Sunburn Related to UV Radiation Exposure, Age, Sex, Occupation, and Sun Bed Use Based on Time-Stamped Personal Dosimetry and Sun Behavior Diaries

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Objective: To assess when sunburn occurs and who experiences sunburn by personal UV dosimetry and diaries.

Design: Open prospective observational study.

Setting: University hospital.

Participants: A convenience sample of 340 Danish volunteers: children, adolescents, indoor workers, sun worshippers, golfers, and gardeners (age range, 4-68 years).

Main Outcome Measures: Subjects recorded sunburn and sun-exposure behavior in diaries and carried personal, electronic, wristwatch UV radiation (UVR) dosimeters that measured time-stamped UVR doses continuously for a median of 119 days covering 346 sun-years (1 sun-year equals 1 subject participating during 1 summer half-year).

Results: A typical sunburn day was a day off work (91%; odds ratio, 4.1) with risk behavior (sunbathing/exposing shoulders) (79%; odds ratio, 15.9) in May, June, or July (90%) for 6.4 exposure hours (interquartile range, 5-7.7 hours), of which 2.8 hours fell between noon and 3 PM. Subjects had a median of 1 sunburn per sun-year; adolescents, sun worshippers, and indoor workers had more than children, golfers, and gardeners (P<.05). Sunburn peaked at age 20 years, and female subjects had more sunburns than male subjects (P<.01). Skin type IV had fewer sunburns than types I through III (P<.01). Sunburned persons had more risk-behavior days and lower skin type (P<.01) than nonsunburned persons. The median UVR doses received were significantly higher on sunburn days than on nonsunburn days with risk behavior (P<.01). There was a significant correlation between sunburn size and severity; sunburn and sunscreen use; and sunburn and sun-bed use (P<.01 for all 3 comparisons).

Conclusions: Sunburn was highly correlated with risk behavior. Reduction of risk-behavior days and/or exposure hours around noon can reduce sunburn. Sunburn was not found during breaks on normal full-time indoor work or school days.

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Sunburns play an important role in the development of skin cancer, especially malignant melanoma.1-4 The relationship between sunburn and phenotype, age, sex, and behaviors that place a person at risk for sunburn has been reported by many researchers who conducted retrospective interviews or self-reported surveys, which are subject to recall bias.5-11 In addition, Autier et al12 conducted a dosimeter-based investigation of the connection between UV radiation (UVR) doses and sunburns when sunbathing.12

We report the results of a prospective investigation over a summer half-year. Using personal dosimeters, we recorded the time-related UVR doses during all activities during the period.13 These data were supplemented with corresponding diary information about sunburn, sun-exposure behavior, and location within Denmark or elsewhere to determine who experienced sunburn and when sunburn occurred.

Our goal was to characterize a sunburn day by the UVR dose received at different times of the day, number of UVR exposure hours during the whole day and between noon and 3 PM, ambient UVR, and the type of risk behavior (eg, sunbathing). In addition, we wanted to identify groups prone to sunburn by age, skin type, and type of work so as to better focus potential sunburn prevention campaigns and thereby reduce the risk of skin cancer.

METHODS

STUDY POPULATION

This study was performed in Denmark (latitude, 56° north; longitude, 12° east) over a pe-
AMBIENT UVR EXPOSURE

Ambient solar UVR was measured with a UV biometer, model 501 (Solar Light Co Inc, Philadelphia, Pa) on the roof of a 7-floor building at our hospital. The measurements are expressed in standard erythema doses (SEDs), where 1 SED = 10 mJ/cm² normalized to 298 nm, according to the International Commission of Illumination (CIE) erythema action spectrum.14,15

PERSONAL ELECTRONIC UVR DOSIMETER, SUNSAVER

The UVR dosimeter we used was developed and assembled in our department and includes a sensor and a data logger mounted in a housing together with a digital watch. We chose a silicon carbide photodiode (JECF1-IDE; Laser Components, Olching, Germany) sensitive only in the range of 200 to 400 nm. The sensor has a built-in diffuser and cosine response with spectral response similar to the CIE erythema action spectrum.14 The data logger controls the sensor, which was set to measure every eighth second and to store the average of the last 75 measurements every 10 minutes together with the time. The measurement range of the dosimeter is 0.1 SED/h to 23 SED/h.

The SunSaver is battery driven, can run for 143 days without maintenance, and the data can be transferred to a personal computer. In an earlier study, members of our group collected reliable UVR data from wrist measurements and found a significant correlation between wrist and head UVR doses, with the wrist receiving 50% of the UVR dose received by the head.17

The subjects were instructed to replace their normal wristwatch with the dosimeter, to wear it continuously at least between 7 AM and 7 PM, and not to immerse it in water but rather place it on a towel with the sensor facing upward during swimming (the dosimeter was water resistant but not completely waterproof).13

DIARY

The participants (or the parents of the 22 children younger than 10 years) were carefully instructed how to complete the provided diary. They were to answer Yes or No to the following questions: (1) Did you wear the SunSaver today? (2) Are you off work/school or on holiday today? (3) Are you abroad today? If yes write country code. (4) Did you sunbathe today? (Sitting or lying in the sun with upper body or shoulders exposed to get a tan.) (5) Have you exposed your shoulders or upper body outdoors today? (6) Have you been at the beach or at the sea today? (7) Have you applied a sunscreen today? (If yes, write the factor number.) (8) Did you get sunburned today? If yes: Red? Red and sore? Red, sore, and blistered? On

### Table 1. Distribution of Sunburns per Sun-year

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Sun-years Recruited*</th>
<th>Analyzed†</th>
<th>Total No. of Sunburns</th>
<th>Mean (Median‡) IQR§</th>
<th>No. of Sunburns per Sun-year, 0, 1, 2, or ≥3</th>
<th>Percentage of Sun-years With 0, 1, 2, or ≥3 Sunburns per Sun-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children</td>
<td>96</td>
<td>68 (71)</td>
<td>63</td>
<td>0.9 (0.5) 0-1</td>
<td>50</td>
<td>50, 29, 9, 12</td>
</tr>
<tr>
<td>Adolescents</td>
<td>31</td>
<td>22 (71)</td>
<td>44</td>
<td>2.0 (2) 0-4</td>
<td>36</td>
<td>36, 9, 23, 32</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>120</td>
<td>111 (93)</td>
<td>163</td>
<td>1.5 (1) 0-2</td>
<td>34</td>
<td>34, 28, 18, 20</td>
</tr>
<tr>
<td>Sun worshippers</td>
<td>53</td>
<td>49 (92)</td>
<td>77</td>
<td>1.6 (1) 0-3</td>
<td>29</td>
<td>29, 27, 18, 27</td>
</tr>
<tr>
<td>Golfers</td>
<td>37</td>
<td>31 (84)</td>
<td>24</td>
<td>0.8 (0) 0-1</td>
<td>55</td>
<td>55, 32, 3, 10</td>
</tr>
<tr>
<td>Gardeners</td>
<td>70</td>
<td>65 (93)</td>
<td>45</td>
<td>0.7 (1) 0-1</td>
<td>48</td>
<td>48, 38, 12, 2</td>
</tr>
<tr>
<td>Total</td>
<td>407</td>
<td>346 (85)</td>
<td>416</td>
<td>1.2 (1) 0-2</td>
<td>41</td>
<td>41, 29, 14, 16</td>
</tr>
</tbody>
</table>

Abbreviations: IQR, interquartile range; UVR, UV radiation.

*Fulfilling the inclusion criteria of Scandinavian ancestry, no history of skin disorders.
†Number (percentage) of sun-years (1 sun-year equals 1 subject participating during 1 summer half-year) with both UVR dosimeter and diary readings for more than 30 days of which 21 or more fell in June, July, or August.
‡Golfers and gardeners had significantly fewer sunburns than all other groups except children (P<.05). Children had significantly fewer sunburns than adolescents and sun worshippers (P<.05).
§IQR, 25% to 75%.
A minimal, moderate, or extensive area? We considered a Yes response to question 4 or 5 to indicate “risk behavior,” since a great part of the body would be sun exposed.

STATISTICAL ANALYSIS

We included 390,088 days (74% of total) in our analysis, of which 416 were sunburn days as indicated by both SunSaver measurements and diary information. In all calculations, each of the 346 sun-years was weighted equally, independent of the number of days per sun-year a subject participated. We used nonparametric statistical tests because most of the data were not normally distributed. The results are therefore reported as median (interquartile range [IQR]). The Mann-Whitney U test was used to compare unpaired continuous data between groups; the Spearman rank correlation was used to investigate interactions between 2 continuous measurements; Wilcoxon paired rank-sum tests were performed on paired continuous data; and χ² tests were used to investigate associations between categorical data. Odds ratios (ORs) were calculated on individual days using the Mantel-Haenszel method. In each case, P<.05 was considered significant. We used SPSS for Windows 11.5 (SPSS Inc, Chicago, Ill) for data analysis.

RESULTS

DAYS WITH SUNBURN

On sunburn days we found a significant correlation between UVR dose and exposure hours (r=0.48, P<.01). On sunburn days in Denmark, we also found a significant correlation between UVR dose and ambient UVR (r=0.41; P<.001). In Denmark, the monthly distribution of sunburns was as follows: April, 3%; May, 18%; June, 22%; July, 46%; August, 10%; and September and October, 0%. In July, most of the participants had their holidays and reported significantly more sunburns than in any other month (P<.01). There were clusters of sunburns on a few days with exceptionally high ambient UVR.

The Figure shows the ambient UVR and UVR dose received on June 10, 2000, when the most subjects (14) were sunburned. Sunburn occurred most often on days off work, ie, 378 (91%) of 416 sunburn days (OR, 4.1 adjusted for risk behavior; P<.01), and on days with risk behavior (79% overall [range: adolescents, 91% to gardeners, 60%]; OR, 15.9 adjusted for days off work; P<.01).

SUNBURN DAYS VS NONSUNBURN DAYS WITH RISK BEHAVIOR

In all subgroups, the UVR doses and number of exposure hours were significantly higher on sunburn days than on non-sunburn days with risk behavior (P<.01) (Table 2). In Denmark, we found that ambient UVR was also significantly higher on sunburn days than on non-sunburn days with risk behavior (25.6 vs 22.7 SEDs) (P<.01), as was the percentage of ambient UVR received (median, 21.0%; IQR, 13.8%-32.8% vs median, 9.6%; IQR, 3.8%-19.0%) (P<.01). On non-sunburn days without risk behavior, the median UVR dose received was only 0.1 SED (IQR, 0-0.7 SED) in 1 exposure hour (IQR, 0-2.8 hours).

SUNBURNS PER SUN-YEAR

Adolescents had the most sunburns, significantly more than children, golfers, and gardeners (P<.05). Thirty-two percent of the adolescents had 3 or more sunburns, significantly more than any other subgroup (P<.01). Subjects with 3 or more sunburns per sun-year also had significantly more risk-behavior days than subjects having fewer sunburns or none (P<.05) (Table 1).

SKIN TYPE AND SUNBURN

Subjects with skin type IV had significantly fewer sunburns, more days with risk behavior, higher annual UVR doses, and higher mean daily UVR doses than subjects with skin types I through III (P<.01). However, we found no significant differences in UVR doses on sunburn days among the skin types. Across all skin types, significantly higher UVR doses were found on risk-behavior days with sunburn than without (P<.01). (Table 3).

SUN-YEARS WITH RISK BEHAVIOR WITH AND WITHOUT SUNBURN

Persons who experienced sunburn had significantly more days with risk behavior, a higher UVR dose on risk-behavior days, more days with sunscreen use, and lower skin type than persons without sunburn (P<.01). There were no significant differences between the sunburned and nonsunburned participants in age, annual UVR doses, mean UVR doses, exposure hours per day or between noon and 3 PM, or number of days spent in southern Europe (Table 4).
SUN-YEARS WITH RISK BEHAVIOR ON DAYS OFF WORK IN NORTHERN AND SOUTHERN EUROPE WITH AND WITHOUT SUNBURN

In both northern and southern locations, we found, as expected, a significantly higher UVR dose per sunburn day than per nonsunburn day (northern latitudes, 93% higher; southern latitudes, 62% higher) (Table 5). The subgroups having the most days with risk behavior also had the most sunburns. Even in southern Europe, where the number of risk-behavior days was limited by the length of the holidays, sun worshippers still had significantly more risk behavior and sunburns than children, golfers, and gardeners (P<.05).

AGE, SEX, AND SUNBURN

In adults older than 20 years, there was a significant negative correlation between age and number of sunburns per sun-year (r = -0.29; P<.01). In subjects younger than 20 years, there was a significant positive correlation between age and number of sunburns (r = 0.41; P<.01). Female participants had a median of 1 sunburn (IQR, 0-2 sunburns), which was significantly more than male par-

Table 2. UV Radiation Doses and Exposure Hours Per Sunburn Day and Nonsunburn Day With Risk Behavior*

<table>
<thead>
<tr>
<th>Subject Group</th>
<th>No. of SEDs per Sunburn Day</th>
<th>No. of SEDs per Nonsunburn Day With Risk</th>
<th>No. of Exposure Hours per Sunburn Day</th>
<th>No. of Exposure Hours per Nonsunburn Day With Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Day</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children</td>
<td>5.7 (2.8-15.9)</td>
<td>1.5 (0.5-4.4)</td>
<td>5.8 (4.3-7.2)</td>
<td>3.8 (2.0-5.7)</td>
</tr>
<tr>
<td>Adolescents</td>
<td>7.4 (4.6-9.9)</td>
<td>2.6 (0.9-7.3)</td>
<td>6.2 (4.1-7.1)</td>
<td>4.2 (2.3-6.2)</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>5.1 (2.7-8.2)</td>
<td>2.1 (1.0-4.4)</td>
<td>6.5 (5.0-7.7)</td>
<td>4.3 (2.7-6.2)</td>
</tr>
<tr>
<td>Sun worshippers</td>
<td>6.9 (3.0-11.1)</td>
<td>2.4 (1.0-5.1)</td>
<td>5.8 (4.6-7.3)</td>
<td>4.3 (2.7-6.2)</td>
</tr>
<tr>
<td>Golfers</td>
<td>5.8 (3.3-7.7)</td>
<td>2.9 (1.3-5.3)</td>
<td>7.0 (6.3-8.4)</td>
<td>5.5 (3.7-7.2)</td>
</tr>
<tr>
<td>Gardeners</td>
<td>4.8 (2.9-9.2)</td>
<td>2.7 (1.2-4.9)</td>
<td>6.8 (6.4-8.2)</td>
<td>6.0 (4.7-7.7)</td>
</tr>
<tr>
<td>Total</td>
<td>5.6 (3.0-10.0)</td>
<td>2.2 (0.9-4.9)</td>
<td>6.4 (5.0-7.7)</td>
<td>4.5 (2.7-6.3)</td>
</tr>
</tbody>
</table>

12 Noon to 3 PM

| Subject Group       | No. of SEDs per Sunburn Day | No. of SEDs per Nonsunburn Day With Risk | No. of Exposure Hours per Sunburn Day | No. of Exposure Hours per Nonsunburn Day With Risk |
|---------------------|-----------------------------|------------------------------------------|                                      |                                                   |
| Children            | 3.2 (0.9-10.3)              | 0.6 (0.1-2.2)                            | 2.7 (1.7-3.0)                       | 1.7 (0.7-2.5)                                    |
| Adolescents         | 4.4 (2.6-6.1)               | 1.1 (0.3-4.2)                            | 2.8 (2.2-3.0)                       | 1.8 (1.0-2.7)                                    |
| Indoor workers      | 2.8 (1.3-5.1)               | 0.8 (0.1-2.2)                            | 2.7 (2.0-3.0)                       | 1.8 (0.7-2.7)                                    |
| Sun worshippers     | 3.6 (1.5-6.1)               | 1.0 (0.2-2.7)                            | 2.8 (2.2-3.0)                       | 1.8 (0.8-2.7)                                    |
| Golfers             | 3.2 (1.6-3.8)               | 1.2 (0.4-2.5)                            | 3.0 (2.0-3.0)                       | 2.2 (1.3-2.8)                                    |
| Gardeners           | 2.7 (1.3-4.2)               | 1.1 (0.4-2.4)                            | 2.8 (2.0-3.0)                       | 2.3 (1.5-2.8)                                    |
| Total               | 3.1 (1.4-5.8)               | 0.9 (0.2-2.4)                            | 2.8 (2.0-3.0)                       | 1.8 (0.8-2.7)                                    |

Abbreviations: IQR, interquartile range, 25% to 75%; SED, standard erythema dose.
*Data are reported as medians (IQRs); risk behavior is defined as sunbathing or exposing upper body or shoulders.

Table 3. UV Radiation Doses per Risk Behavior Day With and Without Sunburn by Skin Type

<table>
<thead>
<tr>
<th>Fitzpatrick Skin Type</th>
<th>No. of Sun-years</th>
<th>Sun-years With ≤1 Sunburn, %</th>
<th>UVR Dose per Risk-Behavior Day With Sunburn*</th>
<th>UVR Dose per Risk-Behavior Day Without Sunburn*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>26</td>
<td>77</td>
<td>5.5 (4.3-8.2)</td>
<td>2.2 (1.2-3.5)</td>
</tr>
<tr>
<td>II</td>
<td>83</td>
<td>63</td>
<td>6.8 (2.9-10.6)</td>
<td>3.0 (1.8-4.3)</td>
</tr>
<tr>
<td>III</td>
<td>180</td>
<td>58</td>
<td>6.4 (3.5-9.2)</td>
<td>3.0 (2.0-4.8)</td>
</tr>
<tr>
<td>IV</td>
<td>56</td>
<td>48</td>
<td>7.7 (4.5-17.7)</td>
<td>3.5 (2.1-5.2)</td>
</tr>
</tbody>
</table>

Abbreviations: IQR, interquartile range (25%-75%); UVR, UV radiation.
*Data are presented as medians (IQRs) of standard erythema doses.
†Significantly lower than on days with sunburn (P<.01).

Table 4. Comparison of Sun-years With Risk Behavior With and Without Sunburn*:

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Sun-years</th>
<th>Risk</th>
<th>Sunburn</th>
<th>Sunscreen</th>
<th>UVR Dose per Risk Day</th>
<th>UVR Dose per Day</th>
<th>Annual† UVR Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>With sunburn</td>
<td>173</td>
<td>16</td>
<td>2</td>
<td>7</td>
<td>3.6 (2.6-5.5)</td>
<td>1.0 (0.7-1.5)</td>
<td>179 (133-250)</td>
</tr>
<tr>
<td>Without sunburn</td>
<td>127</td>
<td>13</td>
<td>NA</td>
<td>2</td>
<td>2.8 (1.8-4.4)</td>
<td>0.9 (0.6-1.4)</td>
<td>160 (110-247)</td>
</tr>
</tbody>
</table>

Abbreviations: IQR, interquartile range; NA, not applicable; NS, not significant; SED, standard erythema dose; UVR, UV radiation.
*Unless otherwise indicated, data are reported as medians (IQRs); a sun-year equals 1 subject participating during 1 summer half-year.
†The annual dose was calculated based on the individual measured daily doses and for missing days as the same part of ambient UVR, as in Thieden et al.13
participants (0 sunburns; IQR, 0-1 sunburn), and significantly more days with risk behavior (17 days; IQR, 9-29 days vs 9 days; IQR, 3-19 days). Female subjects applied sunscreen on more days than did male subjects but also had more risk-behavior days without sunscreen (8 days; IQR, 3-16 days vs 5 days; IQR, 2-12 days). Among our subgroups, golfers and gardeners had the lowest number of sunburns and the lowest number of days with risk behavior. Adolescents had the highest number of sunburns: 64% experienced sunburn, and 32% had 3 or more per season as a consequence of a high number of days with risk behavior.\(^8\) Sunburn and UVR dose per sunburn day peaked at age 20 years and decreased with age in adults, which is in agreement with other studies.\(^7,22\) Our results are in agreement with studies reporting that 53% of Canadians older than 15 years\(^8\) and 39% of a representative sample of the British population older than 16 years\(^7\) recalled having been sunburned within the last year. Among our subgroups, golfers and gardeners had the lowest number of sunburns and the lowest number of days with risk behavior. Adolescents had the highest number of sunburns: 64% experienced sunburn, and 32% had 3 or more per season as a consequence of a high number of days with risk behavior.\(^8\) Sunburn and UVR dose per sunburn day peaked at age 20 years and decreased with age in adults, which is in agreement with other studies.\(^7,22\) Even among children, 50% reported sunburn, while in the Danish population study, only 28% recalled having been sunburned.\(^20\) However, a Swedish study reported that people underestimate the number of sunburns when recalling.\(^21\) It is difficult to compare our results with the findings of other groups because the definitions of sunburn are different, and other groups used retrospective interviews or self-reported surveys.\(^3,5-11\) One group used time-stamped UVR dosimeters placed near volunteers on the ground to obtain data on UVR doses and sunburns, but only on sunbathing days.\(^12\) We chose continuous, time-stamped, personal UVR measurements of UVR doses during all kinds of subject activities and supplemented these with diary information. This approach offers the possibility to identify the time and behavior during which sunburn occurs. The UVR dosimeters were wristwatch devices to the participants so as to avoid their influencing sun exposure behavior; changes were noted in behavior in a pilot study where UVR data were open to the users.\(^13\) In our convenience sample, the proportion of subjects younger than 20 years equaled that in the Danish population overall, while adults engaging in outdoor work, outdoor sport, and sun worship were overrepresented. We thus selected an adult population sample that might have a higher UVR exposure than the average Danish population.

A typical day when sunburn occurred in Denmark was a day off work in May through July (90%) with risk behavior (79%) and a median of 6.4 hours' exposure, of which 2.8 hours fell between noon and 3 PM. During this time, there was high level of ambient UVR (>25 SEDs) of which the participant received a median of 21%. This indicates that persons in our latitude without outdoor work get sunburned on working days only if they take part in outdoor activities for several hours mainly around noon.\(^13,19\)

Fifty-nine percent of the subjects had at least 1 sunburn, which is significantly higher than was found in a Danish population study where only 28% recalled having been sunburned.\(^20\) However, a Swedish study reported that people underestimate the number of sunburns when recalling.\(^21\) Our results are in agreement with studies reporting that 53% of Canadians older than 15 years\(^8\) and 39% of a representative sample of the British population older than 16 years\(^7\) recalled having been sunburned within the last year. Among our subgroups, golfers and gardeners had the lowest number of sunburns and the lowest number of days with risk behavior. Adolescents had the highest number of sunburns: 64% experienced sunburn, and 32% had 3 or more per season as a consequence of a high number of days with risk behavior.\(^8\) Sunburn and UVR dose per sunburn day peaked at age 20 years and decreased with age in adults, which is in agreement with other studies.\(^7,22\) Even among children, 50% reported sunburn, while in the Danish population study, only parents only recalled that 16% of their children had sunburn. An explanation for this discrepancy could be that sunburn in children is a sign of parental negligence and therefore is unconsciously underestimated.

### SEVERITY OF SUNBURN

Forty-one percent of the sunburns were characterized by redness of the skin over a small area, 39% over a moderate area, and 6% over an extensive area. Thirty-seven (9%) of the sunburns were reported as red and sore, and 7 sunburns (2%) were red, sore, and blistered. There was a significant association between severity and area affected (\(P<.01\)). There was no significant difference in the severity of sunburn in northern vs southern Europe.

### SUN BED USE PER SUN-YEAR

In 44 of the sun-years, sun bed use was reported for a median of 3 days (range, 1-23 days). The sun bed users had significantly more risk-behavior days, more sunburn days, and higher UVR doses per sunburn day with risk behavior (\(P<.05\)).
Persons engaging in risk behavior without getting sunburned spent significantly fewer days with risk behavior, received lower UVR doses during the risk behavior, especially between noon and 3 PM, and had higher skin type than persons getting sunburned during risk behavior. However, no significant differences in annual UVR doses or exposure hours were found. In contrast to the Danish retrospective interview study, our results based on daily diary reports showed more sunburns in female subjects than in male (P < .01), both in the total group and in the age-related groups of children, adolescents, and indoor workers. Since 79% of the sunburns occurred during risk behavior, this finding suggests women and girls engage in more risk behavior than men and boys. Also, even though they applied sunscreen more often, female subjects still had significantly more risk-behavior days without sunscreen applied than did men. There were no differences in total UVR exposure per season between female and male participants, indicating that women and girls received their UVR exposure in peaks on days with risk behavior when a great part of their body was exposed, while men and boys had a more even exposure pattern. That might explain the higher incidence of malignant melanoma in women. The subjects more often applied sunscreen on sunburn days. This indicates that sunburn occurs when persons know they will engage in risk behavior and expect extended UVR exposure, but (1) the sun protection factor of the sunscreen they used was too low, (2) the sunscreen layer was too thin, or (3) the sunscreen was applied only after they went out in the sun rather than before.

We found a significantly higher UVR dose per sunburn day than per nonsunburn day: in northern Europe, north of Paris (latitude, 49° north), it was 93% higher, and in southern Europe (south of Paris), it was 62% higher. The UVR dose necessary to cause sunburn during risk behavior was significantly higher in southern Europe (62%). An explanation might be that subjects in southern Europe use sunscreens more frequently. In addition, people generally travel to southern Europe later in the season, when their skin might already be darkened by exposure to the summer sun and thus able to tolerate a higher UVR dose before reaching the sunburn threshold.

We found a median increase of 70% in UVR dose per sunburn day in Denmark from April/May to August. A similar percentage increase in UVR sensitivity after UVR exposure has been found after irradiation with artificial UVR sources. This might explain most of the higher dose tolerated in southern Europe. We found no significant difference in sunburn severity between north and south.

In spite of moderate sun bed use, we found that sun bed users experienced more sunburns than non–sun bed users, probably because they had more risk-behavior days and were also more often outdoor sunbathers (P < .01). The pattern might be different among heavy sun bed users. In conclusion, persons had the highest UVR dose on sunburn days with risk behavior. Adolescents and younger adults had the most sunburn days, the most risk-behavior days, and the most exposure hours between noon and 3 PM and thus accumulated the highest UVR dose. Golfers and gardeners received a high UVR dose per season but had fewer days with sunburn and risk behavior and therefore a smaller skin surface area exposed. Sunburn during breaks from normal full-time indoor work or school days was not found in Denmark (latitude, 56° north). Campaigns to prevent sunburn should aim at reducing the number of days with risk behavior and be directed at adolescents, young adults, and sun worshippers. Sun protection campaigns for golfers and gardeners should emphasize the importance of protecting the face, neck, and arms during extended sun exposure.

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