UV Radiation Exposure Related to Age, Sex, Occupation, and Sun Behavior Based on Time-Stamped Personal Dosimeter Readings

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**Objective:** To assess individual time-related (time-stamped) UV radiation (UVR) dose pattern and sun exposure behavior.

**Design:** Open prospective observational study.

**Setting:** University hospital.

**Study Subjects:** Two hundred eighty-five Danish volunteers with apparently healthy skin: children, adolescents, indoor workers, sun worshippers, golfers, and gardeners (age range, 4-68 years).

**Measurements:** We developed a personal electronic UVR dosimeter in a wristwatch (SunSaver) and measured continuously time-related UVR doses in standard erythema dose (SED) and corresponding sun exposure behavior from diaries, resulting in 346 sun-years (median, 119 days). The estimated yearly UVR doses were calculated based on personal and ambient measured doses.

**Results:** The median estimated yearly UVR dose was 173 SEDs (range, 132 SEDs [indoor workers]-224 SEDs [gardeners]), with no significant difference by age ($P=.25$) or sex ($P=.75$). The SED of girls (175 SEDs) was significantly ($P=.04$) higher than that of boys (116 SEDs). Subjects younger than 20 years had an increase of 5 SEDs per year ($P=.03$). Sunbathing or exposing shoulders (risk behavior) outside the beach resulted in a median of 2.5 SEDs per day in northern Europe and 3.2 SEDs per day in southern Europe; however, at the beach, corresponding values were 4.6 and 6.9 SEDs per day. Children and adolescents received more than half their total UVR dose at the beach. Sunburning doses above 10 SEDs per day were connected with sunbathing or exposing shoulders. Of the UVR dose, 50% was received between noon and 3 PM. Only the gardeners received most of their UVR dose (55%) on working days.

**Conclusions:** High UVR doses are connected with risk behavior, except for outdoor workers. There is no need to change sun exposure habits on days without risk behavior.

Arch Dermatol. 2004;140:197-203

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EXPOSURE TO UV RADIATION (UVR) is a well-known risk factor in the development of skin cancer. Considerable debate has surrounded the exact nature of the association between the 3 skin cancer types (basal cell carcinoma, squamous cell carcinoma, and malignant melanoma) and the UVR doses being high and intermittent vs more evenly spread and cumulative.1,2

For UVR exposure, threshold limit values and guidelines for UV exposure have been issued by the International Agency for Research on Cancer (IARC),3 the International Radiation Protection Association,4 the World Health Organization,5 the International Commission on Non-Ionizing Radiation Protection,6 and the American Conference of Governmental Industrial Hygienists.7 In addition to information on sun exposure, doses are estimated based on knowledge obtained by questionnaires, diaries, and ambient UVR measurements.7-10 Personal UVR dosimetry studies11-27 have mainly used dosimeters providing accumulated UVR doses, giving a rather rough picture of the personal exposure pattern.

To be able to analyze the individual sun exposure pattern, it is necessary to have continuous measurements of UVR doses related to the time of the day (time-stamped doses). To overcome this, we developed a small electronic personal UVR dosimeter in a wristwatch (SunSaver), in which measurements are time stamped and logged every 10 minutes. We were, thus, able to plot the UVR dose received at specific times of the day and register pauses in UVR exposure where measurements are 0. We wanted to use the personal elec-
UV biometer was mounted on the roof of a 7-floor building at our hospital. The measurements are expressed in standard erythema doses (SEDs), where 1 SED = 100 J/m² normalized to 298 nm according to the International Commission on Illumination erythema action spectrum.26-30

PERSONAL ELECTRONIC UVR DOSIMETER

The dosimeter (Figure 1) comprises a sensor, a data logger, and a battery. It is mounted in a housing together with a digital watch, and replaced the normal wristwatch. A silicon carbide photodiode (model JECF1-IDE; Laser Components, Olching, Germany) was chosen as the sensor (only sensitive in the range of 200-400 nm). The sensor has a built-in diffuser and a cosine response. The spectral response is similar to the International Commission on Illumination erythema action spectrum from 1987.28 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. The signals are linear with UV intensity and have no offset. The personal electronic UVR dosimeter is battery driven and can run for 145 days without maintenance. The dosimeter is easy to program, and the measurements can be transferred to a personal computer. The measurement range of the dosimeter is 0.1 to 23.0 SEDs per hour. The sensitivity is 0.09 SEDs per hour. By using the sun as a source on 5 cloudless days in early summer, the dosimeters were calibrated against a UV biometer (model 501; Solar Light Co Inc) meter as a reference. The interaction of differences in spectral and cosine responses and the solar spectrum is, thus, included in the calibration. To be able to measure comparable doses, all electronic personal UVR dosimeters were supplied with an individual calibration coefficient.

DIRECTION FOR USE OF THE PERSONAL ELECTRONIC UVR DOSIMETER

The wrist position was chosen because earlier studies had proved the wrist to be a reliable body site for personal UVR dosimetry. The subjects were instructed to wear the UVR dosimeter when they were outdoors, at least between 7 AM and 7 PM, and not to cover the dosimeter with the sleeve or immerse it in water. All subjects were seen 3 times: before the start of the study when they were given information and gave their informed consent, when the dosimeters were tapped during the study, and at the end of the study.

SUN EXPOSURE DIARY

The participants (or the parents of the 22 children <10 years) were provided with a diary each month, where they crossed “yes” or “no” to the following questions: (1) Did you wear the personal electronic UVR dosimeter today? (2) Are you off work or 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 today? A total of 52,388 diary days (94.7%) were completed.

DATA ANALYZED

Personal electronic UVR dosimeter measurements and sun exposure diary data were analyzed from 346 (85.0%) of the sun-years (285 subjects). A sun-year was included if there were dosimeter measurements and corresponding diary information for more than 30 days and at least 21 days in June, July, or August. In addition, 330 (5.6%) of the risk behavior days were left out because the subjects answered “yes” to sunbathing or exposing shoulders while the personal electronic UVR dosimeter showed

Figure 1. The personal electronic UV radiation (UV) dosimeter in a wristwatch (SunSaver) produced in our department and mounted on an adjustable watch strap (RemPern, Gentofte, Denmark). The sensor is placed in the round white eye. The dosimeter was used to monitor time-stamped UV doses. The dosimeter is 36 × 28 × 13 mm, and it is supplied in different colors for the children.

METHODS

STUDY POPULATION

This study was performed in Denmark (latitude, 56° north; and longitude, 12° east) over 3 years: from June 16, 1999, to October 31, 1999; from April 5, 2000, to September 30, 2000; and from April 6, 2001, to August 31, 2001. Three hundred forty volunteers from the Copenhagen area took part in the study, 14 in all 3 seasons and 39 in 2 of the seasons, resulting in 407 sun-years (a sun-year is 1 subject participating in 1 year). The subjects, all with Scandinavian ancestors and without a history of skin cancer, psoriasis, atopic dermatitis, or sun allergy, comprised 133 males and 187 females; the mean age was 30 years (range, 4-68 years). The subjects were chosen to cover all age groups and groups with expected high UVR exposure. The age span of the groups was as follows: 96 children (age range, 4-15 years) (from kindergarten and primary and secondary school), 31 adolescents (age range, 16-19 years) (from high school), and 89 indoor workers (age range, 21-64 years). The high-exposure groups comprised 24 golfers (age range, 27-68 years), 47 municipal gardeners and rangers (age range, 25-60 years), and 53 sun worshippers (age range, 21-63 years). The children and adolescents were recruited through the school headmasters, and all but a few pupils fulfilling the inclusion criteria in the chosen 8 classes participated. The indoor workers were recruited by announcement in a computer company and among employees and students at our hospital. The golfers were recruited from one golf club, the gardeners through municipal departments, and the sun worshippers through a ladies magazine. The Scientific-Ethical Committees for Copenhagen and Frederiksberg approved the study (approval KF11-007/99). Participants and the parents of the children/adolescents gave written informed consent after receiving oral and written information.

AMBIENT UVR EXPOSURE

Continuous measurement of solar UVR was performed with a UV biometer (model 501; Solar Light Co Inc, Philadelphia, Pa). The UV biometer was calibrated with a reference detector traceable to the National Institute of Standards and Technology. The UV biometer was mounted on the roof of a 7-floor building at
0 SEDs, which we considered an error in filling in the diary. This resulted in 39,068 days with both UVR dosimeter and diary data (hereafter called OK days). To compare the individual UVR doses, we adjusted the observation period to a year, knowing that the received UVR during winter is almost negligible, except for winter holidays in sunny places and sun bed use. The estimated yearly UVR doses were calculated based on the individual measured daily doses, and for missing days as the same part of ambient UVR found on comparable days with measurements, by separating days on/off work and being inside/outside Denmark.

STATISTICAL ANALYSIS

In all calculations, each sun-year weighted equally independent of number of days per year a subject participated. Because the measurements primarily were made during the summer and we consider the intrapersonal behavior pattern as homogeneous during this period, we chose to compare the UVR doses actually measured during different behavior with the total individual measured UVR doses for the whole period. The estimated yearly UVR doses are reserved for sex and age correlations (285 subjects). We used nonparametric statistical tests because most of the data were not normally distributed. The results are given as median (range). The Kruskal-Wallis test was used to investigate group effect on continuous data. The Mann-Whitney test was used to compare unpaired continuous data between groups, and the Spearman rank correlation was used to investigate interactions between 2 continuous measurements. Multiple linear regression was used to describe interactions between several variables if the criteria of at least normal distributed residuals were fulfilled. In each case, P < .05 was considered significant. We used SPSS for Windows, version 11.5 (SPSS Inc, Chicago, Ill), for data analysis.

RESULTS

AMBIENT UVR MEASUREMENTS

Table 1 shows the ambient UVR measurements and the percentages of ambient received by the participants in Denmark and on holidays in southern Europe. In Denmark, the median percentage of ambient received was 2.2% (range, 0.0%-29.0%) on working days and 5.5% (range, 0.2%-22.4%) on days off work. The gardeners as outdoor workers varied from the rest of the groups because they received 6.6% (range, 1.9%-17.7%) of ambient UVR on working days. On holidays in southern Europe, the participants received a median of 29.0% (range, 0%-370.2%) of ambient in Copenhagen, with sun worshippers receiving as much as 41.7% (range, 0%-370.2%). Figure 2 shows the distribution over the year of the measured UVR doses for the subjects participating.

MEASURED AND ESTIMATED UVR DOSES

Table 2 shows the total measured UVR doses and the estimated yearly UVR doses. We found almost the same significance pattern whether we compared measured or estimated yearly UVR doses.

UVR DOSES, SEX, AND AGE

For the total population (and the individual adult subgroups), there was no significant difference in estimated yearly UVR exposure by age (P = .25) or sex (P = .75). For children, girls received a median of 175 SEDs (range, 69-556 SEDs), significantly higher than that of boys, 116 SEDs (range, 20-310 SEDs) (P = .04); and the estimated yearly UVR doses increased with age in the 90 subjects younger than 20 years during childhood and adolescence, corresponding to 5 SEDs more per year (r = .23, P = .03).

UVR DOSES AT DIFFERENT BEHAVIORS

To identify the behavior resulting in the highest UVR doses, the data were split into days on work and days off work and whether performing risk behavior. Table 3 shows the distribution. Only the gardeners received most of their UVR dose (55%) on working days (median, 1.4 SEDs per day; range, 0.4-3.8 SEDs per day).

Table 1. Ambient UVR Doses in SEDs From Bispebjerg Hospital, Copenhagen, Denmark, From 1999 to 2001

<table>
<thead>
<tr>
<th>Month</th>
<th>Ambient SEDs</th>
<th>% of Ambient Received in Denmark*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Day</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>15</td>
<td>0.5</td>
</tr>
<tr>
<td>February</td>
<td>48</td>
<td>1.6</td>
</tr>
<tr>
<td>March</td>
<td>142</td>
<td>4.1</td>
</tr>
<tr>
<td>April</td>
<td>368</td>
<td>11.3</td>
</tr>
<tr>
<td>May</td>
<td>591</td>
<td>19.7</td>
</tr>
<tr>
<td>June</td>
<td>603</td>
<td>22.5</td>
</tr>
<tr>
<td>July</td>
<td>611</td>
<td>20.0</td>
</tr>
<tr>
<td>August</td>
<td>442</td>
<td>13.8</td>
</tr>
<tr>
<td>September</td>
<td>267</td>
<td>8.1</td>
</tr>
<tr>
<td>October</td>
<td>98</td>
<td>3.0</td>
</tr>
<tr>
<td>November</td>
<td>32</td>
<td>1.0</td>
</tr>
<tr>
<td>December</td>
<td>12</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Abbreviations: NA, data not applicable; SED, standard erythema dose (1 SED = 100 J/m2); UVR, UV radiation.

*The monthly percentages were calculated daily from median values of 346 sun-years included from 1999 to 2001. The number in parentheses is the number of sun-years included in the particular month.
UVR DOSES AND NUMBER OF SUN-YEARS WITH THE RISK BEHAVIOR

Table 4 shows the large variation in number of sun-years with the risk behavior on days off work/holidays among the groups. Table 5 shows UVR doses and number of days with the risk behavior.

For risk behavior outside the beach in northern Europe, the median value was 2.5 SEDs per day (range, 0.3-15.8 SEDs per day). The sun worshippers received the most (3.4 SEDs per day; range, 1.0-13.1 SEDs per day), and had the most days.

For risk behavior at the beach in northern Europe, the median value was 4.6 SEDs per day (range, 0.3-25.9 SEDs per day), with the gardeners receiving 3.6 SEDs per day (range, 0.4-11.9 SEDs per day) and the adolescents receiving 7.5 SEDs per day (range, 2.1-15.8 SEDs per day).

For risk behavior outside the beach in southern Europe, the median dose was 3.2 SEDs per day (range, 0.1-18.9 SEDs per day), with the adolescents receiving the most (8.3 SEDs per day; range, 3.5-13.8 SEDs per day).

For risk behavior at the beach in southern Europe, compared with the beach in northern Europe, the daily UVR doses were almost double (6.9 SEDs per day; range, 0.4-32.6 SEDs per day), with the adolescents receiving 11.0 SEDs per day (range, 4.1-18.3 SEDs per day) and the children 44% of their total measured dose at the beach.

DAILY UVR DOSES AT OR ABOVE 10 SEDs

A dose of 10 SEDs can cause erythema on sun-unexposed and sun-exposed skin in all our subjects. Of the sun-years, 160 (46.2%) of 346 included days with doses of 10 SEDs or more. The distribution is shown in Table 6.

MIDDAY UVR DOSES

In Denmark from April to September, the UVR dose between noon and 3 PM was a median 43% of the daily UVR. Our population had a median 50% (range, 20%-81%) of the UVR dose between noon and 3 PM, significantly higher ($P < .05$) for children (median, 55%; range, 38%-81%) and adolescents (median, 55%; range, 43%-62%) and significantly lower ($P < .02$) for indoor workers (median, 48%; range, 20%-68%) and golfers (median, 47%; range, 29%-59%) than gardeners (median, 52%; range, 33%-69%) and sun worshippers (median, 52%; range, 39%-65%). The dose received between 7 AM and noon was 21% (range, 3%-48%), and from 3 PM to 7 PM, 27% (range, 4%-66%). We found a strong linear correlation between the UVR doses received between noon and 3 PM and the total measured UVR dose for the individual subjects ($r = 0.98$, $P < .01$). Thus, all subjects received about half of their total UVR between noon and 3 PM independent of the size of their total UVR dose.

COMMENT

Comparing our results with those of other personal UVR dosimeter studies$^{12-27}$ is difficult because different anatomical sites have been used for dosimeter placement. We chose the wrist position, which in an earlier study$^{11}$ was practical and received 50% of the UVR compared with the top of the head, which we consider the anatomical site that receives the most UVR. If the wrist SED is multiplied by a factor of 2, a good estimate of the maximum personal UVR exposure is obtained.$^{11}$

All personal sun exposure doses were related to ambient UVR in Copenhagen (latitude, 56° north), which gives an estimate of the increased risk of going south. During the summer, UVR doses in southern Europe (latitude, 35°-43° north) are 33% to 50% higher than in Copenhagen. Sun holidays in southern Europe can give UVR doses that are higher than the ambient UVR dose in Denmark during the same period. This may be in agreement with the finding that patients with malignant melanoma traveled significantly more often south of the 45° north latitude than matched control subjects.$^7,8$

Figure 2. Daily UV radiation dose in standard erythema doses (SEDs [1 SED = 100 J/m²]) per subject participating in 2000. A, Days in Denmark. The inclusion day differed from April 5 to May 25. The arrows indicate periods with bad weather conditions in Denmark. B, Days outside Denmark.
We found no difference between UVR exposure in male and female subjects, except among children (girls received a 1.5 times higher estimated yearly UVR dose than boys, P = .04). However, our results are in contrast to those of Diffey et al, who found no difference in 180 schoolchildren. We found no correlation between age and estimated yearly UVR dose in subjects older than 20 years, but in subjects younger than 20 years, we found a 5-SED increase of UVR dose per year of age. In other words, if a 5-year-old child received 100 SEDs, an 18-year-old subject received 165 SEDs. An explanation could be that small children instinctively avoid the sun while adolescents may want to get tanned. In the adult group, the UVR exposure was not related to age but to occupation, outdoor sports activities, or being a sun worshipper.

Sun worshippers, golfers, and gardeners received significantly higher UVR doses (P < .05) than indoor workers and children, while the adolescent group of high school pupils was in between and received significantly higher doses only compared with the indoor workers. It has been estimated by the IARC that indoor workers in the mid-latitudes (40°-60° north) received an annual facial dose of 100 to 400 SEDs. If we multiplied our results from the wrist by 2 to obtain the comparable UVR exposure, the median estimated yearly UVR dose for indoor workers is 264 SEDs (range, 34-1682 SEDs). For the outdoor workers, the dose was 448 SEDs (range, 108-1338 SEDs), or 1.7 times the indoor workers and lower than the 2 to 3 times higher dose estimated by the IARC. The dose span measured objectively by our dosimeters was, thus, much wider than estimated by the IARC, although it has been

Table 2. Distribution of Measured and Estimated Yearly UVR Doses in SEDs for Number of Sun-Years Total and in the Subgroups

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No. of Sun-Years</th>
<th>No. of OK Days</th>
<th>Measured SED on OK Days</th>
<th>Estimated Yearly SED</th>
<th>Measured SED/OK Day</th>
<th>Measured Daily SED as % of Ambient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>346</td>
<td>119 (32-176)</td>
<td>110 (11-785)</td>
<td>173 (17-980)</td>
<td>1.0 (0.1-6.7)</td>
<td>5.1 (0.4-46.7)</td>
</tr>
<tr>
<td>Children</td>
<td>68</td>
<td>108 (43-152)‡</td>
<td>90 (12-430)§</td>
<td>147 (20-556)</td>
<td>0.9 (0.1-3.4)</td>
<td>4.1 (0.4-17.1)</td>
</tr>
<tr>
<td>Adolescents</td>
<td>22</td>
<td>115 (49-171)²</td>
<td>120 (27-381)</td>
<td>189 (52-634)</td>
<td>1.0 (0.3-4.1)</td>
<td>4.7 (1.6-18.1)</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>111</td>
<td>123 (32-176)¶</td>
<td>86 (11-337)§</td>
<td>132 (17-841)</td>
<td>0.7 (0.1-4.8)</td>
<td>4.0 (0.5-26.5)§</td>
</tr>
<tr>
<td>Sun worshippers</td>
<td>49</td>
<td>138 (51-165)</td>
<td>138 (43-785)</td>
<td>181 (68-980)**</td>
<td>1.0 (0.4-7.0)</td>
<td>6.1 (2.0-46.7)</td>
</tr>
<tr>
<td>Golfers</td>
<td>31</td>
<td>105 (32-146)‡</td>
<td>123 (57-299)**</td>
<td>217 (106-685)</td>
<td>1.2 (0.7-3.7)</td>
<td>7.5 (3.0-24.1)</td>
</tr>
<tr>
<td>Gardeners</td>
<td>65</td>
<td>121 (58-170)</td>
<td>150 (41-484)</td>
<td>224 (54-669)</td>
<td>1.3 (0.3-4.4)</td>
<td>6.6 (1.5-23.6)</td>
</tr>
</tbody>
</table>

Abbreviations: OK day, day with both UV radiation (UVR) dosimeter and diary data; SED, standard erythema dose (1 SED = 100 J/m²).

*Data are given as median (range) unless otherwise indicated.
†Calculated as the dose on all OK days in percentage of ambient in Denmark on corresponding days for each subject independent of being in Denmark or not.
§Significantly lower than sun worshippers, golfers, and gardeners (P < .01).
¶Significantly fewer than indoor workers, sun worshippers, and gardeners (P < .05).
‡Significantly lower than sun worshippers, golfers, and gardeners (P < .05).
§Significantly fewer than sun worshippers (P = .04).
∥Significantly lower than all other subgroups (P < .03).
**Significantly lower than gardeners (P < .04).

Table 3. Measured UVR Doses in SEDs and Time Off Work/Holidays for Each Group

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Without Risk Behavior*</th>
<th>With Risk Behavior*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SED, Median (Range)</td>
<td>Time, Median (Range), d %†</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15 (0-193)</td>
<td>54 (0-105)</td>
</tr>
<tr>
<td>Children</td>
<td>11 (0-48)</td>
<td>47 (3-65)</td>
</tr>
<tr>
<td>Adolescents</td>
<td>13 (3-26)</td>
<td>44 (3-63)</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>12 (0-71)</td>
<td>60 (0-102)</td>
</tr>
<tr>
<td>Sun worshippers</td>
<td>14 (0-93)</td>
<td>50 (0-105)</td>
</tr>
<tr>
<td>Golfers</td>
<td>13 (0-117)</td>
<td>36 (0-89)</td>
</tr>
<tr>
<td>Gardeners</td>
<td>76 (23-193)</td>
<td>65 (19-102)</td>
</tr>
</tbody>
</table>

Abbreviations: SED, standard erythema dose (1 SED = 100 J/m²); UVR, UV radiation.

*Risk behavior indicates sunbathing or exposing shoulders or the upper body.
†Median percentage of total group values during the mentioned behavior.
reported that some individuals receive considerably greater or smaller UVR doses than the rest.\textsuperscript{12-14} In our study, the 5\% (17 sun-years) with the highest UVR load corresponded to a median of 1010 SEDs (range, 648-1980 SEDs) in annual facial UVR doses. Of this group, all but 2 had sun holidays in the Mediterranean area.

Because high intermittent UVR doses may be especially dangerous for provoking malignant melanoma, it is alarming that 38 (56\%) of the children, 17 (77\%) of the adolescents, and 27 (55\%) of the sun worshippers received 28\% to 38\% of their total measured UVR doses in 3 to 4 days, with UVR of 10 SEDs per day or more.\textsuperscript{1,2,5} High UVR doses are linked to risk behavior. Subjects thus performed risk behavior on 555 (87.3\%) of 636 days with UVR doses of 10 SEDs or more per day.

Although only 86 (25\%) of the 346 sun-years included risk behavior at the beach in southern Europe, the median dose of 44 SEDs in 6 days corresponded to 40\% of the median measured dose for all the participants. For the children and adolescents, the dose at the beach gave 70\% of their groups’ total measured UVR. Reducing the few days with risk behavior can reduce the total UVR load considerably.

Of the UVR load, 50\% was measured between noon and 3PM, although nearly all of our participants have a job or are in school but emphasize that the UVR load on working/school days is low, except for outdoor workers. It is striking that on days with continuous measurements above 0 SEDs between noon and 3PM, the UVR dose was more than double compared with days with just small intervals without UVR exposure (0 SEDs). Much can, thus, be gained in UVR reduction by persuading people to have a break in the middle of the day and seek inside for lunch instead of picnic at the beach.

### Table 4. Data for Sun-Years With the Risk Behavior on Days Off Work/Holidays for the Different Groups and Locations\textsuperscript{*}

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Total No. of Sun-Years</th>
<th>Northern Europe†</th>
<th>Southern Europe‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Outside the Beach</td>
<td>At the Beach</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>346</td>
<td>290 (84)</td>
<td>198 (57)</td>
</tr>
<tr>
<td>Children</td>
<td>68</td>
<td>57 (84)</td>
<td>61 (90)</td>
</tr>
<tr>
<td>Adolescents</td>
<td>22</td>
<td>21 (95)</td>
<td>14 (64)</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>111</td>
<td>89 (80)</td>
<td>69 (62)</td>
</tr>
<tr>
<td>Sun worshippers</td>
<td>49</td>
<td>48 (98)</td>
<td>22 (45)</td>
</tr>
<tr>
<td>Golfers</td>
<td>31</td>
<td>29 (94)</td>
<td>16 (52)</td>
</tr>
<tr>
<td>Gardeneres</td>
<td>65</td>
<td>46 (71)</td>
<td>16 (25)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>65 (19)</td>
<td>86 (25)</td>
</tr>
</tbody>
</table>

\textsuperscript{*}Data are given as number (percentage) of sun-years unless otherwise indicated. Percentages are based on the total number of sun-years. Data from 6 subjects outside Europe are not shown. Risk behavior indicates sunbathing or exposing shoulders or the upper body.

\textsuperscript{†}Being in northern Europe (primarily Denmark).

\textsuperscript{‡}Being in the Mediterranean area.

### Table 5. Measured UVR Doses in SEDs and Time Off Work/Holidays for the Sun-Years With the Risk Behavior\textsuperscript{*}

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Risk Behavior Outside the Beach</th>
<th>Risk Behavior at the Beach</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SED, Median (Range)</td>
<td>Time, Median (Range), d</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern Europe‡</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>15 (0-170)</td>
<td>6 (1-39)</td>
</tr>
<tr>
<td>Children</td>
<td>10 (0.3-102)</td>
<td>5 (1-28)</td>
</tr>
<tr>
<td>Adolescents</td>
<td>26 (0.4-92)</td>
<td>9 (1-24)</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>13 (0.1-170)</td>
<td>6 (1-31)</td>
</tr>
<tr>
<td>Sun worshippers</td>
<td>42 (4-129)</td>
<td>10 (1-39)</td>
</tr>
<tr>
<td>Golfers</td>
<td>14 (0-68)</td>
<td>5 (1-28)</td>
</tr>
<tr>
<td>Gardeneres</td>
<td>13 (0.1-125)</td>
<td>4 (1-23)</td>
</tr>
<tr>
<td>Southern Europe§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>13 (0.3-163)</td>
<td>4 (1-22)</td>
</tr>
<tr>
<td>Children</td>
<td>1 (0.3-163)</td>
<td>2 (1-10)</td>
</tr>
<tr>
<td>Adolescents</td>
<td>25 (19-108)</td>
<td>3 (2-15)</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>9 (0.4-69)</td>
<td>3 (1-15)</td>
</tr>
<tr>
<td>Sun worshippers</td>
<td>13 (1-138)</td>
<td>5 (1-22)</td>
</tr>
<tr>
<td>Golfers</td>
<td>15 (1-72)</td>
<td>6 (1-14)</td>
</tr>
<tr>
<td>Gardeneres</td>
<td>31 (13-58)</td>
<td>5 (3-6)</td>
</tr>
</tbody>
</table>

\textsuperscript{*}Abbreviations are explained in the first footnote to Table 3. Data from 6 subjects outside Europe are not shown. Risk behavior indicates sunbathing or exposing shoulders or the upper body.

\textsuperscript{†}Median percentage of total group values during the mentioned risk behavior.

\textsuperscript{‡}Being in northern Europe (primarily Denmark).

\textsuperscript{§}Being in the Mediterranean area.
doors, because the dose per day to the wrist was 0.3 SEDs (range, 0.3-3.9 SEDs) on working days and 0.6 SEDs (range, 0.1-3.5 SEDs) on days off work. The gardeners as outdoor workers received the main part of their UVR load on working days (median, 1.4 SEDs per day; range, 0.4-3.8 SEDs per day) to the wrist and probably double to the face. This is above the American Conference of Governmental Industrial Hygienists' daily threshold limit value to the face for outdoor workers, corresponding to 1.1 SEDs. Outdoor workers should, therefore, be recommended to use sunscreen, clothes, and a hat on working days. In conclusion, a dramatic lowering of the UVR load could be obtained by reducing the few days with risk behavior, especially at the beach, or by abstaining from staying out all 3 hours between noon and 3 PM.

Accepted for publication May 21, 2003. This study was supported by funding from the European Community Environment and Climate 1994-1998 Work Programme Contract (ENV4-CT97-0556). We thank all the participants and contact persons from the differing groups and the staff of the Department of Dermatology D92, and especially, Jane Sandby-Møller, MD, and Trine Ravn, for assembling SunSavers and data collection. Corresponding author: Elisabeth Thieden, MS (Pharm), Department of Dermatology D92, Bispebjerg Hospital, Bispebjerg Bakke 23, DK-2400 Copenhagen, Denmark (e-mail: et01@bbh.hosp.dk).

REFERENCES


[Table 6. Data for Sun-Years and Exposure to UVR Doses of 10 SEDs per Day or More*]

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No.</th>
<th>% of the Group</th>
<th>Sun-Years With UVR ≥ 10 SEDs/d</th>
<th>Sum of Doses ≥ 10 SEDs/‡</th>
<th>Time With UVR ≥ 10 SEDs, ‡</th>
<th>As a % of Total Measured UVR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>160</td>
<td>346</td>
<td>33 (10-621)</td>
<td>27 (5-85)</td>
<td>2 (1-25)</td>
<td>2.5 (0.6-21.4)</td>
</tr>
<tr>
<td>Children</td>
<td>38</td>
<td>68</td>
<td>43 (10-330)§§</td>
<td>30 (5-85)§§</td>
<td>3 (1-16)§§</td>
<td>2.7 (0.8-13.7)§§</td>
</tr>
<tr>
<td>Adolescents</td>
<td>17</td>
<td>22</td>
<td>22 (10-202)</td>
<td>18 (7-71)</td>
<td>4 (1-17)§§</td>
<td>3.0 (1.6-7.8)§§</td>
</tr>
<tr>
<td>Indoor workers</td>
<td>42</td>
<td>111</td>
<td>53 (10-621)§§</td>
<td>30 (5-85)§§</td>
<td>4 (1-25)§§</td>
<td>3.3 (0.6-21.4)§§</td>
</tr>
<tr>
<td>Sun worshippers</td>
<td>27</td>
<td>49</td>
<td>28 (5-74)</td>
<td>20 (5-39)</td>
<td>2 (1-5)</td>
<td>1.9 (0.8-6.5)</td>
</tr>
<tr>
<td>Golfers</td>
<td>12</td>
<td>31</td>
<td>25 (5-74)</td>
<td>20 (5-39)</td>
<td>2 (1-5)</td>
<td>1.9 (0.8-6.5)</td>
</tr>
<tr>
<td>Gardeners</td>
<td>24</td>
<td>65</td>
<td>36 (10-293)</td>
<td>20 (5-68)</td>
<td>3 (1-18)§§</td>
<td>2.2 (0.7-16.2)</td>
</tr>
</tbody>
</table>

*Abbreviations are explained in the first footnote to Table 2.
‡Data are given as median (range).
§Significantly higher than indoor workers and gardeners (P<.05).
||Significantly higher than indoor workers (P<.05).