FIM cognition scores and were discharged to home less frequently than younger patients (P<.05). Total and daily charges were higher in TJA subjects ≥50kg/m² than <50kg/m² and TJA patients ≥85 years than TJA patients <85 years (P<.001). **Conclusions:** All patients made functional gains during rehabilitation. However, the most costly and lengthy rehabilitation occurred in TJA patients ≥85 years. The Medicare criteria may not effectively identify those most suitable for inpatient rehabilitation. **Key Words:** Age; Arthroplasty; Body mass index; Hip; Knee; Medicare; Rehabilitation.

**Poster 262**

A Multicenter Analysis of Age and Sex Effects on Inpatient Rehabilitation Outcomes Following Total Joint Arthroplasty. Kevin R. Vincent, MD, PhD (University of Florida, Gainesville, FL); Heather K. Vincent, PhD.

Disclosure: K.R. Vincent, None; H.K. Vincent, None.

**Objective:** To determine the effect of advancing age and sex on inpatient rehabilitation outcomes following total joint replacement. **Design:** A retrospective, multicenter study. **Setting:** 15 independent inpatient rehabilitation facilities along the U.S. east coast. **Participants:** Patients admitted for inpatient rehabilitation following total joint arthroplasty. These factors age and female sex are both associated with less favorable outcomes in inpatient rehabilitation following total joint arthroplasty. These factors need to be considered for resource allocation and discharge planning. **Key Words:** Arthroplasty; Comorbidity; Rehabilitation.

**Poster 263**

Degenerative Hip Disease and Coexisting Thoracic Meningioma: A Case Report. Keith M. D’Souza, MD (Marijanjoy Rehabilitation Hospital, Wheaton, IL); Vasilios Stambolis, MD.

Disclosure: K.M. D’Souza, None; V. Stambolis, None.

**Setting:** Freestanding inpatient rehabilitation hospital. **Participant:** A 76-year-old woman with flank and hip pain. **Case Description:** Subject noted insidious onset and gradually progressive bilateral hip and flank pain since January 2004. On evaluation in September 2005, radiographs showed sclerosis of bilateral femoral heads. The subject underwent left total hip arthroplasty (THA) with subsequent ipsilateral foot drop. Neuropathy of left tibial and peroneal nerves was noted on electromyography. **Assessment/Results:** The subject underwent THA of the contralateral hip in March 2006, with subsequent foot drop. The subject continued to experience weakness and was referred for electromyography. The neurologist noted the subject had developed urinary incontinence, and anesthesia around her sacrum and perineum. Muscle weakness and increased tone with positive Babinski reflex was noted in both lower extremities. Emergent magnetic resonance imaging showed a thoracic mass causing cord compression. Surgical resection of the mass (meningioma) was done. Flank pain resolved postoperatively. During the course of inpatient rehabilitation, muscle strength and urinary retention improved significantly. **Discussion:** Because the subject had 2 anatomically distinct pathologic processes at work, both affecting the lower extremities, the developing cord compression was unfortunately not detected earlier. This was complicated by the fact that the meningioma was in the thoracic instead of the expected lumbar region. Additionally, the current incidence of nerve lesions following unilateral THA is 1% to 1.1%, with up to 80% involving the peroneal branch of the sciatic nerve alone. Bilateral sciatic neuropathy due to THA done at 2 different times by 2 different surgeons is exceedingly rare, but may be explained by the double crush syndrome. **Conclusions:** Imaging studies of both lumbar and thoracic regions must be ordered for patients presenting with features of lumbar cord compression. Additionally, in case of postoperative peripheral neuropathy, proximal lesions affecting axonal flow must also be ruled out. **Key Words:** Arthroplasty; Meningioma; Rehabilitation; Sciatic neuropathy.
Poster 264
Early Effects of the Centers for Medicare Services Criteria on Patient Care Following Total Joint Arthroplasty. Heather K. Vincent, PhD (University of Florida, Gainesville, FL); Kevin R. Vincent, MD, PhD.

Disclosure: H.K. Vincent, None; K.R. Vincent, None.

Objective: To examine the early effects of the Centers for Medicare Services (CMS) criteria for eligibility for rehabilitation following total knee (TKA) and hip (THA) arthroplasty on patient discharge dispositions and acute care length of stay (LOS) and hospital charges. Design: Retrospective, exploratory study. Setting: A tertiary care hospital and affiliated inpatient rehabilitation hospital. Participants: Patients with TKA and THA; clinical data repository information and medical records of patients from 2000 and 2006. Interventions: Not applicable.

Main Outcome Measures: Discharge disposition location, acute care hospital charges, acute care LOS, and patient variables (demographics, insurance carrier, comorbidities). Results: Patient population demographics and profiles were similar in 2000 and 2006. In TKA, the acute care LOS increased from 3.68 days (range, 1–21d) to 4.16 days (range, 1–34d). Total daily acute care hospital charges increased from $7384 to $14,893. In 2000, 45.9% of TKA patients were discharged to inpatient rehabilitation compared with 29.3% in 2006. In THA, LOS increased from 4.1 days (range, 1–21d) to 4.5 days (range, 2–52d). Total daily acute care hospital charges increased from $7103 to $17,311. 10.5% of THA patients were discharged to inpatient rehabilitation in 2000, whereas 31.1% were discharged to rehabilitation in 2006. In both TKA and THA, more patients were being discharged to skilled nursing facilities and to home with home healthcare. Reimbursements were reduced by 29.7% and 24.0% in THA and TKA, respectively, from 2000 to 2006. Conclusions: Given the impending restrictions imposed by the CMS criteria, these preliminary data suggest that joint arthroplasty patients remain in acute care longer at a greater expense, and fewer TKA patients are discharged to inpatient rehabilitation. Patients referred to skilled nursing facilities or home with home healthcare may not receive the same concentration of rehabilitation needed for rapid restoration of function and mobility.

Key Words: Arthroplasty; Centers for Medicare and Medicaid Services; Medicare; Rehabilitation.

Prosthetics, Orthotics, Assistive Devices

Poster 265
Rehabilitation of a 4-Limb Amputee Secondary to Iatrogenic Critical Limb Ischemia: A Case Report. Arash Bidgoli, DO (Pitt County Memorial Hospital, Greenville, NC); James Wells, MD, MPH; Thurman Whitted, MD; Clinton Faulk, MD.

Disclosure: A. Bidgoli, None; J. Wells, None; T. Whitted, None; C. Faulk, None.


Case Description: He developed acute myelogenous leukemia 1 year previously and underwent chemotherapy. Neutropenia, gram-negative sepsis, hypotension, and cardiac arrest ensued. Resuscitation required 4 vasopressors, with resultant ischemic limbs requiring amputation, all healing uneventfully. He was admitted for inpatient rehabilitation, including amputee and prothetic education, aerobic conditioning, aquatics therapy, gait training, psychologic support, and continued medical monitoring. He improved in all areas of mobility, ambulation, and activities of daily living and was discharged home.

Assessment/Results: Initially, he used a power chair for mobility and was nonambulatory and required moderate to maximum assistance for transfers. His FIM instrument score improved from 67 to 100, including donning and doffing his protheses, becoming independent in most functional areas during a hospitalization lasting 6 weeks, and walking 45m (150ft) using protheses. He was able to swim more than 300m (1000y) daily. He developed increased optimism about his future quality of life.

Discussion: Multiple-limb loss secondary to sepsis and pressor support is a rare, catastrophic complication of chemotherapy. This patient had preserved cognition and developed appropriate grief reactions to his loss. With appropriate and timely intervention, he obtained optimal outcomes. Rigorous and comprehensive inpatient rehabilitation programs provide the opportunity to achieve functional independence, leading to a significantly improved perception of quality of life. Inpatient rehabilitation, rather than some lower level of care, allowed for the critical coordination between the patient and his treating team necessary to enable rapid functional gains to an independent level, and to address his emotional needs.

Key Words: Amputation; Quality of life; Rehabilitation.
A 68-year-old transtibial amputee. **Case Description:** We present a transtibial amputee ambulating independently and utilizing a prosthesis for 14 years; his original amputation was secondary to sarcoma. Most recently, he underwent re-excision and radiation therapy for recurrent sarcoma. He was instructed not to wear his prosthesis, to promote wound healing, and developed a 25° of knee flexion contracture. Also during this time, he had a fall incident, landing directly on his residual limb, which further complicated healing. **Assessment/Results:** After referral to the prosthetics clinic, a transtibial residual limb protector (TRLP) was devised to both protect the residual limb in case of another fall and to promote knee extension. The TRLP was constructed of co-polymer plastic in a bivalve clam shell design, with full 64cm (.25in) polyethylene foam padding and a 2.5cm (1in) distal pad, fabric hook-and-loop fasteners as closures, and progressive step hinges to lock the knee joint in various positions of flexion and extension while allowing ease of donning and doffing. The TRLP allowed for maximal 90° of flexion while locking at varying degrees of knee extension. He used the TRLP throughout the day, removing the device for skin evaluation and home exercises. After 30 days, a significant 20° gain in knee extension was noted. **Discussion:** Traditionally, wound healing and contractures are complications encountered frequently in amputee care, which can ultimately limit function. The purpose of this case presentation is to demonstrate the benefits of a TRLP for protection of wound healing and prevention and/or treatment of contractures. **Conclusions:** There is an integral role of TRLP devices in the postoperative care of amputees. At the same time, emphasis is placed on the importance of a comfortable prosthetic fit and ease of donning and doffing to ensure compliance. **Key Words:** Amputation; Orthotic devices; Rehabilitation; Wound healing.

**Poster 271:** Canceled.

**Poster 272**

The Use of 3-Dimensional Quantitative Gait Analysis to Assess a Bilateral Transtibial Amputee Following Initial Prosthetic Fitting. Derek P. Watson, MD (East Carolina University, Greenville, NC); Arash Bidgoli, DO; Peter Gemelli, MD; Blaise Williams, PhD, PT; Thurman Whitted, MD.

Disclosure: D.P. Watson, None; A. Bidgoli, None; P. Gemelli, None; B. Williams, None; T. Whitted, None.

**Setting:** An academic biomechanics lab affiliated with an inpatient rehabilitation facility (IRF). **Patient:** A 39-year-old man status post 4-limb amputation (bilateral transtibial and bilateral transradial). **Case Description:** He underwent bilateral transtibial and transradial amputations following critical limb ischemia secondary to sepsis requiring high doses of multiple vasopressors. At admission to the IRF he was nonambulatory. He underwent a comprehensive rehabilitation program
including amputee and prosthetic education, aerobic conditioning, aquatic therapy, gait training, and prosthetic adjustment. At discharge he was ambulating independently without assistive devices. 

Assessment/Results: On visual analysis, the patient’s gait was slow with decreased cadence, decreased step length, and vaulting during swing phase on the left. After discharge from the IRF, the patient’s gait was examined using 3-dimensional gait analysis, including ground reaction force data. These data indicated the patient’s prostheses were mimicking normal motion at the ankle in the sagittal plane (plantarflexion, dorsiflexion), though the range of motion was less than that of a normal human ankle. There was very little motion in the frontal plane (inversion, eversion). The data also revealed near normal loading response at the knee during heel strike on the right and decreased knee flexion on the left. Hip flexion data was normal bilaterally.

Discussion: Analysis of the data indicates the patient’s prostheses were functioning to enable a normal human gait effectively. The data were limited by the patient only being able to participate in 3 trials, thus making the data quite variable. The motion data collected correlated well with the marketing information provided by the manufacturer regarding the components included in his prostheses. The data were used to instruct the patient and his therapists in appropriate subsequent gait modifications. 

Conclusions: Quantitative gait analysis is useful in assessing and improving amputee gait. Key Words: Biomechanics; Gait; Prostheses and implants; Rehabilitation.

Poster 273

Gait Characteristics, Balance Confidence, and Functional Performance of a Patient With Bilateral Transfemoral Amputation: Comparison Between C-Legs and DAW TK-IPSO Pneumatic Control Knees. Jane Wetzel, PT, PhD; Mary Ann Miknevich, MD (Mercy Hospital of Pittsburgh, Pittsburgh, PA); Mark C. Miller, PhD; Ronald H. Baker, CP, BOCP. 

Disclosure: J. Wetzel, None; M.A. Miknevich, None; M.C. Miller, None; R.H. Baker, None.

Objective: To determine the advantages of mobility in OttoBock C-Legs compared with DAW TK-IPSO pneumatic control knees in a traumatic bilateral transfemoral amputee. Design: Single-subject repeated-measures design. Setting: Gait analysis laboratory. Participant: Active adult bilateral transfemoral amputee and high school baseball coach (age, 42y), ambulatory 8 to 10h/d using 2 Lofstrand crutches and prosthetic limbs. 

Interventions: 2 separate examinations were conducted, one with DAW pneumatic knees and a second with C-Legs. Patient had worn DAW knees for 11 years before the study and later C-Legs, worn 1.8 years before the study. Gait characteristics (motion analysis, force, walking efficiency), self-reported balance confidence and physical performance (Activities-specific Balance Confidence scale, Medical Outcome Study 36-Item Short-Form Health Survey), timed functional stair, and sit-to-stand (STS) were studied. Main Outcome Measures: 6-camera Vicon 512 motion analysis system and Bertec forceplates (type 4060A) were utilized. The Physiological Cost Index was used to compute walking efficiency during steady-state walking. A stopwatch recorded time. 

Results: Comparing gait characteristics in C-Legs with DAW pneumatic knees for this subject showed increased walking speed, stride length, and overall cadence with C-Legs. Stride cycle time and double-limb support time decreased with C-Legs. Forceplate data revealed more equal distribution of weight on the upper extremities (UE) and lower overall force to the right UE using C-Legs. Walking efficiency was greatly improved, approaching normal walking, and the subject reported increased balance confidence with stair climbing, reaching, walking on ramps, and fewer incidence of falls using C-Legs, as well as reduced limitation in moderate activities, lifting, and carrying when using C-Legs. Functional stair time decreased and STS time increased using C-Legs. 

Conclusions: Overall, the functional advantage of using C-legs versus DAW pneumatic knees was demonstrated for this subject. Key Words: Amputees; Gait; Limbs, artificial; Rehabilitation.

Poster 274

Effect of Contralateral and Ipsilateral Cane Use on Peak Vertical Force. Dixie Aragaki, MD (UCLA/VA Greater Los Angeles Healthcare System, Los Angeles, CA); Mary Nasmith, MD; Gretchen Nguyen, MD; Scott Schultz, MD; Jennifer Yentes, MS; Melka Fang, MD. 

Disclosure: D. Aragaki, None; M. Nasmith, None; G. Nguyen, None; S. Schultz, None; J. Yentes, None; M. Fang, None.

Objective: To determine the effects of ipsilateral and contralateral single-point cane use on peak vertical force in younger adults. Design: Prospective pilot study. Setting: Veterans Affairs medical center. Participants: 10 healthy subjects (age range, 26–52y; mean age, 31y) without musculoskeletal, neurologic, or medical issues that would impair gait. 

Interventions: Plantar pressure mapping data were collected from subjects walking in 3 different conditions (relative to a randomly assigned limb): contralateral cane, ipsilateral cane, and no cane. Main Outcome Measures: Immediate effects of cane use on gait cadence and mean peak vertical force on each lower limb (normalized for body weight) were measured for all trial conditions. Results: Mean cadence was higher when participants ambulated without a cane than with a cane on either the contralateral or ipsilateral side (P<.000). Mean cadence did not differ significantly between the ipsilateral and contralateral cane use conditions. Mean peak plantar force (normalized for body weight) was reduced during both the contralateral and ipsilateral cane use conditions on the randomly assigned test limb when compared with walking unaided (P<.006). The mean peak plantar force was lower for the assigned test limb than the opposite limb when walking in the contralateral cane condition (P<.016). 

Conclusions: Ipsilateral and contralateral cane use reduced cadence and mean peak vertical plantar force in healthy, younger subjects. These results may suggest the need for additional attention when first using a cane. Further study of cane use in knee osteoarthritis patients using a similar method may help describe other potential effects on gait, pain, function, and quality of life. Results from this pilot study will be incorporated into a larger randomized controlled trial to assess the efficacy of canes in the management of symptomatic unilateral knee osteoarthritis. Key Words: Canes; Gait; Osteoarthritis, knee; Rehabilitation.

Poster 275

Esbelto Brace for Treatment of Juvenile Idiopathic Scoliosis: Observational Pilot Study. Judith Sánchez Raya, MD (Vall d’Hebron Hospital, Barcelona, Spain); Carmen Gilpérez, MD; Beatriz Camós, O; Joan Bagó, MD, PhD; Esther Pagés, MD, PhD; Ampar Cuxart, MD, PhD. 

Disclosure: J. Sánchez Raya, None; C. Gilpérez, None; B. Camós, None; J. Bagó, None; E. Pagés, None; A. Cuxart, None.

Objectives: To assess lumbar correction with the Esbelto corset (a brace designed to treat Lenke type V lumbar scoliosis) by measuring the Cobb angle, vertebral rotation, lumbar offset, and waist angle modification, and to assess acceptance of the brace by teenage patients. Design: A pilot observational study, with prospectively collected data. Setting: Scoliosis unit in a tertiary public hospital. Participants: 30 teenagers (1 boy, 29 girls; mean treatment age, 14y; range, 10–17y).
Intervention: Esbelto corset treatment. **Main Outcome Measures:** Variables considered were sex, age of onset, age of onset treatment with corset, age of menarche, Risser sign, and waist-fold modification. Radiologic examination of the Cobb angle, lumbar offset, and lumbar rotation (Pedriolle) were performed in initial treatment and posterior periodic patient assessment. **Results:** In all cases, improvement in waist angle and good acceptance of the corset were recorded. Radiologic study confirmed significant improvement in the mean lumbar Cobb measurement (before treatment, $23.8^\circ \pm 7.6^\circ$; post brace, $12.8^\circ \pm 8.8^\circ$; $P<.01$), mean lumbar offset (pre, $1.85\pm1.05$cm; post, $1.09\pm1.04$cm; $P=.01$), and the mean Pedriolle (pre, $10.45^\circ \pm 9.7^\circ$; post, $7.08^\circ \pm 9.8^\circ$; $P=.014$). Mean treatment follow-up was 12 months (range, 2–27mo). **Conclusions:** The Esbelto brace significantly corrects Cobb angle, offset, and lumbar rotation while achieving waist symmetry. It is also satisfactorily and well accepted by adolescents. To complete the study, the series sample size must be larger and the duration of the study must be prolonged until the patient’s maximum growth potential is reached. **Key Words:** Braces; Rehabilitation; Scoliosis.
Spinal Cord Injury

Poster 276
Impact of Age on Motor Recovery Following Acute Spinal Cord Injury. Brian T. Kucer, MD (Thomas Jefferson University Hospital, Philadelphia, PA); Anthony S. Burns, MD; Fred H. Geisler, MD, PhD.; William P. Coleman, PhD.
Disclosure: B.T. Kucer, None; A.S. Burns, None; F.H. Geisler, Fidia Pharmaceutical; Christopher Reeve Foundation; W.P. Coleman, Fidia Pharmaceutical; Christopher Reeve Foundation; International Collaboration on Repair Discoveries; International Campaign for Cures of Spinal Cord Injury Paralysis.

Objective: To study the effect of age on motor recovery following acute spinal cord injury (SCI). Design: Secondary analysis of the Sygen (GM-1 ganglioside) Trial. Setting: Multicenter trial. Participants: Subjects with acute SCI. Intervention: Placebo versus drug. Main Outcome Measures: Percentage of motor score recovery (% recovery) and absolute change in motor score (ΔMS). Results: Subjects with baseline and 52-week data were included (N = 616), then grouped by age (in years): 10 to 29 (n = 308), 30 to 49 (n = 237), and 50 to 69 (n = 71). Each age group was then stratified using the American Spinal Injury Association (ASIA) Impairment Scale: ASIA grade A (complete), ASIA grade B (sensory incomplete), and ASIA grade C and D (motor incomplete). ΔMS and % recovery were calculated at 52 weeks. Placebo and Sygen arms were compared and no significant differences were noted. Treatment arms were combined for further analysis. For ASIA grade A injuries, there were no significant differences between age groups. For ASIA grade B injuries, ΔMS and % recovery were lower for the 30–49 group compared with the 10–29 group (27 vs 42 motor points; P = .007; 34% vs 54%, P = .005), respectively. Recovery was also less for the 50–69 group compared with the 10–29 group (28 vs 42 motor points; 34% vs 54% recovery), but failed to reach significance, which we attribute to the small number of subjects (n = 10) in the older group. For ASIA grade C and D injuries, ΔMS and % recovery were lower for the 50–69 group compared with the 10–29 group (43 vs 53 motor points, P = .049; 65% vs 86%, P = .001), respectively. Recovery for the 10–29 compared with the 30–49 group was essentially the same. Conclusions: Age may not impact motor recovery following clinically complete injuries. Compared with younger subjects (age range, 10–29y), there is less neurologic recovery for sensory incomplete injuries, starting at ages 30 to 49 years, and motor incomplete injuries, starting at ages 50 to 69 years. Key Words: Prognosis; Rehabilitation; Spinal cord injuries.

Poster 277
Barriers to Health Promotion in Women With Spinal Cord Injuries in Nova Scotia: A Qualitative Assessment Pilot Project. Tania R. Bruno, MD (Queen Elizabeth II Health Sciences Centre, Halifax, NS, Canada); Christine Short, MD, FRCPC; Joanne Courtney-Walker, RN.
Disclosure: T.R. Bruno, None; C. Short, None; J. Courtney-Walker, None.
Objective: To determine barriers to well-woman care for women with spinal cord injuries (SCIs). Design: Qualitative study. Setting: Communities throughout Nova Scotia, Canada. Participants: Women, at least 18 years of age, with SCI, registered with the Canadian Paraplegic Association (CPA) to receive information by mail about research opportunities. Interventions: Women were invited to complete an anonymous survey focusing on sexual health, family planning, access to their family physicians’ offices, comfort discussing reproductive health and sexuality with physicians, breast and cervical cancer screening, perceived barriers to accessing well-woman services, and awareness of a tertiary level accessible clinic. Main Outcome Measures: Rates of breast and cervical cancer screening, accessibility to family physicians’ offices, and awareness of a tertiary level accessible clinic were the main quantitative outcome measures for this predominantly qualitative study. Results: 32 of 108 women with SCI registered with the CPA responded to a single mail-out. Of these, nearly 80% reported seeing their family physician on a regular basis, though only half of these women felt comfortable discussing topics related to women’s reproductive health and sexuality. Though the respondents’ doctor’s offices were largely accessible, 47% were not equipped with accessible examining tables and 16% had inaccessible washrooms. Half of the respondents underwent regular breast and cervical cancer screening. The majority (60%) of respondents were unaware of the existence of a tertiary level, accessible facility and nearly three quarters of these women said they would not be able to access this facility due to geographic barriers. Conclusions: Though most women with SCI in Nova Scotia have access to regular family physician visits, physical, financial, geographic, informational, and attitudinal barriers do exist that interfere with the receipt of well-woman care. Key Words: Health services accessibility; Rehabilitation; Spinal cord injuries; Women’s health.

Poster 278
The Effects of Human Adipose Tissue–Derived Mesenchymal Stem Cells Transplantation on Neurologic Recovery in Rats With Spinal Cord Injury. Sang Beom Kim, PhD; Hyun Kwak, PhD (Dona-A University College of Medicine, Busan, Republic of Korea).
Disclosure: S.B. Kim, None; H. Kwak, None.
Objective: To explore whether the transplanted human adipose tissue–derived stem cells (hATSCs) could survive and improve functional recovery after contusive spinal cord injury (SCI) in rats. Design: Case-controlled study. Setting: University laboratory. Animals: 30 female Sprague-Dawley rats (weight range, 250–350g). Interventions: hATSCs, which were isolated from male human liposuctioned tissues, were injected with 20μL of growth medium into 15 female rats and only 20μL of growth medium were injected into the remaining 15 rats used as controls. The procedure was performed 1 week after making contusive SCI by weight drop device. Main Outcome Measures: The functional outcome was evaluated by using the Basso-Beattie-Bresnahan motor rating score and inclined plane test. The histologic morphology was observed by optical microscope with cross-sectional area of the spinal cord. The distribution of donor cells was measured by identifying Y chromosome-positive cells using fluorescent in situ hybridization. Results: hATSCs significantly improved motor recovery compared with the control group 4 weeks after transplantation. The morphometric changes were also better in the hATSCs group. The transplanted cells were partially engrafted into the parenchyma of the injured spinal cord. Conclusions: These data suggest that transplanted hATSCs may have a therapeutic role after SCI. Key Words: Recovery of function; Rehabilitation; Spinal cord injuries; Stem cells.

Poster 279
Changes of Somatosensory Evoked Potential Study Following Functional Improvement in Patients With Incomplete Spinal Cord Injury. Yong Rae Kim, MD (Pochon CHA Univ Bundang CHA General Hospital, Sungnam-si, Kyunggi-do, Republic of Korea); Ki Ho Cho, MD; Sung Hyun Kim, MD.
Disclosure: Y.R. Kim, None; K.H. Cho, None; S.H. Kim, None.
Objective: To evaluate the changes of cortical somatosensory evoked potentials (SEP) following functional improvement in patients with incomplete spinal cord injury (SCI). Design: Before and after...
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Poster 280
Elevated N-Telopeptide in Inpatients With Spinal Cord Injury Who Develop Acute Heterotrophic Ossification. Zhaohui Yang, MD, PhD (Boston Medical Ctr, Boston, MA); Kristin Gustafson, DO; Leslie Morse, MD; Yelena Giorfinkel; Steve Williams, MD. Disclosure: Z. Yang, None; K. Gustafson, None; L. Morse, None; Y. Giorfinkel, None; S. Williams, None.

Objective: To evaluate the relationship between urinary N-telopeptide with spinal cord injury (SCI) severity and the development of heterotopic ossification (HO).

Design: Retrospective study.

Setting: University hospital, rehabilitation ward.

Participants: SCI patients admitted to acute rehabilitation.

Interventions: Chart review was performed for 19 patients admitted between February 3, 2006, and December 27, 2006, with a diagnosis of acute SCI. Main Outcome Measures: American Spinal Injury Association classification of SCI, urine N-telopeptide, and blood creatinine testing was performed on admission, and clinically significant HO confirmed by triple-phase bone scans. Results: N-telopeptide and creatinine ratio was significantly higher in the HO group (311.52±193.53 vs 141.78±132.69, P=.04) and in those with complete injury (245.34±191.53 vs 105.47±61.98, P=.04). Conclusions: Based on preliminary data, N-telopeptide and creatinine ratio show some promise as a clinically useful indicator for HO in the acute phase of SCI. It may show utility as an index for early prevention of HO formation in SCI patients. N-telopeptide is also higher in the subjects with complete SCI, suggesting bone resorption is greater in this group.

Key Words: Ossification, heterotrophic; Rehabilitation; Spinal cord injuries.

Poster 281
Unstable Jefferson Fracture as an Etiology for Persistent Dysphagia and Dysphasia in a Tetraplegic Patient: A Case Report. Franz J. Macedo, DO (University of Wisconsin, Middleton, WI); J. George Thomas, MD; Kelly Logan, DO; Eric Kozlakay, DO. Disclosure: F.J. Macedo, None; J.G. Thomas, None; K. Logan, None; E. Kozlakay, None.

Setting: University hospital, rehabilitation ward. Patient: A 37-year-old C4 tetraplegic, 1 month postinjury, with persistent dysphagia and dysphasia. Case Description: The patient was admitted following a motorcycle crash, with resultant C4 complete tetraplegia. Immediately postinjury, prior to intubation, the patient was vocalizing. Injuries included: stable Jefferson (C1) fracture, C2 complex fracture, C5 fracture and small frontal subdural hematoma. Operative management included C5 corpectomy and C4-7 anterior fusion. Tracheostomy was placed 3 weeks postinjury for ventilatory dependence. There was glottic swelling post tracheostomy, treated with intravenous dexamethasone, with good results. The patient was transferred to the rehabilitation ward at 6 weeks. At that time the patient had dysphagia, hypophonia, and lingual weakness. Over the next 4 weeks, there was no appreciable improvement in vocalization, swallow function, or lingual weakness. Videofluoroscopic swallow evaluation showed lingual weakness and resolution of glottic edema. Magnetic resonance imaging of the head and neck, to evaluate the brainstem for injury, showed unstable Jefferson fracture with resultant basilar invagination and development of high T2-signal intensity within the lower brainstem and upper cervical cord. The orthopedic spine service placed the patient in cervical traction to decompress the brainstem. Subsequently, cervical fusion with halo placement was performed. 2 weeks after decompression and fusion, tongue weakness improved and vocaliza-
tion was improving. 4 weeks after decompression, swallow function returned and the patient was tolerating a speaking valve with strong voice. **Assessment/Results:** History, clinical data, and diagnostics all support an unstable Jefferson fracture and resulting brainstem myelopathy as cause for persistent dysphagia and dysphasia. **Discussion:** Causes of dysphagia and dysphasia include: trauma following intubation, glottic edema, damage to recurrent laryngeal nerve, and head trauma. When symptoms persist, evaluation for less common causes should be performed, including involvement of the brainstem. **Conclusions:** Documented here is an unstable Jefferson fracture as an etiology for persistent dysphagia and dysphasia in a tetraplegic patient. **Key Words:** Dysphagia; Myelopathy; Rehabilitation.

**Poster 283**

**Disclosure:** E. Casey, None.

**Setting:** Acute inpatient rehabilitation facility. **Patient:** A patient with spina bifida with progressive tetraplegia. **Case Description:** A 23-year-old woman with a history of congenital myelomeningocele, Chiari II malformation, and paraplegia who was at a modified independent level with upper-extremity activities of daily living (ADLs), wheelchair mobility, and transfers until age 22. In February 2006, she began developing progressive tetraplegia leading to total dependence over the course of a year. Clinical evaluation and imaging revealed that her decline in functioning was likely due to tethered cord syndrome. She had previously undergone a cord detethering procedure in 1996 during a cervical to sacral fusion, so her neurosurgeon recommended a complete transection of her spinal cord in an effort to prevent further deterioration and potentially restore the previous level of function. **Assessment/Results:** Following transection of her spinal cord at T10, there was improvement in her distal upper-extremity strength and sensation above T10. She then underwent an inpatient rehabilitation program focused on upper-extremity strength, range of motion, and fine motor skills to maximize her functional independence. **Discussion:** Tethered cord syndrome is a stretch-induced disorder of the spinal cord leading to progressive motor and sensory dysfunction, incontinence, and musculoskeletal dysfunction. This syndrome can be extremely debilitating, and in the case of our patient, led to significant functional decline (she went from minimum assistance to modified independent to dependent with all mobility and ADLs). Although rarely performed, the technique of transecting the spinal cord followed by a focused, multidisciplinary approach to rehabilitation can lead to functional recovery and improved quality of life. **Conclusions:** Spinal cord transection and subsequent inpatient rehabilitation is of benefit in a small group of myelodysplastic patients with progressive loss of function due to tethered cord syndrome. **Key Words:** Meningomyelocele; Quadriplegia; Rehabilitation; Spinal cord injuries.

**Poster 284**
Three-Phase Bone Scintigraphy Identifying Complex Regional Pain Syndrome as the Etiology of Autonomic Dysreflexia Associated With Positional Changes in Spinal Cord Injury: A Case Report. Jimmy M. Henry, MD (Temple University Hospital, Philadelphia, PA); Harry Schwartz, MD.

**Disclosure:** J.M. Henry, None; H. Schwartz, None.

**Setting:** Acute inpatient rehabilitation hospital. **Patient:** A 23-year-old right-handed Hispanic woman. **Case Description:** The patient sustained C5 American Spinal Injury Association grade A tetraplegia following traumatic spinal cord injury (SCI). She underwent C5-T7 anterior and C4-T1 posterior decompression and fusion with C5 through C7 diskectomy. She suffered frequent episodes of autonomic dysreflexia (AD) due to constipation, kinked urinary catheter, and positional changes, the latter occurring during transfers. In addition, she complained of sacral dysesthesias not relieved by rest or medications. A triple-phase bone scan (TPBS) was obtained 16 weeks post SCI to exclude heterotopic ossification (HO) as an exciting cause of her AD. The study did show, during blood pool phase, mildly increased uptake in the knees and hips bilaterally; in the delayed phase, there was increased symmetric uptake in the hips, knees, ankles, and feet. These findings were initially interpreted to be suggestive of “arthritis” without evidence of HO. A second read described a pauciarticular or juxta-articular pattern of uptake consistent with that seen in complex regional pain syndrome (CRPS) or neurogenic arthropathy. **Assessment/Results:** In a young SCI patient, CRPS or neurogenic arthropathy rather than osteoarthritis (OA) would be more compelling. It is further characterized by pauciarticular or juxta-articular distribution of uptake as opposed to the periarticular pattern seen in OA. She was empirically started on a prednisone taper and had less frequent episodes of AD related to positional change. **Discussion:** In this case where positional change appeared to be the primary precipitating event of AD, the diagnosis of CRPS elucidated by TPBS seemed logical, and was further confirmed by her significant improvement with steroid treatment. **Conclusions:** TPBS may be used to identify CRPS as a potential cause of AD associated with positional change in SCI. **Key Words:** Autonomic dysreflexia; Complex regional pain syndrome; Rehabilitation; Scintigraphy.

**Poster 285**
A Unique Approach to a Paraplegic Patient With a Nonhealing Femur Fracture: A Case Report. Christopher Stephenson, MD (Univ of California, Davis, Sacramento, CA); Holly Zhao, MD.

**Disclosure:** C. Stephenson, None; H. Zhao, None.

**Setting:** A tertiary medical center outpatient spinal cord injury (SCI) clinic. **Patient:** A 45-year-old man with history of T10 American Spinal Injury Association grade A SCI for 21 years presented with a right distal femur fracture. **Case Description:** The patient presented with a comminuted distal right femur fracture secondary to a fall. Nonsurgical management with a Bledsoe knee brace was recommended by orthopedic surgery. Due to presence of severe osteoporosis and spasticity in the fractured limb, there was very poor fracture healing 5 weeks after the initial injury. The patient was referred to our SCI clinic for spasticity management. We felt that the increased spasticity in the fractured limb was a result of the reaction to deep pain in the fractured site. Therefore, a combination of oral analgesics and botulinum toxin injection to the quadriceps was instituted to decrease the localized spasticity. In addition, a bone stimulator was used to promote bone healing. **Assessment/Results:** There was significant callus formation around the fracture site 7 weeks after botulinum toxin injection, initiation of analgesics, and a bone growth stimulator. Range of motion of the knee was preserved and the patient returned to his previous functional level. **Discussion:** Osteoporosis is common in people with SCI and management of long-bone fractures among those patients is a unique clinical challenge. Successful healing of the fracture is important to maintain their independence and quality of life. **Conclusions:** Adequate control of pain and spasticity, in combination with a bone stimulator, is a unique and practical approach in management of long-bone fractures in patients with SCI. **Key Words:** Fractures; Osteoporosis; Rehabilitation; Spinal cord injuries.

Identifying testosterone deficiency in patients with spinal cord injury (SCI). **Design:** Prospective survey. **Setting:** Department of physical medicine and rehabilitation at the Medical College of Wisconsin and SCI unit at the Milwaukee Veterans Administration medical center. **Participants:** 60 randomly selected healthy male veterans with SCI assigned to 3 age groups—21 to 40 years, 41 to 60 years, and 61 to 80 years—irrespective of time and level of injury. There was no control group; instead we used the results of prevalence of hypogonadism in normal healthy men from a longitudinal survey done by the National Institute of Aging. **Interventions:** Measurement of serum levels of total testosterone, luteinizing hormone, follicle stimulating hormone, prolactin, albumin, and thyroid-stimulating hormone. **Main Outcome Measures:** Identifying testosterone deficiency in veterans with total serum testosterone levels below 320 μg/dL, identifying testosterone deficiency as a result of primary versus secondary hypogonadism, correlation of testosterone deficiency with neurologic level of injury, nutritional status, and age of the veterans. **Results:** Up to 45% of our enrolled veterans had testosterone deficiency. The incidence of testosterone deficiency based on the 3 age groups was 21% in the 21- to 40-year group, 48% in the 41- to 60-year group, and 40% in the 61- to 80-year group. The highest prevalence of low testosterone levels were among those veterans with complete SCIs (American Spinal Injury Association grades A and B), lumbar, and lower thoracic injuries. **Conclusions:** Testosterone deficiency is significantly higher after SCI and prevalence of low testosterone is directly related to the level and severity of the injury. **Key Words:** Hypogonadism; Rehabilitation; Spinal cord injuries; Testosterone.

**Poster 287**

Incidence and Outcomes of Vascular-Related Spinal Cord Injury. William O. McKinley, MD; John E. Gibbs II, MD (VCU Health Systems, Richmond, VA); Sean McKinley. Disclosure: W.O. McKinley, None; J.E. Gibbs II, None; S. McKinley, None. **Objective:** To compare injury characteristics, demographics, and functional outcomes of patients with vascular-related spinal cord injury (SCI) with those with traumatic SCI. **Design:** A retrospective review of patients with vascular-related SCI. **Setting:** Admissions to an SCI rehabilitation unit at a level 1 tertiary university trauma center. **Participants:** 27 consecutive patients with vascular-related SCI. **Interventions:** Not applicable. **Main Outcome Measures:** Length of stay (LOS), FIM instrument motor scores, and discharge to home rates. **Results:** Etiology of vascular-related SCI was most often related to postsurgical events (37%), aneurysm dissection (19%), and systemic hypotension (19%). Pertinent premorbid medical history most commonly included coronary artery disease (56%), hypertension (56%), and diabetes (37%). SCI-related complications most commonly included neurogenic bladder and bowel (89%), urinary tract infection (67%), pain (56%), and pressure ulcers (33%). When compared with traumatic SCI (n = 560), patients with vascular-related SCI comprised significantly less of the SCI rehabilitation admissions (3% vs 61%), were older (58 vs 40 y), and more often female (33% vs 16%). Injury characteristics revealed that vascular-related SCIs were more commonly located in the thoracic region (74% vs 38%) and were more often incomplete injuries (74% vs 57%). Improvements in American Spinal Injury Association scores were seen in 15% of vascular-related SCI patients. Similar outcomes were noted between the 2 groups for acute care LOS (18 d vs 16 d), rehabilitation LOS (33 d vs 34 d), FIM motor changes (21.7 vs 22.8), and discharge to home rates (78% vs 75%). **Conclusions:** Patients with vascular-related SCI comprise a small subset of all SCI rehabilitation admissions. When compared with traumatic SCI, their functional outcomes were similar. **Key Words:** Rehabilitation; Spinal cord injuries.

**Poster 288**

Cauda Equina Arachnoiditis After Transforaminal Epidural Steroid Injection: A Case Report. Moshe Ben-Roohi, MD (NYU School of Medicine, New York, NY); Eugene Bulkin, MD; Kenneth Vitale, MD. Disclosure: M. Ben-Roohi, None; E. Bulkin, None; K. Vitale, None. **Setting:** Urban rehabilitation hospital. **Patient:** A 64-year-old woman with history of L4-5 laminectomy and fusion who developed herniated nucleus pulposus at L3-4 with left-sided radicular symptoms. **Case Description:** Immediately after a left L3-4 transforaminal fluoroscopically guided epidural steroid injection (ESI), the patient developed band-like umbilical and radiating leg pain, decreased sensation from T10 level down, and paraplegia. A high-dose steroid protocol was administered and stat thoracolumbar magnetic resonance imaging (MRI) showed clumping of the cauda equina at L3-4, small intrathecal fluid collection tracking the facet, and disk herniation (noted preprocedure) without evidence of epidual hematoma, cord compression, or infarction. Subsequent examination revealed: no perianal sensation, sphincter tone, or anal wink; saddle anesthesia pattern; L1 motor level with right motor zone of partial preservation to S1; downgoing toes, no ankle clonus; and areflexic limbs (except +2 right knee). The patient was admitted to inpatient rehabilitation. Repeat MRI at 1 week showed cauda equina enhancement consistent with arachnoiditis, and no cord infarction or arteriovenous malformation and fistula. Electromyography suggested severe cauda equina involving left more than right. Urodynamic study confirmed areflexic bladder with no sensation after infusion of cold fluid. **Assessment/Results:** The patient developed an atypical form of acute severe cauda equina syndrome following epidural injection, without cord infarction, vascular injury, or infection. **Discussion:** To our knowledge, this is the first reported case of cauda equina arachnoiditis following transforaminal ESI. The weakness extending proximally is atypical. This case is also unique because there was no evidence of cord infarction or hematoma compromising neural structures. Possible causes are discussed with review of literature. Radiologic, electrodiagnostic, and urodynamic workup is presented. **Conclusions:** Cauda equina syndrome can be a rare complication of transforaminal ESIs. Pain rehabilitation specialists need to be aware of this rare, potentially dangerous complication, especially in patients with history of spinal fusion and stenosis. **Key Words:** Cauda equina syndrome; Injections; Radiculopathy; Rehabilitation.

**Poster 289**

Acute Spinal Cord Injury and Infection With Resistant Acinetobacter Calcoaceticus-Baumannii Complex: Successful Innovations in Rehabilitation During Isolation—A Case Report. Albert Recio, MD, PT (University of Washington, Seattle, WA); Zachary Bohart, MD, MS; Spencer Havens, MD, MS; Steven Stiens, MD, MS. Disclosure: A. Recio, None; Z. Bohart, None; S. Havens, None; S. Stiens, None. **Setting:** Spinal cord injury (SCI) unit of a tertiary care hospital. **Patient:** A 30-year-old active duty Army sergeant who sustained a C5 American Spinal Injury Association grade A SCI from a gunshot wound to the thoracic region (74% vs 38%) and were more often incomplete injuries (74% vs 57%). Improvements in American Spinal Injury Association scores were seen in 15% of vascular-related SCI pa-
wound while serving in Operation Iraqi Freedom. **Case Description:** We report a systematic retrospective case review of his acute SCI rehabilitation, which was medically complicated by infection with acinetobacter calcoaceticus-baumannii complex contracted while in Iraq. Isolation equipment and protocols were designed to enable regular hands on contact for proprioceptive neuromuscular facilitation, transfers, wheelchair fitting, mobility training, and environmental control. **Assessment/Results:** After 1 month of comprehensive acute interdisciplinary rehabilitation in an isolated hospital room on the SCI unit, he attained a functional level comparable to C5 complete patients rehabilitated in our unit. Patient and wife team achieved 1-person assist Hoyer lift transfers, wheelchair sitting for 1 hour twice daily, independent recline pressure releases, and joystick control of a power wheelchair, as well as minimum assistance upper-body dressing and independence in self-feeding after setup. The “Yes You Can” educational manual was reviewed in its entirety. **Discussion:** Concerns about serious infectious organisms are increasing in rehabilitation facilities. Isolation has been implemented to protect patients and staff. Isolation can also potentially challenge patients’ rights of access to medical care, psychologic adaptation, mobility options, and environmental interaction. However, innovations in intervention of rehabilitation practice can improve function in this setting. These challenges were overcome with increased education, greater inclusion of the spouse and primary nurse in the rehabilitation process and scheduled visits of the entire team. **Conclusions:** If isolation on an SCI unit is necessary, it is still feasible to conduct a comprehensive multidisciplinary rehabilitation program while strictly adhering to contact isolation. Further study is required to establish interdisciplinary protocols for patients and families requiring isolation in the rehabilitation setting. **Key Words:** Acinetobacter calcoaceticus; Isolation; patient; Rehabilitation; Spinal cord injuries.

**Poster 290**

**Quality of Life Evaluation in Spinal Cord Injury Patients Comparing Different Bladder Management Techniques.** Miguel Angel González Viejo, MD, PhD (Vall d’Hebron Hospitals, Barcelona, Spain); Judith Sánchez Raya, MD; Georgia Romero, MD; Joan Conejero, MD.

**Disclosure:** M. González Viejo, None; J. Sánchez Raya, None; G. Romero, None; J. Conejero, None.

**Objective:** To examine the quality of life (QOL) among patients with spinal cord injury (SCI) requiring bladder management techniques, using the King’s Health Questionnaire (KHQ). **Design:** Cross-sectional study. **Setting:** SCI unit in a tertiary university public hospital. **Participants:** 91 SCI patients (76% men, 24% women) were randomly chosen (average age, 40y; range, 16–75y; average time since spinal injury, 11.4y). They were classified according to the use of different bladder management techniques: clean intermittent self-catheterization (n=22) (CISC), external condom catheter (n=21) (ECC), and indwelling (Foley) catheter (n=48) (IC). **Interventions:** Patients completed a validated QOL questionnaire for urinary incontinence (KHQ), as well as a subjective evaluation of the main problems related to spinal injury. **Main Outcome Measure:** The KHQ. We evaluated the existence of statistically significant differences among them. **Results:** Total score in the KHQ for the sample was 39.9±54.4, with higher scores in those patients with ECC (43.5±24). A thorough analysis of the test did not show any significant differences. Patients treated with ECC reported higher physical role limitation scores (P=0.02) than patients treated with IC and CISC. Sexuality was the main concern of most patients, followed by defecatory dysfunction, urinary incontinence, and deambulatory problems. **Conclusions:** Patients treated with ECC reported a higher global score on the KHQ, although no significant differences were reported among the 3 groups. Our patients are mainly concerned about sexual problems. **Key Words:** Bladder; Rehabilitation; Spinal cord injuries; Urinary incontinence.

**Poster 291**

**Asymptomatic Persistent Bradycardia in Ventilator-Dependent Tetraplegia: A Case Report.** Matt P. West, MD (Medical College of Wisconsin, Milwaukee, WI); Kevin White, MD.

**Disclosure:** M.P. West, None; K. White, None.

**Setting:** Tertiary inpatient hospital spinal cord injury (SCI) unit. **Patient:** A 65-year-old man with C2 complete tetraplegia secondary to a fall. **Case Description:** Since the injury, he has been ventilator-dependent and persistently bradycardic despite medical treatment including theophylline. He has a cardiac history of atrial fibrillation over the last 10 years for which he has undergone cardioversion twice and has been on amiodarone. Amiodarone was discontinued with the onset of bradycardia following his SCI. 1 month postinjury, the patient had worsening bradycardia, with a heart rate in the mid-30s corresponding with episode of unresponsiveness. 5 months postinjury, he had asymptomatic persistent bradycardia with heart rate in the mid 30s and no signs of cardiopulmonary distress. Bradycardia is a known complication to acute injury secondary to dissociation between the parasympathetic and sympathetic response during spinal shock; however, he persistently had asymptomatic bradycardia for over 6 months. **Assessment/Results:** Cardiology was consulted to re-evaluate the patient’s bradycardia. The patient’s heart rate was monitored using a pulse oximeter machine. Recordings were made every 20 minutes over a 3-day period to evaluate trends. Although the patient was asymptomatic, for brief periods he maintained rates in the 30s. After discussing his case with everyone involved, including the patient’s family, a cardiac pacemaker was implanted. **Discussion:** Cardiac pacemaker implantation as a treatment for symptomatic bradycardia in acute high-level tetraplegia has been known to occur but the incidence of pacemaker placement in asymptomatic persons is not known. **Conclusions:** Though bradycardia is a known complication of high-level cervical cord injuries within the first few months, there is continued autonomic dysregulation in the chronic phase. Even in the face of asymptomatic bradycardia, there is often the possible indication for pacemaker implementation. **Key Words:** Bradycardia; Cardiac pacemaker, artificial; Rehabilitation; Spinal cord injuries; Tetraplegia.

**Poster 292**

**Neurosarcoidosis Presenting as Progressive Low Back Pain and Weakness Years After Laminectomy: A Case Report.** Jeffrey A. Gehret, DO (Thomas Jefferson Univ. Hospital, Philadelphia, PA); Guy W. Fried, MD.

**Disclosure:** J.A. Gehret, None; G.W. Fried, None.

**Setting:** Acute inpatient rehabilitation hospital. **Patient:** A 65-year-old African-American woman with a 45-year history of progressive low back pain (LBP), lower-extremity weakness, and gait instability worsened after each pregnancy. **Case Description:** The patient presented 4 years after initial thoracic laminectomy for LBP, lower-extremity weakness, and gait instability. The patient underwent thoracic laminectomy (T10-11) for presumed stenosis in 2002, with partial improvement of early myelopathy. Years later the patient presented with progressive myelopathy, diffuse lymphenadopathy, and an intracranial mass, in addition to a large enhancing lesion in the thoracic cord. **Assessment/Results:** The spinal lesion was consistent with a neoplastic intramedullary lesion at the site of the prior laminectomy. She underwent surgery for biopsy and possible excision. Frozen section was consistent with noncenseating granuloma. It was
decided not to excise the abnormal tissue. Treatment with steroids and intensive rehabilitation with ambulation training using a reciprocating walker resulted in remarkable functional improvement. Discussion: Intramedullary spinal neurosarcoidosis is an uncommon manifestation of sarcoidosis. It occurs in less than 1% of sarcoidosis cases. Usually spinal cord involvement is not an isolated or first manifestation of the disease. Correlation between symptom resolution and resolution of imaging findings is poor, especially with spinal cord lesions. Conclusions: Although rare, sarcoidosis of the spine should be considered in the differential diagnosis of LBP and weakness, particularly in patients considering surgery. Correct diagnosis and early treatment with steroids can minimize neurologic complications and decrease morbidity.

Key Words: Myelopathy; Rehabilitation; Sarcoidosis.

Poster 293
Man With Cervical Myelopathy Syndrome With Poliomyelitis-Type Motoneuron Disease Secondary to West Nile Virus: A Case Report. Harvey J. Navrkal, MD (Mercy Hospital PM&R Residency Program, Pittsburgh, PA).

Disclosure: H.J. Navrkal, None.

Setting: Acute care hospital. Patient: A 50-year-old man with motoneuron disease secondary to West Nile virus (WNV). Case Description: Following a “flu” syndrome, a 50-year-old man developed a cervical myelopathy syndrome. This rapidly progressed to generalized weakness and an encephalitis and meningitis presentation. He was hospitalized and placed on a mechanical ventilator for 4 months. Diagnostic workup revealed WNV infection (confirmed by the Centers for Disease Control and Prevention) with a complicated course involving poliomyelitis-type motoneuron disease. 24 months after discharge, he has been followed for a cervical myelopathy type syndrome. Magnetic resonance imaging of his brain and cervical cord remained unremarkable. Nerve conduction studies (NCS) of bilateral upper extremities showed diffuse motor-sensory polyneuropathy. There were components of median and ulnar tunnel syndrome as well, with dispersion of sensory amplitudes. Electromyography of bilateral upper extremities showed severe diffuse nerve root and muscle denervation consistent with diffuse motoneuron disease. He is undergoing rehabilitation of his upper-extremitiy function. Assessment/Results: At more than 2 years after his hospitalization for a paralytic poliomyelitis type of infection caused by WNV, the patient continues to make progress in his rehabilitation. Further developments will be discussed. Discussion: This is the first reported case, to our knowledge, of a severe generalized polio-like syndrome caused by WNV, with almost complete resolution of all symptoms at 24 months, with the exception of a slowly improving cervical myelopathy syndrome. Chronic inflammatory demyelinating polyneuropathy with secondary axonal changes was a diagnostic consideration, although the patient lacked any significant sensory symptoms. Conclusions: It is possible to have a residual segmental disorder of the anterior horn cells following a paralytic poliomyelitis syndrome caused by WNV. Superimposed tunnel syndromes may complicate the NCS. Key Words: Poliomyelitis; Rehabilitation; West Nile virus.

Poster 294
Mechanical Insufflation-Exsufflation Use in Persons With Tetraplegia: A Population-Based Study. James Crew, MD (University of Washington, Seattle, WA); Stephen Burns, MD.

Disclosure: J. Crew, None; S. Burns, None.

Objectives: To describe the characteristics of persons with spinal cord injury (SCI) who have been prescribed mechanical insufflation-exsufflation (MIE) units for outpatient use, and to examine pulmonary morbidity and mortality pre- and post-MIE prescription. Design: Retrospective cohort study. Prescription of MIE was verified from a prosthetic equipment database, and clinical data were abstracted from electronic medical records. Setting: Veterans Affairs SCI service. Participants: All persons receiving care through the SCI service who received MIE units for outpatient use during 2000 to 2006. Interventions: Not applicable. Main Outcome Measures: Patient demographics, hospitalization rates, and respiratory complications. Results: From a population of 883 persons who received care through the service during the study period, 41 (4.6%) were prescribed MIE units. Among chart-reviewed participants, mean age ± SD was 57.4 ± 13.8 years (range, 28–83) and mean age at onset of tetraplegia was 42.8 ± 16.0 years. All participants had tetraplegia, and the most common neurologic level was C5 (22% of participants). Pulmonary comorbidities were common in this cohort, with 65% of participants having at least one. Median time from first hospital admission to MIE prescription was 26 months. The pre-MIE rate of hospitalization with respiratory complications was .48 per year. Post-MIE hospitalization rate determination is ongoing. Conclusions: Approximately 5% of persons with SCI followed at the study center have received MIE units for outpatient use. Subsequent analyses will determine whether respiratory complication rates decreased following prescription of MIE units. Key Words: Pneumonia; Rehabilitation; Respiratory therapy; Spinal cord injuries.

Poster 295
Butylinum Toxin Type A to Improve Sitting Ability in a Patient With Tetraplegia and Hip Dislocation: A Case Report. Adam Berliner, DO (Jackson Memorial Hospital, Miami, FL); Suzanne Duncan, MD; Ronald Tolchin, DO.

Disclosure: A. Berliner, None; S. Duncan, None; R. Tolchin, None.

Setting: University-based multidisciplinary tertiary care center. Patient: A 24-year-old man with tetraplegia and left hip dislocation. Case Description: The patient, who was involved in a motor vehicle collision resulting in C5 complete tetraplegia, later developed difficulty in lying supine and propelling his wheelchair. Left hip imaging revealed a dislocation with sclerosis superiorly. Orthopedic evaluation determined that relocation was not possible. On examination, he was found to have severe lower-extremity spasticity. The left hip was internally rotated and the greater trochanter was superior to the right. An initial trial of 500U of botulinum toxin type A (BTX-A) was administered to reduce spasticity in the muscles surrounding the left hip. 3 months later, another 500U of BTX-A was administered in conjunction with dehydrated alcohol motor point blocks. Both sets of injections were followed by comprehensive physical therapy to reduce tone in the hip. Assessment/Results: Within 2 weeks of the initial treatment, the patient reported improved sitting posture and ability to operate his wheelchair. He noted significantly more improvement following the second procedure. Discussion: The use of neurotoxin injections for the management of spasticity is supported by several studies. Several case reports describe the use of BTX-A for dislocation of the temporomandibular or cricoarytenoid joints with favorable results. However, there are currently no studies addressing the use of neurotoxin injections for hip dislocation in spinal cord injury. A comprehensive review of the literature revealed 1 retrospective study looking at combining botulinum toxin with phenol to treat spasticity in children with cerebral palsy. Conclusions: The use of injected neurotoxins may be beneficial in treating patients with hip dislocation associated with lower-extremity spasticity and should be further investigated. Additional studies should address the safety and efficacy of combining neurotoxins to achieve greater spasticity reduction. Key Words: Botulinum toxin type A; Hip dislocation; Rehabilitation; Spinal cord injuries.
Poster 296
Acute Transverse Myelitis in a Patient Diagnosed With Herpes Simplex Virus Meningitis With a Known History of Myasthenia Gravis: A Case Report. Gautam Kothari, DO (Sinai Hospital of Baltimore, Baltimore, MD).
Disclosure: G. Kothari, None.
Setting: Acute inpatient rehabilitation unit. Patient: A 64-year-old woman with a history significant for myasthenia gravis post thymectomy. Case Description: The patient was initially admitted with headache, fever, and malaise and subsequently diagnosed with aseptic meningitis. On hospital day 3, the patient complained of severe weakness, numbness, and intermittent burning, sharp pain involving her bilateral lower extremities, beginning at the ankles and radiating to the upper abdominal and mid thoracic area. Examination revealed mild hypertonicity and decreased strength and patellar hyperreflexia involving bilateral lower extremities, and decreased sensation to light touch and pinprick involving bilateral lower extremities extending to the mid-thoracic level. Magnetic resonance imaging with gadolinium of the thoracic spine revealed an abnormally increased T2 signal involving the spinal cord extending from T1-6, and an abnormal signal involving the spinal cord at T8 and T10. There was an increase in the size of the spinal cord at the level of these lesions. Lumbar puncture displayed elevated cerebrospinal fluid white blood cell count with a lymphocytic predominance. Polymerase chain reaction for herpes simplex virus was positive. Assessment/Results: A diagnosis of transverse myelitis was made, and the patient was admitted to acute inpatient rehabilitation. The patient was treated with intravenous steroids as well as gabapentin and tramadol for pain, and baclofen for spasticity. The patient’s symptoms as well as functional status improved throughout the course of her rehabilitation stay. Discussion: Clinicians should be aware of transverse myelitis as an unusual complication of herpes simplex virus (HSV) meningitis and should consider this complication in patients with HSV meningitis presenting with lower-extremity weakness and numbness, particularly in patients with other autoimmune dysfunctions, including myasthenia gravis. Conclusions: Rehabilitation should be implemented early in recovery to maximize the patient’s functional improvements. Key Words: Herpes simplex virus; Myasthenia gravis; Myelitis, transverse; Rehabilitation.

Poster 297
Cardiovascular Responses During Ejaculation in Spinal Cord Injured and Able-Bodied Men. Andrei Krassioukov, MD, PhD (University of British Columbia, Vancouver, BC, Canada); Frederique Courtois, PhD; Marc Belanger, PhD.
Disclosure: A. Krassioukov, Christopher Reeve Foundation; F. Courtois, Christopher Reeve Foundation; M. Belanger, Christopher Reeve Foundation.
Objective: To evaluate the cardiovascular changes occurring during vibrostimulation for sperm retrieval procedures in men with spinal cord injury (SCI) and able-bodied controls. Design: Not provided. Setting: Not provided. Participants: 6 SCI men with chronic tetraplegia and 12 healthy control men volunteered for the study. The average age of SCI subjects was 36 and of controls, 29 years. Intervention: SCI participants were asked to use vibrator stimulation (Ferticare) to reach ejaculation and control participants were asked to masturbate to ejaculation. Main Outcome Measures: Continuous electrocardiography as well as systolic blood pressure (SBP) and diastolic blood pressure were recorded. All parameters were obtained at baseline, ejaculation, and every 2 minutes following ejaculation, for a total of 20 minutes postejaculation. Results: The resting SBP was lower in tetraplegic subjects than in controls (102±11.8mmHg vs 127±9.7mmHg). Bradycardia at rest was noted in tetraplegics (69.5±14bpm). At ejaculation, there was a significant increase in SBP in the SCI group (36±9.5mmHg vs 5±5.3mmHg). In SCI subjects, RR intervals varied on average at baseline from .897 to .932ms, with noticeable prolongation with vibrator stimulation to 1.063ms. In able-bodied men, RR interval varied on average during baseline from .838 to .679ms, with .849ms at ejaculation. Cardiovascular parameters returned to the resting level very shortly after ejaculation in controls but not in SCI men. Conclusions: The ejaculation following vibrostimulation procedure in SCI men is accompanied by significant cardiovascular responses that are not evident in able-bodied men. Key Words: Cardiovascular system; Rehabilitation; Sexual and gender disorders; Spinal cord injuries.

Poster 298
Disclosure: A. Mizrachi, None.
Setting: Inpatient spinal cord injury (SCI) unit. Patient: A 28-year-old woman. Case Description: The patient awoke, 2 years ago, with bilateral arm and hand numbness. Subsequently, she underwent magnetic resonance imaging (MRI) and computed tomography (CT) scan of her head. The CT scan was negative, and MRI revealed a right vestibular schwannoma. She underwent a cyberknife treatment and a 6-month follow-up MRI revealed no reduction in the tumor. Over the next 2 years, the patient developed abnormal gait. She experienced a decrease in hearing and a new MRI revealed an increased mass of a cerebellar pontine angle tumor budding the brainstem and internal auditory canal. A discussion was held about the potential complications concerning the surgery. Assessment/Results: The patient decided to undergo a translabyrinthine right-sided craniotomy and excision of vestibular schwannoma. Postoperatively, the patient was in respiratory distress and had no voluntary movements in her extremities. She had numerous attempts at extubation and reintubation due to respiratory distress. She underwent tracheotomy. The patient’s neurologic exam revealed a C4 American Spinal Injury Association (ASIA) grade C tetraplegia. Discussion: The patient underwent a right-sided craniotomy with subsequent excision of a right vestibular schwannoma and postoperatively became a C4 ASIA grade C tetraplegic. Conclusions: There is a possibility of the tumor causing compression and subsequent injury; I feel most likely the injury was due to a lack of perfusion to the spinal cord, either intra- or postoperatively. The procedure of a craniotomy and subsequent tumor removal of any kind carries the risk of infection, hemorrhage, stroke, and hemodynamic instabilities, as well as SCI. Unfortunately in this case, one of the potential complications described to the patient occurred. Although a postoperative course of this nature is rare, it is important to illustrate the extreme risks of this kind of procedure, as they do occur. Key Words: Quadriplegia; Rehabilitation.

Poster 299
Motion Analysis of Head and Neck While Wearing Football Equipment. Christine E. Norton, MS, ATC (Mayo Clinic, Jacksonville, FL); Michael D. Osborne, MD.
Disclosure: C.E. Norton, None; M.D. Osborne, None.
Setting: Acute inpatient rehabilitation unit. Patient: A 64-year-old man with a history of right cerebellar pontine angle (CPA) tumor. Case Description: The patient decided to undergo a translabyrinthine right-sided craniotomy and excision of vestibular schwannoma. Postoperatively, the patient was in respiratory distress and had no voluntary movements in her extremities. She had numerous attempts at extubation and reintubation due to respiratory distress. She underwent tracheotomy. The patient’s neurologic exam revealed a C4 American Spinal Injury Association (ASIA) grade C tetraplegia. Discussion: The patient underwent a right-sided craniotomy with subsequent excision of a right vestibular schwannoma and postoperatively became a C4 ASIA grade C tetraplegic. Conclusions: There is a possibility of the tumor causing compression and subsequent injury; I feel most likely the injury was due to a lack of perfusion to the spinal cord, either intra- or postoperatively. The procedure of a craniotomy and subsequent tumor removal of any kind carries the risk of infection, hemorrhage, stroke, and hemodynamic instabilities, as well as SCI. Unfortunately in this case, one of the potential complications described to the patient occurred. Although a postoperative course of this nature is rare, it is important to illustrate the extreme risks of this kind of procedure, as they do occur. Key Words: Quadriplegia; Rehabilitation.
equipment is worn. **Design:** Correlation-prediction study. **Setting:** Outpatient clinic. **Participants:** 11 healthy male subjects (age range, 18–30 y) with no history of cervical injury. **Interventions:** Subjects were fitted with a football helmet and a mouthpiece with an opaque marker and positioned supine while resting on modified shoulder pads. Subjects’ heads were positioned in neutral, and lateral dynamic fluoroscopic images were collected while the head and neck were passively moved through flexion and extension range of motion (ROM). Next, static anteroposterior (AP) fluoroscopic images were captured at 5 specified positions throughout the ROM. **Main Outcome Measures:** 2 points on the opaque mouthpiece were digitized to calculate the angular location of the skull during the passive motion. The body of C4 and C5 were digitized using a modified Dvorak procedure. **Results:** The mean flexion and extension ROM was 8.2° ± 2.7° at C4-5 and 48.8° ± 6.2° for the head. The mean lateral flexion ROM was 10.8° ± 3.4° at C4-5 and 35.6° ± 6.4° for the head. The Pearson correlation coefficient between the head and C4-5 motion was r equal to −.192 (P < .001) in the lateral view and r equal to −.764 (P < .001) in the AP views. **Conclusions:** While wearing football equipment, motion between the head and lower cervical spine correlated more strongly in the frontal plane than the sagittal plane. The total ROM of the skull is much greater than that of the cervical segments. **Key Words:** Cervical vertebrae; Range of motion, articular; Rehabilitation; Sports medicine.

**Poster 300**

Intrathecal Baclofen and Bupivacaine Combination Therapy for Spasticity With Neuropathic Pain in Spinal Cord Injuries: A Case Series. Maulik Bhalani, MD (University of South Florida, Tampa, FL); Celeste Lombardi, MD; Carlos Ramirez, ARNP; Thomas Mobley, PharmD; Satinderpaul S. Satia, MD.

**Setting:** Acute spinal cord injury (SCI) unit. **Participants:** 2 men and 1 woman with chronic tetraplegia and severe spasticity and neuropathic pain. **Case Descriptions:** This case series reports the outcomes of combination therapy using intrathecal baclofen (ITB) and intrathecal bupivacaine on 3 chronic tetraplegic patients with severe spasticity and neuropathic pain. The patients were a 38-year-old C8-T1 American Spinal Injury Association (ASIA) grade C tetraplegic for 15 years, a 39-year-old C3 ASIA grade A tetraplegic for 3 years, and a 45-year-old C7 ASIA grade C tetraplegic for 7 years. All 3 patients in this study had failed several oral therapies for spasticity and neuropathic pain (eg, baclofen, tizanidine, diazepam, clonidine, gabapentin, amitriptyline, doxepin). Spasticity, as measured by the Modified Ashworth Scale (MAS) scores, were 2, 3, and 3, and pain scores on the visual analog scale (VAS) were 8, 7, and 7, respectively, prior to initiation of ITB and bupivacaine combination (intrathecal bupivacaine) therapy. **Assessment/Results:** MAS scores and VAS pain scores postintrathecal bupivacaine were 0, 0, and 1, and 8, 4, and 2, respectively. There was proven benefit seen in these patients in terms of the resolution or lessening in severity of symptoms of spasticity and neuropathic pain. **Discussion:** Spasticity and neuropathic pain are common debilitating problems among the SCI population. These case reports demonstrate the benefit of using intrathecal bupivacaine to reduce spasticity and neuropathic pain when used in cases that are refractory to ITB monotherapy and oral therapies for neuropathic pain. **Conclusions:** The current intrathecal bupivacaine therapy regimen decreased spasticity and neuropathic pain in chronic tetraplegic SCI patients. **Key Words:** Muscle spasticity; Pain; Rehabilitation; Spinal cord injuries.
CPK are likely muscle injury from the initial trauma. However, the increase in CPK during the first week of inpatient rehabilitation suggests new muscle injury. The origin of this injury may be related to stretching of insensate muscle, activity of intact muscles, or pressure injury from sitting. This phenomenon deserves further study to determine the origin of the muscle injury as well as the clinical impact. **Key Words:** Creatine kinase; Rehabilitation; Spinal cord injuries.

**Poster 303**

Paraplegia After Implantation of Spinal Cord Stimulator and Resultant Hematoma Development in a Patient With Chronic Pain: A Case Report. Vijay S. Sidhwani, DO (New York University Medical Ctr, Rusk Institute of Rehabilitation Medicine, New York, NY); Daniel D. Feldman, MD.

Disclosure: V.S. Sidhwani, None; D.D. Feldman, None.

**Resultant Hematoma Development in a Patient With Chronic Paraplegia After Implantation of Spinal Cord Stimulator and Extramedullary Cavernous Hemangioma of the Thoracic Spine**

Warycha, MD (SUNY Downstate Med Ctr, Brooklyn, NY); Melissa Bednar, MD; Timur Yasin, MD; Muhammad Arif, MD; Paul Pipia, MD.

Disclosure: B. Warycha, None; M. Bednar, None; T. Yasin, None; M. Arif, None; P. Pipia, None.

**Setting:** Tertiary care hospital. **Patient:** A 19-year-old woman with postlaminectomy syndrome. **Case Description:** The patient’s history involved multilevel degenerative disk disease, knee derangement, neck fusion, and multiple failed back surgeries. She subsequently had a T8-9 spinal cord stimulator implanted for chronic pain control. 2 days after the procedure she returned to the emergency department for severe abdominal pain and computed tomography (CT) was performed. Just prior to the test the patient noted significant difficulty transferring onto the examination table, and by its end reported the inability to move either of her legs. CT revealed an acute epidural hematoma. The patient underwent immediate T7-11 laminectomy for evacuation of the epidural hematoma and removal of the stimulator. Postoperatively she was treated with high-dose methylprednisolone. Follow-up magnetic resonance imaging scans of her thoracic and lumbar spine showed no residual epidural hematoma. On admission to acute rehabilitation, the patient was diagnosed with T11 American Spinal Injury Association grade A complete spinal cord injury and exhibited flaccid paralysis of her legs bilaterally. **Assessment/Results:** 2 weeks after development of the thoracic epidural hematoma, the patient began to demonstrate 1+/5 muscle strength of hip flexors, ankle dorsiflexors, and great toe extension of her left side. Additionally, there was clinical evidence of vague sensory return in the perianal area, and questionable active contraction of the perianal musculature. The patient continues to undergo acute inpatient rehabilitation at this time. **Discussion:** Rarely has paraplegia been reported as a complication of spinal cord stimulator implantation. Only a few cases have been documented in the literature to date. **Conclusions:** Physiatrists should be aware that, despite precautions used by neurosurgeons, serious complications may result from implantation of spinal cord devices and may warrant acute inpatient rehabilitation. **Key Words:** Hematoma, epidural; Pain; Paraplegia; Rehabilitation; Spinal cord.

**Poster 304**

Extramedullary Cavernous Hemangioma of the Thoracic Spine Causing Spinal Cord Compression: A Case Report. Bohdan Warycha, MD (SUNY Downstate Med Ctr, Brooklyn, NY); Melissa Bednar, MD; Timur Yasin, MD; Muhammad Arif, MD; Paul Pipia, MD.

Disclosure: B. Warycha, None; M. Bednar, None; T. Yasin, None; M. Arif, None; P. Pipia, None.

**Setting:** Tertiary care hospital. **Patient:** A 19-year-old woman with medical history of type 1 diabetes mellitus who presented to the rehabilitation clinic with complaints of progressive lower-extremity weakness and 2 days of urinary retention. **Case Description:** The patient’s ambulatory status had declined over the course of 1 month. Several months prior to admission, the patient had undergone arthroscopic surgery of the left knee for a plica, which had caused pain and difficult ambulation. Since that time, the patient’s pain had improved but immobility had persisted and worsened. On examination, the patient was noted to have hyperreflexia and decreased strength of the lower extremities. The patient was sent to the emergency department for emergent magnetic resonance imaging (MRI) to rule out cord compression. **Assessment/Results:** MRI examination of the spine revealed an enhancing extramedullary mass of the posterior canal causing cord compression at the T6 level. Neurosurgery was consulted and the patient underwent decompression laminectomy and resection of mass. Pathologic reports confirmed an extramedullary cavernous hemangioma. The patient was admitted for inpatient rehabilitation for strengthening and ambulation training. **Discussion:** Vertebral hemangiomas are congenital vascular malformations of unknown etiology. Spinal lesions may cause symptoms of a varying degree with regard to pain, radiculopathy, and impairment. Although computed tomography (CT) or MRI are excellent adjuncts, diagnosis is secured only through histologic analysis. Surgical intervention is only reserved for refractory cases or those causing vertebral collapse or compression. **Conclusions:** Patients presenting with spinal hemangioma may clinically exhibit varying degree of impairment and quality of pain. It is important to further evaluate the possibility of neural invasion with CT or MRI when signs of cord compromise are evident. Intervention is almost always required to salvage function in such cases. **Key Words:** Hemangioma; Rehabilitation; Spinal cord.

**Poster 305**

Changes in Resiliency During Inpatient Rehabilitation Following a Spinal Cord Injury. Ann Marie Warren, PhD (Baylor Institute for Rehabilitation, Dallas, TX); Tanisha Toaston, DO; Brian White, BS; Simon Driver, PhD; R. Lance Bruce, MD.

Disclosure: A. Warren, None; T. Toaston, None; B. White, None; S. Driver, None; R.L. Bruce, None.

**Objectives:** To examine the relationship between resiliency and rehabilitation outcomes in inpatients with traumatic and nontraumatic spinal cord injuries (SCI); and to determine if resiliency and pertinent psychosocial variables change at different times during inpatient rehabilitation. **Design:** A repeated-measures design was used whereby participants completed 4 questionnaires at 3 different times during their inpatient status. Questionnaires were completed (1) at admission, (2) after approximately 3 weeks as an inpatient, and (3) at discharge. **Participants:** Purposive sampling was used to select participants with criteria including age and type of injury. Participants were all adults with a traumatic or nontraumatic SCI who were inpatients at the Baylor Institute for Rehabilitation. **Interventions:** Not applicable. **Main Outcome Measure:** Participants completed the Connor-Davidson Resilience Scale, Patient Health Questionnaire—9, Satisfaction With Life Scale, and the Intrinsic Spirituality Scale 3 times during their inpatient status. Demographic, etiology of injury, and FIM instrument scores were also obtained for each participant. **Results:** The results indicated a relationship between resiliency and rehabilitation outcomes for inpatients with SCI. People with greater resiliency demonstrated more positive rehabilitation outcomes. Findings also demonstrated changes in resilience, psychosocial functioning, and functional rehabilitation at different times during inpatient rehabilitation. **Conclusions:** The relationship between resiliency and rehabilitation outcomes has the potential to improve patient care post SCI. For example, if practitioners are able to identify a person’s level of resiliency at admittance to an inpatient program, then they may be able to modify the rehabilitation program and tailor it to the patient to maximize outcomes during inpatient rehabilitation, and possibly as an outpatient in the community. Thus, future studies should track resilience and physical and psychosocial outcomes of the patient once they...
have returned to the community. **Key Words:** Rehabilitation; Spinal cord injuries.

**Poster 306**

**Nontraumatic Brown-Sequard Syndrome in a 16-Year-Old Following a Pharyngeal Infection: A Case Report.** Jasmine Martinez, DO (Thomas Jefferson University, Philadelphia, PA); Christopher S. Formal, MD.

Disclosure: J. Martinez, None; C.S. Formal, None.

**Setting:** Spinal cord rehabilitation unit. **Patient:** A 16-year-old boy who presented for a comprehensive rehabilitation program following spinal cord compromise. **Case Description:** The patient presented after the onset of progressive right-sided weakness with no associated trauma. Physical examination revealed right-sided weakness with associated left-sided loss of sensation. A resolving dermatologic outbreak was also noted. The patient had recently been treated for impetigo and an upper-respiratory infection, which had affected the right side of his face and oral pharynx. **Assessment/Results:** Magnetic resonance imaging of the cervical spine revealed widened right-sided odontoid—C1 arch space with high abnormal signal intensity. An abnormal signal intensity in the right side of the spinal cord at the level of C3-4 with mass effect was also noted. Due to the peculiarity of the patient’s injury and presentation, multiple diagnostic evaluations were performed under the direction of consulting physicians, including neurosurgery and pediatric orthopedic surgery. No evidence of genetic, anatomic, or autoimmune etiologies were found to account for this patient’s injury. **Discussion:** Nontraumatic atlanto-axial subluxation in association with pharyngeal infection was originally described by Sir Charles Bell in 1830. Frequently called Grisel’s syndrome, it is an uncommon, but important condition requiring prompt diagnosis in cases at risk for neurologic compromise. **Conclusions:** Making the diagnosis of Grisel’s syndrome is “thinking of it.” A suggestive history of procedures or infection in the region with an unexpected unfavorable evolution of cervical spine problems may prompt one to think of Grisel’s syndrome. **Key Words:** Rehabilitation; Spinal cord injuries.

**Poster 307**

**A Case of Depression With Catatonia Limiting Rehabilitation Following Spinal Cord Injury.** Matthew D. Johnson, DO (Tufts - New England Medical Ctr, Boston, MA); Marika Hess, MD; Radhika Bapineedu, MD.

Disclosure: M.D. Johnson, None; M. Hess, None; R. Bapineedu, None.

**Setting:** Dedicated spinal cord injury (SCI) unit with acute and chronic injuries. **Patient:** A 74-year-old man status post new central cord injury. **Case Description:** Patient X presented after acute treatment of cervical SCI suffered in a fall. 2 weeks into rehabilitation, the patient participated in a group meeting where prognosis, functioning, and possibility of incomplete recovery were discussed in detail with staff and family present. The next morning the patient was found completely unresponsive to stimuli but with stable vitals. Sternal rub yielded no response. Labs revealed no electrolyte abnormalities. Computed tomography of the head was negative for acute disease. Neurology consultation was obtained but when the consultant went to see the patient he found him responsive and answering selective questions. The patient later reported he could hear and understand the entire time but would not respond. The patient had a similar episode 2 days later and again did not respond to any stimuli but later began perseverating on his wish to die. These episodes repeated frequently and intermittently and alternated with participation in therapy and improved affect. **Assessment/Results:** The patient exhibited 2 characteristics qualifying him as catatonic (a DSM-IV modifier): motor immobility and extreme negativism or mutism. The patient’s affect improved with antidepressants and situational adjustment. **Discussion:** This case provides an extreme example of the difficulty caused by the emotional burden of SCI. This patient was unable to participate in rehabilitation of any form while having the episodes. **Conclusions:** Anhedonia and depression are unfortunate emotional effects of SCI. Loss of function, extended hospitalization, and deprivation of usual social interaction all have negative effects on the human psyche and can present an obstacle to rehabilitation. We describe an extreme case of depression with catatonia following SCI, resulting in a central cord syndrome. **Key Words:** Catatonia; Depression; Rehabilitation; Spinal cord injuries.

**Poster 307A**

**A Structured Program to Reduce Pressure Ulcer Prevalence in Spinal Cord Injury: A Program Report.** Sunil Sabharwal, MD (VA Boston Healthcare System, W. Roxbury, MA); Elizabeth Tammaro, CRRN; Maura Nee, ARNP.

Disclosure: S. Sabharwal, None; E. Tammaro, None; M. Nee, None.

**Setting:** A U.S. Veterans Affairs spinal cord injury (SCI) center that provides a lifelong continuum of services to veterans with SCI. **Program:** We initiated a structured program to improve compliance with guidelines to reduce pressure ulcer prevalence in our SCI population, based on a previously conducted review that demonstrated crucial deficits. Input from focus groups was conducted to identify barriers, and best practices were incorporated. **Program Description:** Baseline prevalence was determined through review of people with SCI served in fiscal year 2006. Interventions include initiation of a template that serves as a checklist reminder and promotes consistent documentation of items related to pressure ulcer prevention. This template consolidates clinical information from various sources in the electronic record, and includes Braden scale score, nutritional evaluation, and pertinent lab values. Specified elements of patient and caregiver education are addressed. The template is administered at least annually (as part of the SCI annual evaluation) and as needed based on changes in medical and functional status. Patients are stratified by degree of risk based on clinically delineated criteria. A registry of patients identified at high risk for pressure ulcer was developed with targeted interventions based on risk. Compliance with this program is ensured by monitoring and provider-specific feedback, and incentives such as physician pay for performance. **Assessment/Results:** Baseline prevalence of pressure ulcer was assessed to be 21.8% (93/425 patients). Discussion: To date, the response to this initiative from providers as well as patients has been largely positive and preliminary data show significant improvements in documented compliance with critical elements of guidelines. **Conclusions:** The setting of lifelong care continuum for SCI provides opportunities to implement and monitor effect of interventions to decrease pressure ulcer prevalence that can serve as a model for other programs. **Key Words:** Practice guidelines; Pressure ulcer; Rehabilitation; Spinal cord injuries.
Stroke

Poster 308
The Effect of Botulinum Toxin Type A on Walking Speed in Poststroke Patients: A Subgroup Analysis of Patients in a 2-Part, 32-Week, Multicenter Study. Fiona Napier-Flood, PhD (Allergan Australia, Gordon, NSW, Sydney, Australia); John Oliver, MD; John D. Rogers, MD; Jane Deane, BSc.

Disclosure: F. Napier-Flood, Allergan Australia; J. Oliver, Allergan Australia; Allergan Australia; J.D. Rogers, Allergan Australia; J. Deane, Allergan Australia.

Objective: To investigate whether botulinum toxin type A (BTX-A) (Botox) treatment increases walking speed in poststroke patients.

Design: Part I: 18- to 20-week, double-blind, randomized, placebo-controlled trial; and part II: 12-week, open-label follow-up trial. Setting: 7 sites in Australia. Participants: Of 85 poststroke patients in the original study, 47 with spastic equinovarus deformity impeding voluntary movement (baseline Ashworth Scale score, 2 or 3) and a baseline walking speed of less than 10m/13s were included in the analysis. Interventions: In part I, patients received either 200 or 300U of BTX-A or placebo into the posterior tibialis, soleus, and either the flexor digitorum longus or gastrocnemius. In part II, patients received up to 300U of BTX-A. Patients entered part II at least 12 weeks after the first injection if their Ashworth score had returned to baseline. Patients were assessed at 4-week intervals following the first and second injections. Main Outcome Measures: All results are presented as percentage change from baseline in walking speed. Walking speed was calculated as the time taken to walk 10m. Results: BTX-A increased walking speed by 18.8%, 14.4%, and 25.8% at 4, 8, and 12 weeks post-treatment (P = .028, P = .001, P = .001, respectively). Placebo increased walking speed by 19.8% (P = .026) at 4 weeks; however, no significant change was seen at 8 or 12 weeks. A second injection of BTX-A increased the walking speed by 25.9%, 38.8%, and 39.3% at 4, 8, and 12 weeks (P = .005, P = .001, P < .001), respectively. Patients receiving their first BTX-A injection in part II significantly increased walking speed by 35.5% at 12 weeks (P = .04). Adverse events reported were consistent with the known safety profile of BTX-A. Conclusions: BTX-A significantly improved walking speed in poststroke patients and was safe and well tolerated. Key Words: Botulinum toxin type A; Rehabilitation; Walking.

Poster 309
Measuring Hand Dexterity in Hemiparetic Patients: 3 Different Scoring Systems. Francesca Gimigliano, MD; Arturo D’Antonio, MD; Cesare Di Palma, MD; Ciro Barbati, MD; Giovanni Iolascon, MD (Second University of Naples, Naples, Italy).

Disclosure: F. Gimigliano, None; A. D’Antonio, None; C. Di Palma, None; C. Barbati, None; G. Iolascon, None.

Objectives: To compare 3 different scoring systems in order to evaluate the level of dexterity of the upper limb in stroke hemiparetic patients; and to correlate the level of dexterity with the level of disability as measured by Barthel Index. Setting: Observational cohort study. Design: Rehabilitative care unit for subacute neurologic patients. Participants: 30 hemiparetic patients (mean age, 67y; range, 28–95y); 14 men (mean age, 66y) and 16 women (mean age, 69y).

Interventions: Not applicable. Main Outcome Measures: Motricity Index (grip item), Arm Functional Test (AFT) (manipulation items), performance time and Functional Ability Scale (FAS), Motor Activity Log (MAL) (amount of use [AOU] scale), and Barthel Index. Results: The Pearson correlations were as follow: between AFT and performance time, and Motricity Index, –.88 (P < .01); between AFT and FAS, and Motricity Index, .89 (P < .01); between AFT and performance time, and MAL, –.89 (P < .01); and between MAL and Motricity Index and MAL, .96 (P < .01). Objective measurement of perceived verticality can be used to establish appropriate treatment protocols and monitor progress in rehabilitation. Key Words: Cerebrovascular accident; Rehabilitation; Vision disorders.

Poster 311

Disclosure: F.X. Palermo, St Mary’s and ACP.

Setting: Outpatient and inpatient setting. Participants: Series of 11 patients with both recent and long-standing cerebrovascular accidents. Case Descriptions: 11 patients with a variety of strokes, whose improvement with standard rehabilitation therapy techniques had slowed, were provided a program of transcranial direct current stimulation (tDCS) combined with peripheral patterned neuromuscular stimulation. Transcortical stimulation was applied with the anode over...
the motor humunculus of the affected brain region. The peripheral stimulation was applied to the opposing neuromuscular structures of the affected limb. Upper-extremity treatments were applied to the forearm flexors and the hand intrinsics counterbalanced by the wrist and finger extensor. Lower-extremity stimulation applications were placed over the thigh and hip musculature. Assessment/Results: 7 of the 11 treated patients showed positive functional improvements after 3 or fewer sessions. 2 patients had absolutely no voluntary finger motion before the treatment despite extensive therapy. After 2 treatments, both were able to voluntarily extend their fingers to minus 30° of finger extension and were able to participate in functional therapy. Improvement persisted at a reduced level but for extended times up to 3 months on follow-up. Those who did not show functional improvement had considerably larger stroke volumes by comparison. Discussion: Researchers have demonstrated significant improvements in motor performance using tDCS. The concern is that the effects on the brain are nonfocal. By adding neuromuscular stimulation in an agnostic-antagonist or functional pattern, the activity in the related portion of the brain are nonfocal. By adding neuromuscular stimulation in an agnostic-antagonist or functional pattern, the activity in the related portion of the brain are nonfocal. Combining tDCS with peripheral functional neuromuscular stimulation appears to have synergistic efficacy in incomplete stroke patient recovery. These results are more profound and longer lasting than reported with either tDCS or neuromuscular stimulation alone. Key Words: Electric stimulation; Rehabilitation; Stroke.

Poster 312
Severe Hemiballismus After Stroke: The Unique Challenges of Rehabilitation—A Case Report. Michael Mallow, MD (Temple University Hospital, Philadelphia, PA); Carol Anne Dillon, MD. Disclosure: M. Mallow, None; C.A. Dillon, None.
Setting: Inpatient rehabilitation unit. Patient: An 81-year-old woman with hemiballismus. Case Description: The patient was admitted with a 1-week history of involuntary right-sided movements. Magnetic resonance imaging on admission revealed left subthalamic nucleus infarction. The patient had uncontrollable flailing movements of her right arm and leg, no cognitive defects, and only slight right-sided weakness. On transfer to the rehabilitation unit, treatment with clonazepam was initiated, however, this provided minimal improvement. The patient’s movements were frequent and of high amplitude, resulting in extreme difficulty with all tasks, and presented a constant source of stress and aggravation to the patient. As a result, multiple physical and psychologic modalities were employed to provide symptomatic relief and to prevent injury. Modifications were made to the patient’s wheelchair and environment. The affected limbs were weighted and braced to enable participation in physical therapy. Occupational therapy focused on adaptive activity of daily living strategies. Relaxation techniques, including massage and breathing exercises, were employed. Assessment/Results: During her treatment, the patient’s FIM instrument scores improved despite the persistence of hemiballismus. On discharge, the patient was equipped with practical methods to deal with the physical and mental aspects of her illness. Discussion: Hemiballismus is a relatively rare disorder manifesting in uncontrolled, large-amplitude movements of the extremities. There are several reports in the literature outlining the medical treatment of these movements, but no reports exist concerning rehabilitation strategies for such patients when medications fail or need to be adjusted. Conclusions: A multidisciplinary and adaptive approach is needed to successfully rehabilitate patients with hemiballismus after stroke. Key Words: Hemiballismus; Rehabilitation; Treatment outcome.

Poster 313
The Therapeutic Effect of Inhibitory Repetitive Transcranial Magnetic Stimulation on Right Inferior Frontal Gyrus in Subcortical Aphasia. Kwang-Ik Jung, MD (Hallym University Sacred Heart Hospital, Anyang-si, Republic of Korea); Ji-Hun Lee, MD; Woo-Kyoung Yoo, MD; Dong-Hyun Kim, MD; Jeong-Ki Lee, MD; Dong-Sik Park, MD. Disclosure: K. Jung, None; J. Lee, None; W. Yoo, None; D. Kim, None; J. Lee, None; D. Park, None.
Objective: To investigate whether suppression of right inferior frontal gyrus (Broca’s homologue) by 1-Hz repetitive transcranial magnetic stimulation (rTMS) can improve speech recovery. Design: Comparative, repeated-measure study. Setting: Rehabilitation unit at a university hospital. Participants: 8 subcortical aphasia patients who were 3 months to 3 years poststroke onset. Interventions: We applied low frequency rTMS on right Broca’s homologue twice a week for 6 weeks. rTMS was performed with intensity of 80% of motor threshold for 10 minutes (600 pulses) at a 1-Hz frequency. Main Outcome Measures: Subjects were tested with Korean Version of the Western Aphasia Battery before and after the procedure. Also they were tested with parallel short forms for the Korean-Boston Naming Test and Animal Naming Test serially for outcome measure. Results: Significant improvement was observed in picture naming at post-rTMS only in nonfluent aphasia patients but not in fluent aphasia patients. Conclusions: rTMS may provide a novel treatment for aphasia by possibly modulating the distributed, bi-hemispheric language network. Key Words: Aphasia; Magnetics; Rehabilitation; Stroke.

Poster 314
Nutritional Status and Functional Outcome in Stroke Patients. Giovanni Iolascon, MD (Second University of Naples, Naples, Italy); Francesca Gimigliano, MD; Sergio Bertogliatti, MD; Francesco P. Formisano, MD; Concetta N. D’Onofrio, MD; Raffaele Gimigliano, MD, PhD. Disclosure: G. Iolascon, None; F. Gimigliano, None; S. Bertogliatti, None; F.P. Formisano, None; C.N. D’Onofrio, None; R. Gimigliano, None.
Objective: To investigate the role of nutritional status, as a predictive factor, on final outcome in postacute neurologic patients and to study the frequency of poor nutritional status in patients recovered in a rehabilitative care unit for subacute neurologic pathologies. Design: Observational cohort study. Setting: Rehabilitative care unit for subacute neurologic patients. Participants: 30 stroke patients (mean age, 68y; range, 33–94y): 15 men (mean age, 66y) and 15 women (mean age, 70y). Interventions: Not applicable. Main Outcome Measures: Tricipital plica and Barthel Index (maximum score, 20). Results: In our cohort population, the mean of the admission Barthel Index score was 5.01. 14 (46.66%) of 30 patients had a tricipital plica greater than 8mm; in this group of patients, the mean improvement in Tricipital plica was 3.74±4.60. 7 (23.33%) of 30 patients had a low-normal nutritional status (albumin, ≤2.5g/dL); in this group of patients, the mean improvement in Tricipital plica was 2.12±3.21. 13 (76.66%) of 30 patients had a low-normal nutritional status (albumin, >2.5g/dL); in this group of patients, the mean improvement in Tricipital plica was 2.91±3.74. Conclusions: There was no significant correlation between tricipital plica and albumin. The admission nutritional status is a very important predictive factor for final functional outcome in stroke patients. Serum albumin is certainly the most predictive parameter of functional recovery. Clinical evaluation of the nutritional status performed by the measure-
ment of the tricipital plica does not seem to be useful. **Key Words:** Nutritional status; Rehabilitation; Stroke; Treatment outcome.

**Poster 315**

**Callosal Apraxia Without Callosal Lesion Following Multiple Embolic Infarcts in the Anterior Cerebral Artery Distribution: A Case Report.** Thomas S. Savadove, MD (Temple University/Moss Rehab, Philadelphia, PA); Ming K. Hsieh, MD.

**Setting:** Stroke unit in acute rehabilitation hospital. **Patient:** A 56-year-old woman with multiple bilateral anterior cerebral artery (ACA) infarcts. **Case Description:** The patient presented to the rehabilitation hospital after treatment for stroke. Magnetic resonance imaging showed multiple small acute infarcts in the bilateral ACA distribution, but no lesion in the corpus callosum. There were also prior infarcts in the right frontoparietal, left parietal, and left cerebellar regions, which had not affected upper-extremity function. Exam showed left hemiparesis (4/5). Right side was nonparetic (5/5) in the upper extremity. Left-hand grip was strong but the patient had impaired function on bimanual tasks. She was able to use the left hand given adequate stimulus (squeezing fingers), but had difficulty making spontaneous movements. She was unable to perform alternating movements. **Assessment/Results:** Intensive physical and occupational therapy improved function of the left hand. The patient developed markedly improved functional capacity with regard to bimanual activities of daily living such as dressing and eating. However, she remained unable to perform alternating movements with her hands, despite her functional gains. **Discussion:** This is a callosal apraxia without a callosal lesion after embolic stroke involving numerous small ACA infarcts. As classically described, it affects only the left upper extremity despite involvement of both cerebral hemispheres. The lack of right upper extremity involvement precludes the diagnosis of sympathetic or left parietal apraxia. It presented a challenge in the rehabilitation of the patient, because integrated function between the 2 upper limbs was significantly impaired despite adequate strength and independent function of each side. **Conclusions:** Presence of a callosal apraxia may not be readily apparent when dealing with 1 or multiple ACA infarcts. This deficit requires more directed therapies to integrate the apractic left upper limb into functional activities despite the apparently mild impairments on that side. **Key Words:** Apraxia; Cerebrovascular accident; Rehabilitation.

**Poster 316**

**Poststroke Depression and Acute Mental Status Change: A Case Report.** Sandeep Rathi, MD (Bellevue Hospital, NYU School of Medicine, New York, NY); Christopher Lee, MD.

**Setting:** Acute rehabilitation hospital. **Patient:** A 44-year-old man with history of hypertension and diabetes was admitted for right middle cerebral artery cerebrovascular accident. **Case Description:** The patient was admitted to inpatient rehabilitation service with a resultant left-sided hemineglect and hemiparesis. At that time, the patient was at a moderate assistance level for transfers, ambulation, and activities of daily living. It was also noted that the patient had a flat affect and exhibited other signs of depression. Psychiatry was consulted and the patient was started on sertraline for poststroke depression. The patient made excellent gains in physical therapy and was subsequently able to ambulate greater than 90m (300ft) with a straight cane. Prior to discharge, the patient became increasingly more lethargic, somnolent, and confused. A mental status workup was initiated and a noncontrast head computed tomography showed no acute changes. A review of lab studies revealed a sodium level of 120mmol/L. On physical exam, the patient was euolemic. **Assessment/Results:** The patient was diagnosed with hyponatremia secondary to the syndrome of inappropriate antidiuretic hormone release (SIADH). The patient’s sertraline was held and the hyponatremia slowly resolved, along with the patient’s confusion. **Discussion:** According to recent studies, upward of 60% of patients who are poststroke suffer from depression. This case represents a complication of treatment of early poststroke depression. The increasing use of selective serotonin reuptake inhibitors (SSRIs) in poststroke patients and their potential side effects need to be fully understood by physiatrists leading to improved monitoring of laboratory as well as clinical markers. **Conclusions:** Although poststroke depression remains a significant complication and needs to be addressed, physiatrists who are involved in the care of these patients must understand the potential side effects of SSRIs to avoid complications such as mental status change secondary to SIADH. **Key Words:** Cerebrovascular accident; Depression; Rehabilitation; Sertraline.

**Poster 317**

**Differences and Disparities in Poststroke Rehabilitation and Mortality: Results of a Large Population-Based Study in Northern California.** M. Elizabeth Sandel, MD (Kaiser Foundation Rehabilitation Ctr and Hospital, Vallejo, CA); Hua Wang, MD, PhD; Joe Terdiman, MD, PhD; Leighton Chan, MD, MPH; Jeanne Hoffman, PhD; Ashley Berhel, BA; et al.

**Setting:** Acute rehabilitation hospital. **Patient:** 22,914 stroke patients hospitalized for acute stroke from 1995 to 2004. The cohort includes unique stroke inpatient discharges. **Interventions:** Not applicable. **Main Outcome Measures:** Service delivery and mortality. **Results:** Mean age of the cohort was 71.2 years; sex distribution was 51.4% women; race and ethnicity was 65.3% white, 9.6% African American, 7.6% Asian, and 6.3% Hispanic. Urban population was 89.1%. Median household income was $56,382. 85% of patients had ischemic strokes; 15% had hemorrhagic strokes. Median acute length of stay was 3 days (mean, 5.5d). Results suggest variations in the types and extent of postacute care based on differences in age, sex and gender, race and ethnicity, socioeconomic status, and/or geographic area. **Design:** Retrospective cohort study tracking patients for 390 days following hospitalization for a first stroke. **Setting:** A health system with a 3-million membership population and multiple levels of care. **Participants:** 22,914 stroke patients hospitalized for acute stroke from 1995 to 2004. The cohort includes unique stroke inpatient discharges. **Objectives:** To determine if there are differences and disparities in referral and enrollment and mortality in postacute stroke rehabilitation based on race and ethnicity, sex and gender, age, socioeconomic status, and/or geographic area. **Design:** Retrospective cohort study tracking patients for 390 days following hospitalization for a first stroke. **Setting:** A health system with a 3-million membership population and multiple levels of care. **Participants:** 22,914 stroke patients hospitalized for acute stroke from 1995 to 2004. The cohort includes unique stroke inpatient discharges. **Interventions:** Not applicable. **Main Outcome Measures:** Service delivery and mortality. **Results:** Mean age of the cohort was 71.2 years; sex distribution was 51.4% women; race and ethnicity was 65.3% white, 9.6% African American, 7.6% Asian, and 6.3% Hispanic. Urban population was 89.1%. Median household income was $56,382. 85% of patients had ischemic strokes; 15% had hemorrhagic strokes. Median acute length of stay was 3 days (mean, 5.5d). Results suggest variations in the types and extent of postacute care based on differences in age, sex and gender, race and ethnicity, socioeconomic status, and service area. Services were grouped according to level of care and highest intensity of service received within the 390 days postdischarge, including inpatient rehabilitation (IRF), skilled nursing facility (SNF), home health (HH), and outpatient care. Patients whose highest level of rehabilitation was SNF or HH were older and more likely female. Asian and African-American patients were more often treated in an IRF. Rural patients were less likely to receive HH or IRF care. Mortality rates varied depending on race and ethnicity, age, and level of care, with the highest rates in SNF and nontreatment groups. **Conclusions:** Even in an integrated health system with multiple options for referral and enrollment and a coordinated system of care delivery, variation in care delivery, setting of care, and mortality in a stroke population are evident. **Key Words:** Rehabilitation; Stroke.
Poster 318
Rehabilitation Access, Utilization, and Satisfaction of Poststroke Survivors. Gerard E. Francisco, MD (University of Texas Health Science Ctr, Houston, TX).
Disclosure: G.E. Francisco, None.
Objective: To describe the rehabilitation access, utilization, and satisfaction of stroke survivors and caregivers. Design: Telephone and web-based survey conducted in early 2006. Setting: Survey. Participants: Stroke survivors with persistent motor or speech difficulties randomly selected from the database of a national stroke organization. 440 stroke survivors (ischemic, 74%; white, 85%; mean number of strokes, 1.5; mean stroke duration, 3.3y). 63% had most recent stroke at least 3.3 years ago. Interventions: Not applicable. Main Outcome Measures: Not applicable. Results: Although 58% claimed they did not need assistance for activities of daily living (ADLs), about half still had difficulty with various tasks, such as ambulation, hand movement, and instrumental ADLs. 44% identified neurologists as the primary doctors involved with poststroke recovery, while 23% named primary care physicians. Only 15% named physiatrists. 86% received rehabilitation intervention: physical (93%), occupational (79%), and speech (65%) therapies. 68% of those who did not receive rehabilitation were not given a prescription even though they felt they needed therapies. 14% claimed they did not need rehabilitation services and 14% declined rehabilitation recommendations. 6% lacked financial resources for rehabilitation. Respondents identified recovery of walking as the most important goal (26%), followed by improved ADLs (8%) and speech (8%). 57% felt that rehabilitation was extremely or very successful in achieving personal recovery goals. Among those who were not satisfied with rehabilitation, 34% identified lack of progress as the reason, while 32% identified lack of funding, 15% medical comorbidities, and 12% spasticity. Conclusions: The majority of stroke survivors surveyed had received rehabilitation and were satisfied with these services in relation to achieving their personal recovery goals. An alarmingly low proportion of the survivors identified physiatrists as the physicians responsible for their rehabilitation care. Key Words: Cerebrovascular accident; Drug utilization; Personal satisfaction; Rehabilitation.

Poster 319
Bone Quantitative Ultrasound in Hemiparetic Upper Limb and Level of Dexterity. Giovanni Iolascon, MD, PhD (Second University of Naples, Naples, Italy); Francesca Gimigliano, MD; Raffaele Di Blasio, MD; Tommaso Valentino, MD; Raffaele Gimigliano, MD, PhD.
Disclosure: G. Iolascon, None; F. Gimigliano, None; R. Di Blasio, None; T. Valentino, None; R. Gimigliano, None.
Objectives: To evaluate the difference in bone mineral assessment, using phalangeal quantitative ultrasound (QUS), between the paretic and nonaffected upper limb in subacute stroke patients and between the dominant and nondominant upper limb in subacute stroke patients and in a group of healthy people; to correlate amplitude-dependent speed of sound and the dexterity in the hemiparetic upper limb; and to investigate the bone mineral status of stroke patients. Design: Observational cohort study. Setting: Rehabilitation care unit for subacute strokes. Participants: 469 patients (305 black, 85 white, 79 Hispanic) admitted with a stroke to acute rehabilitation between 187d and 24/30. Interventions: Participants: 469 patients (305 black, 85 white, 79 Hispanic) admitted with a stroke to acute rehabilitation between 187d and 24/30. Main Outcome Measures: Phalangeal QUS, Motricity Index, and arm function test. Results: 80% (24/30) of our cohort population presented amplitude-dependent speed of sound values of less than −3.2 SD (T score), considered the cutoff for the diagnosis of osteoporosis; in the healthy control group, the percentage of osteoporotic subjects was the 27%. There was no significant difference in amplitude-dependent speed of sound between the affected and unaffected side. There was no significant difference in amplitude-dependent speed of sound between the dominant and nondominant hand in both groups. There was no correlation between the phalangeal amplitude-dependent speed of sound and the level of dexterity of the hemiparetic hand. Conclusions: The bone status evaluation performed by QUS can be important in the investigation of the wide range of stroke risk factors. We did not find any significant correlation between the recovery of dexterity level and bone mineral ultrasound data. Key Words: Bone mineral density; Rehabilitation; Stroke; Ultrasound.

Poster 320
Passive and Active Functional Tasks Are the Main Reasons for Treatment of Upper-Limb Spasticity in Poststroke Patients Among Neurologists, Physiatrists, and Primary Care Physicians. Amanda M. VanDenburgh, PhD (Allergan, Irvine, CA); Susan Abu-shakra, MD; Mitchell F. Brin, MD; Frederick Beddingfield III, MD, PhD.
Objective: To determine the major reasons for the treatment of upper-limb spasticity in poststroke patients among the leading 3 specialties that evaluate and manage these patients. Design: Physician survey conducted by Beta Research Corp. Setting: Internet-based. Participants: 523 physicians were contacted. A total of 50 neurologists, 50 physiatrists, and 300 primary care physicians (PCPs) fulfilled eligibility criteria and completed the survey. Interventions: Not applicable. Main Outcome Measures: Physician demographics and patient population characteristics pertaining to poststroke spasticity were collected. Results: The average number of adult stroke patients evaluated per month was 23.8 for neurologists, 17.9 for physiatrists, and 38.6 for PCPs. Approximately half of these patients had spasticity in the upper and/or lower limbs (10.3, 10.0, 12.5, respectively). A majority of the upper-limb spasticity patients presented with a clenched fist. The main treatment goals in this population were: relief of pain and discomfort and improved access to the palm for hygiene purposes (passive function goals), or to improve the ability to grasp and hold objects (active function goals). Conclusions: The major reasons cited for treatment were improvement in passive function (pain and discomfort, hand hygiene) and active function (grasping, holding). Key Words: Hygiene; Muscle spasticity; Pain; Rehabilitation; Stroke.

Poster 321
Inpatient Stroke Rehabilitation Measures and Racial Differences. Scott Davidoff, MD (Temple University, Philadelphia, PA); Ian Maitin, MD, MBA; Robert Ruchinskas, PsyD.
Disclosure: S. Davidoff, None; I. Maitin, None; R. Ruchinskas, None.
Objective: To examine outcomes between races after inpatient stroke rehabilitation. Design: Retrospective study using the Uniform Data System. Setting: Inpatient rehabilitation unit at an urban-based university hospital. Participants: 469 patients (305 black, 85 white, 79 Hispanic) admitted with a stroke to acute rehabilitation between January 2002 and August 2006. Interventions: Not applicable. Main Outcome Measures: Functional gains at the time of discharge were measured by FIM change and FIM efficiency, defined as FIM change per length of stay days. Other variables used in analysis were length of stay (LOS), disposition, and marital status. Etiologic diagnosis was categorized as hemorrhagic, ischemic, or late-effect stroke via ICD-9.
codes. Results: Analysis of variance revealed no significant differences among black, white, or Hispanic groups for their FIM admission, FIM change, or FIM efficiency scores. Regression analyses showed that demographic variables, such as race and marital status, had no predictive power when determining FIM change, FIM efficiency, or disposition location. Additionally, neither marital status nor stroke type was associated with LOS, disposition, or FIM efficiency. However, as expected, FIM change (r = −0.419) and FIM efficiency (r = −.341) correlated significantly (P < .001) and were predictive of discharge location, meaning that those with poorer functional outcomes were less likely to return home. Conclusions: In contrast to previous studies, our data show no significant racial disparities in functional gains or any measured variable after stroke rehabilitation. This lack of effect may be due to similarities in functional status on admission, or the fact that all of our patients came from similar levels of socioeconomic status. The setting in an urban-based university hospital affords the opportunity to compare a diverse population of stroke patients. Eliminating any preconceived bias of racial disparities is beneficial toward achieving rehabilitative goals. Key Words: Race; Rehabilitation; Stroke.

Poster 322
Electric Stimulation to Prolong the Duration of Botulinum Toxin Type A Effect on Spasticity: A Double-Blind, Placebo-Controlled Study. Alberto Esquenazi, MD (MossRehab, Elkins Park, PA); Nathaniel Mayer, MD. Disclosure: A. Esquenazi; N. Mayer, unrestricted educational grant from Allergan.

Objective: To demonstrate the potential temporal-enhancing effect of electric stimulation on the clinical effects of botulinum toxin type A (BTX-A) in patients with spasticity. Design: Double-blind, placebo-controlled trial. Setting: Gait and motor control analysis laboratories. Participants: 34 subjects with hemiparesis from stroke or traumatic brain injury and elbow or ankle Ashworth Scale score of more than 2/4. Interventions: After treatment with BTX-A (Botox) to elbow flexors or ankle plantarflexors with a dose of 180 to 400U of BTX-A, patients were randomized to active electric stimulation (muscle contraction) or sham electric stimulation (sensory stimulus) for 30 minutes to the injected muscles and repeated twice daily in 1 month. Active electric stimulation parameters: 20Hz, 200μs, 20 minutes on and off, at an intensity of 22 to 90mA. Sham stimulus intensity was greater than 19mA. Patients were contacted every week and maintained a log. Main Outcome Measures: Ashworth and Tardieu scale scores were obtained before injection and every 2 weeks until return to baseline. Results: Increased duration of effect, based on Ashworth or Tardieu scales was evident in patients receiving active electric stimulation when compared with the sham group and with clinical experience. Elbow effect duration increased from 16 weeks (11–20) for the control group to 28 weeks for the intervention group (14–46). The ankle treatment had shorter duration for both the control (9wk, 4–12) and active groups (20wk, 11–30). Conclusions: Electric stimulation produced muscle contraction of BTX-A injected muscles within 1 hour of injection and continuing it for 30 minutes twice daily increases the duration of effect. Electric stimulation appears to be beneficial and should be considered as a tool to enhance the valuable effects of BTX-A in the management of upper motoneuron syndrome–related muscle overactivity. Further studies are needed to optimize duration of electric stimulation and further elucidate the differences between the ankle and elbow. Key Words: Botulinum toxins; Electric stimulation; Muscle spasticity; Rehabilitation.

Poster 323
Do Recurrent Stroke Patients Have Poorer Functional Outcomes Compared With First-Time Stroke Patients After Inpatient Rehabilitation? Yee Sien Ng, MRCP (Singapore General Hospital, Singapore, Singapore); Heyyoune Jung, MD; Yi Chiong, MRCP; Peter A. Lim, MD.

Disclosure: Y. Ng, None; H. Jung, None; Y. Chiong, None; P.A. Lim, None.

Objectives: To establish the demographics and functional outcome data for patients with recurrent stroke and to compare these data with first-time stroke patients. Design: Prospective cohort study. Setting: Inpatient rehabilitation unit within a tertiary teaching hospital. Participants: 94 consecutive recurrent stroke patients over a 4-year period. Interventions: Not applicable. Main Outcome Measure: FIM instrument. Results: Recurrent strokes constitute 9.5% (94/992) of all strokes admitted for inpatient rehabilitation in our unit. The mean age was 63.6 ± 12.5 years and 58.9% were men. The mean number of cerebrovascular risk factors was 2.19 ± 0.11 and hypertension (91.5%) was the most common risk factor. The admission and discharge total FIM scores were 65.8 ± 24.5 and 77.9 ± 25.4, respectively, and this gain was highly significant (P < .001). The mean FIM efficiency was .724 ± .066 points/d. The mean length of stay (LOS) was 18.3 days and 85.1% of these patients were discharged to home. When recurrent stroke and first-time stroke patients were compared, recurrent stroke patients were older (P = .007) and significantly more were hypertensive (P = .004) or had diabetes mellitus (P = .001) However, the recurrent stroke and first-time stroke cohorts did not differ in rehabilitation LOS (P = .520), the absolute number of risk factors (P = .258), the number of medical complications during rehabilitation (P = .225), frequency of depression in rehabilitation (P = .883), or rates of home discharge (P = .278). Compared with first-time stroke patients, recurrent stroke patients had similar admission total FIM scores (P = .344), but had lower discharge total FIM scores (P = .002), FIM gain (P < .001), and FIM efficiencies (P = .003). Conclusions: Recurrent stroke patients make significant functional gains and can still benefit from comprehensive rehabilitation. However, their poorer functional outcomes compared with first-time stroke patients indicate that stroke recurrence is important in the prognostication, rehabilitation, and discharge planning for this stroke subset. Key Words: Rehabilitation; Stroke; Treatment outcome.

Poster 324
Amantadine to Improve Rehabilitation in Chronic Stroke Patients: A Case Report. Jun Zhang, MD (Kessler Medical Rehabilitation Research and Education Corp, West Orange, NJ); Uri Adler, MD; Anna Barrett, MD. Disclosure: J. Zhang, None; U. Adler, None; A. Barrett, None.

Setting: University-based rehabilitation institution. Patient: A 70-year-old woman with multiple medical problems including diabetes and cerebrovascular accident, with continuously decreased activities of daily living (ADLs) and frequent falls. Case Description: The patient, with multiple medical problems including diabetes, right middle cerebral artery infarct with left hemiparesis 2 years ago, decreased ADLs, and frequent falls, was admitted to hospital for mental status change status post fall at home. The computed axial tomography and magnetic resonance imaging scans of brain were negative for acute change. She was transferred to an acute rehabilitation facility because of functional decline. Fatigue was not reported. Assessment/Results: The patient was found to have mild weakness on the left side and gait ataxia. The patient was difficult with both physical therapy (PT) and occupational therapy (OT) because of a lack of attention span. Neuropsychologic evaluation showed significant cognitive deficit; findings included: Mini-Mental State Examination (MMSE) score of 18/30, and

inability to recall 4 recent presidents’ names (eg, only 2/4). After thorough diagnostic workup of dementia failed to show any correctable cause, amantadine was started. It was noticed that the patient became much more engaged with both PT and OT with rapid improvement. MMSE score increased to 22/30 after about 2 weeks and she was discharged to home. Discussion: It was previously reported that amantadine has been used to treat patients with traumatic brain injury (TBI) for functional arousal and communication, and to decrease fatigue in patients with TBI, spinal cord injury, and multiple sclerosis. However, it has not been widely used to treat cognitive deficits in chronic poststroke patients. This patient had significant improvements possibly because of improved imitative and planning, increased arousal, or other factors to be determined. Conclusions: Screening poststroke patients for cognitive impairment and using amantadine to pharmacologically intervene may facilitate recovery. Future studies of amantadine in rehabilitation of chronic stroke patients is indicated. Key Words: Amantadine; Cerebrovascular accident; Memory disorders; Rehabilitation.

Poster 325
Disclosure: J. Padova, None; L. Werner, None; R. Mahoney, Employee: Motorika USA; A. Esquenazi, Grant from Motorika USA.
Objectives: To assess patient efficacy, to study patient inclusion and exclusion criteria, and to guide practical use of a new robot-assisted therapy platform for stroke patients. Design: Pilot study, with each patient as his/her own control. Setting: Outpatient therapy program in a rehabilitation hospital. Participants: 10 subjects with hemiparesis due to a stroke. Intervention: 2 to 3 one-hour sessions per week, for a maximum of 6 weeks, consisting of progressively engaging patients in repetitions of functionally oriented arm movements with robot assistance, using the Reo Pro therapy platform. Main Outcome Measures: Clinical scales administered at baseline and discharge included: arm portion of the upper-extremity motor section of the Fugl-Meyer Assessment (FMA); perceived exertion, Modified Ashworth Scale, pain scale, common clinical observations, and log data from the Reo. Results: Patients received between 7 and 14 sessions of treatment and performed between 3380 and 11,110 functional arm movements during the course of treatment; average session time was 50 minutes; FMA scores increased between 2 and 11 points; and overall trends demonstrated a reduction in perceived exertion, reduction in shoulder pain, and reduction in Ashworth score. No adverse effects were reported. Conclusions: The Reo Go demonstrated safety and efficacy as an adjuvant for rehabilitation of subjects after stroke. The outcome trends demonstrate the role of the Reo system in assessing patient recovery potential. Additional work will focus on examining the relationship between patient recovery and the treatment dosage for functional outcomes, and integration of the Reo measurements into clinical practice. Key Words: Assistive devices; Rehabilitation; Robotics; Stroke.

Poster 326
Power Mobility Use for Persons With Stroke: A Prospective Training Study and Retrospective Chart Review. Anita D. Mountain, MD (Dalhousie University, Halifax, NS, Canada); R. Lee Kirby, MD; Gail Eskes, PhD; Cher Smith, BS,OT; Hilary Duncan, BSc.
Disclosure: A.D. Mountain, None; R.L. Kirby, None; G. Eskes, None; C. Smith, None; H. Duncan, None.
Objectives: To test the hypothesis that persons with stroke can safely and effectively use power mobility devices; to examine the effects of spatial neglect on performance; and to evaluate the past frequency of power wheelchair prescription for persons with stroke. Design: Prospective, uncontrolled, within-participant comparisons and retrospective chart review. Participants: 10 current inpatients (age range, 41–87y; 5 with neglect), and 100 charts of previous inpatients, with a primary diagnosis of stroke. Setting: Tertiary-level rehabilitation center. Intervention: Prospective participants received 5 wheelchair skills training sessions of up to 30 minutes each. Main Outcome Measures: For the prospective study, the participant’s power wheelchair skills were tested before and after training, using the Wheelchair Skills Test — Power Mobility version (WST-P, version 3.2). Results: The group’s overall mean score improved from 9 (26%) out of 35 to 24 (69%) between WST-P testing sessions 1 and 2 (P<.001). The mean score of the subgroup with neglect improved from 6 (17%) to 20 (57%) (P<.05) and the subgroup without neglect improved from 12 (34%) to 29 (83%) (P<.05). There was no difference between the subgroups with and without neglect on WST-P session 1 (P=.295), but the neglect subgroup performance was lower on WST-P session 2 (P<.05). Other cognitive domains did not differ between the subgroups on a cognitive screening exam (Cognistat), except performance on the construction subtest (P=.018). The chart review revealed that only 2 of 100 persons with a primary diagnosis of stroke had been considered for power mobility use during their inpatient stays and in follow-up. Conclusions: Although the non-neglect group achieved significantly higher overall scores on WST session 2, both groups benefited significantly from training. Persons with stroke, including those with neglect, should not be excluded from consideration of power mobility as a means of functional mobility. Key Words: Hemispatial neglect; Rehabilitation; Stroke; Wheelchairs.

Poster 327
Effective Cerebral Blood Flow Increase and Rehabilitation Effect Following Cilostazol Administration. Shuji Matsumoto, PhD (Kagoshima University, Kagoshima City, Japan); Megumi Shimodozono, PhD; Kazumi Kawahira, PhD.
Disclosure: S. Matsumoto, None; M. Shimodozono, None; K. Kawahira, None.
Objective: To investigate the effects of cilostazol on cerebral blood flow (CBF) and rehabilitation by administering cilostazol to patients with chronic cerebral infarction. Design: Prospective, self-controlled study. Setting: An inpatient rehabilitation center in Japan. Participants: 12 poststroke patients who had an episode of stroke more than 4 weeks previously participated in the present study. Interventions: Patients were administered cilostazol at daily doses of 200mg for 4 weeks. For 4 weeks after hospital admission, the patient was treated with 100mg/d of aspirin and conventional rehabilitation comprising physical therapy and occupational therapy. After these 4 weeks, 200mg/d of cilostazol was administered in addition to the aspirin as antplatelet medication for a further 4 weeks. Main Outcome Measures: CBF, Brunnstrom stage, Barthel Index, and Mini-Mental State Examination (MMSE). CBF in both hemispheres of the affected side and nonaffected side were quantified using Xenon-CT. Results: At baseline, CBF was 31.4±4.2mL/min per 100g in the affected side and 33.8±4.4mL/min per 100g in the nonaffected side. At the end of treatment, CBF increased by 12.4% in the affected side and by 13.0% in the nonaffected side; this difference was significant. Significant improvements in Brunnstrom stage, Barthel Index, and MMSE were seen during the study. In most patients, cilostazol administration effectively increased CBF and promoted rehabilitation. A significant improvement in functional outcome was observed during cilostazol administration as compared with aspirin administration, as evaluated by Brunnstrom stage, Barthel Index, and MMSE. Conclusions: We believe cilostazol is a useful drug for improving the clinical condition.
of patients suffering from chronic cerebral infarction after stroke and preventing the secondary occurrence of this condition. Key Words: Cilostazol; Rehabilitation; Stroke; Treatment outcome.

Poster 328
Improved Functional Outcomes With Treatment of Hypersonmolence in Bilateral Thalamic Infarction: A Report of 2 Cases. Keith M. D’Souza, MD (Marianjoy Rehabilitation Hospital, Wheaton, IL); Padma Srigiriraju, MD.

Disclosure: K.M. D’Souza, None; P. Srigiriraju, None.

Setting: Freestanding acute rehabilitation hospital. Patients: A 76-year-old man and 48-year-old woman. Case Descriptions: A 76-year-old man (case 1) was found unresponsive at home. In the emergency department, he had waxing and waning consciousness. Magnetic resonance imaging (MRI) was significant for bilateral thalamic infarction. Methylphenidate (Ritalin) was initiated by the consulting physiatrist at an acute care hospital. At time of admission to a rehabilitation hospital, the subject required maximal assistance for activities of daily living (ADLs) and minimal assistance for ambulation and transfers. A 48-year-old woman (case 2) was noted to be unresponsive by spouse. Serial MRIs noted evolving bilateral thalamic infarction. At admission to the rehabilitation hospital, the subject continued to be hypersomnolent and required maximal assistance for ADLs, ambulation, and transfers. Assessment/Results: In case 1, the patient’s hypersomnolence improved with methylphenidate and he made significant functional gains. He was discharged home on methylphenidate, requiring minimal assistance for ADLs and standby assistance for ambulation and transfers. In case 2, treatment was initiated with bromocriptine, resulting in improved arousal and functional gains. She continued to make progress and at discharge to home, and she required minimal assistance for ADLs, ambulation, and transfers. Discussion: Hypersomnia has been associated in the literature with thalamic infarction. Both cases described above had bilateral thalamic infarction with initial periods of unresponsiveness and subsequent hypersomnolence. Both subjects not only benefited from psychostimulants in addition to standard therapies, but also use of psychostimulants increased participation in therapies, resulting in improved functional outcomes. Both subjects continued to benefit from psychostimulants at interval follow-up. Conclusions: Physiatrists should be aware of the higher incidence of hypersomnolence in patients with thalamic infarction. Additionally, use of psychostimulants in patients with daytime somnolence is beneficial and improves functional outcomes. Key Words: Bromocriptine; Disorders of excessive somnolence; Methylphenidate; Rehabilitation; Thalamus.

Poster 329
Hydroxymethyl Glutaryl Coenzyme A Reductase Inhibitor-Induced Rhabdomyolysis Presenting as Unilateral Pain in a Patient After Stroke: A Case Report. Saloni Sharma, MD (Thomas Jefferson University, Philadelphia, PA); Barbara J. Browne, MD.

Disclosure: S. Sharma, None; B.J. Browne, None.

Setting: Acute rehabilitation hospital. Patient: A 45-year-old man with a history of hypertension, right parietal infarction 2 weeks prior to admission, and right anterior and middle cerebral artery distribution infarction 1 week prior to admission to a rehabilitation hospital. Case Description: The patient presented with hemiparesis, hemisensory deficits, and inattention throughout the left upper and lower extremities. 3 days prior to his rehabilitation admission, he was placed on simvastatin. Assessment/Results: During his first 2 days of acute rehabilitation, he had no complaints of pain. On the third day, 6 days after being placed on simvastatin, he reported pain and muscle spasms only on the right side of his body. The following 3 days he continued to have pain in this distribution, and laboratory studies revealed significantly increased creatinine kinase and creatinine levels. Simvastatin was discontinued 8 days after it was started and his pain began to decrease the next day. The patient was transferred to an acute care hospital and aggressively treated for rhabdomyolysis. The following day he reported no pain. The simvastatin was not restarted, his creatinine phosphatase kinase continued to decrease, and his creatinine level returned to baseline. Discussion: Rhabdomyolysis typically presents with diffuse and bilateral muscle cramps, and is a well-known painful and life-threatening adverse effect of hydroxymethyl glutaryl coenzyme A (HMG-CoA) reductase inhibitors. HMG-CoA reductase inhibitors are consistently prescribed to stroke survivors. Yet, literature describing the potential unique presentation of HMG-CoA reductase inhibitor-induced rhabdomyolysis in a stroke survivor as unilateral pain and muscle spasms is severely lacking. Conclusions: Ultimately, the differential for unilateral pain in a stroke survivor with hemisensory deficits, unilateral neglect, and hemiparesis, while taking a HMG-CoA reductase inhibitor, should include HMG-CoA reductase inhibitor-induced rhabdomyolysis. A basic investigation may substantially reduce potential patient morbidity and mortality. Key Words: Cerebrovascular accident; Pain; Rehabilitation; Rhabdomyolysis.

Poster 330
Stroke in a 37-Year-Old With Bardet-Biedl Syndrome: A Case Report. Amanda B. Truckssess, MD (UVA, Charlottesville, VA); Mary G. Bryant, MD.

Disclosure: A.B. Truckssess, None; M.G. Bryant, None.

Setting: Acute inpatient rehabilitation hospital. Patient: A 37-year-old woman with new-onset left hemiparesis. Case Description: The patient was an obese female with syndactyly, hypertension, and end-stage renal disease (ESRD), admitted with new-onset left facial droop and left arm weakness. Stroke workup was positive for a distal right middle cerebral artery infarct and scattered infarcts within the right insular cortex. Echocardiogram was positive for cardiac vegetation. The patient was treated with long-term broad spectrum antibiotics and aortic and tricuspid valve repair and replacement. Given the patient’s unusual features, neurology, ophthalmology, and internal medicine were consulted. A diagnosis of Bardet-Biedl syndrome was presumed. Karyotype analysis was sent. The patient was transferred to the acute inpatient rehabilitation hospital when stable. Assessment/Results: The FIM instrument motor subset score on admission and discharge from the rehabilitation hospital were 34 and 60, respectively. Importantly, the patient was ambulating at a supervision level for distances over 90m (300ft) at discharge. Given the patient’s obesity, this relieved a significant burden for her caregivers. Discussion: Bardet-Biedl syndrome is a rare pleiotropic genetic disorder characterized by obesity, retinal degeneration, polydactyly and syndactyly, hypogonadism, mental retardation, and cystic kidneys, often leading to ESRD and blindness. To date, at least 11 different genes have been identified. The underlying cause of Bardet-Biedl syndrome has been shown to be defects in the basal bodies and/or primary cilia. Additional research is underway. Conclusions: Bardet-Biedl syndrome is a rare genetic disorder that results in significant disability secondary to severe obesity, ESRD, and blindness. Physiatrists should be aware of the syndrome given the implications for genetic counseling, treatment, and multidisciplinary care coordination. Given a physiatrist’s unique training, physiatrists are ideal care coordinators for patients with complex disabilities such as those associated with Bardet-Biedl syndrome. Key Words: Bardet-Biedl syndrome: Obesity; Rehabilitation; Stroke.
Poster 331
Rare Case of Cerebral Amyloid Angiopathy in a Patient With Recurrent Stroke: A Case Report. Alberto Lin, MD (Rush University Medical Ctr, Chicago, IL); Christopher D. Reger, MD; Xuong Tang, DO; Hoang Vu, DO; Jafar Siddiqi, MD.
Disclosure: A. Lin, None; C.D. Reger, None; X. Tang, None; H. Vu, None; J. Siddiqi, None.

Setting: Not provided. Patient: A 68-year-old man with previous hemorrhagic stroke with residual expressive aphasia and new acute left hemiplegia. Case Description: The patient presented with acute left hemiplegia. Head computed tomography revealed a new hematoma (2.5×3.6cm) in the right high posterior frontal region. The hematoma appeared heterogeneous, reflecting 2 hemorrhages of different ages. A brain magnetic resonance imaging re-demonstrated the hematoma, and on gradient echo report, hemosiderin was present at the cortical surface of bifrontal lobes and scattered throughout the right occipital, left parietal, and bilateral temporal lobes. Subsequent brain magnetic resonance angiography and bilateral carotid Dopplers were unremarkable. Per Boston criteria (clinical findings coupled with imaging studies), the patient was diagnosed with probable cerebral amyloid angiopathy (CAA). Assessment/Results: Previously functionally independent, the patient was moderate to maximum assistance for all activities of daily living and transfers on admission. Gait and stair evaluation was limited secondary to left hemiplegia. Within a week, the patient had progressed with improved left lower-extremity strength and movement. Patient continues to progress in function. Discussion: Cerebral hemorrhages caused by amyloid angiopathy rarely occur and are commonly associated with Alzheimer’s dementia. CAA-related intracranial hemorrhage (ICH) represents only 2% of all ICH and is an important cause of hemorrhage in normotensive elderly patients without trauma. It leads to peripheral nerve deficits and is consistent with superficial central nervous system hemosiderosis. When it occurs, it usually affects the subcortical parieto-occipital region and is frequently recurrent. In this patient, however, this was a consequence of his second stroke; CAA was not diagnosed after his first stroke. Definitive diagnosis of CAA is made with a postmortem examination. Conclusions: In the rare disease of CAA, short-term prognosis is comparable to the general stroke population, however, long-term prognosis is poor due to the recurring nature of CAA-related ICH. Key Words: Amyloid angiopathy, cerebral; Rehabilitation; Stroke.

Poster 332
Improved Language Expression in Chronic Broca’s Aphasia After Transcranial Direct Current Stimulation Over the Right Inferior Frontal Cortex. Yun H. Park, MD (Samsung Medical Ctr, Sungkyunkwan University School of Medicine, Seoul, Republic of Korea); Suk Hoon Ohn, MD, MS; Hee-Jeong Chun, SLP; Sung-Tae Kim, MD, PhD; Peter K. Lee, MD, PhD; Yun-Hee Kim, MD, PhD.
Disclosure: Y. Park, None; S. Ohn, None; H. Chun, None; S. Kim, None; P.K. Lee, None; Y. Kim, None. Supported by the Korea Science and Engineering Foundation grant funded by the Korea government (no. M10640000206N44002210).

Objective: To investigate the functional relevance of right hemispheric activation in patients with chronic Broca’s aphasia after stroke and also the linguistic effectiveness of transcranial direct current stimulation (tDCS). Design: Crossover case studies. Setting: University hospital. Participants: 2 right-handed, chronic Broca’s aphasia patients. Interventions: Using functional magnetic resonance imaging (MRI), activation of right inferior frontal cortex (Broca homologue area) during naming task was determined. Stimulation point on the scalp was identified using each patient’s 3-dimensional MRI scan and In2Vision software. tDCS was delivered using Phoressor. The anode was placed on right inferior frontal area and the cathode was placed on left supraorbital area. Patients received anodal and sham stimulations, with a 48-hour washout period between the 2 sessions. Anodal stimulation was delivered for 30 minutes at an intensity of 1mA. For sham stimulation, current was applied only for 10 seconds. Main Outcome Measures: Immediately before and after tDCS, patients were tested with the Korean version of Boston Naming Test. Patients were asked to name the picture as soon as it was shown. We measured the correct response and reaction times (RT1, RT2). RT1 was defined as the time between onset of picture and onset of first phoneme, and RT2 was the time to complete utterance. Results: Naming improved in 2 patients after anodal tDCS but not after sham tDCS. The mean correct response was increased by 2 points and the mean RT1 and RT2 were shortened by 2.35 seconds and 2.15 seconds, respectively. Conclusions: In patients with chronic Broca’s aphasia, activation of the right frontal cortex seemed to have functional relevance in language expression and anodal tDCS was effective in stimulating the language-related areas. Key Words: Aphasia, Broca; Electric stimulation; Rehabilitation; Stroke.

Poster 333
Angiotsensin-Converting Enzyme–Induced Angioedema in a Woman With a History of Ischemic Strokes: A Case Report. Blaine F. Washington II, MD (Rush University Medical Ctr, Chicago, IL); Christopher D. Reger, MD.
Disclosure: B.F. Washington, None; C.D. Reger, None.

Setting: Tertiary care hospital. Patient: A 53-year-old woman with history of left frontal ischemic strokes. Case Description: The patient developed right occipital headache on awakening with numbness, tenderness, edema, and tingling involving the left hand, with possible new left-sided weakness. Noncontrast head computed tomography revealed chronic left frontal and parasagittal hypodensity with adjacent prominent sulci and chronic basal ganglia ischemic infarctions. She was subsequently admitted to the neurology unit to undergo evaluation for stroke. She had been placed on an angiotensin-converting enzyme (ACE) inhibitor in the recent past, secondary to uncontrolled hypertension. Assessment/Results: Magnetic resonance imaging of the brain did not show evidence of an acute infarction but there was left frontal encephalomalacia from previous strokes. On exam there was evidence of left hand palmar erythema, numbness, and tingling. Left hand radiographs were normal except for the presence of soft tissue edema. She was diagnosed with angioedema likely caused by the recent addition of the ACE inhibitor. Her symptoms resolved with discontinuation of the ACE inhibitor. She was admitted to acute rehabilitation and was discharged home at her previous functional mobility. Discussion: This is a case of a patient with a history of strokes since 34 years of age, with a presentation that could be consistent with a neurologic or neuropathic disorder. Given her history, it was determined that she should be ruled out for such a process. The incidence of angioedema secondary to ACE inhibitors is rare and is reported in the literature to occur in about 0.1% to 0.2% of the general patient population. Conclusions: This case demonstrates how the clinical symptoms of angioedema in a patient with multiple neurologic risk factors for stroke can mimic certain symptoms of a neurologic or neuropathic disorder. Key Words: ACE inhibitor; Angioedema; Rehabilitation; Stroke.

Poster 334
Early Rehabilitation to Prevent Pneumonia in Oropharyngeal Dysphagia Poststroke: A 6-Month Follow-Up Study. Stefano Maserio, MD (University of Padova, Padova, Italy); Roberta Perobon, MD; Chiara Previto, MD; Rosario Marchese-Ragona, MD; Claudio Ferraro, MD; Marco Ortolani, MD.
Disclosure: S. Maserio, None; R. Perobon, None; C. Previto, None; R. Marchese-Ragona, None; C. Ferraro, None; M. Ortolani, None.
Objective: To determine whether early rehabilitation treatment influences the incidence of pneumonia and swallowing recovery time in poststroke patients with oropharyngeal dysphagia. Design: A prospective case series with a 6-month follow-up. Setting: Acute stroke unit and rehabilitation department. Participants: 62 consecutively admitted stroke patients with oropharyngeal dysphagia, with sufficient cognition to participate in rehabilitation training (with a Mini-Mental State Examination score ≥21). 48 patients (28 men, 20 women; average age, 73.1 ± 11.0y) completed the trial. Interventions: Swallowing function was evaluated through bedside and fiberoptic endoscopic evaluation of swallowing (FEES) at the start of rehabilitation and at 6-month follow-up. Rehabilitation treatment, starting 5.3 ± 3.2 days after stroke (average, 12.2 sessions, lasting about 1h, 4×/wk), included oral motor exercises and breathing coordination, procedures to increase oropharyngeal sensory input, different postural techniques to obtain safer swallowing, and dietary modifications. Main Outcome Measures: Pneumonia episodes and restart of oral feeding. Results: 30 patients showed aspiration at first FEES (time poststroke, 6.2 ± 3.9d) but only 5 showed aspiration at the 6-month evaluation. After the 6-month follow-up, 4 (8.3%) of 48 patients had suffered pneumonia. There was no significant relationship between the appearance of pneumonia and sex, stroke side (left, right), type of lesion (ischemic, hemorrhagic), and other clinical variables (abnormal volutional cough, dysphonia, dysarthria, voice change after swallowing) (P range, .310–.080). After 6 months, 44 patients showed complete recovery of prestroke swallowing (of whom 35 had recovered within the first month), 3 patients required a modified diet, and 1 enteral nutrition. Conclusions: Compared with historical control studies without rehabilitation treatment, our results showed that early rehabilitation produces dramatic reductions in pneumonia rates and more rapid reuptake of feeding. Key Words: Cerebrovascular accident; Deglutition disorders; Pneumonia; Rehabilitation.

Poster 335
Outcome Predictors for Transforaminal Cervical Epidural Steroid Injections. Dale A. Kimbrough, BS (Ross University School of Medicine, Edison, NJ); Bina Mehta, MD; Ali Shakir, MD. Disclosure: D.A. Kimbrough, None; B. Mehta, None; A. Shakir, None.

Objective: To retrospectively identify prognostic factors of patients with cervical radicular pain who had a positive outcome following transforaminal cervical epidural steroid injections (TF-CESI). Design: Retrospective cohort study. Setting: Private practice pain clinic. Participants: 94 patients with radiographically diagnosed cervical disk herniations or spinal stenosis and a clinical presentation of neck and arm pain, who underwent TF-CESI from February 2005 to January 2006. Complete data were available for 94 patients (of 117 charts reviewed). Interventions: Not applicable. Main Outcome Measures: These patients were divided into 2 groups, those who perceived benefit at 1 month postinjection and those who did not. Prognostic variables evaluated consisted of: age, sex, body mass index, tobacco usage, employment status, narcotic medication usage, preprocedure pain intensity, preprocedure pain duration, preprocedure pain distribution, and diagnosis. Results: 65% of patients reported benefiting from TF-CESI. Patients who were working were statistically more likely to perceive benefit. Also, in patients with cervical spinal stenosis, those whose pain extended below the elbow were statistically more likely to perceive benefit. This was not the case for patients with cervical disk herniations. All other factors evaluated were not found to be predictive of outcome. Conclusions: In the treatment of cervical radicular pain utilizing TF-CESI, we found that patients who were employed were more likely to perceive benefit. Also, for those whose pain was secondary to cervical spinal stenosis, patients with pain extending below the elbow were more likely to perceive benefit. By identifying predictive factors, we can better select who will benefit from TF-CESI. This will lead to improved outcomes and lower overall expenditures. Key Words: Injections, epidural; Radiculopathy; Rehabilitation.

Poster 336
Lumbar Facet Cyst Removal Using Minimally Invasive Endoscopy: A Case Report. Angela M. Krull, MD (The SMART Clinic, Sandy, UT); Michael Giovanniello, MD; Scott Adelman, MD. Disclosure: A.M. Krull, None; M. Giovanniello, None; S. Adelman, None.

Setting: Outpatient interventional PM&R spinal medicine clinic. Patient: A 51-year-old woman with L3-4 facet cyst causing foraminal and paracentral stenosis, back pain, and radicular leg symptoms. Case Description: The patient presented with back and leg pain with lumbar magnetic resonance imaging findings of a 12×12×8mm facet cyst exerting mass effect on the traversing left L4 nerve root. She had no focal neurologic deficits on physical examination. A left L3-4 transforaminal epidural steroid injection provided 3 weeks of relief. This was followed by an attempted facet cyst lysis using a transforaminal approach, with repeated epidural steroid injection at this level. Postprocedurally, the patient developed a spinal headache, which was treated successfully with a transforaminal blood patch. After 4 months of conservative management, including 4 epidural steroid injections, the patient continued to require narcotic medication for her back and leg pain and was unable to perform her regular work activities secondary to pain. This patient was then offered an L3-4 endoscopic foraminoplasty and facet cyst lysis with intraoperative electromyography monitoring. Assessment/Results: The patient experienced 90% reduction in her back and lower extremity immediately after the procedure. She stopped taking narcotic medications and was able to resume full work activities within a few days. Discussion: Lumbar endoscopy is widely used to perform diskectomies using a transforaminal approach, which avoids disruption of the lamina and ligamentum flavum. Surgical facet cyst removal typically requires disruption of the lamina. Conclusions: This case demonstrates that a minimally invasive transforaminal endoscopic approach represents an improved and expanded technique for managing refractory symptoms related to a lumbar facet cyst. Key Words: Cysts; Injections; Low back pain; Radiculopathy; Rehabilitation.

Poster 337
Elite Male Adolescent Gymnast Who Achieved Union of a Persistent Bilateral Pars Defect: A Case Report. Allan Vrable, DO (UM-JMH, Miami, FL); Andrew Sherman, MD. Disclosure: A. Vrable, None; A. Sherman, None.

Setting: Tertiary care academic spine institute within an academic hospital. Patient: A 15-year-old adolescent male elite gymnast. Case Description: This patient initially began to complain of lower back pain 18 months before our evaluation. After competing through the pain for 6 months, he eventually stopped competing for 1 year. Exam revealed extension-induced pain. Computed tomography (CT) scan performed 18 months after the onset of pain revealed bilateral acute lumbar spondylolysis without listhesis at L5-S1 and nonunion of the fracture. Bone scan (normal) confirmed the fracture to be old. Treatment was initiated by applying a bone stimulator 4 hours a day and warm and form brace for 6 weeks. Isometric trunk exercises supervised by a physical therapist were permitted with the brace. Assessment/Results: After only 6 weeks of the aforementioned treatment, the subject showed clinical improvement at the follow-up visit. The subject also embarked on a self-administered herbal treatment. CT scan performed 12 weeks after the initial scan showed complete union of the fracture, correlating with clinical improvement. 2 years later, the...
athlete remains completely pain-free, training regularly, and able to compete on a national, and possibly international level. **Discussion:** Spine injuries occur commonly in elite adolescent athletes and are usually self-limiting. Lumbar spondylolisthesis, a unilateral or bilateral defect of the pars interarticularis, when diagnosed promptly typically heals with correct treatment and results in pain relief and return to sport. However, in some cases, a pseudoarthrosis occurs. In cases where the spondylolisthesis occurs without spondylolisthesis, surgery is typically not recommended and patients are counseled that the defect is permanent. **Conclusions:** This case suggests that the possibility exists that healing can occur, even years after the onset of the injury, and, in patients with persistent pain and disability, can correlate with clinical improvement. **Key Words:** Back pain; Rehabilitation; Spondylolisthesis; Treatment outcome.

**Poster 338**

**Ultrasound-Guided Tendon Sheath Injection With Methylprednisolone for Severe Posterior Tibial Tendonitis: A Case Report.** Boqing Chen, MD (Ctr for Advanced Pain Management and Rehabilitation LLC, Metuchen, NJ); Todd P. Stitik, MD; Patrick M. Foye, MD; Christopher Castro, DO; Michael Mehnert, MD; Gerald Malanga, MD.

Disclosure: B. Chen, None; T.P. Stitik, None; P.M. Foye, None; C. Castro, None; M. Mehnert, None; G. Malanga, None.

**Setting:** An outpatient physiatry musculoskeletal office. **Patient:** A 74-year-old man. **Case Description:** The patient presented with persistent and severe left medial ankle pain and swelling, with difficulty ambulating for 6 weeks. He had no benefit from oral anti-inflammatory agents and was unable to tolerate physical therapy due to pain. He was essentially unable to bear weight on the affected limb. Examination revealed significant swelling and mild erythema in the entire left ankle region, which was most prominent medially. There was significant local tenderness along the course of the posterior tibial tendon. The lower-limb neurologic examination was normal except for weakness of left ankle inversion. An ultrasound scan revealed significant tenosynovitis of the left tibialis posterior tendon without tendon tear and ankle joint effusion. An acute posterior tibial tenosynovitis was diagnosed. The patient received an ultrasound-guided injection of 40 mg of methylprednisolone into the left posterior tibial tendon sheath. **Assessment/Results:** 5 days after injection, ultrasound rescan of the posterior tendon sheath revealed significant reduction of tendon sheath swelling. The patient’s left ankle swelling and pain also diminished steadily. He was then fitted with a left ankle brace. At 4 weeks postinjection, he reported 95% improvement and was able to ambulate without any assistive device. **Discussion:** Treatment of posterior tibial tendonitis generally includes nonsteroidal anti-inflammatory drugs, an ankle orthosis, rest, physical therapy, and possibly surgery. Without image-guidance, “blind” injection of the posterior tibial tendon is generally contraindicated because the tibialis posterior tendon is a weight-bearing structure, and there is a potential risk of future tendon rupture with inadvertent injection of corticosteroid into the tendon itself. **Conclusions:** We present what is, to our knowledge, the first case of an ultrasound-guided tendon sheath injection with corticosteroid for severe posterior tibial tenosynovitis. **Key Words:** Rehabilitation; Tenosynovitis; Ultrasound, interventional.

**Poster 339**

**Diagnostic Value of Ultrasonography for Clinical Medial Epicondylitis.** Gi-Young Park, MD, PhD (Keimyung University School of Medicine, Daegu, Republic of Korea); Sung-Moon Lee, MD; Jung-Ho Bae, MD; Michael Lee, MD.

Disclosure: G. Park, None; S. Lee, None; J. Bae, None; M. Lee, None.

**Objectives:** To investigate the ultrasonographic findings of medial epicondylitis and to assess the value of ultrasonography as a diagnostic method for the detection of clinical medial epicondylitis. **Design:** Prospective, single-blind study using ultrasonography. **Setting:** An outpatient rehabilitation clinic in a tertiary university hospital. **Participants:** 21 elbows of 18 consecutive patients with clinical medial epicondylitis and 25 elbows of 15 patients and 5 volunteers without medial epicondylitis. **Interventions:** Not applicable. **Main Outcome Measures:** A specialist in rehabilitation medicine made the clinical diagnosis of medial epicondylitis on symptoms and clinical signs in physical examination. The ultrasonographic diagnosis was determined by an experienced radiologist as detecting at least 1 of the abnormal findings: a focal hypoechoic or anechoic area, tendon nonvisualization, intratendinous calcification, and/or cortical irregularity. Ultrasonographic images were also evaluated for the abnormal findings. **Results:** 20 of 21 elbows with clinical medial epicondylitis and 23 of 25 elbows without medial epicondylitis were diagnosed correctly on ultrasonography. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of ultrasonography in the diagnosis of clinical medial epicondylitis was shown to be 95.2% (20/21), 92.0% (23/25), 90.9% (20/22), 95.8% (23/24), and 93.5% (43/46), respectively. According to the severity of tendon abnormalities, tendinopathy was diagnosed in 15 elbows (71%) and partial-thickness tear, including 1 intrasubstance tear, in 5 elbows (24%). The most common ultrasonographic abnormality was focal echogenic abnormalities (15 hypoechoic, 5 anechoic) of the tendons, followed by 10 cortical irregularity, 6 tendon thickening, 5 intratendinous calcifications, and 4 increased vascularity. **Conclusions:** Ultrasonography proved to be a highly sensitive and specific method for the detection of clinical medial epicondylitis. In addition, it provided useful information about the severity and pathologic stage of tendon pathology. **Key Words:** Epicondylitis, lateral humeral; Rehabilitation; Ultrasonography.

**Poster 340**

**Effect on Hip Osteoarthritis of Mud Bath and Underwater Exercises: A Randomized Controlled Trial.** Stefano Masiero, MD (University of Padova, Padova, Italy); Elisa Gomiero, MD; Lara Bonaldo, MD; Claudio Ferrari, MD; Marco Ortolani, MD.

Disclosure: S. Masiero, None; E. Gomiero, None; L. Bonaldo, None; C. Ferrari, None; M. Ortolani, None.

**Objectives:** To compare the efficacy of an approach combining thermal therapy (mud pack and spa bath treatment) and underwater exercising (TT-UE) with conventional therapy, in patients with primary osteoarthritis (OA) of the hip. **Design:** Single-blind, randomized controlled trial. **Setting:** Thermal-rehabilitation center. **Participants:** 63 outpatients randomly assigned to the TT-UE (n = 34) and conventional therapy (n = 29). **Intervention:** The TT-UE group underwent a 12-day cycle of mature mud pack application, bathing in natural mineral thermal water rich in bromine-iodine, massage therapy according to the standard protocol, and underwater exercises (eg, mobilization, hip traction, muscle strengthening), in a spa pool (~50 min/d), at a thermal facility of the Euganean Basin (Padua, Italy). The conventional therapy group was treated for the same number of sessions with traditional rehabilitation that included magnetotherapy, electrotherapy, and therapeutic exercises (mobilization, axial traction of the hip, functional re-education). During the treatment period, all patients stayed in the treatment center. **Main Outcome Measures:** Range of motion (ROM) (with IncliMed goniometer), Western Ontario and McMaster University Osteoarthritis (WOMAC) Index, and nonsteroidal anti-inflammatory drug (NSAID) consumption. **Results:** Findings were based on comparison of 2 groups matched for clinical and initial degree of impairment. In the TT-UE group, ROM significantly in-
creased for flexion, abduction, and internal rotation (P range, 0.040—0.11), WOMAC pain, stiffness, and physical function scores were significantly lower (P range, 0.001—0.001) at the end of treatment, and the effects persisted at 3-month follow-up. In addition, analgesic and NSAID consumption during follow-up was higher in the TT-UE group, but not significantly so (P = 0.09). Conclusions: The patients with OA of the hip who received thermal therapy in combination with underwater exercising showed greater reductions in pain, motor impairment, and improvements in functional abilities, and these benefits persisted over time. Key Words: Hip; Hydrotherapy; Osteoarthritis; Rehabilitation.

Poster 341
Does the Menstrual Cycle Phase Correlate With Injury Rate in Teenage Athletic Girls? Sophia Lal, DO (Medical College of Wisconsin, Milwaukee, WI); Anne Z. Hoch, DO.
 Disclosure: S. Lal, None; A. Z. Hoch, None.

Objective: To study the possible association between phases of menstrual cycle (follicular: days 1–12; ovulatory: days 13–15; luteal: days 16–28) and injury rates of high school girls. Design: Injury data were collected sequentially from high school female athletes by their athletic trainer. Injury was defined as loss of practice or competition for at least 1 day. Injury date, diagnosis made by trainer or physician, first day of last menstrual period, menarche, and history of amenorrhea and oligomenorrhea were recorded. Using the chi-square test of homogeneity, observed injury rates per phase were compared with expected injury rates (if random and proportional to the days in each menstrual phase). Setting: Local high school. Participants: 95 girls ages 14 to 17 on a school or club team who were injured between 2002 and 2005. Interventions: Not applicable. Main Outcome Measures: Type of injury and day of menstrual cycle on which subject was injured. Results: We observed 54 injuries in the follicular phase (expected, 40.7), 7 in the ovulatory phase (expected, 10.2), and 34 in the luteal phase (expected, 44.1). The $\chi^2$ test was statistically significant ($P = 0.021$). Therefore, there was a significant association between menstrual phases and number of injuries. The observed number of injuries in the follicular phase was greater than what would be expected by chance ($\chi^2$ test, $P = 0.037$). Conclusions: Compared with the expected proportion, this study found a disproportionately high number of girls with injuries during the follicular phase. Key Words: Athletics; Female; Follicular phase; Rehabilitation; Wounds and injuries.
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