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EDITORIAL

MAKING TIME TO READ

Claire Johnson, MSEd, DC
Editor

Staying current with practice and research trends not only helps us to be better at what we do but also helps the profession. Thus, one of the goals for the Journal of Manipulative and Physiological Therapeutics (JMPT) is to reach as many people in the profession as possible. This particular issue welcomes a new group of subscribers to our readership. The American Chiropractic Association has arranged for its members to receive the JMPT (either free or at a discount depending on membership category) as a membership benefit. In addition, the American Chiropractic Association now recognizes the JMPT as its scientific peer-reviewed journal.

The JMPT will continue to remain independent and free from political influences. The National University of Health Sciences, owner of the journal, upholds the journal’s compliance with the high standards of the International Committee of Medical Journal Editors (www.icmje.org) and World Association of Medical Editors (www.wame.org) guidelines, which express support for editorial freedom and best publication practices. We will continue to strive to provide the best scientific information that impacts practice and future research. However, for us to do this successfully, it is up to the readership to participate by reading the contents.

Making the time to read information, which would best serve our patients or impact future research, is not easy. However, staying abreast of what is happening in our field is an important part of what we do to sustain ourselves and impact our future. It has been suggested that our profession is at a crossroads.1 Each of us has the opportunity to make a difference on which direction our profession takes.

As a child, I would watch my father return home from working at the hospital, pick from his stack of specialty journals, and read. Reading was part of his expectation of being a professional. He was not a researcher, but a practitioner, and yet even after a long day at work, he still found the time to read his journals. Unfortunately, many in practice have not been formally trained how to read scientific journals. During preclinical or clinical training, many of us were not acculturated with how to make consuming research a normal part of our lives. Therefore, we must make a choice to implement reading into our regular routines.

Many would agree that reading provides a variety of benefits. However, there may be others who find no value in reading. Some may have the misconception that we only need science to prove that “chiropractic works” or that journals should be accessed only when one needs them for evidence of the efficacy of chiropractic.2 And, there may be others who think that reading intellectually challenging journal articles may dilute our thinking processes, undermine our enthusiasm, damage our practice management strategies, or harm the profession. Although I do not have a double-blind controlled trial to support the counter argument to these statements, I suggest that regularly reading scientific journals will have a positive impact on the profession, strengthen future research, and ultimately improve patient care. However, to accomplish these, each of us needs to create the time to read sound scientific material and do so with an analytical eye.

To support our readers to include reading as part of their regular routine, we provide several easy ways to access the JMPT. In addition to receiving the print copy of the journal, JMPT subscribers have online access to all online back issues. Go to www.mosby.com/jmpt, and you can search a topic of interest or author or browse the back issues. The pdf file function allows you the option to view articles on the computer as they are found in the print journal. You may print these articles and take them with you, perhaps to read during breaks.

In addition, the JMPT provides a free table of contents service to anyone who wishes to sign up (www.mosby.com/jmpt). As soon as the latest JMPT issue is published, the table of contents will be sent to the e-mail of your choice so that you may select which articles you wish to read. This free service provides a friendly reminder that it is time to catch up on reading the latest in chiropractic research.

Making the time to read has both personal and profession-wide impact and is one of our professional duties. Whether you choose to dip your toe in the water by reading only the titles, wade in by skimming the abstracts, or dive in by reading the journal from front to back, I welcome all readers to join us in making reading the scientific literature a part of our professional lives.

REFERENCES

Evidence of long-term benefits of manipulation. Muller and Giles (p. 3) report on results from a long-term follow-up of a randomized clinical trial. In this study, patients having chronic mechanical spinal pain syndromes who received spinal manipulation gained significant benefit in both short- and long-term outcomes.

A better understanding of the nature of radicular pain. Bove, Zaheen, and Bajwa (p. 12) look more closely at the subjective characteristics of radicular pain. They find that radicular pain was reported as “deep” rather than “superficial,” and pain was typically reported at sites correlating with multiple spinal levels. They suggest that myotomal and sclerotomal charts may have more diagnostic benefit compared with dermatomal charts for patients with radicular pain.

Consent in chiropractic practice investigated. Langworthy and le Fleming (p. 15) investigate approaches to consent among a sample of practicing UK chiropractors. Their findings suggest that consent may be poorly understood or selectively implemented among those in the UK chiropractic profession. They offer suggestions for ways to address these issues.

A closer look at neck pain and function. Lee, Nicholson, and Adams (p. 25) present their findings on the association between neck muscle endurance, cervical range of motion, and neck pain. They offer how these findings may have an impact on how patients are evaluated and managed.

Improving how students learn manipulative skills. Enebo and Sherwood (p. 33) offer information that may impact how students and practitioners learn and improve manipulation skills. Data are presented on how feedback, practice schedule, and experience level may impact learning high-velocity low-amplitude prone thoracic spinal manipulation.

The autonomic relationship to musculoskeletal injury. Grimm, Cunningham, and Burke (p. 44) investigate the differences in autonomic function between individuals with acute musculoskeletal injury and healthy controls. Their findings suggest that the interaction between skin and vasomotor sympathetic nerves in response to acute musculoskeletal injury may result in changes in autonomic function.

Muscle testing. Pollard et al (p. 52) take a closer look at muscle testing by comparing 2 practitioners of differing skill levels to identify if they could reliably agree on the presence of a weak or strong deltid or psoas muscle.

Comparing the risk of vertebral basilar artery injury: manipulation versus whiplash. Haneline and Triano (p. 57) offer a comparison of biomechanical evidence between cervical chiropractic manipulative therapy and whiplash that suggests that the healthy vertebral artery is not at risk from properly performed chiropractic manipulative procedures. They offer a discussion of the recent evidence associated with causes of vascular accidents.

An unusual case report. Wessely, Kettner, and Pierre-Jerome (p. 64) describe a case report of an unusual presentation of a lymphoma in the rib of a patient who had previously received an organ transplant, which is an atypical finding in the skeletal system.

Snapping hip syndrome and SI joint dysfunction. Konczak and Ames (p. 67) describe the chiropractic management of a marathon runner with internal snapping hip syndrome and sacroiliac joint dysfunction. This case report outlines the assessment, diagnosis, and treatment of this condition.

Does the chiropractic manipulation model need revision? Vernon and Mrozek (p. 68) propose revisiting the Sandoz model. This commentary offers a new outlook on how we might consider joint dysfunction and manipulation.
LONG-TERM FOLLOW-UP OF A RANDOMIZED CLINICAL TRIAL ASSESSING THE EFFICACY OF MEDICATION, ACUPUNCTURE, AND SPINAL MANIPULATION FOR CHRONIC MECHANICAL SPINAL PAIN SYNDROMES

Reinhold Muller, PhD,a and Lynton G.F. Giles, DC, PhD b

ABSTRACT

Objective: To assess the long-term benefits of medication, needle acupuncture, and spinal manipulation as exclusive and standardized treatment regimens in patients with chronic (>13 weeks) spinal pain syndromes.

Study Design: Extended follow-up (>1 year) of a randomized clinical trial was conducted at the multidisciplinary spinal pain unit of Townsville’s General Hospital between February 1999 and October 2001.

Patients and Methods: Of the 115 patients originally randomized, 69 had exclusively been treated with the randomly allocated treatment during the 9-week treatment period (results at 9 weeks were reported earlier). These patients were followed up and assessed again 1 year after inception into the study reapplying the same instruments (ie, Oswestry Back Pain Index, Neck Disability Index, Short-Form-36, and Visual Analogue Scales). Questionnaires were obtained from 62 patients reflecting a retention proportion of 90%. The main analysis was restricted to 40 patients who had received exclusively the randomly allocated treatment for the whole observation period since randomization.

Results: Comparisons of initial and extended follow-up questionnaires to assess absolute efficacy showed that only the application of spinal manipulation revealed broad-based long-term benefit: 5 of the 7 main outcome measures showed significant improvements compared with only 1 item in each of the acupuncture and the medication groups.

Conclusions: In patients with chronic spinal pain syndromes, spinal manipulation, if not contraindicated, may be the only treatment modality of the assessed regimens that provides broad and significant long-term benefit. (J Manipulative Physiol Ther 2005;28:3-11)

Key Indexing Terms: Acupuncture; Chiropractic; Medicine; Spinal; Pain

C hronic spinal pain is commonly triggered by an injury or disease,¹ and mechanical spinal pain presents a diagnostic and treatment challenge because reaching a specific diagnosis is often impossible.² A pathological cause cannot be identified for most episodes of spinal pain³ with only approximately 15% of patients being given a definitive diagnosis.⁴

The search for effective conservative treatments for acute and chronic nonspecific low-back pain has been largely inconclusive,⁵ as is the case with neck and thoracic spine pain. Conflicting claims exist for nearly every form of conservative therapy for low-back disorders, probably because studies have been performed among widely differing types of patients with back pain or because of methodological problems.⁷ Thus, there is still sparse conclusive knowledge about the absolute efficacy of any intervention for chronic spinal pain syndromes, although Giles et al⁸ found a high level of patient satisfaction with a multidisciplinary team approach to spinal pain syndromes. A review of the conflicting literature on the efficacy and effectiveness of medication, acupuncture, and spinal manipulation for chronic uncomplicated spinal pain treatment can be found in Giles and Muller.⁹
What is not disputed is that chronic spinal (ie, neck and “back”) pain syndromes have an immense impact on public health, pose an enormous financial strain on the health systems in developed countries, and affect the economy by lost working time through illness. The high incidence of back pain, its chronic and recurrent nature in many patients, and its contribution as a main cause of absence from work are well known. Furthermore, the rise in the use of nontraditional health care providers partly reflects the large number of patients with chronic pain, especially spine-related disorders, who feel they must go outside mainstream medicine to find help.

The immense burden of chronic spinal pain syndromes, in terms of suffering as well as in financial terms, stands in stark contrast to the paucity of evidence-based knowledge about their diagnosis and treatment. It is against this background that the Giles and Muller randomized clinical trial was designed with a rigorous protocol and a broad range of outcome measures in an attempt to overcome the above-mentioned methodological problems and to add much-needed evidence-based knowledge to this important area.

In their 109-patient randomized clinical trial, Giles and Muller included both neck and “back” (ie, low back and thoracic spine) pain patients as it would have been unethical to treat only 1 painful spinal level and to ignore a concurrent additional painful spinal level, particularly when 47 (68%) of 69 patients presented with pain at more than 1 spinal level.

Giles and Muller, using a “fastidious” approach (ie, standardized treatment regimens of medication, needle acupuncture, or spinal manipulation with respect to the type, frequency, and duration of each treatment regimen), showed in a public hospital-based multidisciplinary spinal pain unit pilot study and in the subsequent larger study that in patients with chronic (ie, >13 weeks’ duration) spinal pain, spinal manipulation, if not contraindicated, seems to result in greater short-term (9 weeks) improvement than acupuncture and medicine. There were no particular distinguishing features for pain other than pain of “mechanical” origin in all of the 3 spinal areas. In addition, there were no mechanisms of injury that were distinct enough to warrant separate investigation or management, and all patients were considered to have mechanical joint dysfunction after extensive investigations (ie, physical examination and various forms of imaging with or without laboratory tests as indicated by the history).

A thorough systematic review of the literature indicates that evidence-based knowledge (ie, originating from randomized clinical trials using standardized treatment regimens) about the short-term efficacy of different conservative treatment regimens for chronic spinal pain syndromes is scarce, and it is virtually nonexistent with respect to long-term benefit.

Very few long-term (ie, of at least 1-year follow-up) clinical trials of treatment(s) of patients with various spinal problems could be located for low-back pain and chronic neck pain. Moreover, these trials deliberately followed a pragmatic methodology (ie, details of the type, frequency, and duration of each treatment were at the discretion of the treating clinician) as opposed to a fastidious approach (ie, exclusively standardized treatment regimens) and consequently lacked the methodological scientific rigor necessary to be able to attribute an observed effect to only 1 specific standardized treatment modality.

The present study assesses the extended follow-up (of at least 1 year) efficacy of medication, needle acupuncture, and spinal manipulation, as standardized and exclusive treatment regimens. Patients with chronic spinal pain syndromes from the fastidious approach of the Giles and Muller randomized clinical trial were eligible for this study if they adhered to the study protocol for their treatment period.

**METHODS**

**Study Protocol**

A randomized clinical trial using exclusive and standardized treatment modalities (ie, using a “fastidious” as opposed to “pragmatic” approach) was conducted at the multidisciplinary spinal pain unit of Townsville’s General Hospital from February 1999 to October 2001. Patients with chronic (>13 weeks) spinal pain syndromes were randomly allocated to 1 of 3 exclusive and standardized treatment regimens: medication, needle acupuncture, or spinal manipulation. A range of validated subjective questionnaires and objective measurements were taken initially and at the end of the study treatment period. Detailed methods of this trial were published and are only summarized in this extended follow-up paper. The same validated subjective instruments were used again as the extended follow-up questionnaires that were sent out to patients 12 months after their inception into the study.

Inclusion and exclusion criteria for this extended follow-up study are the same as for the short-term study. Inclusion criteria were having “mechanical” spinal pain syndrome for a minimum of 13 weeks and being at least 17 years of age. Exclusion criteria were nerve root involvement, spinal anomalies other than sacralization or lumbarization, pathological conditions other than mild to moderate osteoarthrosis, greater than a grade 1 spondylolisthesis of L5 on S1, previous spinal surgery, or leg length inequality of >9 mm with postural scoliosis. The only additional criterion of this long-term study was that only those were included who received exclusively their randomly allocated treatment regimen during the 9-week treatment period.

**Randomization**

Patients satisfying the inclusion and exclusion criteria and giving their informed consent were subsequently randomly allocated by drawing 1 envelope from a box of well-shuffled sealed envelopes containing 1 of 3 possible...
treatment codes as detailed in the short-term study in a balanced way to 1 of 3 exclusive and standardized treatment regimens: medication, acupuncture, or manipulation.

**Interventions**

Medication patients were normally given celecoxib (Celebrex) (200 to 400 mg/d; 27 patients) unless celecoxib had previously been tried; the next drug of choice was rofecoxib (Vioxx) (12.5 to 25 mg/d; 11 patients), followed by acetaminophen (paracetamol) (500-mg tablets 2-6 per day; 5 patients). These doses were typical of those used in daily practice and conformed to the MIMS Australia (www.mims.com.au) pharmaceutical product information publication and to the manufacturer's Consumer Medicine Information leaflet. In addition, doses were related to patients' weight with the severity of symptoms playing a minor role. In 4 cases where celecoxib was prescribed at 200 mg/d, the medical physician increased the dose to 400 mg/d, when indicated by symptoms at review and if there had been no adverse reaction. Because all patients had already tried some form of medication, it was necessary to have a choice of 3 drugs from which to choose one that had not already been tried by a patient. Additional fortnightly 20-minute office visits defined this intervention until patients became asymptomatic or achieved a status of feeling that they had achieved acceptable pain relief.

Acupuncture was performed using sterile HWATO Chinese Acupuncture Guide Tube Needles (50 mm long; 0.25-mm gauge) for 20-minute appointments. For each patient, 8 to 10 needles were placed in local paraspinal intramuscular maximum pain areas, and approximately 5 needles were placed in distal acupuncture point meridians according to the “near and far” technique (upper limb, lower limb, or scalp). Once patients could satisfactorily tolerate the needles, needle agitation was performed by turning or ‘flicking’ the needles at approximately 5-minute intervals. Two 20-minute office visits per week defined this intervention until patients became asymptomatic or achieved a status of feeling that they had achieved acceptable pain relief.

High-velocity low-amplitude spinal manipulative thrust to a joint was performed as judged safe and usual treatment by the treating chiropractor for the spinal level of involvement to mobilize the spinal joints at that level. Two 20-minute office visits per week defined this intervention until patients became asymptomatic or achieved a status of feeling that they had achieved acceptable pain relief.

**Ethical Approval**

Ethical approval for all parts of the study was granted by the Northern Regional Health Authority’s Hospital Institutional Ethics Committee (reference 32/94).

The patient flow chart is detailed in Fig 1: Out of the initially randomized 115 patients, a subsample of 69 patients received exclusively the randomly allocated treatment regimen during the short-term study treatment period and was therefore eligible for the extended follow-up study period.

**Outcome Measures**

The extended follow-up questionnaire comprised the identical validated subjective measurement instruments as used at the initial visit and at the end of the 9-week treatment period: pain frequency scores; Visual Analogue Scale (VAS) for pain intensity, the Oswestry questionnaire (Oswestry) for low-back and thoracic spine pain (“back” pain), the Neck Disability Index for neck pain, and the Short-Form-36 Health Survey questionnaire (SF-36). For details, please refer to Giles and Muller.

The bending and extension measurements were not available for the extended follow-up because the wide catchment area and a mobile population impeded the physical reexamination of patients.

The extended follow-up questionnaires were routinely mailed out to patients 12 months after their treatment period concluded. An additional final effort was made at the end of the overall study period (November 2002) to locate the few patients that had changed their address or had not returned their extended follow-up questionnaires at 12 months after their study treatment period.
Potential Confounders

Sex, socioeconomic status, age, body mass index (BMI), and duration of pain syndromes before inception were identified as potential confounders and consequently recorded.

Data Handling and Statistical Analysis

Color coding of patients’ data (different to the 9-week study) was used to ensure that no one involved with data analysis would be aware of the treatment provided. Data were analyzed using SPSS version 10 (SPSS, Inc).

Because the frequency distributions of the main outcome measures proved to be skewed, medians were used as measures of central tendency and quartiles as measures of dispersion. Consequently, nonparametric test procedures were used for testing numerical variables. Preintervention follow-up changes within the 3 treatment groups were tested using an exact version of the paired Wilcoxon signed rank test. For comparisons between the 3 treatment groups at inception, an exact version of the Mann-Whitney U test was used. All tests relating to categorical variables were assessed with exact $\chi^2$-type tests. Additional checks for potential confounders (including sex, age, socioeconomic status, BMI, and the duration of the pain syndromes before inception to the study) and possible interactions of these confounders were performed by multiple regression models and logistic regression approaches. For all tests, a $P$ value of below .05 was regarded as statistically significant.

This study was concerned with an area where no accepted “gold standard” exists and where very little is known about the absolute benefit of the different treatment regimens. Consequently, the main emphasis of analysis relates to paired precomparison/postcomparison to assess absolute efficacy and was performed in 2 blocks: the “intention-to-treat” (ITT) and the “compliers-only” analysis, respectively.

Dissatisfied patients who had to change treatment modalities or were otherwise noncompliant before the 9 weeks’ follow-up proved to have no distorting effect on the outcome as reported in the respective ITT analysis of the short-term study. The present ITT analysis ($n = 62$) is consequently based on all patients eligible for this extended follow-up study ($n = 69$) who returned the extended follow-up questionnaire ($n = 62$). Only 7 patients not returning the long-term follow-up information (ie, all of them left the area where they were monitored to track patients and to determine whether any of these patients actually had re-presented to the multidisciplinary spinal pain unit or to another clinic within the public hospital for spinal pain treatment during the extended follow-up period. During patient tracking, it was found that 22 patients received, at some stage after their study treatment period but within the extended follow-up period, a different type of treatment from the randomized regimen. Consequently, a compliers-only analysis ($n = 40$) was performed that was restricted to those patients who never (including the extended follow-up period of at least 1 year) received any treatment other than the randomly allocated regimen through the free public hospital system (Fig 1).

RESULTS

Participants and Follow-up

Overall, a total of 62 extended follow-up questionnaires were obtained from 69 patients eligible for this extended follow-up study reflecting a retention proportion of 90%. One person had left Australia, 3 army members were relocated and could not be traced for confidentiality reasons, and 3 patients left the area without any trace. The overall median extended follow-up period was 12 months (with a minimum of 12 months and a maximum of 36 months) with most (75.8%) of these questionnaires returned at exactly 12 months after the commencement of treatment. The median follow-up time for all groups was identical (12 months).

Table 1 details initial characteristics of the 62 extended follow-up patients and the respective groups in the 3 treatment modalities. None of the comparisons of the initial measurements between the 3 treatment groups revealed any significant differences.

Main Analysis

Intention-to-Treat Analysis. Table 2 details the findings of the initial status (T1) and the extended follow-up measurements (TE) of at least 1 year for all 62 patients who returned the long-term follow-up questionnaire and adhered to the randomized treatment during the study treatment period, although may thereafter have received other than the randomized treatment during the extended follow-up period.

Compliers-only Analysis. Table 3 displays the same type of information but only for the subgroup of 40 patients who never received any other than the randomized treatment during the study treatment period and within the extended follow-up period. However, of these 40 compliers, some received additional treatments in their randomized treatment regimen after their treatment period: 2 required 1 to 4 acupuncture follow-up visits, 3 required 1 to 4 medical follow-up visits, and 3 required 1 to 4 spinal manipulation follow-up visits.

In both Tables 2 and 3, the displayed $P$ values refer to statistical tests comparing the initial measurements before the study treatment period (T1) and the extended follow-up period (TE) of at least 1 year for all 62 patients who returned the long-term follow-up questionnaire and adhered to the randomized treatment during the study treatment period, although may thereafter have received other than the randomized treatment during the extended follow-up period.
questionnaires (TE). Not a single comparison between the results obtained at the end of the study treatment period (9 weeks) and the results obtained for this extended follow-up observations (TE) study returned any significant result neither for the ITT nor the compliers-only analysis (data not displayed).

In the ITT analysis (Table 2), in both the manipulation and the acupuncture groups, improvements in each of the 7 examined measurements are observed when the extended follow-up findings (TE) are descriptively compared with the pretreatment measurements (T1). Subsequent statistical testing revealed that, in both groups, 6 of the 7 variables were at or below the significance level. The medication group, in contrast, descriptively deteriorated in 2 of the 7 variables (pain frequency neck, and pain scale [VAS] neck), and only a single variable (SF-36) displayed a significant improvement.

In the compliers-only analysis (Table 3), improvements were observed in all variables in both the manipulation and the acupuncture group when the TE findings are descriptively compared with the T1 measurements. The medication arm descriptively deteriorated in 2 items. Statistical testing
revealed that only in the manipulation group, 5 of the 7 observed improvements were statistically significant which compares with only 1 item in each of the acupuncture and the medication groups, respectively.

The percentages of those who received, at any time after randomization, a treatment other than the allocated regimen (because of side effects or because it was considered that the allocated treatment showed no effects) differed significantly \((P < 0.05)\) between the treatment groups. The respective percentages were manipulation 38.7%, acupuncture 53.3%, and medication 81.2%, respectively. For these calculations, 10 noncompliers during the 9-week study treatment period and 7 patients who did not return the extended follow-up questionnaires in the present study were excluded (Fig 1).

For all the main outcome measures, additional analyses were performed to assess potential confounding of variables such as age, sex, BMI, pain duration (of both neck and back), and involvement in litigation. Bivariate analyses proved that none of the assessed variables were significantly correlated with the main outcome measures. Additional multivariate models also disproved any influence of these variables on the outcome measures thus effectively excluding the presence of any relevant confounding bias.

**DISCUSSION**

This is, to the authors’ knowledge, the first report on long-term efficacy of 3 distinct and standardized treatment regimens for patients with chronic spinal pain syndromes using a “fastidious” approach; that is, the only type of study from which potentially valid inferences of cause and effect can directly be drawn.\(^{24}\) The validity of the study (ie, the absence of different types of bias) is hereby essential and will be discussed first.

**Selection Bias**

The study sample has a broad socioeconomic background and a wide age range. Quite stringent exclusion criteria guaranteed a pathologically homogeneous sample. It was successfully ascertained that all “dropouts” occurring during the study treatment period, as well as during the extended follow-up period thereafter, occurred for reasons unrelated to the study outcome (ie, moving overseas, being transferred, etc). A high retention proportion of 90% for this extended follow-up study, together with the above stated facts, supports the generalizability of the findings.

**Information Bias**

Intention-to-treat analyses including noncompliers (1 for the 9-week treatment period\(^9\) and 1 for the presented study) revealed results quite consistent with the respective compliers-only analyses thus effectively diminishing any relevant misclassification bias from noncompliers. A different color code was used from that in the 9-week analysis to ensure successful blinding\(^{25}\) of data analysis. All data handling and analyses were again performed before the treatment color code was broken. The senior biostatistician was involved.

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**Table 3. Results of compliers only analysis \(n = 40\)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total ((n = 40))</th>
<th>Manipulation ((n = 19))</th>
<th>Acupuncture ((n = 14))</th>
<th>Medication ((n = 7))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain frequency, back</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>4 (4-5)</td>
<td>4 (4-5)</td>
<td>5 (3.5-5)</td>
<td>4 (3-5)</td>
</tr>
<tr>
<td>TE</td>
<td>4 (1.3-4.8)</td>
<td>3 (1-4), (P = .002)</td>
<td>4 (1.8-5), (P = .13)</td>
<td>4 (1-4), (P = .44)</td>
</tr>
<tr>
<td>Pain frequency, neck*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>4 (3.5-5)</td>
<td>4 (4-5)</td>
<td>4 (2-5)</td>
<td>4 (1-5)</td>
</tr>
<tr>
<td>TE</td>
<td>2 (1-4)</td>
<td>2 (1-4), (P = .006)</td>
<td>2 (0-5), (P = .24)</td>
<td>4 (2.5-4), (P = .75)</td>
</tr>
<tr>
<td>Pain scale (VAS), back</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>5 (3-7.8)</td>
<td>5 (3-7)</td>
<td>5.5 (4-8)</td>
<td>3 (0-8)</td>
</tr>
<tr>
<td>TE</td>
<td>3.4 (1.9-6.1)</td>
<td>2.8 (0.7-6.2), (P = .06)</td>
<td>4.5 (2.4-5.7), (P = .13)</td>
<td>3.1 (1.9-3.6), (P = .47)</td>
</tr>
<tr>
<td>Pain scale (VAS), neck*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>6 (3.5-8.5)</td>
<td>6 (3.5-7)</td>
<td>6 (4-9)</td>
<td>6 (1.5-8.5)</td>
</tr>
<tr>
<td>TE</td>
<td>2.7 (0.2-5.7)</td>
<td>2.3 (0.4-4.8), (P = .004)</td>
<td>2.5 (0-7.9), (P = .1)</td>
<td>3.9 (2.9-5.7), (P = .44)</td>
</tr>
<tr>
<td>Oswestry Back Pain Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>26 (14-31)</td>
<td>22 (10-30)</td>
<td>29 (21-46)</td>
<td>24 (14-30)</td>
</tr>
<tr>
<td>TE</td>
<td>16 (5-28)</td>
<td>9 (4-24), (P = .12)</td>
<td>19 (5-37), (P = .02)</td>
<td>20 (4-42), (P = .5)</td>
</tr>
<tr>
<td>NDI*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>36 (20-47)</td>
<td>28 (18-40)</td>
<td>42 (20-50)</td>
<td>47 (21-55)</td>
</tr>
<tr>
<td>TE</td>
<td>20 (4-35)</td>
<td>18 (6-27), (P = .02)</td>
<td>24 (0-36), (P = .06)</td>
<td>30 (13-49), (P = .31)</td>
</tr>
<tr>
<td>SF-36</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>47 (33-64)</td>
<td>57 (38-68)</td>
<td>45 (31-52)</td>
<td>41 (23-74)</td>
</tr>
<tr>
<td>TE</td>
<td>70 (49-83)</td>
<td>80 (59-88), (P = .006)</td>
<td>53 (38-75), (P = .1)</td>
<td>70 (50-85), (P = .02)</td>
</tr>
</tbody>
</table>

Displayed are medians with interquartile ranges. \(P\) values refer to tests between initial (T1) and extended (TE) assessments. For all variables except SF-36, a decrease in the score indicates improvement; for SF-36, an increase indicates improvement.

* Analysis restricted to those who had a neck problem at least once \((n = 29)\).
neither in the data collection process nor in any daily business of the center, thus minimizing information bias.

Blinding of the physician was not possible; even if, for instance, a “sham” acupuncture treatment would have been regarded as ethically justifiable, the acupuncturist would still have to know what treatment to perform. Blinding of the patients was not possible because there is, for instance, no known practical way to perform a sham manipulation. The potential for information bias, in this context, however, seems limited by the standardized treatment regimens and the fact that the clinician was not involved in measuring outcome. Information bias arising from a placebo effect or from a self-limiting effect is highly unlikely because patients in this study had chronic spinal pain syndromes (the average duration of having this exceeded 2 years) and had long histories of having sought pain relief. Improvement caused by the abovementioned effects could be expected in cases with acute spinal pain but seems rather unlikely in long-term cases.

Confounding Bias

Table 1 indicates that the 3 groups were very similar in their characteristics at inception. Additional bivariate and multivariate analyses of potential effects of these characteristics on the outcome measures also disproved any relevant confounding bias.

According to Turk and Rudy,27 no clinical study can be completely valid because of the complexities of extended follow-up trials; however, we have attempted to conduct a well-executed extended follow-up randomized trial with a rigorous protocol, and the overall validity of the reported findings does not seem to be negatively affected by any obvious bias. The main emphasis of this study was to assess absolute efficacy; consequently, within-group comparisons constituted the basis for analysis. Additional across-group comparisons, as often used in clinical trials to assess relative efficacy (eg, when new treatments are compared with an accepted “gold” standard), would have resulted in 2-dimensional testing (ie, determining and validating a gold standard within the same data set) defying any meaningful interpretation. The validation process (ie, the relative comparison) consequently has to be reserved for future trials.

However, the presented trial with successful randomization, thorough concealment, and within-group analyses applied the most powerful design possible to a research area where no accepted gold standard exists and where the emphasis, at this early stage of the research process, has to be on absolute, as opposed to relative, efficacy.

It should be noted that definitions of chronicity for low-back pain have been suggested by various authors such as Nachemson and Bigos28 and by Skouen et al.29 For the reported study, the definition for chronic pain duration was more than 13 weeks, so it is against this definition that these results are to be interpreted.

The overall results of this extended follow-up efficacy study appear to favor the application of manipulation and suggest that manipulation, if not contraindicated, and, to some extent, also needle acupuncture seem to successfully achieve long-term benefits in chronic spinal pain syndrome patients. However, no such benefit could be observed for medication. These results not only corroborate the findings of the 9-week analysis3 but also of the smaller pilot study.12 It seems noteworthy that the comparison of the percentages of those who had to change the treatment modality (because of side effects or unsatisfactory results) also appears to favor manipulation in that manipulation showed by far the lowest proportion (38.7%) of changeovers compared with acupuncture (53.3%) and medication (81.2%). Consequently, spinal manipulation appeared to provide the highest satisfaction. Moreover, both the 9-week findings and the extended follow-up results are consistent with conclusions by Meade et al,10,11 who, on comparing chiropractic with hospital therapists for treating low-back pain as they would in day-to-day practice (“pragmatic” approach), reported that those treated by chiropractic derived more short-term and long-term benefit and satisfaction than those treated by hospital therapists.

Medication apparently did not achieve an improvement in chronic spinal pain, although the SF-36 indicator of general health status did show an improvement (P = .02) for general health status. This may reflect some satisfaction with not having the inconvenience of needing to attend twice weekly for treatment and/or may also suggest that medication did not act as a nocebo.

It is interesting that the application of manipulation and acupuncture seem roughly equally successful in the ITT analysis, but only manipulation seems of broad-based long-term benefit in the compliers-only analysis. A more detailed look at the noncompliers data revealed that 4 of the 6 patients in the acupuncture arm who had some other type of treatment than the randomly allocated regimen during the extended follow-up period were actually treated with manipulation. Therefore, an artificial inflation of the effect of acupuncture treatment in the ITT analysis by additional manipulation therapy seems likely. The compliers-only analysis therefore seems to provide information that is more accurate.

The ITT analysis, however, is per se relevant because it displays the information that would be available from a similar trial in a larger metropolitan setting where the information on additional treatment may not be collected (or at least only less reliably). The setting of the present trial in a small, geographically relatively isolated community which is served by only 1 major public (providing free treatment) hospital rendered it possible to directly collect precise information on possible additional treatments during the extended follow-up period by checking the single public hospital’s computer records.

This advantage of the small community setting, however, is partly offset by a long inception period (several years) to
reach the minimum necessary sample size. In this context, it seems noteworthy that because of the necessarily stringent inclusion and exclusion criteria, 533 patients had to be seen (and treated) at the unit to achieve the reported sample sizes, reflecting that only around 1 (22.3%) of 5 patients fulfilled the inclusion /exclusion criteria.

Another general reason for the relatively small sample sizes for the extended follow-up analysis, however, lies in the very nature of this strictly fastidious approach itself: the group of strict compliers necessarily dwindles with increasing period of observation as the likelihood increases that additional treatment (eg, simple pain killers) is used by those in the long-term condition. This consequence of the fastidious approach, however, is easily compensated for by the fact that it is the only approach where an observed effect can be unambiguously attributed to 1 specific treatment modality only (if the study follows an otherwise rigorous methodology). Moreover, it seems worth reiterating that statistical testing takes into account the sample size and the observed effects proved to be both medically relevant and statistically significant.

It should be emphasized that this study was exclusively concerned with chronic spinal pain, and therefore, no statement whatsoever can be made about the potential role of the investigated regimens in treating acute spinal pain syndromes.

CONCLUSION

Chronic mechanical spinal pain syndromes are prevalent conditions that tend to create a cluster of related problems reaching from withdrawal from social activity to a compromised immune function. The associated resulting direct and indirect costs in industrialized communities are vast. A large community study seems to be the next logical step to address this important problem and to further investigate the reported findings. Consideration should also be given to assessing the efficacy of other treatment modalities. This suggested study should be based on a fastidious approach and incorporate an expanded multidisciplinary team to gain further evidence-based information on the absolute and also the relative efficacy of all forms of available treatments.

The results of this “fastidious” approach were able to add some information regarding the efficacy of treatment regimens in patients with chronic spinal pain syndromes. Overall, patients who have chronic mechanical spinal pain syndromes and received spinal manipulation gained significant broad-based beneficial short-term and long-term outcomes. For patients receiving acupuncture, consistent improvements were also observed, although without reaching statistical significance (with a single exception). For patients receiving medication, the findings were less favorable. Larger studies are now clearly justified.

REFERENCES


SUBJECTIVE NATURE OF LOWER LIMB RADICULAR PAIN

Geoffrey M. Bove, DC, PhD, Asia Zaheen, MD, and Zahid H. Bajwa, MD

ABSTRACT

Background: Lumbar pathologies may cause the perception of leg pain, but the character of this pain has not been described. Diagnosis is often based on dermatomal charts, but observations reveal that the pain is not typically perceived on the skin.

Objective: To document the incidence of superficial versus deep pain localization among patients with lumbar radicular pain.

Methods: Twenty-five patients with lower limb radicular pain were questioned to determine the specific localization of their pain. The investigator categorized the pain location into general areas (eg, posterior thigh or anterior leg). Patients were asked if their pain was perceived as being on the skin or deep, as a forced choice question. These data were gathered in 2 conditions: at rest (spontaneous pain) and during a straight leg raise test (mechanically evoked pain). Data were recorded using a standardized form for later analysis.

Results: In all cases, symptoms were reported to be in deep structures. Pain was typically reported at sites correlated with multiple spinal levels.

Conclusion: Because radicular pain symptoms are perceived in deep structures rather than on the skin, the diagnostic value of dermatomal charts is questioned. Clinicians are advised to be specific when questioning patients with radicular pain symptoms and to refer to myotomal and sclerotomal charts when making diagnoses. (J Manipulative Physiol Ther 2005;28:12-14)

Key Indexing Terms: Pain; Sciatic Neuropathy; Straight Leg Raise

A fundamental characteristic of radiating pain is that it is perceived in a different location than the causative lesion. The best-known example of radiating pain is the lower extremity pain associated with lumbar disk disease and known as “sciatica,” which affects up to 40% of the adult population. Despite the prevalence of such painful conditions, the localization of pain has rarely been described, especially in terms of “deep” versus “superficial.” Because the myotomal and sclerotomal (deep) and dermatomal (superficial) innervation patterns are dissimilar, the clinical interpretation of symptoms may be dependent on this sort of localization. The primary goal of this study was to determine whether lower limb radicular pain is perceived by patients to be deep or superficial. To this end, we questioned patients presenting to our pain clinic with diagnoses of lumbar radiculopathy about the localization of their spontaneous and mechanically evoked leg pain.

METHODS

The Beth Israel Deaconess Medical Center Committee on Clinical Investigation approved this protocol. All data collection was performed by one of the authors (AZ), who was unaware of the main hypothesis of the study. The records of scheduled patients aged 25 to 65 years were checked for diagnoses of lumbar radiculopathy. Before their scheduled examination, such patients were invited and gave verbal consent to participate.

While lying supine on the examination table, the investigator asked the patients about the pain they were currently perceiving (spontaneous pain), using a standardized script. Patients were not asked to provide pain descriptors, nor were such descriptors recorded. They were asked to localize their symptoms as specifically as possible. The investigator categorized the location of symptoms as anterior, posterior, medial, and/or lateral for the buttocks, thigh, knee, leg, and/or foot. For each region where pain was reported, patients were also asked if the pain was perceived “on the skin” or “deep,” using these standard terms. All data were recorded on a standardized form.

A straight leg raise (SLR) test was then performed, and the approximate angle at which symptoms appeared was
The subjective reports of the patients to the same questions about pain localization during this test were recorded. Ankle dorsiflexion was then performed, and patients were asked if this worsened their pain. The responses were summarized in chart format.

**RESULTS**

Subjective pain perceptions from 19 right and 10 left legs of 25 patients were recorded (Table 1) from the 25 sequential patients who were asked to participate. All 29 legs were reported to generate spontaneous pain. In all cases, the pain was reported to be deep, not superficial. Straight leg raising evoked pain in 24 (83%) legs, at a mean level of 58° (SD 16.7). Evoked pain was also reported to be deep in all cases. Ankle dorsiflexion aggravated the symptoms in 20 (83%) of these legs. The 95% exact binomial confidence interval for both spontaneous and evoked superficial pain being reported in 0 of 29 cases is 0 to 0.12; in other words, the prevalence of superficial pain probably lies, in either case, between 0% and 12%.

The regions of spontaneous pain were compared with myotomal charts of the lower limb, and the corresponding root levels were recorded. In all but 1 case, multiple roots seemed affected. In only 1 case did symptoms in the distribution of multiple roots “skip” any level. In the majority of cases, the regions and spinal levels of evoked pain were either the same or were a subset of the areas of spontaneous pain (Table 1). In 2 cases, the evoked symptoms were more widespread than the spontaneous symptoms. Eleven patients reported spontaneous anterior thigh and/or knee pain, and in 2 different cases, evoked pain was reported in these areas, indicating L2 and/or L3 involvement.

**DISCUSSION**

The most striking finding in this study was that in all cases, the spontaneous and evoked pains were reported as deep rather than superficial. This contrasts to previous reports that 22% of patients with radicular symptoms had superficially perceived spontaneous leg pain. The principal difference may be that the cited reports examined cases

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**Table 1. Reports of spontaneous and evoked pain from all legs and correlating root levels**

| Case | Glut | Thigh | Knee | Leg | Foot | Glut | Thigh | Knee | Leg | Foot | L2 | L3 | L4 | L5 | S1 | S2 |
|------|------|-------|------|-----|------|------|-------|------|-----|-----|-----|----|----|----|----|----|----|
| 6    | p    | apml  | apml | apml| apml| pl   | apml  | apml | apml| apml| se  | se  | se  | se  | se  | se  |
| 3    | pl   | pl    | pl   | pl  | pl   | pl   | pl    | p    | pl  | pl   | se  | se  | se  | se  | se  | se  |
| 5    | pl   | pl    | pl   | pl  | pl   | pl   | pl    | p    | pl  | pl   | se  | s   | se  | se  | se  | se  |
| 4    | pl   | pl    | pl   | pl  | apml| apml| apml  | p    | apml| apml| se  | se  | se  | se  | s   | s   |
| 23   | pl   | p     | p    | p   | p    | p    | p     | p    | p   | p    | se  | se  | se  | se  | se  | se  |
| 24   | pl   | p     | p    | p   | p    | apml| apml  | a    | a   | a    | c   | e   | e   | s   | s   | se  |
| 20   | p    | p     | p    | p   | p    | p    | p     | p    | p   | p    | se  | se  | se  | se  | se  | se  |
| 29   | l    | l     | l    | l   | al   | l    | l     | al   | al  | al   | l    | s   | s   | s   | s   |
| 8    | pl   | apml  | apml | apml| apml| pl   | pl    | a    | a   | a    | se  | se  | se  | s   | s   |
| 11   | pl   | apml  | apml | apml| apml| a    | a     | a    | a   | a    | se  | se  | se  | s   | s   |
| 27   | p    | apml  | apml | apml| apml| pl   | pl    | pl   | pl  | pl   | se  | se  | se  | se  | se  |
| 10   | pl   | pl    | pl   | pl  | pl   | pl   | pl    | pl   | apml| apml| e   | e   | e   | e   | s   |
| 2    | p    | al   | al   | al  | pl   | al   | pl    | a    | a   | a    | s   | s   | s   | s   |
| 7    | p    | pl    | pl   | pl  | pl   | pl   | pl    | pl   | apml| apml| e   | e   | e   | e   | s   |
| 22   | p    | p     | p    | p   | p    | p    | p     | p    | p   | p    | se  | se  | se  | se  | se  |
| 16   | p    | p     | p    | p   | p    | p    | p     | p    | p   | p    | s   | s   | s   | se  |
| 25   | p    | p     | p    | p   | p    | s    | s     | s    | s   | s    |
| 28   | p    | p     | p    | p   | p    | s    | s     | s    | s   | s    |
| 1    | p    | l     | l    | l   | al   | al   | al    | e    | e   | e    | s   | s   |
| 9    | pl   | pl    | pl   | pl  | pl   | pl   | pl    | pl   | pl  | pl   | se  | se  | se  | se  | se  |
| 26   | pl   | a     | a    | a   | a    | a    | a     | a    | a   | a    | se  | se  | se  | se  | se  |
| 17   | apml | apml  | apml | p   | p    | p    | p     | p    | p   | p    | s   | s   | s   | s   |
| 18   | apml | apml  | apml | p   | p    | p    | p     | p    | p   | p    | s   | s   | s   | s   |
| 12   | a    | a     | a    | a   | a    | a    | a     | a    | a   | a    | se  | se  | se  | se  |
| 13   | a    | a     | a    | a   | a    | a    | a     | a    | a   | a    | se  | se  |
| 14   | a    | a     | a    | a   | a    | a    | a     | a    | a   | a    | se  | se  |
| 15   | a    | a     | l    | a    | a    | a    | a     | a    | a   | a    | se  | se  | e   |
| 19   | pl   | pm    | pm   | pm  | pm   | pm   | pm    | pm   | pm  | pm   | s   | se  |
| 21   | pl   | pm    | pm   | pm  | pm   | pm   | pm    | pm   | pm  | pm   | s   | se  |

Cases were arranged by the relative extent of the spontaneous pain symptoms. Glut, Gluteal; a, anterior; p, posterior; m, medial; l, lateral. s, Spontaneous; e, evoked symptom in location consistent with listed nerve root, from myotomal chart.²

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Lower Limb Radicular Pain
in which surgery had been or would be performed, whereas our patients were mainly referred to the pain clinic as nonsurgical candidates. In addition, the cited authors attributed superficial symptoms to more severe nerve involvement, which is a distinct possibility.

The difference between deep versus superficial pain has clinical and biologic implications. Clinically, spontaneous pain and the SLR test are used to help diagnose which nerve roots are involved in a radiculopathy. The symptoms are often compared with dermatomal charts. However, in the absence of reports of spontaneous or SLR-evoked cutaneous pain, dermatomal charts are clearly not the ideal diagnostic reference. These data suggest that myotomal and sclerotomal charts have more diagnostic potential.

On the other hand, the data may indicate that pain symptoms have limited diagnostic utility, especially considering that pain was reported correlating to multiple levels in almost all cases. Biologically, these data imply fundamental differences within primary afferent nociceptive neurons. The neurons innervating musculoskeletal structures may respond differently to pathologic lesions that cause radicular symptoms from the neurons innervating cutaneous structures. These ideas are consistent with recent reports that intact afferent neurons innervating muscle develop spontaneous activity after nerve injury, whereas cutaneous neurons do not. This could explain deep spontaneous pain after nerve injury. Also, the axons of deep but not cutaneous afferent neurons develop spontaneous activity and more importantly mechanical sensitivity during neuritis. This provides a potential mechanism for both spontaneous and mechanically evoked pain perceived as “deep.”

There was a distinct difference between the number of spinal levels involved in spontaneous pain compared with evoked pain. We hypothesize that this reflects different mechanisms for spontaneous versus evoked pain and that both could be explained by changes affecting primary afferent nociceptors. Although little data exist to support such hypotheses, our previous report showed that when axons are inflamed, some nociceptive neurons spontaneously generate action potentials (could lead to spontaneous pain), whereas others become mechanically sensitive (could lead to evoked pain). The present observations could be caused by such basic neurophysiological differences.

The apparently multiple spinal level involvement of the symptoms and the different distributions of spontaneous and evoked pain are not consistent with commonly held concepts of focal pathologies (eg, discal herniation). However, autologous nucleus pulposus from a compromised intervertebral disk is known to cause intrathecal inflammation that would not be expected to be restricted by nerve root levels, but rather by the spread of the intradiscal material. The extent of radicular symptoms, assessed by the number of spinal levels involved, may be related to the extent of inflammation and may be a measure of severity. However, there is a confounder in the concept of nonspecific extension of inflammation to other spinal levels as a cause of the symptoms reported: there were no reports of contralateral symptoms. We have no hypothesis to offer as explanation for this.

**CONCLUSION**

This project indicates that questions regarding “volume,” in addition to area of pain, give qualitatively different diagnostic information. Future comparisons of symptoms, physical findings, and imaging will be necessary to clarify the significance of such symptoms and whether they impact clinical decision making.

**REFERENCES**

CONSENT OR SUBMISSION? THE PRACTICE OF CONSENT WITHIN UK CHIROPRACTIC

Jennifer M. Langworthy, MPhil, a and Christine le Fleming, BSc(Hons), MSc Chiropractic b

ABSTRACT

Background: A patient’s right to accept or reject proposed treatment is both an ethical and legal tenet. Valid consent is a multifaceted, controversial and often complicated process, yet practitioners are obligated to try to obtain consent from their patients. Its omission is a common basis for malpractice suits and increasing utilization of complementary and alternative services in conventional medical settings is intensifying the focus on medical liability issues. This has important implications for individual professions and their members.

Objective: To investigate approaches to consent among a small (n = 150) sample of practicing UK chiropractors.

Results: Of 150 randomly selected chiropractic practitioners in the United Kingdom, 55% responded. Of these, 25% report not informing patients of physical examination procedures prior to commencement. By contrast, only 6% do not fully explain proposed treatment, although over one-third do not advise patients of alternative available treatments. Nearly two-thirds of the practitioners report that there are no specific procedures for which they always obtain written consent and 18% that there are no instances in which they document when verbal consent has been obtained. Nearly-three percent said they always discuss minor risk with their patients but only 23% report always discussing serious risk. When treatment carries a possible risk of a major side-effect only 14% of the sample obtain formal written consent. Documentation of patient understanding is omitted by 75% of practitioners in this sample.

Conclusion: Results suggest that valid consent procedures are either poorly understood or selectively implemented by UK chiropractors. (J Manipulative Physiol Ther 2005;28:15-24)

Key Indexing Terms: Informed Consent; Chiropractic; Ethics; Malpractice; Risk

Certainly in the UK, today’s patient is encouraged to be much more involved in the decision-making surrounding their healthcare. A successful doctor/patient relationship depends on trust borne out of respect for the patient’s autonomy and right to accept or reject proposed treatment.¹ This is both an ethical and legal tenet. Autonomy in this regard means that the patient makes decisions about his or her healthcare intentionally, with understanding of relevant issues and without undue influence.² In order that they can exercise this right, patients must be given sufficient information and in a form they can understand.

Valid Consent

Consent is often wrongly equated with a patient’s signature on a consent form. While the signature is evidence that some form of process has occurred, it is not proof of valid consent.³ For example, if a patient is hurried into signing a form having not been given sufficient information, the consent may not be valid despite the signature. Moreover, for consent to be valid the patient must demonstrate mental capacity for the required decision-making.⁴

Valid consent is central in all forms of healthcare, from the least invasive through major surgery. While opponents suggest that it can interfere with the doctor/patient relationship and disrupt free communication,⁵ associated benefits include increased patient satisfaction and reduced malpractice claims.⁶

Informed consent comprises four main elements, these being disclosure, comprehension, voluntariness and competence.¹³⁷⁸

- Disclosure – the provision of information regarding risks, benefits, alternative treatments and the consequences
of not having the proposed treatment, which could be either positive or negative. It may also include costs, the likely duration of treatment and who will administer it.

The benefits of treatment are usually apparent, that is the alleviation or removal of the problem for which the patient has sought clinical assistance. However, the patient should be informed if recovery will not be complete or permanent. Ideally, patients should also be made aware of the natural history of the complaint if it is such that actual treatment is not necessary and simple advice, if adhered to, will produce the desired outcome. Where treatment is required, then patients should be informed of all available options and their respective risks and benefits. Nevertheless, some observers have reported that in practice treatment options are not routinely provided, while from the legal perspective, the requirement to disclose options is not consistently recognised by the courts.

Risk

It is the disclosure of risk that is the most controversial and uncertain element of the consent process. It is complicated by an individual’s perception of risk, which is guided by the use of heuristics. These are short cuts that enable a simplification of the decision-making process. For example, a patient may rationalize the risk by believing an event is more likely to happen to someone else. However, this may result in substantial under- or over-estimation of the risk.

There are then implications for how information is presented by the clinician to the patient during the consent process. How such information is framed can affect a patient’s perception of the risk, such as the citing of survival or mortality data or the explanation of risk in terms of a range of values rather than a specific point estimate. Other studies have demonstrated extensive misunderstanding of verbal descriptions of probability compared to pictorial descriptors.

Beauchamp and Childress suggest that drawing analogies to events familiar to a patient is a successful way of communicating specialised information. Calman subsequently offered the following risk categorisation:

- HIGH: a greater than 1 in 100 chance (1%) of an accident occurring
  - eg. transmission of chicken pox or measles
- MODERATE: a 1 in 100 to 1 in 1000 chance (0.1-1%)
  - eg. death from smoking 10 cigarettes a day
- LOW: a 1 in 1000 to 1 in 10,000 (0.1-0.01%)
  - eg. death from a road traffic accident
- VERY LOW: a 1 in 10,000 to 1 in 100,000 (0.01-0.001%)
  - eg. death from accident at home or work
- MINIMAL: a 1 in 100,000 to 1 in a million (0.001-0.0001%)
  - eg. death on railway
- NEGLIGIBLE: a less than 1 in a million chance (<0.0001%)
  - eg. death by strike of lightning

Manipulation

One of the most controversial areas in musculoskeletal healthcare is that of risk associated with manipulation of the cervical spine. The controversy centers on the as yet non-reliable quantification of risk attached to this maneuver and its link with the inducement of stroke. In a recent review, Haldeman, Kohlbeck and McGregor reported a potential risk of dissection of a vertebral artery after manipulation of between 1:400,000 treatment sessions to 1:1.3 million. They concluded that the type of patient most at risk or the type of manipulation most likely to cause the dissection could not be ascertained from the literature. They suggest that individuals who already have a dissecting artery will have neck pain and headaches and are therefore more likely to present for treatment as offered by chiropractors and other providers of physical therapy. Smith, Johnston, Skalabrin et al also note that it is unclear whether minor trauma or simple self-initiated head and neck movement can produce dissection and whether spinal manipulation either causes dissection or exacerbates a pre-existing dissection leading to stroke. Other studies have concluded that screening tests for vertebrobasilar artery insufficiency are of no value when trying to predict stroke, while recent findings on the mechanical forces involved in spinal manipulation suggest that they are not sufficient to physically tear a vertebral artery.

All this makes it very difficult for the practitioner to discuss with confidence inherent risk with patients attending for this type of treatment or any other where risk cannot be reliably quantified. However, in Canterbury vs Spence the court ruled that all material risks should be disclosed. In White vs Turner and Rawlings vs Lindsay material risks were defined as significant risks which pose a threat to the patient’s life, health or comfort and that risks can be considered material even if there is only a small chance of serious injury or death. The case of Hopp vs Lepp in 1980 addressed the issue of probable risk. Here, the court also concluded that possible risks which, in a particular case, have the potential for serious consequences if they do occur, eg, death or paralysis, should be deemed material and disclosed. Case law has determined that this risk can be equal to or less than a 1% chance. Nevertheless, in a study of 10 patients with ischemic stroke secondary to vertebral artery dissection or internal carotid artery dissection, all following manipulation by a chiropractor, it was found that informed consent was obtained from only one of the ten cases. Comprehension – information becomes worthless if the patient is unable to understand it. Furthermore, although consent can be non-verbal, some commentators have urged caution in reliance on implied consent. For example, a
Malpractice

Omission of consent is a common basis for malpractice suits. In a study, of 36 (surgical) cervical spine malpractice cases, 64% of claims were based on the absence of informed consent, second only to increased pain and suffering at 72%. In a review of more than 600 cases occurring during a 10-year period, over 50% of the cases brought against UK National Health Service medical consultants for private practice work included allegations related to consent.26

Case law shows that malpractice claims against practitioners of complementary and alternative medicine are broadly similar to those brought against physicians.27 In the United States, claims against chiropractors in the 1990s amounted to approximately one-third of those made against primary care allopathic physicians.27 It has been reported that 5% of practising US chiropractors are involved in litigation as defendants at any one time, such that each year 3/100 chiropractors are sued.28

In the UK, claims against chiropractors made to the Medical Insurance Agency (MIA) virtually doubled in the years 1997–2000.28 Among the reasons for these claims was failure to disclose risk and obtain valid consent. The obligation from both ethical and legal perspectives to seek informed consent is not less applicable to chiropractors and other practitioners of complementary and alternative medicine than it is to medical doctors. The specific motivators leading patients to sue their health care providers have been investigated.29 These include an attempt by the patient to seek information about treatment because it was not provided or explanations were not timely; concern that nothing is being done to prevent a recurrence of an adverse event; in an attempt to improve the standard of care or to ensure accountability, or as an effort to correct poor communication as a result of the patient’s perception of the way the doctor spoke to them or did not respect or listen to the patient. The Tito report30 also concluded that increased litigation against healthcare providers might be due to unrealistically optimistic expectations of healthcare held by the patient as a result of practitioner reluctance to discuss all possible risks associated with various treatments.

Consent and Chiropractic

In the case of chiropractic, there is a shortage of published information directly addressing how members of the profession approach the issue of consent. A search of the literature revealed only one such report. This was an Australian study31 and revealed that consent to chiropractic management was usually implied. Formal verbal consent was seldom acquired, written consent, never. Nearly half (47%) of patients surveyed reported that their chiropractor never sought permission prior to physical examination while 52% reported that their consent to treatment was not asked for. Jamison also found a marked reluctance among the practitioners to initiate discussion about possible serious side effects of treatment and 85% of the patients confirmed that they had never discussed adverse effects of chiropractic care with their chiropractor.

The UK General Chiropractic Council describes informed consent as that “given by a person who has been supplied with all the necessary relevant information.”32 Yet what equates to the provision of adequate explanation is not easy to quantify33 and remains open to interpretation, not least perhaps due to patient diversity. Therefore, how consent is informed and what it constitutes appears to be largely dependent upon the views and practices of the individual practitioner. The current study sought to identify what these may be within a sample of UK registered chiropractors and responds to the call contained within the Tito report30 for more research into the reality of informed consent in daily practice.

Methods

A 34-item questionnaire was developed and underwent a small pilot exercise (n = 15). Areas addressed included procedures surrounding examination and treatment, written vs verbal consent, disclosure of risk, patient understanding, third party consent and opinion within the UK chiropractic profession regarding guidance on the issue of consent. Response options were either dichotomous or on a scale of “always,” “sometimes,” “only if asked” or “never.” Some questions included an open section to allow for a more detailed response.

One hundred and fifty UK chiropractors were randomly selected from professional registers using a method of computer-generated random numbers. This involved the entering of names and addresses into an Excel spreadsheet and deploying the random number generation option contained within the program. Following minor amendment as a
result of piloting, a questionnaire was sent to each of these 150 practitioners, together with a stamped-addressed envelope. Data were subjected to descriptive frequency analysis.

**RESULTS**

Eighty-three chiropractors replied representing a response rate of 55%. The majority of respondents were male and the mean age was 39 years, with a mean time in practice of 10 years. Eighty-four percent graduated from European chiropractic teaching institutions, 11% from North American and 5% from Australian and South African colleges.

Twenty-nine percent (29/83) of respondents reported not describing physical examination procedures in full at the first visit prior to the exam commencing (Table 1). In contrast, only 6% (5/83) said that they did not fully explain proposed treatment. Ninety-five percent (79/83) stated that they discuss the likely duration of a course of treatment with their patients and three quarters (76% [63/83]) reported they inform them of costs likely to be accrued. While most respondents (95% [79/83]) describe the benefits of their proposed treatment to patients and explain the consequences of not having it, over one-third (35% [n = 29/83]) do not advise of any alternative treatment(s) available.

**Written vs Verbal Consent**

Seventeen (20%) of the 83 respondents reported that they obtain written consent to perform a physical examination, as opposed to over half (n = 47) who acquire it verbally (Table 2). Three claimed to obtain both. Almost two-thirds (59% [49/83]) of the practitioners stated that there are no specific procedures for which they always obtain written consent. Where written consent is sought, 19% (16/83) reported that this is done while the patient is still in the waiting room. Fifteen (18%) of the practitioners said there were no instances in which they document when verbal consent has been obtained. When asked whether there are any particular types of procedures or circumstances where informed consent is not required, responses provided included such scenarios as where the patient is a friend, spouse or colleague; for orthopedic and neurological examination; in the case of notifiable disease; where the patient’s health can cause harm to others, eg, schizophrenia and when a patient presents with a problem similar to a previous complaint.

Verbal consent is sought slightly more frequently than written permission at the beginning of a course of treatment (53% [44/83] and 46% [38/83] respectively). Others, albeit a small minority, expressed the view that the patients’ presence in the clinic, their agreement to lie on the bench and commencement of treatment by the chiropractor all indicate consent.

**Risk**

With regard to risk, nearly all (93%) (77/83) respondents stated that they always mention any minor risk that their proposed treatment may involve (Table 1). The opposite was true in relation to major risk, with 23% (19/83) reporting that they always raise these with their patients. Reasons...
disclosed for not discussing them included (i) minimal risk and disputed evidence, (ii) not wishing to alarm patients, (iii) forgetfulness and (iv) the possibility of confusing patients with medical jargon. When risk is divulged to the patient, 51% (42/83) of the practitioners said that they quantify these in accordance with figures from recent literature. When treatment carries a possible risk of a major side-effect, very few (14% [12/83]) of the practitioners reported that they obtain formal written consent.

X-Ray

For 20 respondents, a question regarding the provision of an explanation of risk associated with x-ray was documented as not applicable. Of the remainder, three-quarters stated that they explain these to their patients. In a further question asking the practitioners to disclose whether they obtain either verbal or written consent prior to taking an x-ray, 17 of the responders appeared not to obtain either.

Concomitant Complaints

Less than half (45% [37/83]) of the sample always obtain consent to treat a new complaint that arises during a course of treatment. This compares to 48% (40/83) who sometimes do and 2% (2/83) who never seek permission when this occurs.

Third Party Consent

To treat or examine a competent child under 16 years of age, less than one-third (24/83) accept consent from the child him/herself (Table 3). In this scenario, all who responded accept parental consent. Similarly, with the exception of one, the consent of a legal guardian was also acceptable to all of the practitioners. In the case of an adult who is unable to provide consent, the majority (77% [64/83]) said that they would seek consent from either a legal guardian or another family member (72% [60/83]).

Understanding

To evaluate patient understanding of the information they have been given, most (61% [51/83]) responders reported that they simply ask the patient if they understand what they have been told. Others said they use their own judgement and experience or watch the patient’s facial expression and body language. Confirmation of patient understanding is

<table>
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<tr>
<th>Table 2. Verbal vs. written consent</th>
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<tbody>
<tr>
<td>Yes (%)</td>
</tr>
<tr>
<td>Obtain formal consent to perform physical examination</td>
</tr>
<tr>
<td>Obtain formal consent to proceed with a course of treatment</td>
</tr>
<tr>
<td>Obtain consent before every treatment</td>
</tr>
<tr>
<td>Obtain consent in the waiting area</td>
</tr>
<tr>
<td>Never document verbal consent</td>
</tr>
<tr>
<td>Are there any specific procedures for which written consent is always obtained?</td>
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<table>
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<th>Table 3. Third-party consent</th>
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<tr>
<td>Obtain consent before treating a child</td>
</tr>
<tr>
<td>Obtain consent before treating a child from:</td>
</tr>
<tr>
<td>• the child</td>
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<tr>
<td>• a parent</td>
</tr>
<tr>
<td>• a legal guardian</td>
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<td>• a foster parent</td>
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<td>• a grandparent</td>
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<tr>
<td>• an accompanying friend or relative</td>
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<tr>
<td>• the partner of a parent</td>
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<tr>
<td>Obtain consent for an incompletely adult form:</td>
</tr>
<tr>
<td>• a legal guardian</td>
</tr>
<tr>
<td>• a member of the family</td>
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<tr>
<td>• an accompanying adult</td>
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<td>• another health professional</td>
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documented by only one-quarter (21/83) of the responding practitioners (Table 4).

Supporting Visual & Written Aids

All respondents reported using visual aids such as model spines to help with their explanations to patients (Table 4). Sixty percent (50/83) stated that they always or sometimes provide their patients with written information to help them reach an informed decision. Forty-three (86%) of this group said that they treat patients at that same visit, with one chiropractor reporting that they let the patient decide whether or not they want to be treated on the same day.

Guidance

Two-thirds of the sample said that they were more aware of the importance of informed consent than when they graduated but felt that they had not received adequate guidance on the matter (Table 5). Most wanted such guidance to be supplied by their professional association, the General Chiropractic Council and/or the training institutions. A small number said that it should come from insurance companies or be part of continuing professional development.

DISCUSSION

This study sampled only a small proportion of UK chiropractors and, as such, its findings cannot be promoted as representative of the profession as a whole. However, the results suggest that inconsistency and non-compliance is associated with the obtaining of valid informed patient consent among the UK chiropractic profession.

Although those who responded to this survey were more aware of the importance and need for consent than when they first graduated, there was a feeling that they have not received adequate guidance on the issue. The current Code of Practice (1999) issued by the UK statutory regulatory body, the General Chiropractic Council (GCC), is limited in its advice on consent. Nonetheless, the results of this study provide some evidence that the advice that has been issued is at times either overlooked or selectively implemented. For example, the Code of Practice clearly states that failure to obtain consent before instituting any examination or treatment may lead to criminal or civil proceedings. Yet despite this, nearly one-third of the respondents do not explain examination procedures to their patients prior to their commencement, less than half routinely obtain consent to treat a new complaint arising during a course of treatment, while some feel that it is not necessary to obtain consent if the patient is a friend, family member or has a problem similar to a previous complaint.

Also of concern is the number of practitioners who report obtaining written consent from the patient while they are in the waiting room. Consent obtained in these circumstances cannot be considered informed or valid. The patient will have received no specific explanation of forthcoming examination procedures, while it is not possible for the practitioner to devise an appropriate treatment plan prior to examination, thus the consent would not cover therapeutic interventions.

The choice as to whether to obtain verbal or written consent appears to be arbitrary. Nonetheless, the UK Department of Health recognises that while it is rarely a legal requirement to seek written consent, it is good practice to do so if treatment is complex or where there may be possible serious complications.3 It would seem that UK chiropractors might not strongly adhere to this principle, as evidenced by the majority of respondents to this study who reported that there are no specific procedures for which they always obtain written consent. This includes situations where treatment carries the possibility of a serious adverse reaction.
Just 19 of the 83 respondents in this study reported that they always raise with their patients the issue of serious risk when associated with proposed treatment. Given the potential gravity and impact on all concerned should a catastrophic event occur, the non-disclosure of proven risk or serious risk that is recognized albeit not unequivocally quantifiable, represents a serious breach of both ethical and legal responsibility on the part of the majority of responders to this study. Of further concern is that only 12 of the responding practitioners actually proceed to obtain written consent for treatment of this nature. The proportion of the practitioners who do not document when verbal consent has been obtained, irrespective of the nature of the complaint or treatment, increases the concern.

The reasons behind the reluctance to engage the issue of serious risk are in most cases well intentioned, primarily where the chiropractor does not want to alarm patients, particularly when the risk is very small or in the light of inconclusive evidence. On the other hand, practitioners may stand accused of being defensive or of deliberately withholding pertinent information that should be made available. Moreover, there is legal precedent that states it is invariable practice that it was a practitioner’s immutable practice to inform patients of all associated risk no matter how great or remote. This “invariable practice” argument has been shown to find little favour with the judiciary in cases where it is claimed that pertinent information was not provided.

From another perspective, well-documented evidence of the implementation of informed consent will help lessen the opportunity for detractors to legitimately undermine the profession at times of misadventure. More generally, such routine and overt demonstration of commitment to best practice is a sign of a mature and ethical profession, which again leaves critics little room to manoeuvre.

Competence is central to autonomous decision-making and autonomy applies only to those who are capable of making a decision and then acting upon it. Yet a patient may be competent to make a decision concerning 1 part of their treatment but not another. Similarly, s/he may demonstrate competence at a particular point in time but not at another during an episode of care. Furthermore, a patient’s competence and thus autonomy may be adversely affected by pain or other physical or psychological factors. Therefore, determination of competence is not as straightforward as it might at first appear and involves exploration of communication efficacy, comprehension, reasoning skills and a stable value system within the patient. In relation to the current study, age appears to be an additional confounder as illustrated by the number of practitioners who do not recognise the competence of individuals under the age of 16 years, despite the position of prevailing UK law. Moreover, practitioners who take the view that the mere presence of a patient in the clinic or their willingness to lie on the examination table is sufficient indication of consent in the absence of open discussion of all relevant details, cannot reliably judge the competence of the patient. Consequently, it is unlikely that they can accurately distinguish between the fine line of consent and submission.

The same applies to those chiropractors who reported using their own judgement and experience or observation of the patient’s facial expression and body language to determine whether or not the patient has understood what they have been told. Although the majority of respondents to this study do attempt to establish levels of understanding among their patients, they do this simply by asking them whether or not they understand what has been conveyed to them. This only requires a “yes/no” answer, which is not demonstrative of the degree of understanding. Moreover, the ability to recall, recognise and retain information as true measure of comprehension has been disputed and it has been suggested that subjective evaluation of a situation by a patient is more representative of comprehension.

Some patients may have cognitive and emotional problems with understanding clinical information and appear not to want to participate in making decisions about their treatment. However, it has been argued that this does not undermine their potential to provide valid consent but that it does require better communication skills among clinicians.

Poor communication between patients and healthcare providers is a recurrent theme in litigation. Good communication skills are essential to the success of the clinical encounter and this is particularly evident in relation to informed consent. Nevertheless, research into this area of clinical training has revealed these skills to be generally poor. In a study of communication skills and competence in relation to informed consent among a group of medical students during an OSCE examination (objective structured clinical examination), Srinivasan found that while 90% of the candidates demonstrated ability to effectively deal with a patient’s physical concerns, only 50% undertook a relevant psychological assessment. Moreover, half were unable to recognize associated psychological issues that might influence the patient’s decision. Reiterating previous
recommendations that patient comprehension can be improved if a variety of communication approaches are used, Gausman & Forman recommend that healthcare providers be trained in additional and/or different communication skills that can address the problem of poor comprehension, including reading difficulties, across at least three diverse groups of patients.

In the chiropractic literature there appears to be a lack of published information relating to the role of communication skills in obtaining valid consent. This may be an area that undergraduate training institutions and providers of continuous professional development might wish to further develop. Apart from improving the quality of information provided to their patients, it will negate the concern held by practitioners like those in this study who use the fear of confusing patients with the use of medical jargon as a reason for not fully implementing valid consent procedures. Moreover, greater exposure and expertise in additional and varying communication strategies may give the chiropractor greater confidence when discussing the “grey areas” of clinical care, particularly, for example, in discussing risk when current knowledge is inconclusive but ethically and legally deemed material.

Consent is surrounded by much debate and controversy regarding the merits and pitfalls of paternalism vs. autonomy. It has been observed that paternalism focuses more on the patient’s care and outcomes rather than the patient’s needs and rights. A process encompassing all 4 of these elements may represent a more satisfactory approach. This would rule against absolute paternalism, it being irreconcilable with individual rights and respect for the patient. Those who advocate patient autonomy expound the belief that the decision-making process should be in the remit of the patient as it is who they have to live with or bear the consequences of any action or inaction. Such an approach is not without problems and patients who reject the practitioner’s recommendations without careful consideration of their own preferences ultimately risk causing themselves greater harm. Those who oppose an autonomous approach to medical decision-making raise the concern that a patient may sometimes choose a course of action that results in immediate short-term improvement but has no long-term benefit. In recognition that many patients may not be able to cope with absolute autonomy, an alternative model known as enhanced or guided autonomy has been advocated. This is based on 2-way communication between the doctor and patient involving an exchange of ideas and views, negotiation in the settlement of any differences and the sharing of power and influence. It requires a genuine commitment to shared decision-making in order that an appropriate management plan can be instigated which encompasses the doctor’s professional recommendations as well as the patient’s ideas, concerns and expectations, but critics fear that this still asks too much of the patient. Multifaceted, consent is more than a single interaction between the doctor and patient involving mechanical repetition of procedures, hazards and options. Aside from the arguments about paternalism and autonomy and legal and indemnity issues, the consent process affords the opportunity to educate patients and allows them to participate in their healthcare. Others advocate the consent process as part of treatment.

It is debatable whether valid consent in its purest form is attainable. As such, it may be that practitioners feel that the consent process as advocated in theory is somewhat divorced from the realities of daily practice. However, it has been argued that while consent can rarely be fully informed it can be adequately informed. The results of the current study suggest that there is room for improvement within the UK chiropractic profession regarding consent procedures. Traditionally, primary care practitioners have experienced relatively low rates of malpractice claims, thought partly to be due to mutual trust and communication between doctor and patient. Based on data from the insurance industry, it appears that lately this has changed and primary care practitioners today face a much greater risk of litigation against them. As the UK Secretary of State for Health has recently urged, “Above all else, for trust to thrive there has to be informed consent. Not a tick-in-the-box regime but consent that is based on discussion and dialogue, where consent is actively sought and positively given.”

**CONCLUSION**

The results of this study suggest that valid informed consent is somewhat poorly understood or implemented by members of the UK chiropractic profession, most notably in contentious areas such as risk. However, there appears to be a concern that an increased awareness of the need to obtain valid consent has not been matched by sufficient support and guidance from UK chiropractic statutory, professional or educational bodies.

On a wider perspective, there is perhaps a dichotomy between implementing adequate consent procedures for legal requirements as opposed to what constitutes good practice. Whatever the pros and cons, patients do have a legal right to information about their treatment and this is supported by Human Rights legislation recently introduced into UK law.

Consent is a complex issue. Nevertheless, this does not negate the responsibility of clinicians to obtain valid consent from their patients. In the UK, it may be helpful if the GCC were to provide the profession with expansive guidance on the issue of valid consent, including what it is, what it entails, and how it should be evidenced. Given its ethical and legal significance, the current emphasis on active rather than passive care, the apparent need for better informed patients, opportunities to provide chiropractic services in mainstream healthcare settings, and the focus on matters
surrounding medical liability, it is important that it can be demonstrated that chiropractors are committed to valid consent procedures. Therefore, there may be an argument for linking valid consent procedures with re-registration. In the first instance, this could be done through mandatory audits. The difficulties and concerns inherent in this are recognised, including professional resistance to the regulation of practice procedures. Yet with greater acceptance comes greater accountability. While some may fear that linking consent to registration is potentially overly castigatory, not only would it provide more systematic protection for the individual practitioner, it would send a powerful message to the general public and current/future patients, as well as to other external health and policy agencies.

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Background: Despite the high prevalence and cost of neck-pain problems, there is currently little data available on the physical characteristics associated with different levels of neck pain.

Objective: To investigate associations between categories of response to neck pain/discomfort and (1) the endurance time of neck muscles, neck range of motion (ROM), and neck and head morphology, (2) sensitization or stretch effects arising from repeating end-of-range measurements, and (3) self-report data from neck pain and disability questionnaires.

Design: A cross-sectional study design.

Methods: Fifty-five Australian volunteers with and without neck pain, who were not taking time off work, were measured for neck muscle endurance, active neck ROM, cranio cervical and thoracic posture, neck length, and head circumference and completed questionnaires about any neck pain/discomfort and disability.

Results: Twenty-two subjects reported a level of neck pain/discomfort that had required treatment (treated neck pain), a group of 17 subjects reported experiencing low-level neck pain/discomfort on a recurrent basis for which they had not sought treatment (untreated neck pain), whereas 16 subjects had no experience of neck pain or discomfort (no pain). Neck muscle endurance time was significantly lower for both pain groups. The affective dimension of the Short-Form McGill Pain Questionnaire and neck disability questionnaires were scored significantly higher by subjects who had sought treatment than by those in either of the untreated groups. Both pain groups showed a range decrease for most directions of neck motion at second measurement.

Conclusions: Neck muscle endurance times, repeated end-ROM testing, the Short-Form McGill Pain Questionnaire, and disability questionnaires may distinguish between groups with untreated, treated, and no neck pain. (J Manipulative Physiol Ther 2005;28:25-32)

Key Indexing Terms: Spine; Active Range of Motion; Articular; Neck Muscles; Physical Endurance; Neck Pain

Neck pain is common in the general population, with 70% of individuals affected at some time in their lives and 5% to 10% of adults having a disabling neck-pain problem. Whiplash is the most common cause of neck injury after motor vehicle accident and is an important cause of chronic disability. However, neck pain can arise from unspecified causes. A recent population-based study suggested that in young adults, approximately one third wake up with neck pain or stiffness once per week. The effects of chronic symptoms and the disability arising from neck-pain problems can have substantial economic consequences. For example, the costs related to chronic neck problems in the Netherlands in 1996 were estimated at US$868 million, and more than US$29 billion per year is spent in the United States on treatment and compensation for whiplash injuries.

Despite the prevalence and cost of neck problems, few studies are available that evaluate the physical characteristics that may be associated with neck pain. Research on the lower limbs of basketball players has found anthropometric measures to be better risk predictors of injury than flexibility, but no information is currently available on pain and structural measures of the head and neck. Some authors have proposed applying categories related to the time course of development of neck-pain problems. Grant et al have suggested that there is a group of people who have neck symptoms but who are not yet receiving any treatment. This group is classified as having minor musculoskeletal or subclinical dysfunction. It has been suggested that early
management of such cases may prevent progression to more serious neck problems.9,10 This untreated-pain group is of particular interest with respect to the development and progress of pain, as they represent the category intermediate between individuals with no pain and those seeking treatment. For anatomically defined pain symptoms, Von Korff et al11 have proposed that research is needed to determine the factors that differentiate treated and untreated individuals, where both have painful symptoms. This classification of subjects into treated and untreated groups has been used previously in studies of orofacial pain12 and temporomandibular joint disorders.13

Several authors have postulated an association between measures of posture, range of motion (ROM), muscle strength, and the experience of neck pain and disability. Joint ROM is an important component of assessments of disability.14 Dall’Alba et al15 reported that cervical movements in the sagittal plane can be used to discriminate between asymptomatic people and patients with whiplash-associated chronic neck pain. Hanten et al16 and Jordan et al17 also found that chronic neck-pain patients had significantly less range in extension, protraction, and retraction than asymptomatic subjects, but it is not clear what relationship exists between neck mobility and different levels of neck pain.

McKenzie18 and Haughie et al19 have proposed that nonspecific neck pain results from poor posture, arising through the sustained, long-term, abnormal physiological loads that such postures impose on the neck,20,21 with a consequent reduction in neck muscle strength.22 Currently, associations between neck pain, neck posture, and neck muscle endurance have not been firmly established. Grimmer23 did not find any relationship between extreme neck postures and reports of neck pain. Jull et al24 showed that craniovertebral angle did not change with treatment of cervicogenic headaches, thus change in symptoms was not accompanied by a change in posture. Other studies have also disagreed on the association between neck posture and the presence of neck pain.16,25-27

Muscle strength assessment is frequently used in clinical trials to evaluate treatment progress, and furthermore, muscle strength exercises are used as treatment for neck pain.24,28-30 Weakness of neck muscles has been proposed to contribute to persistent neck pain.25,26 However, there is conflicting evidence for the proposed causative relationship between neck pain and neck muscle strength. Grimmer and Trott32 failed to show an association between deep short flexor weakness of the neck and neck pain in their population-based study, but Grant et al9, using a different measurement protocol, reported an association. Some authors have reported reduced neck muscle strength in neck-pain patients who sought treatment, compared with matched healthy controls.19,33 It remains unclear whether lack of strength is a cause or a consequence of neck pain. A test of neck muscle endurance is needed to determine whether neck extensor muscle impairment can aid in distinguishing between groups

with no pain, and untreated and treated neck pain. Such a test needs to be combined with other available measures to find which are the most clinically useful and to ascertain which are the most sensitive to early onset of neck pain/dysfunction.

The purpose of this study was to compare the endurance time of neck extensor muscles, self-reported pain and disability, neck ROM, and morphology of the neck and head in groups with no pain, and untreated and treated neck pain.

METHODS

Subjects

Fifty-five volunteers were recruited by advertisements placed on notice boards in the Faculty of Health Sciences, University of Sydney, seeking participants both with and without neck pain. For inclusion in the study, all subjects were to be older than 18 years and to have no medical condition likely to affect mobility of the cervical spine (eg, ankylosing spondylitis). Neck-pain subjects were to have pain/discomfort with certain activities or postures but not to have taken time off work. Subjects without neck pain were to have no experience of any neck, upper body, or spinal problems that had resulted in a restriction of normal activity or time off work. Volunteers were excluded from the study if they had current neck pain or had been under treatment for neck pain within the previous 6 months. Approval for the study was obtained from the Human Ethics Committee of the University of Sydney, and each subject gave informed consent before testing. Twenty men and 35 women with an age range of 19 to 72 (mean age: men, 42; women, 38) years volunteered.

Procedure

Anthropometrics and neck ROM measures were taken, followed by an interview to gather demographic data and any history of neck pain and any treatment. Next, a second application of all ROM tests was carried out to elicit any sensitization or stretch effects arising from repeating end-range measurements. After this, a neck muscle endurance test was performed, and lastly, pain and disability data were collected using the Short-Form McGill Pain Questionnaire (SFMPQ),34 the Neck Pain and Disability Questionnaire (NDPQ),35 and the Functional Rating Index (FRI).36 These instruments were administered to subjects regardless of whether they experienced any neck pain.

The Cervical Range of Movement device (CROM) (Performance Attainment Associates, St Paul, Minn), the Dualer digital inclinometer (Jtech American Fork, Utah), and a tape measure were used for tests of (1) active cervical ROM, (2) spinal posture, and (3) segment length of the neck and head circumference, respectively.

Cervical flexion, extension, rotation, and lateral flexion ranges of motion were measured with the CROM device, as described by Youdas et al.37 For the measurement of
protraction and retraction, the vertebra locator and the forward head arm of the CROM device were used. The starting position was neutral sitting with the sagittal inclinometer of the CROM set at zero to standardize the head position. The bottom tip of the vertebra locator was placed on the subject’s C7 spinous process and positioned vertically by adjusting the spirit level on top of the locator. The forward head arm, marked in half centimeters along the horizontal distance, was maintained horizontally during the test by adjusting the subject’s head to keep the sagittal inclinometer at zero. The vertebra locator and forward head arm are intersected at a right angle to allow a measure of protraction or retraction in centimeters to be taken. Then, the subject was asked to move his head horizontally backward or forward as far as possible from the starting position, for retraction and protraction, respectively.

Thoracic kyphosis was measured using the Dualer digital inclinometer, during both comfortable standing and sitting. Locating marks were made on the skin at the T12 and T1 spinous processes, employing the protocol described by Maitland. With the subject standing comfortably, the Dualer inclinometer was placed at the T12 spinous process and the sensor set to zero, then repositioned at the T1 spinous process, with the resulting measure determining degree of thoracic kyphosis. The Garrett et al protocol was used to measure craniocervical posture using the CROM device.

With a tape measure, posterior neck length was measured from the external prominence of occipital protuberance to the C7 spinous process, and anterior neck length was measured from the outermost tip of the mandible to the sternal notch. Head circumference was measured around the cranium horizontally at the level of the point between eyebrows.

The neck extensor endurance test used was based on the low-back extensor test described by Biering-Sorensen and the neck extensor endurance test. Subjects were asked to lie prone on a plinth, with their head and neck initially supported over the end and arms alongside their trunk. To counter-support the upper thoracic spine, a strap was placed across the T2 level. A Velcro strap was fixed around the skull, level with the top of the ears. A Myrin goniometer (LIC rehab vardrum, Solna, Sweden) was placed on the Velcro strap immediately above the superiormost tip of the left ear and was used as gravity inclinometer in the sagittal plane. An extendable tape measure was attached to the Velcro strap at the point between subject’s eyebrows, with the case hanging just short of the floor, pendulum fashion. Endurance was measured by removing the support, then requiring the subject to hold the head steady in a position with the chin retracted and the cervical spine horizontal (Fig 1). For the neck extensor endurance test, the discontinuation criteria of the low back Biering-Sorensen test were adapted, so the test was discontinued if the subject terminated it because of fatigue or pain, or if they could not hold their head horizontal any longer, such that the suspended tape measure case touched the floor for longer than 5 seconds or on more than 5 occasions. The test was also terminated if the subject lost more than 5° of upper cervical spine retraction for more than 5 seconds, as measured with the Myrin goniometer. Holding time was recorded in seconds. Although 600 seconds was the target time given to all subjects for the test, if anyone could continue to hold for longer, they were encouraged to do so, and this was recorded as their holding time.

Analysis
Independent-samples t tests, with a type I error rate set at 0.05, were used to evaluate any differences between groups in terms of neck muscle endurance time, demographic data, and structural measurements. Pain and disability data were also compared between groups. On each neck ROM variable, groups by repeated-measures analyses of variance were conducted using 2 orthogonal between-groups contrasts, comparing groups with and without pain, then pain groups with and without treatment. Associations between the measured variables were examined using the Pearson correlation coefficient.

Results
All 55 subjects were placed into 1 of 3 categories based on their care-seeking behavior, with these categories being no pain, untreated neck pain, or treated pain. Twenty-two subjects reported a level of neck pain/discomfort which had required treatment (treated neck pain), a group of 17 subjects reported experiencing low-level neck pain/discomfort on a recurrent basis which had not required
treatment (untreated neck pain), whereas a further 16 subjects reported no experience of neck pain or discomfort (no pain). The groups did not differ on any of the measured demographic and anthropometric variables. Mean values, SDs, and $P$ values for the $t$ tests are presented in Table 1. All subjects were at least able to commence the neck muscle endurance test, but success at the test with a 10-minute goal varied between groups. Individual holding times are shown in Fig 2. Mean holding times were 350.4 seconds for the treated-pain group (SD, 199.3; 95% CI, 262.0-438.8), 480.8 seconds for the untreated-pain group (SD, 167.8; 95% CI, 394.5-567.1), and 608.3 seconds for subjects without pain (SD, 39.9; 95% CI, 587.0-629.6). Neck muscle endurance times were significantly lower in both treated and untreated neck-pain groups when compared with the no-pain group ($F_{1,52} = 25.87, P < .001$; $F_{1,52} = 8.76, P = .006$, respectively), and the treated-pain group’s time was significantly less than the holding time achieved by untreated-pain subjects ($F_{1,52} = 4.70, P = .037$).

Summary self-report results from the SFMPQ, NPDQ, and FRI questionnaires are presented in Fig 3. When scoring the NPDQ, only 19 questions were used, as the last question regarding pain medication was not applicable for all subjects. For the NPDQ and FRI, untreated subjects scored higher than subjects with no pain ($F_{1,52} = 25.50, P < .001$; $F_{1,52} = 16.13, P < .001$), and those with treated pain scored significantly higher than those with untreated pain ($F_{1,52} = 15.29, P < .001$; $F_{1,52} = 14.84, P < .001$). With the SFMPQ,

**Table 1. Demographic and anthropometric data with between-group test outcomes**

<table>
<thead>
<tr>
<th></th>
<th>No pain (n = 16), mean values (SD)</th>
<th>Pain/no pain test, $P$ value</th>
<th>Untreated pain (n = 17), mean values (SD)</th>
<th>Treated pain (n = 22), mean values (SD)</th>
<th>Pain-type test, $P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>40.5 (15.1)</td>
<td>.554</td>
<td>38.4 (15.3)</td>
<td>37.9 (12.1)</td>
<td>.920</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>167.5 (11.4)</td>
<td>.631</td>
<td>168.1 (9.7)</td>
<td>164.5 (9.4)</td>
<td>.249</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>68.8 (16.0)</td>
<td>.989</td>
<td>70.8 (10.7)</td>
<td>67.20 (12.2)</td>
<td>.346</td>
</tr>
<tr>
<td>Head circumference (cm)</td>
<td>56.2 (2.6)</td>
<td>.486</td>
<td>56.4 (1.8)</td>
<td>55.4 (1.9)</td>
<td>.093</td>
</tr>
<tr>
<td>Posterior segment length of the neck (cm)</td>
<td>14.4 (1.1)</td>
<td>.551</td>
<td>14.1 (2.1)</td>
<td>14.1 (1.7)</td>
<td>.937</td>
</tr>
<tr>
<td>Anterior segment length of the neck (cm)</td>
<td>14.8 (1.4)</td>
<td>.397</td>
<td>14.8 (0.9)</td>
<td>14.2 (1.4)</td>
<td>.201</td>
</tr>
</tbody>
</table>

Fig 2. Individual neck muscle endurance holding times.

Fig 3. Mean scores for the 3 groups on the SFMPQ subscales, the NPDQ and FRI.
the pattern was different. Usual pain was rated on a 100-mm Visual Analogue Scale. The sensory dimension subscale has 11 descriptors (throbbing, shooting, stabbing, sharp, cramping, gnawing, hot-burning, aching, heavy, tender, and splitting). The affective subscale has 4 descriptors (tiring-exhausting, sickening, fearful, and punishing-cruel). On the ‘sensory’ and ‘usual pain’ subscales, subjects with untreated or treated pain did not differ, but both pain groups rated significantly higher than the no-pain group ($F_{1,52} = 31.27$, $P < .001$; $F_{1,52} = 27.39$, $P < .001$). On the affective subscale, scores were greater for those with treated pain than those with untreated pain ($F_{1,52} = 14.70$, $P < .001$), but subjects with untreated pain were not significantly different from those with no pain.

At the first set of ROM measures, only protraction range showed a significant difference between the treated-pain and untreated-pain groups ($F_{1,52} = 4.81$, $P = .035$). At the second test, when the no-pain and neck-pain groups were compared (Fig 4), left rotation, right rotation, and extension showed a group-specific change, with ROM not changing for subjects with no pain but decreasing (sensitizing) for those with neck pain ($F_{1,52} = 16.04$, $P < .001$; $F_{1,52} = 6.75$, $P = .022$; and $F_{1,52} = 6.44$, $P = .014$, respectively). This pattern was similar, although not significant, for flexion ($F_{1,52} = 2.55$, $P = .116$). There were no significant differences between the 2 pain groups in the extent of sensitization on any measure. Side flexion movements to the left and right and protraction showed general sensitization.

**Fig 4.** Mean values and SE for cervical ROM tested on 2 occasions. The second end-of-range test can be considered to be a provocation test.
effects for all subjects at second measurement (F1,52 = 16.32, P < .001; F1,52 = 11.03, P = .002; and F1,52 = 8.95, P = .004, respectively). Only retraction showed no between-group differences or effects of repeated testing.

With respect to posture measurements, thoracic kyphosis angle (Fig 5A) was significantly greater in standing than in sitting (F1,52 = 39.07, P < .001), but there were no differences between groups. As expected, craniocervical posture (Fig 5B) was more retracted in upright sitting than in comfortable sitting (F1,52 = 80.58, P < .001). On this measure, however, treated-pain subjects showed significantly more retraction than untreated neck-pain subjects in comfortable sitting (F1,52 = 4.82, P = .035), although not in upright sitting (F1,52 = 3.07, P = .88).

Correlations were evaluated between measures of physical structure and neck muscle endurance time (Table 2). By assuming the shape of human head to be spherical and its density 1.11 g/cm³, an approximation to the torque acting on the neck during the endurance test was obtained.42 Calculated torque is greatest for the combination of large head and long neck, and less for a small head combined with a short neck. The relationship between torque and holding time was positive, indicating that it was subjects with greater torque at the neck who achieved longer holding times (r = 0.28, P = .04). Thus, a small but significant proportion of variance in holding time could be predicted from the size of the head and neck.

**DISCUSSION**

People with neck pain who had never sought treatment and people with neck pain who had sought treatment but who had not taken time off work showed similar ROM measures. However, each group differed with respect to endurance time, pain, and their disability questionnaire responses.

Few studies have compared neck strength for symptomatic and asymptomatic subjects,17-43 and the comparison has required the use of expensive equipment.24,29 In the current study, a simple and inexpensive test was used, using a modified version of the Biering-Sorensen low-back extensor test,41 and significantly lower endurance times were found for pain subjects. Most pain-free subjects achieved the allocated goal of 10 minutes, whereas most subjects with pain could not. Subjects in the untreated-pain group who could not reach the target time tended to cease the test because of muscle fatigue, whereas treated-pain group subjects tended to cease because of pain. Other researchers have reported similar results, ie, a significant reduction of neck muscle strength in neck-pain subjects.17,33,44

In their NPDQ and FRI responses, subjects with untreated neck pain were intermediate between the treated-pain and no-pain groups. On the SFMPQ, untreated-pain subjects scored similarly to those with treated pain on the sensory subscales (aching, throbbing, stabbing, shooting, etc) but on the affective scale rated their pain as no more frightening, punishing, or sickening than those without pain. This suggests that at the point when people come to interpret their neck pain as frightening, punishing, or sickening, they tend to seek treatment. Consistent with this, Leclerc et al45 reported that a high level of psychological distress was associated in neck-pain subjects with either seeking treatment or visiting a health care professional. Likewise, Von Korff et al11 found that patients with temporomandibular pain with high levels of psychological distress were more likely to seek health care.

Range of motion in both directions of rotation, and extension, showed a group-specific interaction effect, whereby they did not change at second measurement for subjects without pain but decreased for those with neck pain. Thus, the second ROM test can be considered a provocation test, in that it was only at second testing that between-groups differences emerged. Therefore, it seems that these directions of motion are ones that maximally stress painful cervical structures.

All second measurements were taken within a 10-minute period after the first. The experience of going to end of
range twice within this time affected some of the measured values in all subjects. Both left and right side flexion and protraction ranges were significantly reduced on the second measurement regardless of group, thereby showing a general sensitization effect. It is possible that these movements place stress on pain-sensitive structures, and limiting range at second measurement may protect against such stress. There were no significant differences between the 2 pain groups in the extent of sensitization on any measure. Therefore, it seems that impairments of neck ROM may develop at the early stage of neck pain.

Of all the range measures, the one with the greatest apparent resilience was retraction. End-of-range tests of this movement were not altered by repeated measurement, nor were there any differences between groups. Furthermore, from the data, it may be suggested that in upright sitting, treated-pain subjects used a greater degree of retraction as an unloading technique. This may be antalgic, or because they had been taught to, because performing retraction is a common treatment technique. The findings of the current study suggest that retraction is the only nonprovocative direction of neck movement.

Paradoxically, there was a small but significant positive relationship between the magnitude of the torque experienced at the neck in prone and endurance time. This can be interpreted as a use effect, whereby those with larger heads and longer necks may have developed greater neck muscle endurance capability as a consequence of daily activity. One implication of this finding is that resisted exercise may have a role in neck-pain rehabilitation.

**CONCLUSION**

In a comparison of groups with different levels of neck pain, differences observed were (1) lower neck muscle endurance time with pain groups, (2) higher score in the affective dimension of SFMPQ and both disability questionnaires for the group with treated pain, and (3) increased left and right rotations in the no-pain group but decreased in both pain groups at second measurement. These data suggested that neck muscle endurance, SFMPQ and neck disability questionnaires, and both ranges of rotation may be useful measurements to distinguish between groups with different levels of neck pain.

**REFERENCES**


EXPERIENCE AND PRACTICE ORGANIZATION IN LEARNING A SIMULATED HIGH-VELOCITY LOW-AMPLITUDE TASK

Brian Enebo, DC, and David Sherwood, PhD

ABSTRACT

Objective: To evaluate the effect of practice schedule, type of feedback, and experience level on simulated force production accuracy in chiropractic students.

Methods: Thirty-three chiropractic students simulated a high-velocity low-amplitude prone thoracic spine manipulation. Three force goals based on percent of maximum thrusting ability were used in blocked and random variable practice. Participants received either visual feedback or knowledge of performance feedback regarding their force-time history. Serial retention tests without feedback followed blocked and random variable practice. Peak and average rates of thrust development, as well as the constant error, absolute constant error, and variable error of peak force production, were calculated.

Conclusion: Familiarity and practice of high-velocity low-amplitude spinal manipulation resulted in greater accuracy of peak force production. Lower error scores were observed in acquisition with blocked variable practice. However, short-term accuracy was enhanced in retention when participants had used random variable practice. Random variable practice combined with visual feedback improved force production accuracy in retention. The variability of peak force production increased to 61% of maximum thrusting ability and then decreased. The greatest accuracy with least variability of peak force production was seen near 75% of maximum thrusting ability. (J Manipulative Physiol Ther 2005;28:33-43)

Key Indexing Terms: Manipulation; Chiropractic; Feedback; Force; Measurement; Motor Skills

An important component of learning a motor skill and improving performance is the ability to detect and correct errors. However, self-detection and correction of errors are difficult when the requirements of a motor skill are such that a coach or teacher cannot provide specific or immediate quantitative feedback. Because of this, learning a novel movement can be frustrating. Students of chiropractic manipulative technique, for example, are faced with this learning problem.

One procedure commonly taught to chiropractic students is high-velocity low-amplitude (HVLA) manipulation of the thoracic spine. Two problems associated with learning manipulative techniques are difficulty maintaining proper preload and improper peak thrusting force. Traditionally, an instructor or classmate provides qualitative feedback to the student learning HVLA spinal manipulation. For example, students rely on a partner to provide feedback regarding maintenance of preload, speed of thrust, and magnitude of thrust. Because instructors cannot provide quantitative feedback of thrust parameters, students learn by experience the loads used to treat joint dysfunction. Clinically, unknown errors in producing a force may give therapists the illusion of repeating the same procedure at every therapy session. Variations in applied forces during manual therapy may effectively produce different treatment outcomes. Although students learn manual procedures with qualitative feedback, using quantitative feedback may facilitate teaching force production.

In addition, spinal manipulative therapy teaching methods that use qualitative feedback may encourage an implicit rather than explicit learning strategy. Implicit knowledge is knowledge that a learner finds difficult or impossible to describe verbally, whereas a learner possessing explicit knowledge can describe a procedure verbally. Individuals who have trained primarily with implicit learning strategies may have difficulty expressing explicit knowledge. In the example of spinal manipulation, students may not know the quantitative magnitude of force they should produce and therefore have difficulty consistently repeating that force. However, for some procedures, it may be advantageous to allow individuals to learn through discovery versus providing explicit knowledge about that movement. Whether this holds for learning a spinal manipulative procedure is unknown.
The purpose of this study was to address some of the current limitations present in teaching HVLA spinal manipulation, specifically evaluating experience level, practice variability, feedback, and force variability.

Experience

The ability to perform HVLA spinal manipulation with improved accuracy and decreased variability may be related to experience level. In their work with professional musicians, Ericsson et al.8 suggested that the amount of deliberate practice with a particular task is a crucial feature to increasing performance level. Deliberate practice requires effort, learner motivation, and the use of preexisting knowledge and feedback during practice to improve performance.8

Although deliberate or clinical practice may enable individuals to perform a manipulative procedure with limited knowledge of force-time history parameters, this ability does not necessarily equate to performance consistency. Adams and Wood,9 for example, found chiropractors with an average of 8 years of practice experience showed large variability in their estimation of force used during a manipulative procedure. Improving a practitioner’s explicit knowledge through training methods using precise feedback may improve doctor performance. When evaluating the effect of experience on manipulative skill performance, the amount of actual practice an individual has with a procedure should be considered. Cohen et al.10 evaluated HVLA thoracic spine manipulation in chiropractic interns and practicing doctors. Although the clinically experienced group showed larger preload and peak thrust force means, large intraparticipant variability of force production made the findings between groups statistically insignificant. In addition, two thirds of the clinically experienced group were considered inexperienced with the manipulative procedure. This group may have shown better performance had they been tested with a procedure with which they were familiar. Adams and Wood11 compared force generation between students in their last year of training with practicing doctors, reporting that greater peak force magnitude and shorter thrust times developed with clinical experience or practice.

Based on the manual therapy and motor learning literature, experience level was evaluated by comparing groups of students who differ in amount of domain knowledge relating to HVLA spinal manipulation and who differ in the amount of actual HVLA spinal manipulation practice. It was predicted that error scores would decrease as HVLA spinal manipulation domain knowledge or experience increased.

Practice Schedule

The way in which a practice session is organized can affect motor learning and performance. Schmidt,1 in his description of schema theory, suggested an advantage of using variable practice over constant practice. Variable practice occurs when an individual practices different variations of 1 procedure and may be structured as either blocked or random. For example, in blocked variable practice, 1 manipulative procedure is performed with 1 level of force several times before practicing a different force level. For random variable practice, 1 manipulative procedure is used, but more than 1 level of force is practiced in a random order. Although no specific literature was found relating HVLA spinal manipulation to practice schedule, examples from the motor learning literature do provide a basis for structuring a practice schedule.

In a rapid aiming experiment, blocked variable practice of different amplitudes with knowledge of results feedback produced lower error scores in acquisition compared with random variable practice with knowledge of results feedback.12 However, during retention with no knowledge of results, the group given random variable practice had lower error scores. Similar findings occurred when movement time was varied.13 During impulsive force production, groups using variable practice performed better at retention than individuals who practiced the target force only.14 Differences between blocked and random practice in acquisition and retention have been attributed to contextual interference and memory development.

Contextual interference occurs when 1 procedure is practiced with others, creating increased cognitive effort during a practice session.15,16 Contextual interference can be created by the movement itself, practice schedule, and mental processing strategies used by the learner.17 As the degree of contextual interference increases, acquisition performance of a motor skill decreases but retention performance increases.15,17 Apparently, random variable practice creates a beneficial level of contextual interference.14

Two popular explanations for contextual interference revolve around the effect on memory. The Elaboration Hypothesis states that different skills practiced together remain in working memory allowing a learner to make comparisons between each of the practiced movements, thus increasing cognitive effort and contextual interference.17 The Reconstruction Hypothesis states that information regarding movements in previous trials is lost from working memory. To perform a variety of movements, a learner must constantly retrieve the appropriate motor program from long-term memory.17 Because of this, random variable practice produces increased cognitive effort and therefore greater contextual interference than blocked variable practice.

Based on the motor learning literature, 2 practice schedules consisting of blocked and random variable practice were compared. It was predicted that blocked variable practice of 3 force goals would result in lower error scores during acquisition, whereas random variable practice of 3 force goals would result in lower error scores during retention.
FEEDBACK

Two common forms of feedback used to guide movements are knowledge of performance feedback and visual feedback. Knowledge of performance feedback provides information regarding movement characteristics and is provided at the end of the movement by a coach or instructor. For example, “preload was lost” or “peak force was too low.” The ability to use visual feedback during the movement depends on the movement itself. For example, quick movements require an open loop control process when sensory feedback-based corrections are not possible during the movement. Schmidt et al18 suggested that corrections based on visual feedback are not possible during ballistic movements with durations of 200 milliseconds or less. Slifkin et al19 found 150 milliseconds to be the minimum time for visual processing when holding a constant level of force. Because of short movement times with HVLA spinal manipulation, concurrent visual feedback might provide little information to the learner.

Knowledge of performance facilitates greater learning compared with no or reduced frequencies of knowledge of performance.20 In a review of knowledge of performance, Ammons20 suggested that information provided to the learner should be specific and that the time interval between practice trials should be kept short because long time delays negatively affect learning. In acquisition, participants given knowledge of performance were able to produce requested pressures; however, accuracy decreased when knowledge of performance was withheld in retention trials.21

Feedback that is too precise might overload the learner, create confusion, and inhibit motor learning.22 Here, precision refers to the accuracy of the information provided as feedback. In long-term retention, Tomlinson23 found that verbal feedback produced greater performance than did visual feedback, suggesting that less precise feedback may cause individuals to incorporate other movement cues relating to error. In addition, Annett21 found that precise knowledge of results, either verbal or visual, when compared with schedules of reduced feedback and less precise feedback produced good accuracy during acquisition but decreased accuracy during retention trials with no knowledge of results.

Two studies have provided chiropractic students with feedback during simulated HVLA force production. In the first, individuals received either qualitative (verbal knowledge of performance) or quantitative (visually presented force level) feedback.23 In acquisition, participants practiced 2 force ranges (light and heavy) with feedback, followed by blocked retention without feedback. However, the light force ranged from 42.5 to 515.0 N, and the heavy force ranged from 680.6 to 845.2 N, resulting in broad error bandwidths for each subject. In the second study, 1 group practiced manipulative procedures on their own outside of class, whereas the second group practiced 3 manipulative procedures on a handheld simulator.24 Significant differences occurred between groups with respect to direction of thrust, suggesting improvements in performance for the group trained on the simulator. However, it was not possible to attribute these changes solely to the use of the simulator because the practice history outside of class for the control group was not recorded. A difference in practice alone could explain the observed differences, with deliberate weekly practice improving performance.8 In addition, greater learning may have occurred in the experimental group because of the contextual interference created by random practice of 3 separate manipulative procedures.15

To evaluate the effect of feedback on learning a ballistic force production procedure, 2 different forms of feedback were provided. Participants were provided with either verbal knowledge of performance feedback or continuous visual feedback of their force-time history. Based on the feedback literature, it was expected that participants provided with visual feedback would show less movement error compared with those given knowledge of performance feedback.

FORCE VARIABILITY

Increasing peak force can lead to increased variability in force production with some of this variability being inherent to the neuromusculoskeletal system. For example, during static and dynamic force production activities, there is a relation between force variability and force production. Schmidt et al,25 as well as Sherwood and Schmidt,26 showed an increase in force variability up to approximately 65% of maximum force with decreased force variability after 65% of maximum.

Preload magnitude might also explain some of the variability of peak force production during manipulative thrusts. Herzog et al27 and Hessell et al28 showed a significant positive correlation between peak force and preload force. Combining this relation with the force variability research,25,26 variability in preload force may affect peak force magnitude and variability.

To evaluate the variability of ballistic force production, 3 peak force goals based on maximum effort were used. Force goals were selected on the basis that force variability may decrease after 65% of maximum thrusting ability. Also, because preload force may affect peak force, a constant preload force was selected based on maximum force production capability. It was expected that force variability during ballistic force production would be greater at the 55% goal compared with the 35% or 80% target goals.

No studies were identified in the literature that evaluated the effect of experience, practice schedule, and feedback on spinal manipulative performance. Looking specifically at
the development of force from preload force through peak force, the above factors were investigated. In this study, participants were assessed on a novel instrument allowing the simulation of a common thoracic spine manipulative procedure. A simulator enabled students to practice a procedure with quantitative feedback, without risk of injury to a patient or classmate.

**METHODS**

The testing apparatus (Fig 1) was constructed of extruded aluminum (80/20 Inc; 1010) and supported by a wooden base. A load cell (Omega Engineering Inc, Stamford, CT; LC101-250; maximum load = 1112 N) was powered by a 10-V external power supply (Omega Engineering Inc; PSS-10) and measured force in compression. A 9 × 9 inch piece of 0.75-inch plywood padded with 0.5-inch closed cell foam, covered with vinyl, was attached to an aluminum plate. The aluminum plate attached securely to the load cell. A USB data acquisition system A/D converter (Omega Engineering Inc; OMB-DAQ-55) read the load cell output. Data from the A/D converter, sampled every 80 milliseconds (12 Hz), were passed to a computer for visual feedback and data recording (Omega Engineering Inc; Personal DaqView, 1.9.5).

Two compression springs (Century Spring Corp, Los Angeles, CA; #73435, rate = 33267 N/m and #336, rate = 9960 N/m) in parallel provided resistance to downward movements. Because the load cell measured force in 1 plane only, accessory movements in other than the desired plane of vertical movement were minimized.

The testing device was constructed to simulate a posterior to anterior spinal manipulative procedure with vertical displacement based on available literature. For content validity of the current study, spring compression according to applied load was found to approximate values from cadaveric studies.²⁹

The reliability across practice trials was assessed because future use for the apparatus involves repeatedly practicing thrusts. Known loads were applied to the contact plate, and output of both the data acquisition system and software program were recorded. No discrepancies were found across a variety of known loads.

The 33 participants (18 women, 15 male) ranged in age from 22 to 42 (mean age = 29, SD = 6.7) years. All participants were enrolled in the first 4 semesters of a chiropractic-training program and received course credit for participation. Table 1 outlines subjects’ levels of experience by semester. Study approval was received through the human research committee at the University of Colorado, Boulder. All participants provided their signed consent after being informed as to the purpose of the study.

Before testing each participant, the thrusting apparatus and data collection software were calibrated against known loads. Then, each participant’s maximum force producing ability over 3 attempts was recorded. The largest force value of the 3 attempts was used as the maximum force. Three force goals, 80%, 55%, and 35% of maximum force producing ability, were used in variable practice. Standardizing the force goals allowed for comparison across participants and groups. Although no standard values exist for preload force or peak force in the thoracic spine, a preload force goal was based in part on the manipulative therapy literature and so that a meaningful force gain occurred between preload and peak force. Participants began goal force production from a preload value of 20% of maximum force production ability. For data collection, participants pressed downward on the contact plate, first applying preload and then generating force to 1 of the 3 determined force goals. From preload, an additional 15%, 35%, and 60% of maximal effort was required to reach the 35%, 55%, and 80% force goals, respectively. During

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**Table 1. Spinal manipulation experience by semester**

<table>
<thead>
<tr>
<th>Semester (n)</th>
<th>Course work providing practice with SMT</th>
<th>Course work providing domain knowledge with SMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (n = 7)</td>
<td>No</td>
<td>Anatomy and palpation</td>
</tr>
<tr>
<td>2 (n = 12)</td>
<td>No</td>
<td>Palpation II, clinical spinal biomechanics, semester 1 classes</td>
</tr>
<tr>
<td>3 (n = 8)</td>
<td>First class in progress</td>
<td>First joint manipulation class, semesters 1 and 2 classes</td>
</tr>
<tr>
<td>4 (n = 6)</td>
<td>Second class in progress</td>
<td>Second joint manipulation class, semesters 1-3 classes</td>
</tr>
</tbody>
</table>

Both joint manipulation classes included prone thoracic spine high-velocity low-amplitude manipulation. SMT, Spinal manipulative therapy.
acquisition, presentation of the force goals occurred in blocked and random order.

After acquisition, a retention test was performed, with force goals presented in serial order. Each participant performed 11 acquisition trials of each force percentage goal (33 trials blocked practice; 33 trials random practice) in either a blocked then random or random then blocked practice schedule. Within each group (semester), participants were randomly assigned to receive either visual feedback or knowledge of performance feedback regarding their force-time history during acquisition. The only constraint was that each group would have approximately equal number of participants in each feedback condition. This randomization resulted in a total of 16 participants in the vision condition and 17 participants in the knowledge of performance condition.

Markers were placed on a computer monitor indicating force goals and preload goal. The markers provided a 10% bandwidth of accuracy about each force goal. Visual feedback was the real-time viewing of the force-time history for each acquisition trial on the computer monitor. Knowledge of performance, provided at the end of each trial, was verbal feedback with regard to accuracy of force goal (eg, “too much force”) and maintenance of preload force (eg, “preload was lost”). Knowledge of performance feedback was also based on a 10% bandwidth of error. At the end of random and blocked acquisition, participants performed immediate serial retention tests without visual or knowledge of performance feedback. Each serial retention test comprised 30 total trials consisting of 10 trials at each force goal. The presentation of force goals during serial retention was as follows: 55%, 80%, 35%, 55%, 80%, 35%, etc.

A 4-factor, type of feedback (2) × group task familiarity and experience (4) × type of variable practice (2) × force goals (3), analysis of variance with repeated measures on the last 2 factors was performed. Where type of feedback was either concurrent visual feedback or verbal knowledge of performance, task familiarity and experience differed across 4 semesters; type of variable practice was either random or blocked, and force goals were based on 3 different percents of maximum thrusting ability. Fig 2 illustrates the force-time history–dependent measures analyzed for each participant across trials.

Dependent measures were (1) lowest force value at the beginning of the thrust (ie, lowest force value between preload force and peak force, where preload force is the most stable force value in the 500-millisecond preceding peak force), (2) peak force, and (3) time to peak force (time from force value at the beginning of the thrust to peak force). In addition, average and peak rates of thrust
development across force goals and semester were analyzed. Average rate of thrust development was calculated by dividing change in force (peak force minus lowest force value after preload force) by time for thrust. Peak rate of thrust development was calculated by first evaluating each 80-millisecond window between the lowest force value after preload force and peak force to find the window with the largest force gain and dividing that value by 80. In acquisition, the first trial of each force goal was excluded, resulting in 30 total trials for analysis.

Constant error (CE, a measure of accuracy, the average error from the target), absolute constant error (|CE|, a measure of accuracy, considers error without regard to direction), and variable error (VE, a measure of movement inconsistency or variability) of peak force production were computed. Error scores were averaged across 10 acquisition trials and 10 retention trials by participant and level of group experience for each force goal. Graphs present absolute force data because absolute force is likely more relevant to manipulative performance and patient safety than relative force values. Unless otherwise indicated, mean differences are based on a 2-tailed hypothesis with α = .05. Pairwise comparisons are based on least significant difference.

RESULTS
Task Familiarity Versus Experience
As predicted, greater familiarity and practice with HVLA spinal manipulative procedures resulted in lower error scores. In acquisition and retention, less task-related domain knowledge and experience resulted in higher error scores for peak force production.

 Acquisition. In general, participants with the least spinal manipulation familiarity and experience (ie, semester 1) showed decreased accuracy in force production. Mean error scores in acquisition are presented in Table 2. The main effect for experience (CE) was significant (F[3,25] = 3.71, \(P = .02, \eta^2 = 0.31\)), whereas a trend toward significance was found for CE (F[3,25] = 2.62, \(P = .07, \eta^2 = 0.24\)). Although a significant main effect for experience (VE) was present, F[3,25] = 2.87, \(P = .05, \eta^2 = 0.26\), VE did not show a consistent pattern across level of experience (Table 2).

 Retention. Force production accuracy improved as familiarity with spinal manipulation increased. Fig 3 shows CE and |CE| scores by experience during retention. The main effects of experience for both CE (F[3,25] = 4.29, \(P = .01, \eta^2 = 0.34\)) and |CE| (F[3,25] = 4.02, \(P = .01, \eta^2 = 0.32\)) were significant. CE scores were significantly lower for semester 4 compared with semester 1 (\(P = .01\)), whereas |CE| scores were significantly lower for semester 3 compared with semester 1 (\(P = .02\)).
No main effect of experience was found for VE.

Blocked Versus Random Practice in Acquisition and Retention

**Acquisition.** As predicted, better force accuracy production and less variability were seen in acquisition with blocked variable practice compared with random variable practice. Mean error scores by type of variable practice are presented in Table 3. The main effect for type of variable practice was significant for \( CE \) (\( F[1,25] = 8.45, P < .01, \eta^2 = 0.25 \)), \(|CE|\) (\( F[1,25] = 6.05, P = .02, \eta^2 = 0.20 \)), and VE (\( F[1,25] = 15.64, P < .01, \eta^2 = 0.39 \)). Fig 4 compares acquisition and retention for CE of peak force production during random and blocked variable practice.

**Retention.** As hypothesized, greater force production accuracy (CE) was observed in retention after random variable practice compared with blocked variable practice (Fig 4). The main effect for type of variable practice was significant (\( F[1,25] = 4.43, P = .04, \eta^2 = 0.15 \)). Error scores in retention after blocked and random variable practice are presented in Table 3. No significant main effects of practice for CE or VE were observed.

**Type of Feedback**

There was no significant main effect of feedback for CE or VE in force production. It was predicted that visual feedback of the force-time history would result in lower error scores compared with feedback with knowledge of performance. **Constant error.** In retention, visual feedback combined with random variable practice resulted in the lowest CE in force production.

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**Table 4. Nominal and actual peak forces**

<table>
<thead>
<tr>
<th>Nominal peak force goals</th>
<th>35</th>
<th>55</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of maximum (%)</td>
<td>35</td>
<td>55</td>
<td>80</td>
</tr>
<tr>
<td>Average peak force goal (N)</td>
<td>259.7</td>
<td>408.6</td>
<td>594.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual peak forces produced</th>
<th>49</th>
<th>61</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of maximum</td>
<td>49</td>
<td>61</td>
<td>75</td>
</tr>
<tr>
<td>Average peak force (N)</td>
<td>365.4</td>
<td>450.5</td>
<td>561.8</td>
</tr>
</tbody>
</table>

Nominal percent of maximum and average peak force goals based on participants maximum thrust capability. Actual percent of maximum and average peak forces based on recorded peak force values and illustrate overshooting at the lower force goals and undershooting at the largest force goal.
production compared with all other conditions (Fig 5). In retention, the positive interaction of random practice with visual feedback was significant ($F_{[1,25]} = 5.32, P = .03, \eta^2 = 0.18$) (Fig 5).

**Absolute constant error.** Lower force production errors occurred with visual feedback compared with knowledge of performance feedback. The significant main effect of feedback for |CE| in acquisition was $F_{[1,25]} = 6.98, P = .01, \eta^2 = 0.22$.

**Force Levels**

It was predicted that peak forces at the 55% force goal would show greater variability compared with either the 35% or 80% force goals.

**Constant error and absolute constant error.** Demonstrating a range effect in acquisition and retention, CE and |CE| decreased from the 35% target goal to the 80% target goal. Significant main effects of force were found for CE in acquisition ($F_{[1,25]} = 101.03, P < .01, \eta^2 = 0.80$) and retention ($F_{[1,25]} = 218.47, P < .01, \eta^2 = 0.90$), as well as for |CE| in acquisition ($F_{[1,25]} = 28.21, P < .01, \eta^2 = 0.53$) and retention ($F_{[1,25]} = 10.44, P < .01, \eta^2 = 0.30$) (Fig 6).

**Variable error.** In retention, the relation between VE and target force for both random and blocked practice conditions was quadratic. Greater force variability was observed at the 55% goal, compared with either the 35% or 80% goals. The main effect for force was significant, $F_{[1,25]} = 9.63, P < .01, \eta^2 = 0.28$. Because of range effects (Fig 6), nominal force goals did not equal actual average force production. Specifically, for nominal force goals of 35%, 55%, and 80% of maximum ability, actual peak force production was 49%, 61%, and 75%, respectively (Table 4).

**Other Results: Peak and Average Rates of Thrust Development**

Peak and average rates of thrust development were analyzed to account for differences in movement time because faster movement times can contribute to error through a speed-accuracy trade-off.\(^{30}\) Peak and average rates of thrust development in acquisition and retention across experience level and force goal are presented in Table 5.

**Table 5. Maximum rates of thrust development: experience level and force goal**

<table>
<thead>
<tr>
<th>Experience level</th>
<th>Force goal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80%</td>
</tr>
<tr>
<td><strong>Acquisition</strong></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>3.6 (.34)</td>
</tr>
<tr>
<td>Average</td>
<td>2.5 (.29)</td>
</tr>
<tr>
<td><strong>Retention</strong></td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>4.0 (.37)</td>
</tr>
<tr>
<td>Average</td>
<td>2.7 (.30)</td>
</tr>
</tbody>
</table>

Peak and average rates of thrust development in acquisition and retention. Experience level: S1 < S2 < S3 < S4. All values in N/ms. SE in parentheses. S, Semester.

**DISCUSSION**

**Task Familiarity Versus Experience**

Students with the least amount of specific knowledge about spinal manipulation performed with less accuracy and greater variability in force production compared with students with greater knowledge and practice of HVLA spinal manipulative procedures. This difference, seen in semester 1 students, provides support for the first hypothesis: greater familiarity with HVLA domain knowledge (eg, anatomy, palpation, and clinical biomechanics) facilitates learning, but actual practice with manipulative procedures results in better performance. This finding is generally consistent with the motor learning literature; performance improves as domain knowledge and amount of deliberate practice increase.\(^{8}\) This finding is also in general agreement with the manipulative therapy literature,
namely, experience leads to a higher level of skilled spinal manipulative performance.

**Blocked Versus Random Practice in Acquisition and Retention**

As predicted, blocked practice of 3 different target forces resulted in better accuracy (Fig 4) and lower variability (Table 3) during acquisition compared with random practice. Observations of this effect are prevalent in the motor learning literature and have been attributed to contextual interference.\(^{12,14,16}\) Blocked variable practice is less taxing on cognitive processes,\(^{17}\) perhaps enabling individuals to focus more clearly during the initial stages of learning a motor movement compared with random variable practice.

In retention, greater accuracy was observed after random variable practice. Random variable practice had the strongest effect on CE (Fig 4), although trends toward improved variability and \(|CE|\) were seen (Table 3). These results support the second hypothesis and are consistent with findings from others.\(^{14,31}\) Through an effect on memory, structured practice that creates contextual interference results in lower performance during acquisition but improved performance during retention.\(^{15,31}\) As the variability in practice increases, there is improved sensitivity for estimating the outcome of a movement\(^1\) resulting in less movement-related errors.

**Type of Feedback**

Lending support to the third hypothesis, CE was lower in retention for the group that received visual feedback compared with knowledge of performance feedback (Fig 5). Prior research in the area of movement-related feedback suggests the dominance of visual feedback over other types of feedback.\(^{32}\) For example, Newell\(^{33}\) found visual feedback to improve performance compared with auditory feedback in a manual positioning experiment. Although no significant main effect for type of feedback occurred in retention during the present study, a significant feedback by practice interaction showed an advantage of visual feedback over knowledge of performance when combined with random practice.

In Fig 5, a dramatic performance advantage in retention is shown when random variable practice was combined with visual feedback. The difference in performance between blocked and random variable practice with visual feedback may be related to contextual interference, because in both practice conditions, participants received the same form of feedback. In comparison, the similar performance accuracy in blocked and random variable practice conditions with knowledge of performance may be caused by the form of feedback. Compared with visual feedback, knowledge of performance provides information that is less specific and not as context-rich. As a result, participants did not accurately produce force goals, regardless of the contextual interference created through variable practice.

This finding is especially relevant to chiropractic educators and the teaching methods used in the classroom. Traditional HVLA spinal manipulation teaching methods generally provide nonspecific feedback to students. This feedback may be less specific compared with the information provided through knowledge of performance in the present study. As such, an argument is made for the use of a thrust simulator for developing HVLA spinal manipulation skills early in a chiropractic-training program.

**Force Levels**

Variability in force production increased to the 55% of maximum force goal and then decreased, resulting in lower \(VE\) for both the 35% and 80% of maximum force goals. When the range effect across force goals is considered (Fig 6), nominal force goals of 35%, 55%, and 80% of maximum become 49%, 61%, and 75%, respectively. Peak variability occurring at 61% of maximum force production is consistent with work by others.\(^{25,26}\)

In Fig 6, a range effect with more overshooting of the 35% goal force and a tendency for less overshooting and even undershooting at the 80% goal force are shown. This finding is relevant to doctors who attempt to apply different force magnitudes based on the characteristics of a patient’s condition.

The relation between peak force goal and \(VE\) is relevant to doctors attempting to provide consistent spinal manipulative peak forces across patients and treatment sessions. Specifically, force production of 49% of maximum ability results in lower accuracy but greater consistency compared with thrusts at 61% of maximum. Thrusts at 75% of maximum ability show greater accuracy and consistency compared with thrusts at 61% of maximum.

The pattern of variability across force goals may help to explain the wide range of peak thrust means reported in the literature. Future use of the thrust simulator could include use with licensed practitioners, providing valuable data with regard to thrust maximums and average peak force.

**Other Results: Peak and Average Rates of Thrust Development**

In acquisition, average and peak rates of thrust development increased from the 35% goal to the 80% goal. Although no movement time constraints were given to participants, this finding is not unexpected. An underlying feature of HVLA manipulation is that it be performed quickly. As the magnitude of the force goal increases, movement time must decrease for the speed of the manipulative thrust to remain consistent with the requirements of the procedure. Similar findings occurred in retention.

Unexpectedly, peak and average rates of thrust development decreased as familiarity and experience with HVLA
spinal manipulative procedures increased. If rate of thrust development is an integral feature of successful spinal manipulation, rate of thrust development might be expected to increase with experience level. However, there is a relation between movement speed and accuracy, whereby accuracy decreases as movement speed increases. Considering this speed accuracy trade-off, it follows that rate of thrust development might decrease to increase accuracy. However, both rate of thrust development and accuracy increased from the 35% force goal to the 80% force goal (Table 6, Fig 6). This finding is relevant to chiropractors, suggesting that force accuracy can be achieved even as peak HVLA manipulation forces and rate of thrust development increase.

Finally, the advantage of blocked variable practice compared with random variable practice in acquisition may in part be caused by the lower cognitive effort required in blocked variable practice, allowing participants to focus on accuracy, even as speed increases.

Limitations and Suggestions for Future Study

Using a simulator to assess and teach spinal manipulative skills may be of benefit. Although both accuracy and variability improved at short-term retention using random variable practice with visual feedback, it is not known if the learning effect would remain at long-term retention intervals. In addition, although the simulator may be useful to the student learning HVLA manipulation, it is not known whether skills attained through practice with this simulator will transfer to the ‘real world’ application of spinal manipulation. Previous work by Triano et al suggested that random practice on a simulator might transfer to manipulation of the lumbar spine, at least early in a professional training program. Future study should include a long-term retention test to determine learning permanency as well as a skills transfer test of manipulation on human beings after practice with a simulator.

The testing device used in this experiment was designed to approximate HVLA spinal manipulation used by chiropractors. However, measurement of force production was limited to 1 direction. Accuracy and consistency may change if additional directions of movement are considered. In addition, measurement of force production in more than 1 direction more closely approximates spinal manipulation on human beings.

Students who were less knowledgeable of HVLA spinal manipulation procedures performed with less accuracy and greater variability. However, the present study did not evaluate what specific knowledge is relevant to HVLA spinal manipulation competency or how that information is acquired from semester to semester.

Finally, to compare performance by task familiarity and experience, it was necessary to use intact groups. A small number of groups for comparison as well as small numbers within each group limited data analysis. Large interparticipant differences within groups will affect significance. Further study with larger group sizes as well as groups with more experience would be of benefit, especially in exploring trends and interactions noted in the current study.

Table 6. Rates of thrust development across force goals in acquisition

<table>
<thead>
<tr>
<th>Force goals</th>
<th>35%</th>
<th>55%</th>
<th>80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average RTD in blocked acquisition</td>
<td>1.3 (0.6)</td>
<td>1.8 (0.6)</td>
<td>2.6 (1.1)</td>
</tr>
<tr>
<td>Peak RTD in random acquisition</td>
<td>1.4 (0.7)</td>
<td>2.0 (0.8)</td>
<td>2.6 (0.9)</td>
</tr>
<tr>
<td>Average RTD in blocked acquisition</td>
<td>1.8 (0.8)</td>
<td>2.8 (0.8)</td>
<td>4.0 (1.4)</td>
</tr>
<tr>
<td>Peak RTD in random acquisition</td>
<td>2.0 (0.8)</td>
<td>2.9 (1.0)</td>
<td>3.9 (1.0)</td>
</tr>
</tbody>
</table>

All values in N/ms with SDs in parentheses. RTD, Rate of thrust development.

Conclusion

Variability of peak force production increased to 61% of maximum thrusting ability. The greatest accuracy and least variability were seen when participants peak force production averaged 75% of their maximum ability (561.8 N).

Familiarity and practice with HVLA spinal manipulation were associated with greater accuracy of peak force production compared with less experienced participants. Because of this, it may be of benefit to delay teaching HVLA manipulative procedures until a student’s familiarity with spinal manipulative procedures has increased.

Practicing a manipulative procedure with different force magnitudes may assist performance and retention through the creation of contextual interference. The acquisition of HVLA spinal manipulation was enhanced with blocked variable practice compared with random variable practice. However, random variable practice improved the short-term retention of a simulated HVLA spinal manipulative procedure. In addition, random variable practice combined with visual feedback of the force-time history resulted in greater learning and short-term retention compared with blocked variable practice with visual feedback or knowledge of performance feedback with either practice schedule.

Variable practice may also have an added benefit to clinicians. Specifically, treatment sessions with patients often involve spinal manipulation of more than a single spinal region and vertebral level. As such, variable practice of more than 1 force level may more closely mimic the ‘real world’ application of spinal manipulation.
REFERENCES

Objective: To determine differences in peripheral and cardiovascular autonomic function between individuals with acute musculoskeletal injury (<1 week) and healthy controls.

Methods: Autonomic cardiovascular modulation, baroreceptor sensitivity, skin conductance, and peripheral skin temperature were obtained in 6 subjects with acute musculoskeletal injury and 6 age- and sex-matched controls. Power spectral analysis was performed on both beat-to-beat R-R intervals and continuous systolic blood pressure (SBP) peaks. Baroreceptor sensitivity was derived using both heart rate and blood pressure spectral analysis components.

Results: The SD of R-R intervals was significantly different for the acute injury group relative to controls (49.8 ± 10.5 vs 76.8 ± 12.7 ms; P < .01). Continuous SBP peaks and skin conductance (sympathetic vasomotor and sudomotor indices, respectively) were significantly higher (59.6 ± 6.7 vs 23.8 ± 6.4 mm Hg/Hz, and 3.87 ± 1.04 vs 2.19 ± 0.3 mhos; P < .01, respectively) and baroreceptor sensitivity lower (0.97 ± 0.07 vs 1.10 ± 0.08 mm Hg; P < .02) in the acute injury group compared with controls. Regression analysis revealed a significant relationship between skin conductance and continuous SBP peaks (r = 0.75; P < .01).

Conclusions: These findings suggest that interaction between cutaneous and vasomotor sympathetic neurons in response to acute musculoskeletal injury, reflected as increased afferent input from sensitized nociceptors and other sensory neurons, results in alterations in autonomic function. (J Manipulative Physiol Ther 2005;28:44-51)

Key Indexing Terms: Autonomic Nervous System; Musculoskeletal Physiological Phenomena; Musculoskeletal Injury; Power Spectral Analysis

One of the central hypotheses of traditional chiropractic is that dysfunction of somatic structures, chiefly the musculoskeletal components of the human vertebral column, may have significant impact on regulation of the nervous system, specifically the autonomic nervous system, and hence influence visceral function and health. Although the historical origins of this tenet are rooted in less scientific theories, the foundation of its modern interpretation was based on research performed by the osteopathic investigator Irvin M. Korr. More recent references lend support to the above statement including chiropractic textbooks used at many chiropractic colleges today.

Although often the emphasis is placed on the treatment of the spine in chiropractic health care, it is well established that nociceptive and other aberrant neurological input from dysfunctional musculoskeletal structures of any component of the human frame influences the autonomic nervous system. While it has been shown that noxious as well as innocuous stimuli of somatic structures results in changes in the autonomic nervous system, no definitive human research has shown a clear relationship between articular and muscular dysfunction of the spine and other musculoskeletal structures and autonomic perturbations (particularly beyond the immediate insult). Evaluation of autonomic nervous system function in subjects presenting with acute musculoskeletal soft tissue injury may shed light on such relationships.

It is generally understood that consequences of somatic tissue injury extend beyond the site of insult and include both spinal and supraspinal changes in neuron excitability and activity.

Injury to the somatic tissues of the musculoskeletal system results in heightened afferent input from sensitized nociceptors and other sensory neurons, and in some chronic conditions (ie, those associated with nerve damage), remodeling of the spinal dorsal horn has been reported. Although supraspinal pain modulatory systems were originally considered solely inhibitory of spinal nociceptive sensory input, stimulation of supraspinal sites can also facilitate spinal nociceptive transmission, both of which have
been shown to produce autonomic and behavioral effects such as those associated with the ‘fight or flight’ response.8

Long-term activation of spinal and extraspinal nociceptive afferents contributes to stimulation of the autonomic nervous system that may in turn have a deleterious effect over time on visceral function and homeostasis with the potential to negatively impact health and wellness.9-11 Experimental evidence exists demonstrating a relationship between somatic structures and the autonomic nervous system, mainly via neurological reflex mechanisms.12,13 In contrast, no relationship has been shown between short-term activation of spinal afferents, as found in nonexperimental human subjects with acute musculoskeletal injury, and the autonomic nervous system. The intent of this observational study was therefore to determine whether differences exist in peripheral and cardiovascular autonomic function between individuals with acute musculoskeletal injury and healthy controls.

Materials and Methods

Subjects

Twelve subjects participated in this study, 6 with acute musculoskeletal injury and 6 age- and sex-matched healthy controls. Inclusion criteria for the injury group were acute musculoskeletal injury to the low back or 1 of the extraspinal articulations less than 1 week in duration and level of pain assessed using a Visual Analogue Scale (VAS) between 3 and 6 (Table 1). Before testing, the musculoskeletal injury group received a routine chiropractic physical examination. For both groups, exclusion conditions included known coronary heart and/or artery disease, hypertension, renal function abnormalities, diabetes mellitus, obesity, current cigarette smoking, and medications known to affect the autonomic and/or cardiovascular systems. The institutional review board of New York Chiropractic College granted approval for the study, and informed consent of each subject was obtained before the investigation.

Testing occurred between 2:00 and 4:00 PM in a private and thermo-controlled autonomic laboratory. Subjects were required to rest quietly (prone position) for 30 minutes followed by 5 minutes of peripheral and cardiovascular autonomic data collection. All subjects refrained from beverages containing caffeine and alcohol during the day of the study, and data were collected 2 hours postprandial. Control subjects abstained from exercise 24 hours before study.

Data Collection

Dependent variables obtained included cardiovascular autonomic modulation: beat-by-beat systolic blood pressure (SBP) and R-R intervals (RRIs) of the electrocardiograph (ECG) QRS complex both measured using power spectral analysis, baroreceptor sensitivity, skin conductance, and peripheral skin temperature (Fig 1). To assess peripheral and cardiovascular autonomic modulation, data acquisition was performed on cardiovascular autonomic data, skin conductance, and peripheral skin temperature at a sampling rate of 250 Hz per channel with a 12-bit analog-to-digital converter. R-R intervals and SBP were measured beat-by-beat using lead V5 of the ECG and a continuous tonometry and oscillometric blood pressure instrument (Colin, Medical Instruments Corp, San Antonio, Tex). R-R intervals and SBP data were acquired and spectral decomposition performed using a customized program created with LabVIEW software (National Instruments, Austin, Tex) as previously described14; a more detailed description of the methodology, physiological interpretation, and clinical use is provided in Ref. 16.

For peripheral autonomic assessment skin conductance was recorded by using a pair of Ag/AgCl electrodes, approximately 0.8 cm2 in contact area, filled with conductivity gel placed on the volar surface of the distal phalanges of digits I and II of the hand and then attached with a Velcro strip.15 Data was collected with a Grass model CSA1 Skin Conductance Adaptor then channeled into a Grass P122 amplifier (Astro-Med Inc, W Warwick, RI) and sampled and digitized as previously described. Peripheral skin temperature was obtained by a thermocoupled temperature probe (YSI, Yellow Springs, OH) secured with medical tape to the volar surface of the distal phalanx of digit IV of the hand. The signal was channeled into the computer via an interface module converter (Deban Enterprises, Yellow Springs, OH), and data for all measurements were analyzed off-line.

Signal Processing

All signals were visually inspected for artifact and anomalies and peak detection was performed on all QRS complexes and systolic peaks. The standard deviation (SD) of RRIs (a time domain variable representing global cardiac parasympathetic input16) was calculated. R-R intervals and systolic peaks were then interpolated to provide continuous wave forms. The data were transformed into frequency spectra using discrete Fourier algorithms, and the spectral estimates smoothed by applying a Hamming window function to produce the power spectra.17,18 The standard spectral bandwidths for RRI and SBP parameters each

<table>
<thead>
<tr>
<th>Subject</th>
<th>Injury type</th>
<th>Duration</th>
<th>Pain scale (VAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low back</td>
<td>3 d</td>
<td>3/10</td>
</tr>
<tr>
<td>2</td>
<td>Low back</td>
<td>2 d</td>
<td>6/10</td>
</tr>
<tr>
<td>3</td>
<td>R shoulder</td>
<td>2 d</td>
<td>4/10</td>
</tr>
<tr>
<td>4</td>
<td>R knee</td>
<td>24 h</td>
<td>5/10</td>
</tr>
<tr>
<td>5</td>
<td>Low back</td>
<td>6 d</td>
<td>6/10</td>
</tr>
<tr>
<td>6</td>
<td>L knee</td>
<td>4 d</td>
<td>3/10</td>
</tr>
</tbody>
</table>

R, right; L, left.
Fig 1. Represents signal processing of RRIs and SBP for 1 subject. Graphs a and b show raw digitized (sampling rate 250 Hz per channel) ECG and blood pressure data. Graphs c and d depict histogram of RRIs and SBP, and graphs e and f show interpolated data providing continuous waveforms for both RRIs and systolic peaks.
Table 2. Results: subject characteristics

<table>
<thead>
<tr>
<th>Group</th>
<th>Sex (m/f)</th>
<th>Age (y)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>HR (beats/min)</th>
<th>SBP (mm Hg)</th>
<th>DBP (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute</td>
<td>5/1</td>
<td>25 ± 3.2</td>
<td>175 ± 8.1</td>
<td>88 ± 17.8</td>
<td>64 ± 11.2</td>
<td>128 ± 11.4</td>
<td>71 ± 8.3</td>
</tr>
<tr>
<td>Control</td>
<td>5/1</td>
<td>26 ± 2.5</td>
<td>180 ± 5.1</td>
<td>86 ± 15.7</td>
<td>56 ± 7.4</td>
<td>129 ± 9.7</td>
<td>78 ± 7.3</td>
</tr>
</tbody>
</table>

Results are expressed as mean values ± SD; m/f, Male-to-female ratio; HR, heart rate; DBP, diastolic blood pressure.

Fig 2. The bar chart depicts mean peripheral and cardiovascular data. Dashed line separates the chart for peripheral skin temperature, index $\alpha$, and skin conductance corresponding to units at top of chart, whereas SBPLF, RRIHF, RRILF, and SD of RRI correspond to units at bottom of chart. Both RRI and SBP frequency components are presented as normalized units (NU) calculated by dividing by the difference between the total power and the very low frequency component and multiplying the result by 100.19

The index $\alpha$ was calculated to assess baroreceptor sensitivity. This index is a closed-loop model based on the simultaneous analysis of beat-by-beat changes in RRIs and SBP frequency domain measures and is used to estimate the overall gain of the neural feedback from baroreceptor mechanisms.20,21 This is computed both in correspondence to LF and HF oscillatory components, and an average index is derived from the power spectral density analysis data and calculated as:

$$\alpha = \frac{1}{2} \left[ \left( \frac{RRI_{LF} - SBP_{LF}}{SBP_{LF}} \right)^{1/2} + \left( \frac{RRI_{HF} - SBP_{HF}}{SBP_{HF}} \right)^{1/2} \right]$$

where RRI and SBP represent the spectral power for heart rate and blood pressure variability, and the subscripts LF and HF represent the low-frequency and high-frequency components, respectively. The validity of the index $\alpha$ requires that the coherence (a measure of the linear association between 2 signals in the frequency domain—equivalent to the squared correlation coefficient) between the 2 variability signals is greater than 0.5. The magnitude squared coherence and phase functions between RRIs and SBP were evaluated by cross-spectral analysis for final determination of the index $\alpha$.22
Statistical Analysis

An unpaired Student’s *t* test was applied to determine differences for dependent variables between groups, and results are presented as mean values ± SD. Simple regression analysis was used to describe relationships between sudomotor function (skin conductance) and sympathetic vasomotor modulation with the level of significance for all analyses set at *P* < .05.

RESULTS

No significant differences were observed between groups for subject characteristics or hemodynamic parameters (Table 2). Comparison of autonomic cardiovascular modulation data revealed a significantly higher SBP{sub}LF and a significantly lower baroreceptor sensitivity in the musculoskeletal injury group than the control group (59.6 ± 6.7 vs 23.8 ± 6.4 mm Hg2/Hz; 0.97 ± 0.07 vs 1.10 ± 0.08 mm Hg, respectively, *P* < .02). The SD of RRIs was significantly attenuated in the injury group compared with controls (49.8 ± 10.5 vs 76.8 ± 12.7 ms; *P* < .01); however, no differences were observed for either RRI{sub}LF or RRI{sub}HF frequency domain variables. The peripheral autonomic measure skin conductance was statistically greater in the musculoskeletal injury group than in the control group (3.87 ± 1.04 vs 2.19 ± 0.3 mhos; *P* < 0.01), whereas no difference was found for peripheral skin temperature (Fig 2).

Regression analysis revealed a highly significant positive relationship between skin conductance and SBP{sub}LF (*R*{sup}2* = 0.57, *P* < .01) as shown in Fig 3. The power spectral analysis (Fig 4) illustrates representative acute and control subjects. Note significantly greater power in the LF component (0.04-0.15 Hz range) of SBP in the acute subject relative to the control, suggesting heightened vasomotor sympathetic influence.

DISCUSSION

The results of this observational study showed that both sympathetic vasomotor influence (shown by SBP{sub}LF) and sympathetic sudomotor control (skin conductance) are heightened, whereas the baroreflex mechanism (index α) is attenuated, in subjects with acute musculoskeletal injury relative to age- and sex-matched healthy controls. Our findings suggest that activity of and interaction between cutaneous and vasomotor sympathetic neurons in response to acute musculoskeletal injury, potentially reflected as increased afferent input from sensitized nociceptors and other sensory neurons, can be noninvasively quantified as alterations in peripheral and cardiovascular autonomic modulation. Although this is a small preliminary study, there appears to be a relationship between acute musculoskeletal tissue injury and the autonomic nervous system in human subjects.

Statistical Analysis

Regression analysis revealed a highly significant positive relationship between skin conductance and SBP{sub}LF (*R*{sup}2* = 0.57, *P* < .01) as shown in Fig 3. The power spectral analysis (Fig 4) illustrates representative acute and control subjects. Note significantly greater power in the LF component (0.04-0.15 Hz range) of SBP in the acute subject relative to the control, suggesting heightened vasomotor sympathetic influence.
The low-frequency component of SBP has been used to characterize sympathetic vasomotor modulation and cardiovascular control, and changes in sympathetic outflow are controlled by various receptors (ie, arterial baroreceptors, chemoreceptors, and cardiopulmonary) combined with other direct mechanical or humoral influences and alterations in the activity of higher brain centers (ie, nucleus tractus solitarius). Evidence is available, however, to show that sympathetic neural outflow of a central or peripheral nature exerts a prominent role in selectively modifying and adjusting appropriately to the needs of the cardiovascular system. In view of the number and complexity of these regulatory mechanisms, caution should be exercised when interpreting results obtained from beat-to-beat SBP LF. With this consideration appreciated, our findings suggest that acute musculoskeletal injury results in a shift in the autonomic nervous system toward a sympathetic dominance, as reported with chronic pain.

Precise measurement of galvanic skin response (for this study we used skin conductance) relies on the ability of the autonomic nervous system to modulate sudomotor activity. This dependence is based on the anatomy of the skin, supplied abundantly by eccrine sweat glands that are innervated solely by efferent sympathetic fibers. Specifically, ventral root fibers originating from neurons in the intermediolateral cell column (lamina VII) of the spinal cord synapse on postganglionic sympathetic neurons in the periphery and innervate the exocrine portion of the sweat gland and the muscles controlling piloerection. In response to sympathetic stimulation, an increasing proportion of sweat glands in a given area become active resulting in a change in the skin’s conductivity (decreased resistance and thus an increase in its reciprocal conductance).

Although regression analysis of skin conductance and SBP LF for the 2 groups separately yields no significant relationships, regression analysis of skin conductance and SBP LF for the combined groups reveals that in the injury group, those with heightened sympathetic vasomotor modulation also exhibited elevated sudomotor activity, lending further support to the notion that acute musculoskeletal injury results in heightened global sympathetic autonomic modulation. In addition, the scatter of data points clearly differentiates group membership, and thus future studies with a larger cohort may permit discriminate analysis to predict the independent variable (ie, group membership) based on differences in the dependent variables.

We measured parasympathetic neural influence on cardiac function in both the time and frequency domains, and although no differences were found between groups for frequency domain values, differences were noted for the time domain variable, SD of the RRI s. For continuous ECG recordings, each QRS complex is detected, and the normal-to-normal intervals are established. Therefore, the SD of the RRIs, that is, the square root of variance that is mathematically equivalent to total power of the spectral analysis, represents all cyclic components responsible for variability in the raw signal. A rationale for the absence of a significant difference between groups for the RRIHF is not obvious; however, the large variability (ie, SD) observed in this measure may contribute. A potential explanation for differences between groups for the SD of the RRIs is that it represents global involvement of the autonomic nervous system in cardiac function, whereas the RRIHF component depicts a more precise index of parasympathetic influence.

The index z is based on simultaneous beat-to-beat changes in SBP and RRI frequency domain measures, which interact in a closed-looped relationship, and represents an estimate of the overall gain of the neural feedback from baroreflex mechanisms without providing information on changes in tonic activity. In healthy control populations, the index z has been reported to be reduced during sympathetic activation (active standing) and enhanced during autonomic sympathetic blockade (atenolol). Other investigators have observed a lower index value in patients with uncomplicated essential hypertension suggesting a reduced gain of baroreflex mechanisms. We previously reported in normotensive individuals with paraplegia, relative to able-bodied controls, an attenuated index z value suggesting that the interaction between parasympathetic and baroreceptor feedback control mechanisms is impaired in this population. We postulate that a similar mechanism is responsible for the diminished baroreceptor sensitivity, instead of similar mechanism is responsible for the diminished QRS found in the study herein, such that acute musculoskeletal injury contributes to alterations in the autonomic nervous system in which a change in one system, augmented sympathetic efferent outflow, is accompanied by shifts in others resulting in resetting of the autonomic nervous system (ie, interaction between parasympathetic and sympathetic baroreceptor feedback control mechanisms).

From a clinical perspective, these results add to a growing body of evidence of both controlled and uncontrolled studies demonstrating a relationship between somatic nociceptive and other sensory afferent input and autonomic nervous system modulation, particularly within the sympathetic branch. One of the fundamental premises of chiropractic and osteopathy is that dysfunction in the somatic structures of the body, particularly within the spine, results in nociceptive input that influences autonomic nervous system function. Specifically, it has been hypothesized that such afferent input causes an increase in the thoracolumbar outflow of the sympathetic nervous system and that the efferent sympathetic nervous system can then be actively involved in the generation of pain. This small observational study using human subjects with acute musculoskeletal pain contributes to this hypothesis. Furthermore, if it could be definitively shown that such change in efferent sympathetic activity has a negative impact on health and wellness, the need to address painful dysfunction or injury to the musculoskeletal system using manipulation or
other manual therapies would be indicated. Moreover, we feel it suggests the need for chiropractors to better recognize their role as primary-care portal-of-entry physicians specializing in the care and maintenance of the musculoskeletal system as a whole and not only the spine.

Conclusion

Sprains and strains produce mild forms of nociceptive pain, whereas the pain of arthritis or a tumor that invades soft tissue is chronic and much more intense. Patients with both acute musculoskeletal tissue injury (<1 week) and mild to moderate pain (3-6, VAS) were selected in an attempt to noninvasively quantify interactions between such injury types and the autonomic nervous system, as occurs in some chronic pain states. Our findings suggest that in acute injuries to somatic structures, the autonomic nervous system shifts to a predominance of cardiovascular and peripheral sympathetic modulation as shown by augmentation in sudomotor and vasomotor control and attenuation of baroreceptor sensitivity.

Acknowledgments

The authors thank Ross Kinnard, DC, for his help in this study.

References

INTEREXAMINER RELIABILITY OF THE DELTOID AND PSOAS MUSCLE TEST

Henry Pollard, DC, PhD, a Bronwyn Lakay, MChiro, b Frances Tucker, MChiro, b Brett Watson, MChiro, b and Peter Bablis, DC b

ABSTRACT

Objective: To determine if 2 practitioners of differing skill levels could reliably agree on the presence of a weak or strong deltoid or psoas muscle.

Study Design: Interexaminer reliability study of 2 common muscle tests.

Main Outcome Measures: Cohen $\kappa$ (unweighted) scores, observer agreement, and 95% confidence intervals (CIs).

Results: The results showed that an experienced and a novice practitioner have good agreement when using repeated muscle test procedures on the deltoid ($\kappa$ 0.62) and the psoas ($\kappa$ 0.67).

Conclusions: The manual muscle test procedures using the anterior deltoid or psoas showed good interexaminer reliability when used by an experienced and a novice user. These techniques may be used between practitioners in multidoor assessment/management programs. (J Manipulative Physiol Ther 2005;28:52-56)

Key Indexing Terms: Chiropractic; Muscle Test; Reliability; Psoas Muscle; Deltoid Muscle

Muscle testing is widely used by practitioners to determine the strength of a muscle as well as determine its related neurological functioning. In addition, many practitioners use muscle testing as a part of a diagnostic system related to one or more of the following: spinal hypomobility/subluxation/manipulable lesion, deficiency in nutritional status, indicator of neurological, emotional (neuroemotional technique), and other dysfunction, or as part of systems of treatment such as applied kinesiology (AK). All the above uses, valid or not, presuppose the reliability of the testing procedure. In a review of the English literature from 1966 to the present using the Medline and CINAHL databases with search key words “muscle test” and “applied kinesiology” and “reliability,” only a small number of papers were found on the topic. Many papers were found on the use of isokinetic machine-based muscle testing systems and their reliability. These papers compared isokinetic muscle testing to muscle testing with and without handheld force transducers.

The literature provides examples of studies that have deemed the reliability of manual muscle testing as either good or poor. This work further reports the comparison of the manual muscle test with that done by a handheld force transducer concluding that both are reliable. Other research compares the use of isokinetic testing to that of the handheld transducer type, concluding that both are reliable, but the machine-based approach is superior to the handheld approach. In addition, many examples of different muscles being the object of the testing have resulted in different reliability to the procedure of the manual approach. It is apparent that the reliability of the muscle test may depend on the type of muscle being tested, who is testing it (experienced or novice), in what position it is being tested, and with what procedure.

The muscle test procedures have been in wide clinical use, and practitioners of varying skill levels use them. Although the outcomes of testing by experienced practitioners or novice practitioners have been determined, no comparative testing of these 2 groups has been performed. The results of such a study could be applied to the multidoor practice that frequently use a combination of both senior and novice clinicians (new graduates) sharing the same patient population. Thus, it is the specific aim of this paper to test the interexaminer reliability of a muscle test as performed by an experienced practitioner and a novice practitioner.

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Methods

Experimental Procedure

The project included 106 volunteer participants who responded to advertisements that were placed around a university campus on notice boards in various departments and other communal student areas. Of the 106 participants, 50 were men, and 56 were women. The age range of participants was between 19 and 63 years, with a mean age of 26 years. The project received approval from the Macquarie University Human Ethics Committee before commencement. Participants were requested to complete a consent form before the experimental session after the procedure had been completely explained to them. Their participation was entirely voluntary.

The testing room was arranged so that each of the testers was unable to determine the nature of the others’ activities. Subjects were randomly allocated (via drawing a number from a hat) to one of the practitioners. Each practitioner began testing the muscles in reverse order (ie, one practitioner began with the deltoid and the other began with the psoas). The ‘novice’ student researcher (R1) and the ‘expert’ supervisor (S1) each performed the muscle testing of the anterior deltoid and psoas muscles on each participant. The novice practitioner was a final-year (5th year) chiropractic student, and the expert supervisor was a practitioner with 15 years’ experience in using the technique. Participants were invited into the testing room and instructed that 2 muscle strength tests would be performed on them, 1 on their shoulder and 1 on their hip.

Description of Muscle Test Procedures

The deltoid muscle strength test was first performed by S1, with the participant sitting facing the tester, the tester standing directly in front of subject. The chosen arm was outstretched in front of the subject at right angles to their body, with their hand in a loose fist, their elbow straight, and their forearm pronated with the hand parallel to the floor. In the manual muscle test, the testers placed their hands at a location approximately 5 cm proximal to the ulnar styloid, in the midline of the forearm. The participant was asked to hold that position against pressure exerted by the tester’s hand that was applied in a superior-to-inferior direction. During the test, an algometer (pain-pressure displacement measurement device) was used to determine the amount of load applied to the individual. The same displacement noted in the first test was used for all subsequent attempts at muscle testing to standardize the amount of force used in the testing. Thus, subsequent tests began by placing the algometer at the same location, and the participant was instructed to hold the position once again against pressure. R1 then conducted the upper limb (deltoid) manual muscle strength test in the same manner. The right limb was requested in all cases, unless there was an existing injury to that side. Assessors were again blinded to each other’s results.

The participant was then instructed to assume a supine position for testing of psaas muscle strength. The tester lifted the chosen leg and positioned the extended leg to approximately 30° of hip flexion, 10° of abduction from the midline, and external rotation. Pressure was applied in a superior-to-inferior direction, approximately 5 cm proximal to the medial malleolus on the anteromedial border of the tibia for both the manual muscle testing (by S1 and R1) determined once again by the displacement noted with the algometer testing.

Standardization of the force in testing was important. A displacement device was used to indicate the force used on each individual. It was not the purpose of the study to determine the amount of force used in the muscle test, only to use the same amount of force. By using a displacement device (the algometer), a standardized amount of force was required to achieve the same displacement per patient.

As this study was a pragmatic study using procedures commonly used in the clinical setting, a pragmatic approach to the determination of the weak or strong response to the muscle testing was used. Subjects were indicated to have had a positive response to the muscle test if they produced a “large” subjective change (deemed to be greater than 30°) in the depression of the arm (or leg) using the same force as measured by the same degree of deformation of the algometer. The 2 practitioners subjectively noted findings independent of each other, and results were compared.

Analysis

Statistical analysis of data was made using Cohen κ statistic (used to evaluate results of interexaminer agreement). Statistical interpretation of κ statistics is similar to a correlation coefficient (ie, the highest level of agreement is 1.0, whereas the lowest level is 0). Dawson and Trapp have outlined a scale for qualifying the quality of agreement between examiners. They suggest a κ score of 0.93 to 1.0 as an excellent agreement, 0.81 to 0.92 as a very good agreement, 0.61 to 0.80 as a good agreement, 0.41 to 0.60 as a fair agreement, 0.21 to 0.4 as a slight agreement, and 0 to 0.20 as a poor agreement.

Results

Interexaminer Reliability

The interexaminer reliability for the test-retest protocol between the assessors was determined, and significant reliability was attained between testers for both muscles tested. S1 and R1 muscle tests for the deltoid were identical 82.08% of the time (Table 1). Both examiners recorded a ‘strong’ measure 57 times, and a ‘weak’ measure 30 times with differing measures totalling 19 times. The κ statistic was 0.62, which showed ‘good’ agreement on the κ scale.

The measure of both S1 and R1 for the psoas agreed 84.9% of the time (Table 2). Both examiners recorded...
a ‘strong’ measure 30 times, and both recorded a ‘weak’ measure 60 times with different measures recorded 16 times. The $\kappa$ statistic was 0.67, which once again showed ‘good’ agreement.

**DISCUSSION**

The use of muscle testing for grading the response to injury is widespread and is accepted for such a purpose.\(^1\) By contrast, the use of muscle testing as a vehicle to detect neurological and musculoskeletal functioning elsewhere other than the specific strength testing throughout the peripheral and central nervous systems is less well established.\(^6,24,25\) Much controversy surrounds the use of these procedures for such purposes.\(^2,5,13,26,27\) Although such a debate is a healthy call to arms for the commencement of a research agenda to investigate such procedures, it remains a lofty goal for future investigations.\(^26\)

Before establishing the applied use of such procedures, investigation of the basic functions of this muscle testing approach is needed. Thus, it was the purpose of this paper to investigate the base-level agreement of 2 practitioners with differing skill levels. The determination of the reliability of these commonly used muscle test procedures is important because of a need for practitioners of varying skill levels that use them. The results of this study support the use of these procedures in the multidisciplinary practice. Such clinics frequently use combinations of experienced and inexperienced clinicians sharing the same patient population. Such a scenario is frequently encountered with experienced practitioners employing new graduates.

These skill levels were defined by the use of an intern practitioner versus an established musculoskeletal practitioner (15 years of experience). These practitioners were tested using 2 of the most common muscle testing procedures: the anterior deltoid and psoas muscle tests. These tests are instrumental to AK and other diagnostic system approaches used by manual and other therapists.\(^9\) Because of the prominent role that muscle testing has in the technique of AK, muscle testing reliability is often considered interchangeable with the diagnostic protocol that is AK. Such extrapolation is inappropriate and unfortunate because it leads to confusion within the literature examining both muscle testing and AK protocol.

Our results showed that an experienced and a novice practitioner have good agreement when using repeated muscle test procedures on the deltoid ($\kappa$ 0.62) and psoas ($\kappa$ 0.67). Other researchers have examined the muscle test reliability in these muscles and have found them to have good or better level of interexaminer reliability.\(^1,14\) Frese et al\(^{16}\) found the interrater reliability of the middle trapezius and gluteus medius to be low and concluded that their use in muscle testing should be considered questionable. Ludtke et al\(^{15}\) when attempting to use the anterior deltoid to test subject reactions to insect venom allergy found that the muscle test was an unreliable indicator in patients with known allergy. Also, an older investigation by Grossi\(^{27}\) determined that the muscle spindle technique used by AK practitioners (as it pertains to the isometric quadriceps strength) was also unreliable.

Thus, the results of the various studies can be described as mixed at best. Much crossover has occurred between the reliability of the testing of the actual muscle test and the validity of the application of the muscle test to diagnostic approaches. Many studies have questioned some of the diagnostic uses to which muscle testing has been put.\(^4,5,8,26\) Kenney et al\(^5\) have concluded that AK is unreliable to test nutrient status, whereas Schmitt and Leisman\(^{25}\) in a more recent pilot study have concluded the opposite in a hypoallergenic food hypersensitivity response test using muscle testing.

In a review of chiropractic diagnostic methods, Hestbaek and Leboeuf-Ynde\(^{26}\) concluded that the manual muscle testing used by sacro-occipital technique is reliable but not the diagnostic procedure to which it is applied (as no studies had been performed). They concluded that very little documentation was available at that time to validate the practice of applied kinesiology and its use of muscle testing as a whole. The conclusion by Hestbaek and Leboeuf-Ynde\(^{26}\) is similar to a previous publication, which concluded that during the period 1981 to 1987, the published research on AK was limited by inadequately performed research that prevented the drawing of any clear conclusion as to the efficacy of the procedures.\(^24\)

Despite these repeated calls for quality research into what is one of the most prolific chiropractic procedures, recent researches by Caruso and Leisman\(^{13,14}\) have potentially shown a way for the production of research into the muscle

### Table 1. Interexaminer deltoid manual muscle testing reliability

<table>
<thead>
<tr>
<th></th>
<th>Agreement</th>
<th>S1</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong</td>
<td>57</td>
<td>9</td>
</tr>
<tr>
<td>Weak</td>
<td>10</td>
<td>30</td>
</tr>
</tbody>
</table>

Cohen $\kappa$ (unweighted): observed agreement = 82.08%; expected agreement = 53.24%; $\kappa = 0.62$ (SE = 0.10); 95% CI 0.43 to 0.81; $z$ (for $k = 0$) = 6.35; 2-sided $P < .0001$; 1-sided $P < .0001$.

### Table 2. Interexaminer psoas manual muscle testing reliability

<table>
<thead>
<tr>
<th></th>
<th>Agreement</th>
<th>S1</th>
</tr>
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<tbody>
<tr>
<td>R1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong</td>
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<td>9</td>
</tr>
<tr>
<td>Weak</td>
<td>7</td>
<td>60</td>
</tr>
</tbody>
</table>

Cohen $\kappa$ (unweighted): observed agreement = 84.91%; expected agreement = 53.99%; $\kappa = 0.67$ (SE = 0.10); 95% CI 0.48 to 0.86; $z$ (for $k = 0$) = 6.92; 2-sided $P < .0001$; 1-sided $P < .0001$.\(^5\)}
test. They may help some of the reliability and validity issues associated with the use of the muscle test.

In their recent papers, Caruso and Leisman investigated the force displacement data from an AK muscle test procedure. They were able to determine that experienced practitioners were able to discriminate between a weak and strong muscle by a simple force displacement analysis. They found that experienced researchers gained most of their sensory information from the leading-edge force pulse of the impulse they applied to the muscle they were testing, and the impulse could be visualized by plotting the slope of the force displacement curve (dx/dF). They determined that a weak muscle showed a large slope, whereas a strong muscle showed a small slope. In both related publications, they reasoned that the inability to document or effectively test the dx/dF of the various muscles being tested could explain (at least in part) the variability of the responses found by various researchers. In addition, findings by other researchers, such as Mulroy et al, have added to a potential explanation by suggesting that the outcome testing of large muscles such as the quadriceps may be determined by the strength of the assessor, and not just the target muscle or subject.

Additional to the mechanical factors affecting muscle test performance, mental factors may also affect strength testing. Monti et al have concluded that a belief in a certain statement may affect the output of the muscle being tested. They tested the effect on muscle testing strength while the subject responds to a congruent (true) or incongruent (false) statement and found that incongruent statements result in a weaker muscle test performance than that which used congruent statements. Leisman et al also previously showed that practice can increase the efficiency of subjective muscle testing and that a fatiguing muscle responds differently to strong or weak muscle as measured using integrated electromyography.

The results of our present investigation and that of the various studies reviewed above suggest that the use of the anterior deltoid and psoas muscles for the purpose of muscle testing may be reliable using examiners of differing skill levels. These results may support the use of muscle testing of the deltoid and psoas muscles by different practitioners on a similar population, a scenario that might be encountered in the multidoctor clinic; however, more research is needed.

What cannot be concluded is the reliability of other muscles other than the 2 target muscles of this investigation, although we see no cause as to why other muscles may not be reliably tested when similar care is used. In addition, no conclusion can be made of the reliability or validity of any diagnostic system that may use these reliable muscle tests. Thus, we call for further outcomes-based research into the practice of AK and other diagnostic protocols that use the manual muscle test as a component part of their diagnostic application.

CONCLUSION

The manual muscle testing procedure using the anterior deltoid or the psoas muscle shows good test-retest reliability when used by the experienced and novice users in this study. We find that this investigation can make no claim on the validity of those diagnostic procedures used by practitioners for functions other than basic muscle testing. We suggest further research be undertaken to address the noted shortcomings in the literature on the validity of use of these procedures in conjunction with diagnostic protocols to which they are so often used.

REFERENCES


Michael Haneline, DC, MPH, a and John Triano, DC, PhD b

ABSTRACT

Objective: To examine the similarities and dissimilarities between cervical chiropractic manipulative therapy and whiplash, and their respective relation to cervical artery dissection.

Data Sources: A literature synthesis used MEDLINE-PubMed and MANTIS literature searches. A total list of 99 relevant articles was generated. Additional references were collected from citations incorporated within the included articles.

Results: Both neck manipulation and motor vehicle collision events apply loads to the spinal column rapidly. While neck manipulation loads are slower to develop and displacements smaller, they may reach peak amplitudes on maximum effort comparable to those seen in low-velocity collision experiments. In contrast to reports that the vertebral artery experiences elongations exceeding its physiological range by up to 9.0 mm during simulated whiplash, strains incurred during cervical manipulative therapy have been reported to be approximately one ninth of those required for mechanical failure, comparable to forces encountered in the course of diagnostic range of motion examination. Additionally, long-lasting abnormalities of blood flow velocity within the vertebral artery have been reported in patients following common whiplash injuries, whereas no significant changes in vertebral artery peak flow velocity were observed following cervical chiropractic manipulative therapy.

Conclusions: Perceived causation of reported cases of cervical artery dissection is more frequently attributed to chiropractic manipulative therapy procedures than to motor vehicle collision related injuries, even though the comparative biomechanical evidence makes such causation unlikely. The direct evidence suggests that the healthy vertebral artery is not at risk from properly performed chiropractic manipulative procedures. (J Manipulative Physiol Ther 2005;28:57-63)

Key Indexing Terms: Manipulation; Chiropractic; Cervical Artery Dissection; Whiplash Injuries

Cervical artery dissection (CAD) involving the vertebral artery (VA) and internal carotid artery (ICA) is an uncommon condition that has been reported to occur in rare instances following both cervical chiropractic manipulative therapy (CMT)1-5 as well as whiplash injury.6-9 The precise etiology of CAD has not been established, with most authors considering its cause to be unknown and most likely multi-factorial.10 However, trauma or trivial trauma to the neck is frequently cited in the literature as a risk factor. While there are superficial mechanical similarities between CMT and whiplash, both are rapid events that move the head with respect to the torso, there is significant disparity in the report of suspect incidents involving CAD between them. This work examines some of the similarities and dissimilarities in effort to offer explication of these differences.

Pertinent Anatomy of the Cervical Arteries

The ICA arises from the common carotid artery at its bifurcation and is made up of 4 segments. The cervical segment rises vertically and is located posterior to the external carotid artery. The ICA lies below the sternocleidomastoid muscles and is separated from the external carotid artery by the styloglossus and stylopharyngeal muscles. It is situated anterior to the longus cervicis muscle, and anterior to the transverse processes of the upper third or fourth cervical vertebrae.11 The ICA is known as the petrous...
segment after entering the carotid canal at the base of the skull. As the artery passes through the skull, it becomes the cavernous segment and ultimately the supraclinoid segment. The ICA is freely moveable within its cervical pathway, but becomes fixed to the surface of the bone as it enters the carotid canal above the atlas.

The VA typically arises from the subclavian artery and, like the ICA, has 4 segments. The prevertebral segment lies between the longus colli and the anterior scalene muscles prior to its entering the transverse foramen of C6. The cervical segment passes through the transverse foramina becoming the atlantal segment when it exits through the transverse foramen of C1. This segment transitions from traveling in a vertical direction to horizontal orientation, where it is thought to be most susceptible to injury related to sudden or extreme head movement. The atlantal segment is sheathed in muscles, nerves, and passes through the atlanto-occipital membrane. The VA passes through a groove located behind the articular process of C1, before entering the cranium through the atlantooccipital membrane and the dura mater. The VA is fixed to adjacent structures in the tunnel formed by the transverse foramina by means of a continuous layer of collagen along its entire course (Fig 1). As the intracranial segment, it continues upward across the medulla to the pontomedullary junction. There it joins with the opposite VA to become the basilar artery. The basilar artery extends distally to form the posterior inferior and anterior cerebellar arteries, the internal auditory artery, the superior cerebellar artery, the posterior cerebral artery, and numerous medullary and pontine branches. These arteries supply blood to the portions of the brain occupying the posterior fossa.

**Pathophysiology of CAD**

Briefly, CAD may be caused by an initial tear of the artery’s intimal lining, followed by blood penetrating into the muscular vessel wall. Pulsatile pressure undermines the muscular coat, resulting in a splitting or dissection of the layers. The separation may extend along the artery for variable distances, usually in the direction of blood flow. Another mechanism is an intramural hemorrhage of the vasa vasorum that ruptures into the vessel’s true lumen. The disturbance in local blood flow associated with CAD promotes thrombus formation that may embolize blocking circulation more distally. Transient ischemia or infarction may result from the dissection. The mechanisms initiating intimal tears are uncertain. Some authors have indicated that tearing necessarily implies prior trauma. However, tearing of the intima is common in cases of spontaneous CAD where no known trauma occurred. Hyperhomocysteinemia may represent a potential risk factor leading to structural abnormalities of the arterial wall and increasing the susceptibility to mechanical stress.

When considering all extracranial CADs, ICA dissection (ICAD) occurs approximately 3-5 times more frequently than VA dissection (VAD). VADs are much more likely to be claimed as associated with head movements, such as CMT or whiplash. In a literature review of VAD in children, Hasan et al. noted an association between routine neck movements and the development of VAD in 50% of reported cases even though there was no exposure to sudden neck loading.

There is a distinction between classifications of spontaneous versus traumatic CADs depending upon whether or not there was a significant premorbid injury. The traumatic classification is reserved for cases associated with definite, and often severe, trauma. Major cervical spine trauma has been shown to be associated with VAD in about 24% of cases. Mokri noted that there are conspicuous clinical differences between patients with spontaneous ICAD as compared with the traumatic variety. He reported on a series of 95 patients, indicating that in traumatic dissections, aneurysms were more common, significantly fewer aneurysms resolved or became smaller, and fewer stenoses resolved or even improved. Post-traumatic stenoses progressed to occlusion more often and were more likely to leave the patients with neurological deficits. A significantly higher percentage of the patients with spontaneous dissections were asymptomatic at follow-up compared with the traumatic group. The prognosis from ICAD is controversial. Mokri suggested a good rate of recovery without minimal residual deficit for the spontaneous type and a somewhat less favorable for the traumatic type. Milhaud et al. on the other hand, have recently indicated that ICAD is a more severe disease than previously observed.

The VA is considered most susceptible to strain as it traverses the C1-C2 articulation where it is thought most vulnerable to rotational movements. The proposed mechanism during neck rotation is based on the ipsilateral C1-C2
joint being fixed, while the contralateral side of C1 is propelled forward, effectively stretching the VA (Fig 2). The ICA is most susceptible to strain with the head and neck in combined rotation or lateral flexion and coincident extension. This positioning fixes the otherwise moveable ICA against the anterior surface of the upper cervical vertebrae, and thus becomes susceptible to injury.

This work examines the understanding of mechanisms, available in the literature, for motor vehicle collision (MVC) and CMT loading of the cervical spine in effort to understand the disparity between reported claims of causation of arterial dissection between them.

METHODS

Search Strategy

MEDLINE-PubMed and MANTIS were searched for the years 1966 through 2002. Only English language articles that purported to contain information pertaining to CAD causation, and all case studies and series were selected for review. A series of searches was performed, using the terms “cervical artery dissection,” “vertebral artery dissection,” and “internal carotid artery dissection,” in combination with “cervical manipulation,” “whiplash,” and “sprain.” A second search, using the term “stroke” in combination with “manipulation,” “whiplash,” and “sprain” was done. Finally, a search on “manipulation” and “biomechanics” related to the neck was done. Specific information on the biomechanical features of applied loads (forces and displacements) as well as vertebral artery mechanics and blood flow were sought. The literature generated by the searches was culled for citations incorporated within the articles.

The literature search strategy generated 99 papers. An additional 13 references were harvested from the reference lists of these articles.

DISCUSSION

Forces and Displacements Encountered in Whiplash Compared with Cervical CMT

Van den Kroonenberg et al carried out sled acceleration tests on human subjects to determine linear and angular head accelerations that were produced by velocity changes ranging from approximately 6.5 to 9.5 km/h. They observed that peak head linear accelerations were approximately 2.5 times greater than that of the sled. Head linear accelerations averaged 9 g, but ranged from 3-12 g. The value of the mean peak angular acceleration was 600 rad/sec. Similar tests were carried out by Croft et al, who staged rear impact car-to-car crash tests with resulting velocity changes ranging from 2.9 to 10.1 km/h. The peak head linear acceleration values in these tests ranged from 2.5 to 13.3 g. There were no related injuries or subsequent symptoms reported by any of the participants in this study following the tests. Triano found that CMT procedures also were rapid events with force development averaging 314 N/s and moments acquiring 371 Nm/s. Load rise time, however, was longer than most reported collision studies with peaks at 237 and 207 milliseconds, respectively.

Moments acting on the spine during simulated low-velocity collisions have been reported by a few investigators: Sances et al 1981, Ewing and Thomas (as reported by Sances 1981), Patrick and Chou 1976, and Gadd et al 1993. A large range of loads were tolerated without adverse report from the volunteers with the exception of 1 subject who experienced a short interval of neck soreness at 88.1 Nm. Sagittal plane moments ranged from 50 to 94 Nm during rear impact while coronal plane loads from lateral impact studies were observed from 51 to 143 Nm.

Ono et al found that the maximum head and neck extension angle during 4-8 km/h rear impact sled tests without head restraints was in the range of 40-56 degrees. This excursion was considered to be within normal limits. However, they pointed out that extension in the lower cervical spine was beyond normal physiological limits because of simultaneous axial compression forces that produced a phenomenon of initial upper cervical flexion, with lower cervical segmental hyperextension. The maximum axial compression value reported by the authors was 150 N, maximum lower cervical shear was 241 N, and subjects’ heads reached maximum rearward excursion within 250 ms. One of 12 subjects involved in the study subsequently complained of minor neck discomfort that lasted 3 days.

Triano and Schultz monitored triaxial linear and angular displacement time histories for the head during the
implicated as an instigator of CAD and cervical CMT is bending. Hyperextension of the cervical spine has been amplit ude and direction. Collisio ns, on the other hand, restrict and 1 to promote axial rotation. For the non-dynamic delivery of 2 CMT procedures; 1 intending to restrict and 1 to promote axial rotation. For the non-rotational maneuver, total displacements averaged 31° in flexion, 13° in rotation and 31° in lateral bending. Rotational maneuvers pre-positioned the head in rotation followed by a small increase during the dynamic thrust phase of the manipulation. Total mean displacements were observed at 50° in flexion, 25° in axial rotation and 33° in lateral bending. Hyperextension of the cervical spine has been implicated as an instigator of CAD and cervical CMT is regularly applied to vertebral segments involving cervical extension. However, CMT does not create joint excursions beyond the physiological limits of the adjacent tissues.

External forces generated during cervical spine manipulation have been evaluated by Kawchuk et al. They recorded mean peak forces of 117.7 N (+/− 15.6 N) with mean duration of the applied forces of 101.7 msec (+/− 14.7 msec). Triano used an inverse dynamics model to estimate loads applied by the operator and those passing through the neck. Procedures were applied with the intention of ranging from least clinically effective to maximum clinical effort. When total external force estimates were compared with Kawchuk’s direct measures of applied loads, the results were in excellent agreement. Transmitted loads that were observed are listed in Table 1. Like the experimental crash work, none of the volunteers for manipulation studies reported any significant adverse responses to participation in the study.

In the case of CMT, the manipulative thrust is applied by a skilled practitioner and is delivered with controlled amplitude and direction. Collisions, on the other hand, involve loads acting in an unpredictable fashion that are dependent upon the number of impacts that are experienced, the directions applied and the relative mass and velocities of the colliding vehicles.

Vertebral Artery Mechanics and Blood Flow

Nibu et al carried out experiments using post mortem human subjects in which they concluded that the vertebral artery was elongated to the point of significant traumatic strain during whiplash. They were able to quantify the extent of elongation using an in vitro model. Cervical spine specimens were dissected, while preserving the osteoliga-mentous structures. A nylon-coated flexible cable took the place of the right VA, which was secured to the occipital bone at one end and a custom VA transducer at the other end. The specimens were then mounted on a sled and exposed to horizontal accelerations of up to 8.5 g to simulate the whiplash event. This resulted in VA elongations that exceeded its physiological range by up to 9.0 mm when the head was rotated or laterally flexed.

Panjabi et al more graphically described the mechanism reported by Nibu et al depicting the elongations and instantaneous configurations of the vertebral artery that were associated with whiplash. The authors pointed out that the cervical spine formed an S-shaped curve during the rearward phase of head excursion, with flexion occurring at the upper cervical levels and hyperextension at the lower levels. They indicated that the maximum stretch of the VA occurred during this phase of neck deformation from the whiplash event.

For cervical spine manipulation, however, Symons et al found that the VA incurred strains that were approximately one ninth of those required for mechanical failure. By means of cadaveric studies, the authors set up an experiment where the VAs were instrumented with piezoelectric ultrasonographic crystals to record strains during range of motion and manipulative procedures. They also strained the VA until mechanical failure occurred, in order to determine the maximum tolerable strain value. The results of the study demonstrated that cervical manipulation resulted in average VA strain values of approximately 6.2% distally and 2.1% proximally. They indicated that these values were similar to, or lower than, what was recorded in the course of diagnostic range of motion examination. The VAs had to be stretched from 139% to 162% of their resting length before mechanical failure occurred during failure testing.

Blood flow velocity changes associated with whiplash events were studied by Seric et al. They examined 47 patients who sustained injuries using transcranial Doppler sonography. Patients were evaluated within 1 month and then 6 months following injury. The authors determined that there were statistically significant disruptions of circulation that were manifested as either an increase or decrease in mean blood flow velocities. Within 1 month following injury, increased blood flow velocities affected 68% of left VAs, 62% of right VAs, and 51% of basilar arteries. They indicated that the velocity changes were most frequently associated with arterial spasm. There was also decreased blood flow within the first month that affected 25.5% of left VAs, 10.6% of right VAs, and 27.6% of basilar arteries. At 6 months follow-up, normal values were obtained in approximately 50% of the vessels, but abnormalities persisted in the remainder. They concluded that cervical spine lesions could affect VA blood flow and cause

### Table 1. Load components observed during manipulation of the upper cervical spine during intended least effective to maximal clinical effort

<table>
<thead>
<tr>
<th>Component</th>
<th>Minimally Effective</th>
<th>Maximum Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse</td>
<td>54 N</td>
<td>93 N</td>
</tr>
<tr>
<td>Axial</td>
<td>14 N</td>
<td>34 N</td>
</tr>
<tr>
<td>Anteroposterior</td>
<td>22 N</td>
<td>43 N</td>
</tr>
<tr>
<td>Moment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion/Extension</td>
<td>14 Nm</td>
<td>32 Nm</td>
</tr>
<tr>
<td>Axial Rotation</td>
<td>32 Nm</td>
<td>50 Nm</td>
</tr>
<tr>
<td>Lateral Bending</td>
<td>35 Nm</td>
<td>65 Nm</td>
</tr>
</tbody>
</table>

N = Newtons, Nm = Newton meters.
symptoms of vertebrobasilar insufficiency. Reddy et al\textsuperscript{14} found similar abnormalities of blood flow velocity in trauma patients with relatively minor whiplash injuries, although their group was smaller.

Licht et al\textsuperscript{43} carried out a randomized, controlled and observer-blinded study of VA blood flow changes from cervical manipulation. They measured VA peak flow velocity both before and after cervical manipulative therapy by means of Doppler ultrasound. In their group of 20 otherwise healthy subjects who had biomechanical dysfunction of the cervical spine, they found no significant differences in VA peak flow velocity following cervical manipulation. The authors had theorized that an increased peak flow velocity following cervical manipulation might explain the development of VA dissection that ensues on rare occasions. However, they concluded that in uncomplicated cervical manipulative therapy, this was not the case. In another study by Licht et al,\textsuperscript{44} anesthetized adult pigs were dissected to expose the VA. Blood flow volume was then measured by means of advanced transit-time flowometry. A small and transient increase of VA volume flow following cervical CMT was detected, which only lasted 40 seconds.

The exact incidence rate of cervical CMT or whiplash related CAD is unknown,\textsuperscript{45} and may be either higher\textsuperscript{31} or lower than what the literature suggests as there are no good epidemiological data. Nearly all reports are case studies or case series that often claim causation based strictly on temporal relationship of the event to the appearance of symptoms. The difficulty with using temporal relationships as the sole basis for suspecting causation is that there are four interpretations available:

1) Event A causes event B.
2) Event B causes event A.
3) Both events A and B are caused by a third related event.
4) Neither A or B are related to each other or a third event but are coincidental.

While one cannot argue that a dissection event is responsible for the occurrence of a whiplash injury or a manipulation procedure being performed, the remaining 3 explanations are equally valid.

There are more than 200 reports in the literature of CAD occurring at some time following CMT. In contrast, there are few following MVCs. Moreover, CAD following MVC typically involves high-energy collisions, which result in more severe injuries than those seen in common whiplash.\textsuperscript{14} Loads acting on the neck are similar only when CMT is compared with low energy collision where volunteer participants failed to show any adverse reactions in either the CMT or MVC test groups. Head displacements are generally smaller during CMT than those measured during MVC. Finally, arterial mechanics show significantly less elongation and strain in the CMT studies. VA blood flow, on the other hand, has a relatively high rate of altered flow velocities associated with whiplash injuries. Why then are there so many more reports of CAD in association with cervical CMT?

Absent significant evidence to explain the disparity between these reputed mechanisms of injury and the appearance of case claims in the literature, it is reasonable to look at the relative criteria used to claim causation of VAD. Selection bias has plagued most reports to date that present claims of causation by CMT. Selection of cases was based most often on the temporal relationship of the experience of manipulation by the patient at some time in the recent or remote past.

Alternative explanations and risk factors are frequently ignored.\textsuperscript{46} Moreover, the claim incidence is artificially inflated in that each patient who has experienced an adverse event suspected of arising from CMT is seen by multiple neurologists who may separately report the event.\textsuperscript{47} More obvious bias is evident in cases where the report has mislead the reader by attributing adverse reactions to “chiropractic” manipulation when manipulation was performed by orthopedic surgeons or therapists with no formal chiropractic training.\textsuperscript{2,48}

Given that the initial symptoms of VAD commonly imitate the musculoskeletal pain for which patients typically consult chiropractors,\textsuperscript{49,50} some of these patients may have already been in the process of experiencing CAD.\textsuperscript{51} The associated CMT may have had little or nothing to do with the creation and progression of the ensuing dissection. This point is demonstrated by 5 cases presented by Terrett,\textsuperscript{50} in which patients experienced CAD while waiting for treatment in the chiropractic physicians’ office or after missing a scheduled chiropractic appointment. Had the planned CMTs actually been provided, the practitioners may have been accused for the subsequent CADs.

Numerous activities of daily living have been shown to negatively influence circulation of the cervical arteries in susceptible individuals and have been associated with CAD.\textsuperscript{50} A few of these activities include: childbirth, positioning during surgery, yoga, overhead work, neck extension during x-ray procedures, neck extension for a nosebleed, turning the head while driving, archery, calisthenics, wrestling, emergency resuscitation, swimming, rap dancing, star gazing, sleeping position, beauty parlor events, and Tai Chi.

Most authors consider that an underlying arteriopathy, that has yet to be identified, must be present in CAD.\textsuperscript{19,52} Some of the risk factors for CAD that have been mentioned are fibromuscular dysplasia, Marfan’s Syndrome, cystic medial necrosis, ultrastructural connective tissue abnormalities, and infection in the weeks prior to CAD.\textsuperscript{10,13,53} A recent target of this type of research is an abnormality in homocysteine metabolism that may weaken the arterial structure and predispose the artery to spontaneous damage. While significant effort has been made to identify lists of...
warning signs, there are none yet that seem able to identify patients who may be at risk for CAD.41

**CONCLUSION**

Reported cases of CAD from MVC are uncommon even from high-energy impact. Yet, perceived causation is more frequently attributed to CMT procedures even though the comparative biomechanical evidence makes such causation highly unlikely. Part of this disparity may be related to the higher number of cervical CMTs administered than MVCs. However, this does not account for the observations of significant arterial abnormalities associated with strain more often following MVC.40-43 Moreover, if strain to the cervical arteries were a primary causative factor in the development of CAD, one would expect to see the condition regularly following MVC and never following CMT.

Both neck manipulation and MVC events apply loads to the spinal column rapidly. While neck manipulation loads are slower to develop and displacements smaller, they reach peak amplitudes comparable to those seen in low-velocity collision experiments. A summary comparison of measurements resulting from the various studies is presented in Table 2 and a comparison of the disparate effects of whiplash and cervical CMT on the VA is presented in Table 3. The evidence suggests that the healthy vertebral artery is not at risk from properly performed CMT procedures. However, vulnerable arteries may be at risk associated with virtually any head movement, or the occurrence of spontaneous dissection. Furthermore, the development of CAD does not appear to be dependent upon the forces applied, rather on the artery’s vulnerability. Unfortunately, there are no routine clinical procedures to differentiate between the two.

Neither of the experimental group participants from the various studies reviewed suffered any major adverse complaints. While it is desirable to identify risk factors and limit potential injury even when risk is small, such efforts should be carried out in an objective atmosphere, which is devoid as possible of bias and preconception, or worse, misuse of information.

The evidence provided here suggests that the healthy vertebral artery is not at risk from properly performed chiropractic manipulative procedures. For patients presenting with new neck and headache complaints, preceded by manipulation or motor vehicle collision or not, the best means to detect VA insufficiency is clinical vigilance. If circumstances are in doubt or suspicious, cases may warrant evaluation with Doppler ultrasound, magnetic resonance imaging or magnetic resonance angiography before administering further care.

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CASE REPORTS

POSTLYMPHOPROLIFERATIVE DISORDER AFFECTING BONE AFTER A RENAL TRANSPLANTATION

Michelle A. Wessely, DC, a Norman Kettner, DC, b and Claude Pierre-Jerome, MD, PhD c

ABSTRACT

Objective: To illustrate a posttransplant lymphoproliferative lymphoma presenting as a solitary osseous lesion situated in the rib.

Clinical Features: A 53-year-old man was referred to a surgical department because of persistent local pain over the lower part of his left posterior hemithorax. Due to a previous history of chronic glomerulonephritis, a renal transplant was performed 7 years previously, followed by immunosuppressive therapy with azathioprine cyclophosphamide.

Intervention and Outcome: Surgical removal of the rib lesion was performed because of the patient’s history of the organ transplant. The histological study of the surgically removed tissue revealed diffuse infiltration of the marrow by lymphoid-like cells. There was evidence of interstitial fibrosis, and further immunohistochemical examination showed the presence of B cells in the specimen confirming the diagnosis of B-cell lymphoma.

Conclusion: This case report discusses an unusual presentation of a lymphoma induced by immunosuppressive therapy in a patient who had received an organ transplant. Such lesions may appear in any organ or system, although this is distinctively unusual to involve the skeletal system. (J Manipulative Physiol Ther 2005;28:64-66)

Key Indexing Terms: Bone; Lymphoproliferative disorders; Lymphoma; Immunosuppressive therapy; Scintigraphy

The risk of lymphomas developing in patients undergoing immunosuppressive therapy to prevent allograft rejection has been well documented.1-5 These post transplant lymphoproliferative disorders (PTLDs) are reported by the Cincinnati Transplant Tumor Registry to represent up to 16% of all tumors among organ-transplant patients as opposed to the 5% prevalence of tumors affecting the general population.2,6 The occurrence of PTLD varies among the organ-transplant recipient population, and although any organ or system may be affected, PTLD tends to have a particular predilection for the allograft site.3,6 The highest incidence is among those patients who have undergone heart-lung transplantation (9.4%). The lowest incidence (1%) is reported in renal-transplant recipients.2,3,6 Most PTLDs are of B-cell origin, and their occurrence in the musculoskeletal system has rarely been reported in the literature.3,4,7 To our knowledge, a posttransplant lymphoproliferative lesion of the thoracic cage has not been reported previously. This case report illustrates the presence of a pathologically proven B-cell lymphoma of the rib in a renal-transplant recipient.

CASE REPORT

A 53-year-old man was referred to a surgical department because of persistent local pain over the lower part of his left posterior hemithorax. He had no previous history of local trauma. The pain was localized over the left 10th posterior rib. A chest radiograph revealed a vague increase in density at the level of the left 10th rib. Two bone scans (99m technetium methylidiphosphate) of the chest performed 11 and 6 months before admission displayed regions of homogeneous focal uptake in the region of the posterior segment of the left 10th rib (Fig 1).

Seven years earlier, the patient underwent a right nephrectomy subsequent to chronic glomerulonephritis.
(mesangioproliferative type) resulting in a 60% reduction of kidney function. Consequently, acute progressive uremia and hypertension developed, and a renal transplant was performed, followed by immunosuppressive therapy with azathioprine cyclophosphamide.

On admission, the patient was alert and well oriented. The physical examination revealed no abnormality in the head and neck regions. On auscultation, the lungs were clear, and the heart sounds were normal. A hard tender mass was palpated over the posterior aspect of the left 10th rib. The mass was fixed to the rib. The pain was exacerbated on inspiration and on lateral bending. No associated skin lesions were noted. No peripheral adenopathy was detected. Examination of the abdomen, pelvis, and extremities was unremarkable. A complete blood count revealed no abnormality. Clinically, no signs of systemic disease or organ rejection were detectable. Electrophoresis was performed with negative results.

Based on the patient’s history of the organ transplant and the persistent local pain and the absence of other abnormalities, the decision to surgically remove the lesions was made. The histological study of the surgically removed tissue revealed diffuse infiltration of the marrow by lymphoidlike cells with hyperchromatic nuclei and sparse cytoplasm (Fig 2). There was evidence of interstitial fibrosis with use of the Gomori stain. Further immunohistochemical examination showed the presence of B cells in the specimen confirming the diagnosis of B-cell lymphoma.

**DISCUSSION**

The increase in incidence of lymphoma in post transplant recipients compared with the general population is well supported in the medical literature. These lymphomas represent a spectrum of abnormal lymphocytic proliferation which is indistinguishable from non-Hodgkin lymphoma, usually of B-cell origin. Despite the high frequency of intrathoracic manifestations of PTLD (7%-60% of all organ transplant patients), the involvement of the thoracic wall is rare, and the development of such lesions has not previously been reported.

Several factors have been implicated in the advent of PTLD. These include the oncogenicity of the immunosuppressive therapy and the chronic antigenic stimulation by the allograft. The possibility of a viral infection by the Epstein-Barr virus inducing a lymphocytic proliferation has also been considered. The time course from the organ transplant to the onset of lymphoma varies according to the type of immunosuppressive drugs. Post transplant lymphoproliferative lesions may occur approximately 8 to 15 months in the cyclosporine group, whereas a longer period of 44 to 48 months was reported in the azathioprine cyclophosphamide group. The latter group was used in this case, and the lesions were detected 7 years (84 months) after the therapy was initiated.

The risk of development and prognosis of patients with PTLD may be more related to the degree of immunosuppression than to the type of immunosuppressive drugs used. It has also been reported that the lesions may regress after the withdrawal of the immunosuppressive therapy. In the current literature, there are few publications on post transplant osseous lymphomas, and we are not aware of any report on their regression after the removal of the immunosuppressive drugs.

On conventional radiographs, non-Hodgkin lymphoma of bone is most commonly observed as a purely osteolytic defect in the majority of cases. However, it may be seen in combination with osteosclerosis or less frequently appearing in an homogeneous sclerotic fashion. Radionuclide studies are reported to be more sensitive than conventional radiographs in displaying the lymphatic lesions and usually show intense uptake in the involved areas, as illustrated in our case. Although the skeleton is rarely affected in patients
with PTLD, such a possibility should not be discounted. The presence of a focal bone lesion on conventional radiographs and/or bone scintigraphy in this patient group must be thoroughly investigated with these imaging modalities followed by biopsy.

CONCLUSION

This case report presents an unusual presentation of a solitary bone lymphoma of the rib which was pathologically proven in a renal-transplant recipient. The PTLDs represent lymphomas induced by immunosuppressive therapy in organ-transplant recipients. Such lesions may appear in any organ or system, although this is distinctively unusual to involve the skeletal system.

REFERENCES

Objective: To discuss the assessment, diagnosis and chiropractic management of a patient with sacroiliac joint dysfunction (SIJ) complicated by psoas major snapping hip syndrome (coxa saltans interna).

Clinical Features: A 32-year-old male marathon runner experienced low-back and left hip pain without radiation accompanied by a “popping” in the anterior hip. He ran approximately 100 to 150 km/wk for the prior 3 years. He had stopped running for the previous 3 weeks because of worsening and consistent pain.

Intervention and Outcome: Treatment consisted of side posture SIJ “diversified” manipulation and myofascial release to the psoas muscle twice weekly for 2 weeks. The patient was also taught proprioceptive neuromuscular facilitation exercises of the psoas and iliotibial band muscles. He was instructed to substitute swimming instead of running on a daily basis. Reassessment at 3 weeks found the patient without pain in his hip or back and no clicking or popping in his left hip.

Conclusion: Clinicians should consider that runners who present with coexisting SIJ dysfunction and internal snapping hip syndrome may benefit from the combined management of both conditions. (J Manipulative Physiol Ther 2005;28:67.e1-67.e7)

Key Indexing Terms: Running; Sports Injuries; Sacroiliac Joint; Low-Back Pain; Chiropractic; Hip

In manual medicine, the sacroiliac joint (SIJ) is widely accepted as a potential source of low-back pain. The prevalence of sacroiliac joint dysfunction (SIJD) in the general population has been estimated to be between 13.8% and 47.9%. A typical distance runner may run 130 km/wk in training and will subject his or her body to approximately 40,000 foot strikes per week. This high load is applied on a repetitive basis, increasing the potential of an injury to the SIJ. In the running population, injuries to the SIJ are not as common as those occurring in the lower limb. Injuries pertaining to the back, pelvis, hip, and thigh account for approximately 11% to 35% of all injuries sustained by distance runners and sprinters of varying levels of ability. Although less common in runners, overuse injuries of the lumbar spine and pelvis can frequently be debilitating, requiring prolonged periods of rehabilitation.

Several papers regarding “snapping hip syndrome” refer to this syndrome as “coxa saltans.” In most cases, the audible or palpable “snapping” sensation that characterizes snapping hip syndrome is painless and can be treated conservatively. Snapping hip syndrome can be attributed to a number of causes and is divided into 4 types: internal, external, posterior, and intra-articular.

Internal snapping hip syndrome (ISHS) is characterized by an audible or palpable snapping of a hypertonic iliopsoas tendon over the iliopectineal eminence as the flexed hip is extended. Flexion stress of the lumbar spine is the most common cause of hypertonicity of the psoas muscle. This can result in flexion strain on the SIJ and produce pain in the sacral area and hip. External snapping hip syndrome typically occurs when the thickened portion of the iliotibial band snaps over the greater trochanter or because of fibrosis of the gluteus maximus. Fickel and Schneider both write of the possible association of snapping hip syndrome and SIJ dysfunction. Posterior snapping hip syndrome occurs when the long head of the biceps femoris moves over the ischial tuberosity. Lastly, the iliofemoral ligaments rolling over the femoral head are responsible for the intra-articular type of snapping hip.

Sacroiliac joint dysfunction is a term often used to describe pain in or around the region of the joint that is presumed to be caused by biomechanical disorders of
joint (eg, hypomobility, malalignment, fixation, and subluxation). This paper presents the clinical presentation, diagnosis, and chiropractic management of a case that illustrates the proposed relationship between SIJD and ISHS in a marathon runner.

CASE REPORT

Clinical Presentation

A 32-year-old male marathon runner had low-back and left hip pain without radiation. The pain in the low back and left hip started at the same time 6 weeks before his initial visit. He indicated the “hip pain” was on the lateral aspect of his thigh below the greater trochanter and ended approximately 10 cm above the lateral knee. The patient also indicated that his “back pain” was located 2 cm inferior to the left posterior inferior iliac spine. He attributed the complaints to no particular incident. He reported that he ran approximately 100 to 150 km/wk for approximately the last 3 years. The patient explained that his running was primarily on flat roads, but he did train by running up and down hills once per week. He denied any increase or decrease in symptoms because of variations in training. He stopped running for the previous 3 weeks because of worsening hip and back pain.

The pain in the hip and back were described as “a deep ache” and “generalized stiffness.” He stated that he had the sensation of the hip being “weak” but reported no objective weakness. He frequently felt a “small pop” in the anterior left hip. Normal walking, running, and riding a bicycle aggravated both the hip and low-back pain. Resting relieved the pain, except in the morning when the pain was increased. Approximately 1 year prior, the patient had his running style evaluated at a marathon clinic by a running coach. The coach found no major problems with running style but suggested that the patient buy new shoes 4 times a year to prevent injury because of the high mileage he consistently ran. The patient wore custom-made orthotic foot supports that corrected previously diagnosed bilateral hyperpronation.

He denied any other gait or health problems. He had no history of any other low-back or hip problems. For his current hip and low-back complaint, he had been receiving physiotherapy 3 times per week over the previous 3 weeks. Physiotherapy had consisted of interferential current on the lumbar paraspinal muscles for 10 minutes and supine knee to chest stretching. He had discontinued physiotherapy 5 days before his initial visit because he noted no improvement.

Physical Examination

Examination revealed strong and equal bilateral hip strength in internal rotation, external rotation, abduction, adduction, and extension. In contrast, left hip flexion fatigued within 5 seconds compared with right hip flexion, which fatigued after 10 seconds. Lumbar spine and hip ranges of motion measured with dual inclinometry were within normal limits with the exception of left hip extension, which was decreased by 25% compared with the right. Lumbar, sacroiliac, and hip joint plays were assessed by motion palpation of the joints. Standing motion palpation showed decreased hip and SIJ play into extension on the left compared with the right.

Left Yeoman (Fig 1), SIJ compression (Fig 2), prone passive hip internal (Fig 3) and external rotation (Fig 4), and heel to buttocks tests (Fig 5) all reproduced the pain of chief complaint below the left posterior superior iliac spine.

Fig 1. The Yeoman test. The prone patient’s thigh is passively extended at the hip while the ipsilateral posterior superior iliac spine (PSIS) is held firmly. Reproduction of the pain of chief complaint at the ipsilateral PSIS is a positive test.

Fig 2. The SIJ compression test. The examiner places direct pressure to the side lying patient’s pelvis in line of the SIJ. Reproduction of the pain of the chief complaint at the ipsilateral PSIS is a positive test.
The same maneuvers performed on the right were unproductive. Thomas and Gaenslen tests showed slight decreased range of motion of the left hip into extension when compared with the right, suggesting hypertonicity of the left psoas muscle. Left Ober and Nobel tests showed a mildly hypertonic and tender left iliotibial band. Straight leg raise on the right was unremarkable, but on the left, passively lowering the leg to the table caused a palpable and audible click from the anterior left hip region. The patient noted the click was similar to the “pop” he frequently felt in his hip. Palpation revealed mildly hypertonic and tender lumbosacral paraspinal and erector spinae muscles on the left. On the anterior hip, the left iliopsoas tendon was tender to palpation.

A diagnosis of left SIJD with concomitant ISHS (coxa saltans interna) was made. A mild left iliotibial band syndrome was also present.

**Treatment**

Initial treatment consisted of 3 components to address both the muscular and articular aspects of the complaint. Side posture SIJ diversified manipulation\(^{19}\) was used to enhance the motion of the hypomobile left SIJ. The patient was positioned in a comfortable side lying position with his left side up and left thigh bent less than 90° on the adjusting table. Increased isolation of the joint was achieved by minimizing counter rotation of the patient’s torso and shoulders in relationship to the pelvis. An open-hand contact with the hypothenar aspect of the hand was made on the left PSIS. A high-velocity low-amplitude impulse thrust coupled with transfer of pelvic and torso weight onto the doctor’s hand was applied to the left PSIS. The thrust was along an oblique sagittal plane in an posterior to anterior and inferior to superior direction.\(^{19}\) An audible cavitation was heard.

Myofascial release\(^{20}\) was used to address the hypertonicity of the psoas tendon. The myofascial release used in this case involved the doctor applying moderate digital pressure to the involved tissue in a direction proximal to distal while actively moving the muscle through its range of motion in both eccentric and concentric contraction phases. This action was performed to patient tolerance 3 or 4 times per treatment session. Both manipulation and myofascial release were used during each office visit, and the patient was seen twice weekly for 2 weeks.

The patient was taught proprioceptive neuromuscular facilitation (PNF) exercises\(^{21}\) of the psoas and iliotibial band muscles to facilitate neuromuscular reeducation. The PNF
exercises consisted of 3 sets of 5 repetitions or cycles. The patient was instructed to do the exercises 5 times a day with approximately 1 to 2 hours between sets. He was also instructed to incorporate breathing techniques to enhance relaxation. The patient was instructed in 2 types of PNF exercises. “Hold-relax” PNF exercises involved an isometric contraction of the muscle and “contract-relax” used isotonic resistance. He was instructed to substitute a half hour of daily swimming instead of running.

The patient noted immediate improvement in all his symptoms the day after the first treatment. When asked to rate his improvement from 0% to 100%, he stated that he was “25% improved.” One week later, the patient had noted continued improvement and rated his improvement as “75% improved.” Because of the decrease in his symptoms, the patient decided to run 5-km distances every day and did so without any increase in symptoms. Two weeks after the onset of treatment, he was significantly improved and was running 10 km at a time without symptoms. At this time, the patient stated that he “feels great, 95%.” The patient in this case also commented that he was satisfied that he could return to running and training in the period of less than 3 weeks. This is consistent with Engsberg et al, who state that the majority of runners are pleased that they can maintain regular training during chiropractic treatment.

At this time of treatment, frequency was decreased to 1 time per week, and PNF exercises for the lower extremity were taught to the patient with the goal of preventing future injury. The PNF exercises included the addition of the gastrocnemius, soleus, hamstrings, quadriceps, gluteals, and hip adductors.

Reassessment at 3 weeks found the patient without pain in his hip or back, no clicking or popping in his left hip. The patient described the condition as “100% improved.” Bilateral hip flexor strength was equal and strong, and both the right and left took longer than 10 seconds to fatigue. Lumbar, sacroiliac, and hip joint plays had no restrictions. Left Yeoman, SIJ compression, prone passive hip internal and external rotation, and heel to buttocks no longer provoked pain. Thomas and Gaenslen tests showed minimal and equal bilateral psoas tightness and no pain. Ober and Nobel tests showed normal tone and absence of tenderness in the left iliobial band. Palpation revealed normal tone of the lumbosacral paraspinal, erector spinae muscles, and iliofemoral tendon which were not tender to palpation. The patient was released from treatment. Two weeks after the end of treatment, he ran a 42-km marathon and then another 42-km marathon 6 weeks after the end of treatment without hip or back symptoms. A 6-month follow-up reexamination found the patient still asymptomatic.

**Differential Diagnosis**

The hip and the pelvis are commonly injured in athletes. A variety of sports injuries in the soft tissues or bones may involve the pelvis and the hip. The most common sports-related injuries in the hip, pelvis, and thigh areas are muscle-tendon conditions involving the adductors, hamstrings, abdominals, iliofemoral (ISHS), rectus femoris, and the iliobibial band (external snapping hip syndrome).

Sacroiliac joint syndrome and posterior joint syndromes are the most common referred pain syndromes. Herniated nucleus pulposus and lateral spinal stenosis are the most common nerve root compression lesions. Referred pain syndromes occur nearly twice as often and frequently mimic the clinical presentation of nerve root compression syndromes. Combined lesions occurred in 33.5% of cases. It is suggested that sacroiliac syndromes can coexist with lumbosacral anomalies.

Sacroiliac joint dysfunction is diagnosed by physical examination. No laboratory or radiographic examinations for SIJD exist. Our criteria for the diagnosis of SIJD in this case included positive SIJ pain provocation tests and absence of radiculopathy or other anatomic abnormality. Provocation tests were deemed positive if familiar, similar, concordant pain occurred while the SIJ in question was tested. Evidence of abnormal SIJ motion was identified and
considered in this case but given less priority in arriving at the diagnosis. This was done because despite little data to support the use of symmetry or movement tests in the diagnosis of SIJD, there is some evidence that supports the use of pain provocation tests and the patient’s report of pain.2,8,29,31,32

Regarding the treatment of SIJD, the medical literature advocates the use of bed rest, heat, cryotherapy, nonsteroidal anti-inflammatory drugs, and muscle relaxants. In recalcitrant cases, fluoroscopically guided injection of the SIJ with a corticosteroid and a local anesthetic or sodium hyaluronate (a hyaluronic acid derivative) can be effective.33 Chiropractic treatment of SIJD often includes manipulation to the involved SIJ, cryotherapy, and stretches and/or exercises to the adjacent musculature.10,34,35

The presence of ISHS was identified by an audible and palpable snapping of a hypertonic iliopsoas tendon over the iliopsoas tendinous insertion as the patient’s flexed hip was extended.10,14 Choi et al12 and Pelsser et al36 looked at ISHS with dynamic ultrasonography of the iliopsoas tendon during hip motion in patients with snapping hip syndrome. Distinct abnormal motion of the tendon corresponding temporally to the painful palpable and audible sensation was shown in both studies.12,36 Iliotibial band syndrome was identified by pain in the left lateral hip, and the pain was reproduced by palpation and orthopedic tests that stressed the iliobial band. Additional orthopedic testing showed contracture of the iliobial band. These findings were in absence of other hip or knee abnormalities.

**DISCUSSION**

Meckel37 first described motion in the SIJ in 1816. Since then, many investigations have been made regarding the quantity and quality of motion within the SIJ.

The SIJ is a strong joint with limited mobility. It mechanically serves as a force transducer and a shock absorber. The gluteus maximus and piriformis muscles blend with the SIJ ligaments. The psoas muscle does not directly interact with the SIJ but does superimpose itself over the anterior joint and contributes to SIJ flexion, as well as the self-bracing mechanism of the pelvis.38,39 The SIJ has a complex role as part of 3 closed kinematic chains involving the lumbar spine, sacrum, pelvic girdle, and lower extremities. When problems exist in 1 of the kinetic chains, this will cause dysfunction around and within the other 2 joint systems.38,39

The SIJ has been questioned as a source of low-back pain, because it is suggested that well-recognized pain-sensitive structures, such as the posterior facet joints and nerve roots, may refer pain to the SIJ region. The anatomy and location of the SIJ complicate the situation, because examination procedures presumed to test the joint may actually test other structures in the region. The English medical literature describes dozens of test procedures for the examination of the SIJ. Many of these tests have not shown reasonable levels of validity or reliability.1,2,8,18,29-31,40-42

Currently, the most reliable method shown to establish the diagnosis of SIJD is fluoroscopic-guided intra-articular injection of a local anesthetic preceded by a sacroiliac arthrogram.17,43,44

Many studies do not support the use of a single provocative SIJ maneuver to confirm a diagnosis of SIJD.2,29,30,41,42 A single positive maneuver can, at best, enter SIJD into the differential diagnosis. However, studies suggest that a multitest regimen of 3 to 5 SIJ pain provocation tests may be a reliable method to evaluate SIJD.2,8,29,31,32

With regards to the lumbar spine, pelvis, and hips, the relationship between disturbances to the normal kinematic pattern of these segments during running and increased incidence of injury has been reported.45 Lewit46 suggests that both soft tissue and osseous factors are present in articular dysfunction and that either factor may predominate in any particular case. Anterior pelvic tilt, thought to be associated with tightness of the psoas major muscle,45 or increased lumbar lordosis caused by tight erector spinae47 are examples of other abnormalities.

Studies have assessed and recognized the coordinated movements of the knee, ankle, and subtalar joints during running.48 In comparison, research on the integrated biomechanical function of the lumbar-pelvis-hip complex during running is less common.49 The mechanics of the joint complex has been studied using infrared markers, pressure plates, and electromyography.6,48,50-53 The lumbar-pelvis-hip complex is highly coordinated during running.3,17,43 Awareness of the coordination and interaction of the osseous and muscular factors may facilitate the rehabilitation of running injuries to the pelvis and hip.

**CONCLUSION**

This paper discusses the assessment, diagnosis, and treatment of the proposed relationship between ISHS and SIJD in a marathon runner. Although SIJD is recognized as a cause of low-back pain in runners, its precise role is still under debate. One potential reason that SIJD is still controversial may be because of coexisting conditions such as ISHS complicating the clinical picture. Clinicians should consider that runners who present with coexisting SIJD and ISHS may benefit from the combined management of both conditions.

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COMMENTARY

A REVISED DEFINITION OF MANIPULATION

Howard Vernon, DC, PhD,a and John Mrozek, DCb

We write this commentary to address a problem that we feel exists in the description of chiropractic theory regarding the definition of spinal manipulation. We will first outline the background of the problem and then state the problem as it exists currently. We will then propose a revised definition to more accurately describe spinal manipulation.

BACKGROUND

In 1976, Sandoz1 published an important article entitled “Some physical mechanisms and effects of spinal adjustments.” In this article, Sandoz published a figure which was meant to describe the nature of joint manipulation with respect to where, in the total arc of the motion of a joint, manipulation was proposed to take place. Sandoz’s figure is shown in Fig 1. The figure was particularly effective in identifying several phases of a joint’s total motion, starting with the active range, defined as the range capable of being voluntarily produced by a person with their own motor power. Sandoz postulated that a further movement could be produced passively, either by the person themselves or by an external agent (ie, therapist), where ‘passive’ implied the imposition of externally applied force.

The outer margins of the figure represent the anatomic limit of motion of a joint, beyond which injury would occur to any of the holding elements and, with severe enough force, to the bony elements themselves. Active and passive motions are clearly shown to be less than, that is, within, the anatomic limit.

Sandoz postulated the presence of a “paraphysiologival space,” beyond the passive range, but less than the anatomic limit. It was “into” this space that he postulated that a manipulation occurred. This “space” was described by others as a “zone of end-play,” the “barrier,” or “the capsular pattern.” All of these terms are based on the notion that, at the end of “normal motion,” there exists a zone of elasticity in the joint which can be decreased in a joint which has lost some of its flexibility. The clinical term for this state has, as well, been given various names by all the schools of manipulation. Chiropractors have used the terms “subluxation” and “fixation”; osteopaths use the term “somatic dysfunction”; medical and physiotherapeutic specialists use terms such as “dysfunction,” “barrier,” and “loss of end-play.” All of these terms contain the notion of “hypomobility.” We propose that the generic term for this problem is “joint dysfunction.”

This concept has been incorporated into the description of various palpatory procedures to assess joint motion. The palpatory experience which is proposed to match with normal joint motion is a feeling of smooth motion ending in a feeling of “play” or “spring” at the end of the passive range. Osteopaths used the term “case” to describe this normal palpatory feel. An abnormal finding would be the feeling described in the term “blockage,” whereby the palpated motion is felt to stop before the expected end-range (perhaps as compared with the opposite side if it is healthy) and be accompanied by a “hard end-feel.”

Before stating the problem alluded to in the introduction, it is timely to recognize that recent spinal biomechanics experts have introduced the term “neutral zone” to describe the zone within a joint’s motion which produces little if no actual stress on the intrinsic tissues and within which minimal muscular activity is required for joint stabilization. For example, Panjabi et al determined that the neutral zone for C1-C2 rotation was approximately 28°, whereas the normal full active range is approximately 40°. The notion of an “elastic zone” has also been proposed which is a zone in normal subjects which extends beyond the “neutral zone” and within which tissues undergo physiological levels of strain which increase but still remain less than sufficient to produce disruption or injury of tissues and within which higher levels of muscle recruitment occur for active stabilization. Klein et al have described the situation of clinically restricted joint motion as “being stuck in the neutral zone.”

It is tempting to fit these 2 concepts into the model proposed by Sandoz. A rough equivalence might posit that the neutral zone lies within the “active” range, whereas the
elast zone might approximate the limit of the normal active zone.

**The Problem**

The problem we allude to can be appreciated from an inspection of Sandoz’s original figure. In that figure, he placed manipulation as an “event” which took place at the upper limit of the passive range, presumably at the “barrier” or “paraphysiological space.” Fig 2 depicts this configuration with hypothetical percentage figures. Note that the anatomic limit of motion is considered to be 100%; therefore, the active range is considered to be approximately 80% of that maximum. Based upon our common clinical experience and the documented literature, we propose that the magnitude of the passive range is 10% to 15% of the active range. We also depict the “paraphysiological space” as no more than 1% to 2%, realizing that it has never been measured and is experienced by practitioners as no more than a “play” or “give” at the end of the passive range. Applying these percentages to Sandoz’s model, we can see that manipulation is proposed to take place at upward of 90% to 95% of the total range of the joint in at least one of its operational ranges.

We state the problem as follows: manipulation is proposed to take place at the upper limit of the normal range of a joint, where the paraphysiological space approximates the limit of the anatomic range available to that joint in that particular plane of motion. This does not accord with the practical clinical circumstances in which manipulation is typically applied. Nor does it actually accord with the theory of hypomobility, as noted above. If hypomobility is the “joint state” associated with dysfunction, which, by definition, means it is the clinically important status of the joint, and if it is the purpose of manipulation to address dysfunction by improving mobility, then by definition, manipulation must be delivered to a joint with clinically significantly less-than-normal mobility, that is, not at the end of the normal range of motion.

Is this just a matter of words? Consider the definition of chiropractic in ‘Bill 46’ An act respecting the Regulation of the Profession of Chiropractic, in the Province of Ontario: “moving the joints of the spine beyond a person’s usual physiological range of motion using a fast low-amplitude thrust.”

Now consider the definition of manipulation which was recently used in a systematic review of spinal manipulation for headaches: “low-amplitude, high-velocity thrusts in which vertebrae were carried beyond the normal physiological range of movement without exceeding the boundaries of anatomic integrity.” This quote was attributed to the team of Tuchin et al who used it in their description of manipulation in their report on a clinical trial of spinal manipulation for migraine. Thus, we have a chiropractic group using this definition, which is then repeated verbatim by a nonchiropractic team who criticizes their work.

It would seem that the definition described above and attributed to the work of Sandoz has become firmly entrenched in the profession’s consciousness. And yet, it is wrong!

Another source of this problem could arise from a series of studies by Roston and Wheeler-Haines, Unsworth et al, and Miereau et al which investigated joint cavitation in the metacarpal-phalangeal joint. The first 2 of these studies are mentioned by Sandoz, and the figure plotting the relationship between traction force on this joint versus distraction of the joint surfaces has become part of the theoretical “folklore” of the profession. The work of these authors shows where, in this plot of force versus distraction (Fig 3), a sudden increase of distraction is seen and is accompanied by a “crack.” Miereau et al even showed the vacuum phenomenon which occurred postcrack as evidence of the cavitation which was proposed to be responsible for the cracking sound.

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**Fig 1. Sandoz model.**

**Fig 2. Model with hypothetical percentage figures. AC, Active range; P, passive range; PH, paraphysiological space (small zone of joint play or “give”); A, anatomic limit.**
These studies have been used to support the theoretical foundation of joint manipulation. The problem with these studies is that, although they do depict cavitation occurring at the extremes of normal joint motion, these joints were just that—normal. So the features of what appears to occur in a normal joint undergoing manipulation have osmosed to the circumstances of therapeutic manipulation to a clinically abnormal joint, without appreciation for the important differences between these 2 states.

**DISCUSSION**

Fig 2 shows a hypothetical single normal spinal joint (ie, motion segment) in its plane of rotation. Regardless of the actual absolute amount of unilateral rotation at any specified joint (ie, at C1-C2 = 45°; at L5-S1 = 1°-2°), this range can be divided into the phases identified by Sandoz. As noted above, if the anatomic limit is defined as the point beyond which injury occurs, and if this is designated as 100%, then the active range is well below this limit and the passive range only approaches it. The upper end of the passive zone could probably be renamed the “nociceptive zone,” whereby forced movement into this zone would be painful, but not necessarily fully injurious. However, beyond the anatomic limit of motion, injury and pain would ensue. The “paraphysiological space” is represented in these figures as a 2% zone.

**Fig 3.** Distraction and the creation of the “crack” sound.

**Fig 4.** Typical circumstances in which manipulation is used. For the definition of abbreviations, see Fig 2.

**Fig 5.** Manipulation performed within the clinical physiological range. For the definition of abbreviations, see Fig 2.

**Fig 6.** Expected results of the procedure. For the definition of abbreviations, see Fig 2.
The critical point for our discussion is that Fig 2 represents the motion capacities of a normal joint. One now asks, is manipulation typically performed on such a joint? We would hope the answer is “no.” If the joint is normally mobile, why would one elect to perform a manipulation, when the purpose of that procedure is to impart force to the joint to increase its mobility? It should be noted here that the same argument could be made if, instead of motion, we selected the joint’s alignment as the critical feature. If a joint is normally aligned, why perform manipulation?

If the logic applied here is that manipulation is only performed on joints whose motion is not normal, by which we mean here that it is reduced (the problem of hypermobility or instability will be set aside for now), then Fig 4 we mean here that it is reduced (the problem of hypermobility or instability will be set aside for now), then Fig 4 depicts the typical circumstances in which manipulation is actually used. This figure is described as the “clinical situation,” not the normal situation. The range of motion available in the clinical situation is now called the “clinical physiological range.”

Fig 5 shows that manipulation is performed within the “clinical physiological” range. The figure attempts to show that the actual manipulation is not performed at the limit of the clinical physiological range, for that would provoke pain. Rather, it is performed at a point slightly before this range. The combination of subtle passive motions arranged by the chiropractor at that point creates what has been called the “closed pack” position. From this point on, we assume that a “paraphysiological” space is available within which the joint will cavitate and into which the impulse of the manipulative thrust is performed.

Fig 6 shows the expected result of this single procedure. The clinically restricted joint now has improved range of motion or less pain through more motion. This model has been confirmed by studies such as those by Cassidy et al., Nansel et al., and Whittingham and Nilsson for range of motion increases after manipulation and by studies reviewed in Vernon for decreases in pain after manipulation.

It should be noted here that this discussion has not addressed the potential mechanisms responsible for these changes. These may be mechanical or neurophysiological in nature or, as is likely, a combination of both of these.

As well, we recognize that this model presents an idealized version of joint motion in only one plane. We have not addressed the issue of the more complex, but realistic situation of joint dysfunction in several planes, whereby the actual “fixation” may be found in a 3-dimensional space which requires more careful and perhaps more subtle analysis by the practitioner.

Finally, we have completely ignored the issue of whether manual palpatory procedures can accurately and reliably identify the physical findings to which we allude in this discussion, particularly those hinted at in the paragraph above. These areas are fruitful directions for future thought and research.

CONCLUSION

We propose that what is described as the “Sandoz model” of joint dysfunction and manipulation requires revision. We have presented a revised model which presents the notion of a clinical physiological range of motion which more accurately defines the clinically important “joint state” or joint dysfunction, at least in one plane, and which also more accurately defines where in that state manipulation is applied. We hope this stimulates our readers and encourages their thoughtful critique.

ACKNOWLEDGMENTS

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INFLUENCE OF ACTIVE RELEASE TECHNIQUE ON QUADRICEPS INHIBITION AND STRENGTH: A PILOT STUDY

To the Editor:

A study is more likely to appear in the literature and thus be indexed and publicly accessible, if it shows a strong statistically significant or positive result. A study that does not show such results has a greater chance of ending up in a file drawer, either because the author or his employer did not think the result was worth reporting, or because a journal was less interested in publishing a study that came up with negative findings. This decreased likelihood of study results being published when they are not statistically significant or are otherwise less interesting is referred to as publication bias.

In 1995, journals of complementary and alternative medicine published virtually no studies (1%) with negative results.1 By 2000, the percentage of studies with negative results being published in journals of complementary and alternative medicine had only improved to 5%.2 Furthermore, publication bias has been shown to be rife throughout much of the biomedical literature 3-6 suggesting that the peer-reviewed biomedical literature is far from objective. I therefore applaud the decision of the authors to submit and editors of the Journal of Manipulative and Physiological Therapeutics to publish a recent pilot study7 that set out to determine if active release technique could influence strength and muscle inhibition in the quadriceps muscles of athletes with anterior knee pain, but which came to a negative conclusion.

Some from within the chiropractic profession may still assume that no good can come from making public negative chiropractic research findings. Such is not, however, the case. Progress, which some have suggested is the defining characteristic of science,8 can come in many shapes and forms. The reduction of publication bias, which necessarily depends upon the publication of more negative studies, is one such sign of progress and is therefore a marker of this profession's scientific maturation. Along with all other health care researchers and disciplines the chiropractic profession2-4 and continues to be manifest within chiropractic research (and more generally, scholarship) can and ought to play within schools of chiropractic. As well, they have touched upon 2 (perhaps the most important) factors which have inhibited the development of research climates within our institutions: “philosophy” and poverty. A word about each seems in order.

Dogma masquerading as philosophy is an old tale in the profession2-4 and continues to be manifest within chiropractic in several ways. These range from the widely disseminated, public commitment by college leaders' to inadequately tested constructs (eg, “subluxation-syndrome”),6 to instructors who insist that clinical research is unnecessary or deleterious because chiropractic is based on vitalistic premises,7,8 to those elements within the college community and wider field who argue that “we already know” chiropractic works9 and that the primary purpose of research in chiropractic is to determine basic science mechanisms of presumed effectiveness or “how and why chiropractic works so well.” Given the dearth of investigational skills, output, and skeptical attitudes within so many of our faculties,10-19 the sequestering of researchers and clinician-researchers within research departments may have the paradoxical effect of encouraging the attitude that investigation and scholarship are trivial and esoteric activities for pointy-headed non-clinicians and thereby help to perpetuate uncritical attitudes and dogma.

Underpinning the dogma and scarcity of research skills are the financial limitations of the American chiropractic colleges. Very heavy tuition dependence has been the basic economic dynamic of chiropractic education in the United States since BJ Palmer established the financial formula for training chiropractors in the early years of the

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last century. An unpublished report in 1978 indicated that at the typical, private, free-standing American chiropractic institution, 75% or more of funding for operational budgets derives from tuition, and the lowest tuition dependence of any American chiropractic college that I have ever heard of is 62% (electronic communication with J.F. Winterstein, May 17, 2002). The consequences of this reality are devastating, although seemingly unrecognized (or at least, not often publicly discussed). Heavy tuition dependence impacts who can be hired (eg, instructors vs scholars), how the faculty will be employed (eg, teaching vs investigation), and who will be enrolled as a student (almost anyone who meets the Council on Chiropractic Education’s minimal prerequisites and can pay the hefty tuition). The best of intentions (and there are certainly chiropractic institutions which would like to raise the caliber of scholarship within their communities) has not been able to overcome this poverty and its intellectual consequences.

The grapevine suggests that the derailed effort to establish a state university–based college of chiropractic in Florida may be back on track. Although it may be unfair to pin too many hopes on this still nonexistent institution, the project might provide the context in which Flanagan and Giordano’s model could be implemented. A tax-supported school of chiropractic would presumably be much less tuition-dependent. Competitive salaries and greatly reduced teaching loads could attract the talent and provide the faculty time needed to place the research mission on an equal footing with the goal of training doctors. With lessened need for tuition revenue, much greater selectivity in admissions augurs well for a better crop of chiropractors down the road. And we might expect that the university environment itself could be a factor in encouraging a more critical orientation to all things chiropractic.

I commend the authors for illustrating the potential role of research within chiropractic education and wish them well in their efforts to implement the model.

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In Response:
We endorse Dr Keating’s support of our proposed model. In concurrence, major impediments to developing chiropractic clinician-researchers are (1) mistaking dogma for philosophy and (2) an economic infrastructure that sacrifices academic excellence for financial gain. Comment is warranted on both issues. If chiropractic seeks equity in a pluralistic biomedical society, it is important to achieve philosophical congruence within that culture. Throughout biomedicine, this philosophical orientation is that of science, a dynamic worldview that recognizes and serves a changing epistemology. Dogma is the antithesis of this process. By creating untestable assumptions and solidifying belief without evidence, dogma limits critical thinking and ultimately, free will. This is not
Informed Consent: A Potential Dilemma for Complementary Medicine

To the Editor:

Professor Ernst draws attention to the need for informed consent to be obtained by complementary medicine practitioners. He makes the comment that “the United Kingdom and United States guidelines clearly want the chiropractor to explain (1) the diagnosis, (2) the benefits of the chiropractic approach for neck pain, (3) its risks, and (4) the risks/benefits of other therapeutic options.” A point to be made is that why is complementary medicine expected to go to such lengths when practitioners of orthodox medicine rarely, if ever, seek informed consent for the prescription of the medications which they order? For instance, the prescription of penicillin is so commonplace so as not to apparently require informed consent when it is recommended, yet the mortality rate of such a prescription from anaphylaxis could be 50 times greater than from an outpatient spinal manipulation treatment. The same statistics would apply to most other drug treatments.

Meta-analysis of studies concerning a treatment is a valuable assessment tool, providing that the initial search encompasses the key issues of the therapy. This is not the case here: Ernst’s research ignores the neurological benefits of spinal manipulation therapy. For example, Ernst remarks “other treatments that have shown promise in the treatment of neck pain include exercise therapy, which is virtually free of serious adverse events or complications.” Before recommending this type of therapy to chiropractors, Ernst should recognize that chiropractic does much more than relieve neck pain. The recovery of vision is an acknowledged effect of spinal manipulation, so in dealing with informed consent for spinal manipulation therapy, the risk/benefit ratio has to be considered. It is of little value to recommend exercise therapy, compared with spinal manipulation, if there is no evidence available to validate its effectiveness in regularly improving vision, in appropriate patients, which spinal manipulation clearly does.

The chiropractic profession has only itself to blame for the fact that Professor Ernst has been able to denigrate spinal manipulation therapy by reference to clinical trials, which question its efficacy. It is now 3 decades since it was shown that vision improved with spinal manipulation treatment. The same statistics would apply to most other drug treatments.

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REFERENCES
In Response:

This letter raises several interesting points. “Practitioners of orthodox medicine rarely, if ever, seek informed consent...” If this is true, these practitioners are breaking the rules and should be held accountable for it. To say “they” do not behave ethically so we do not need to either is hardly a reasonable approach.

“The recovery of vision is an acknowledged effect of spinal manipulation...” I would like to see the evidence from conclusive randomized controlled trials for this acknowledged effect. One uncontrolled study of 12 patients is clearly not sufficient. Once the evidence is available, I would include it in any meta-analysis of the subject.

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INFORMED CONSENT: A POTENTIAL DILEMMA FOR COMPLEMENTARY MEDICINE

To the Editor:

What an interesting commentary by Professor Ernst.1 In it he quotes his own systematic review of chiropractic for neck pain and states that this is the most up-to-date review. Unfortunately, he does not say that this review has been thoroughly and ably criticized by Peloso and Gross.2 In fact, they have done such a skilled job at criticizing Ernst’s review that I would refer all your readers to their article in the Journal of Pain [October 2003; 6 (8)]. This critique of Ernst’s work is so detailed and solid that it is a lengthy article, although still worth reading.

However, one can summarize the shortcomings of Ernst’s review as follows:

1. Poor search of the literature, because of costs apparently,
2. Lack of adherence to any strict procedures for review studies, such as The Cochrane Back Pain group.
3. Use of the Jadad system to score the quality of studies. Previous groups have shown this system to be inadequate for any of the physical therapies, and
4. Data analysis done by one person against the recommendations of all standard texts on systematic review.

The shortcomings of this study are so critical that the value of the review is sadly very low. In complete fairness to Ernst, he does mention that the others have come to “more positive conclusions,” but he fails in his commentary to mention what those conclusions are. On the other side of the equation, the potential for vertebral dissection is a possibility that chiropractors have dealt with for many years, and yet still, there is no definitive data on occurrence levels. The Danish retrospective study suggested less than 1 in 1000000.3 Haldeman4 in his study suggests 1 in 5 800 000. Chiropractors should indeed tell patients about this risk, but contrary to Ernst’s idea, this is not an off-putting thing to a patient who is informed about the risks involved in all treatment methods and especially those who have already tried exercise therapy alone. In fact, patients appreciate the honesty of being informed. The unfortunate thing about Ernst’s constant concerns for patients with neck pain is that he has never at any stage published any criticism of informed consent for the use of nonsteroidal anti-inflammatory drugs in the care of neck pain. Present estimates of mortality rates vary, but not far from 1:12000.5 We have yet to hear Professor Ernst suggest that allopathic physicians should tell patients with neck pain that chiropractic is safer treatment than using nonsteroidal anti-inflammatory drugs.

The truth is that patients are entitled to the honest opinion of their treating physician. That will no doubt always be a bias interpretation of the currently available scientific data. In our clinic, we inform patients of the estimated risks and respect their opinions during treatment, but most patients including the medical doctors that we treat are happy to undergo our recommended care.

Ernst should, in my view, relook at this issue while taking account of the valid criticism his previous papers have attracted.

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REFERENCES

In Response:

This comment, I fear, is largely based on a misunderstanding of my article. I do not agree that Peloso et al have invalidated my systematic review with their critique. The commentator omits to mention the fact that the publication of their critique was directly followed by a rebuttal which set the record straight. In any case, I did say (as the commentator mentions) that others came to different conclusions. Most importantly, I do not quite see how this impacts on the intention of my article, that is, to stimulate a discussion on informed consent. The commentator seems to misread my article as a review of the efficacy and safety of spinal manipulation.

The author also believes that I should address the issue of “informed consent for the use of nonsteroidal anti-inflammatory drugs in the care of neck pain”. Yet, I am professor of complementary medicine, not of pharmacology. I would be happy to “suggest that allopathic physicians should tell patients with neck pain that chiropractic is safer treatment than using nonsteroidal anti-inflammatory drugs,” but there are 2 problems with this. First, this is not quite as clear as the commentator thinks—the lack of a formal reporting scheme and the significant level of underreporting of adverse effects invalidate all estimates of adverse effects of spinal manipulation. Second, the absolute risks are almost irrelevant compared with the risk-benefit profiles of each therapy.

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REFERENCES