Estimated ultraviolet doses to psoriasis patients during climate therapy

Lill T. N. Nilsen[1], Elisabeth Søyland[2] & Anne. L. Krogstad[2,3]

[1]Norwegian Radiation Protection Authority, Østerås, Norway, [2]Section for Climate Therapy, Department of Rheumatology, Oslo University Hospital, Rikshospitalet, Oslo, Norway, and [3]Department of Dermatology, Oslo University Hospital, Rikshospitalet, Oslo, Norway

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Correspondence:
L. T. N. Nilsen, Norwegian Radiation Protection Authority, P.O. Box 55, NO-1332, Østerås, Norway.
e-mail: lill.tove.nilsen@nrpa.no

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Summary

Background/purpose: Psoriasis is a chronic inflammatory disease affecting about 2–3% of the population. Sun exposure has a positive effect on most lesions, but ultraviolet (UV) radiation also constitutes a carcinogenic potential. Climate therapy is frequently used to treat patients, with the consequence that they may receive high doses of UV. This paper explores UV doses to patients treated in Gran Canaria.

Methods: Patient UV doses have been estimated for 20 psoriasis patients during a 15-day climate therapy study and compared with the predetermined exposure schedule and doses reported from other studies. Estimates were based on UV measurements and the patients' diaries with information on the time spent in the sun.

Results: On the first day of exposure, the patients received on average 5.1 standard erythema doses (SED) estimated to the skin. The average dose for the 15-day study was 166 SED (250 SED for a regular 3-week treatment period). We found no significant correlation between the reduction in psoriasis area severity index scores and UV doses.

Conclusion: The UV doses were higher than if they had followed the prescribed exposure schedule and also higher than those reported from other climate therapy studies. It seems beneficial to focus on following the prescribed exposure schedule.

Psoriasis is a chronic inflammatory disease affecting about 2–3% of the European population. Plaque psoriasis, the most common form of psoriasis, typically appears as raised areas of inflamed skin covered with silvery white scales. The severity is usually graded as mild, moderate or severe. The psoriasis area severity index (PASI) is the most widely used instrument to evaluate psoriasis lesions. The PASI score varies from 0 (no symptoms) to a maximum of 72, reflecting the surface area affected and the severity of the lesions, i.e. the redness, thickness and scaling (1).

Ultraviolet (UV) radiation from the sun is an effective and natural treatment method for psoriasis (2). Cell proliferation in the basal layer of the skin is increased in psoriasis lesions and UV radiation slows down this process. Furthermore, the combination of ultraviolet B (UVB)-induced apoptosis, increased secretion of anti-inflammatory cytokines and decreased trafficking to the skin may also explain the beneficial effects of UVB treatment on psoriasis and why disease remission can sometimes be sustained for a prolonged period (3, 4). Climate therapy has been offered to psoriasis patients for many years at low-latitude locations such as in the Dead Sea resort and the Canary Islands, and at high-altitude locations, e.g. in Davos, Switzerland. Norwegian psoriasis patients have been offered climate therapy since late 1976 (5). The therapy focuses on sun exposure paralleled by an educational programme.

The original schedule for climate therapy of psoriasis lasted for 4 weeks with 6 h of daily sun exposure, after acclimatization during the first 1–2 weeks (6–8). Recent studies from the Dead Sea area have reported a good response (> 75% reduction in the PASI score) in patients receiving only 3 h of daily sun exposure (excluding the noon hours) for 4 weeks (9–11). Two of these studies (10, 11) monitored the ambient UV dose and showed good results for doses higher than 170 standard erythema dose (SED). Treatment in December, with an ambient dose of 120 SED, showed only a slight improvement (33%). Other studies have also estimated or measured the skin or ambient UV doses in relation to regular climate therapy (7, 12, 13).

Studies from the Dead Sea have also explored shorter therapy periods, but showed a better treatment response for patients treated for 4 weeks compared with only 2 weeks of treatment (6). This is in agreement with a recent Dead Sea study (14) reporting lower percentage PASI reduction for patients receiving a 2-week climate therapy compared with earlier studies. This study showed better results for those receiving more than 3h of daily sun exposure. Due to the risk of sun damage, however, the study recommended that the patients should not exceed the recommended exposure guidelines.

This paper focuses on the measurements of UV radiation using broadband instruments and patients' diaries in relation to climate therapy. The therapy is discussed with respect to UV doses and length of daily sun exposure.

Material and methods

The study was carried out in Gran Canaria (27°N, 15°W). Climate therapy for psoriasis patients at this treatment centre lasted for 3 weeks. The study period lasted for 15 of these days, starting on 15 March 2006. The Regional Ethics Committee approved the study.

Patient material

The study included 20 Caucasian patients (mean age 47.2 years, range 24–65, six females and 14 males) with moderate to severe psoriasis. PASI before climate therapy was 9.8 (mean, range 3.8–18.8). PASI scores were assessed by dermatologists before and after the sun exposure. The patients had stopped using any psoriasis medication 4 weeks before the start of the study. Two of the patients had skin type II and 18 had skin type III according to the Fitzpatrick classification (15).

The patients were supposed to follow a strict exposure schedule on the first day of the study, exposing first the front side of their body for 30 min, the back side for 30 min, followed by 15 min of exposure on each side. The total sun exposure of 1 h and 30 min was planned to take place between 11:00 and 13:00 hours local time. They were also allowed to stay outside after lunch, but only if their skin was properly sun protected, i.e. using a thick layer of sunscreen with sun protection factor (SPF) of 25 (Pediatrics Fotoprotector ISDIN, 25B-10A-IR, Barcelona, Spain). 2 mg/cm^2 represents a protective layer of sunscreen (16). For the subsequent days, the patients were asked to gradually increase the hours of exposure per day, according to a schedule shown for skin type III in Fig. 1. Half the exposure time was scheduled before and half after lunch. After day 10, there were no restrictions on exposure time, except if the patients experienced erythema. For days 2–10, the patients were asked to restrict sunscreen use to locations that easily burned. The patients registered time spent in the sun every day and for every 20-min interval from 09:00 to 17:00 hours local time, as well as use of sunscreen and SPF factor.

UV measurements

Spectral UVB (280–315 nm), UVA (315–400 nm) and CIE-weighted UV irradiances were measured daily and every hour from 09:00 to 17:00 hours local time using two broadband instruments. The CIE-action spectrum is a reference action spectrum for UV-induced erythema in Caucasian human skin (17) valid for the UV region from 250 to 400 nm. One of the broadband radiometers (Solar Light Co. Inc., PMA 2100, Glenside, Pennsylvania, USA) was used with two sensors, one (PMA 2101 UVB sensor, Solar Light Company Inc.) that roughly resembles the spectral responsivity of the CIE-action spectrum

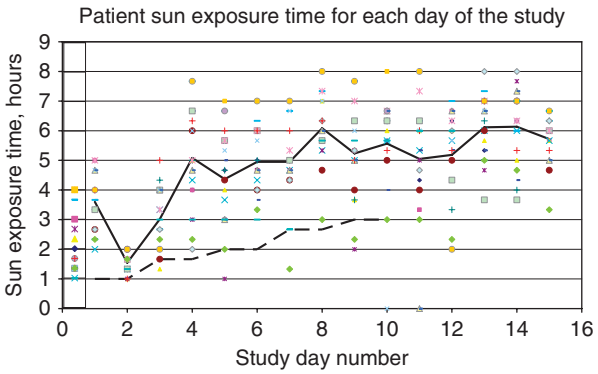

Fig. 1. Sun exposure time registered for each patient and for each day of the study period. The daily mean exposure time is given by the solid black drawn line. The rectangle marking the data points before day 1 shows the exposure times on day 1 excluding the time when sunscreen is used. The prescribed exposure schedule for skin type III for the days 1–10 is given by the stippled black line.

and the other (PMA 2110 UVA sensor, Solar Light Company Inc.) with a fairly flat spectral responsivity in the UVA waveband. The other broadband instrument (Gigahertz-Optik GmbH X1 1 Optometer, Punchheim, Germany) was used with UVB and UVA sensors (XD-9501, Gigahertz-Optik GmbH), both with fairly flat responsivities. Both instruments were positioned to monitor the UV radiation intensity on a horizontal surface, and both have a cosine-corrected field of view. The Solar Light PMA sensors were calibrated against a spectroradiometer (Brewer#185, measurement range 286.5–365 nm, extended for UVA 365–400 nm, Kipp & Zonen, Delft, The Netherlands) at Izaña, Tenerife, before the study. Calibration was performed by Mr Alberto Redondas, Instituto Nacional de Meteorologia (INM), Spain, according to internationally accepted procedures (18, 19). Their spectroradiometer was calibrated in February 2005 and compared with the QASUME Unit (Quality Assurance of Spectral Ultraviolet Measurements in Europe, http://lap.physics.auth.gr/qasume/) in September 2005, showing a difference of −2% (±2% of diurnal variability)in the calibration scale. The PMA sensor calibration factors showed a variation of ±6% for the UVB sensor within the time period 10:30 to 16:00 hours local time and ±2.5% for the UVA sensor between 09:30 and 17:00 hours. These variations are due to differences in cosine response and azimuth variations compared with the spectroradiometer, and broadband sensors are sensitive to temperature changes. The Gigahertz–Optik sensor readings were compared with those of the Solar Light sensors. These instruments have both broadband sensors, operating in the same way and with a fairly constant diurnal variation (±20%). Uncertainty due to variations in the solar zenith angle (SZA) and ozone between the calibration site in Tenerife and the survey site in Gran Canaria can be assumed to be minimal because these conditions are similar on the two islands. The overall measurement uncertainty can then be estimated to ±25%.

UV dose estimates

Spectral UVB and UVA irradiances, in addition to CIE-weighted UVB and UVA irradiances, were calculated for the whole period using a radiation transfer model, libRadtran, for irradiance calculations (20). The model was run for the following conditions: cloudless sky, albedo of 0.05, sea level and ozone values from the TOMS satellite for days 15–29 March 2006 (21). The ozone values varied between 271 and 328 Dobson Units (DU), with a mean of 290 DU. The radiation transfer model produces uncertainties comparable with UV measurements of about 6% (22).

The UV irradiances were adjusted according to the measurements performed in Gran Canaria to account for the real weather situation and possible discrepancies from the model parameters, such as different albedo and aerosol concentrations.

Combining the calculated UV irradiances with the sun exposure time from the patients' diaries, UV doses were estimated for each patient after 1 and after 15 days of sun exposure.

Results

The results are presented as spectral UVB and UVA doses in J/cm^2, as well as CIE-weighted UV doses as SED (1 SED = 100 J/m^2 = 0.01 J/cm^2). Results are presented as mean of the doses ± standard deviation and 95% confidence intervals (CIs). Median doses are presented when data are skewed. UV doses to each patient are set equal to the ambient UV doses divided by two, as only half the body can be exposed at any time. Exposure times and doses are presented for the two cases: (I) including and (II) excluding time when sunscreen was used the first day. Pearson's correlation coefficients were calculated between SED, UVB and UVA doses for the whole treatment period and the percentage reduction in the PASI score. Coefficients of variation were also calculated. All statistical analyses were performed using SPSS 15.0 for Windows. P values ≤ 0.05 were considered statistically significant.

UV exposure

The daily maximum UV index varied between 4 and 9 for the 15 days. The sun exposure time for each day and for each patient (Fig. 1) showed a roughly gradual increase throughout the study period and was much higher than the prescribed exposure schedule. An exception was seen at day 2, when all patients went by bus to and from the hospital in Las Palmas in order to take blood samples and biopsies in connection with another study. The exposure time varied considerably among the patients. When exposure using sunscreen on the first day was excluded, the exposure time was 2.0 ± 1.0 h (median 1.7 h), whereas the corresponding number when sun exposure with sunscreen was included was 3.6 ± 0.9 h (median 3.7 h).

UV dose estimates

Table 1 shows the estimated UV doses to skin after 1 day of sun exposure, both including and excluding the exposure time when using sunscreen. The patients sunbathing with sunscreen during the first day reported using approximately 30 ml of cream (SPF 25). The estimated UV doses for sun exposure when the sunscreen effect was excluded varied between 2.6 and 10.3 SED, with a mean dose of 5.1 ± 2.3 SED (median dose 4.0 SED) (Table 1 and Fig. 2, inside the rectangle). The mean dose was the same for the patients with skin type II and III, but 5.9 ± 2.8 and 4.8 ± 2.1 SED for females and males, respectively. Seven patients exposed themselves to the sun without the prescribed sunscreen after lunch on the first day and thereby received higher UV doses. The potential doses were markedly higher when time with sunscreen was included (Table 1 and Fig. 2). Fourteen out of the 20 patients reported erythema after the first day of sun exposure.

The mean dose after 15 days of sun exposure was 166 ± 25 SED if sunscreen use on the first day was excluded (Table 2): 135 ± 43

Table 1. Estimated ultraviolet (UV) doses to the patients after 1 day of sun exposure*

	UV doses after 1 day of exposure	
	Including all sun exposure time, also when sunscreen is used (n = 20)	Excluding sun exposure time when sunscreen is used (n = 20)
UVB (J/cm^2)		
Mean	0.64	0.36
(95% CI)	(0.57, 0.71)	(0.29, 0.44)
UVA (J/cm^2)		
Mean	26.7	14.9
(95% CI)	(23.7, 29.8)	(11.6, 18.1)
CIE-weighted UV (SED)†		
Mean	9.0	5.1
(95% CI)	(8.1, 10.0)	(4.1, 6.2)

*UV doses to each patient are set equal to the ambient doses divided by two, since only half the body can be exposed at any time.

†CIE-weighted UV dose is given as standard erythema dose (SED). 1 SED = 100 J/m^2 = 0.01 J/cm^2.

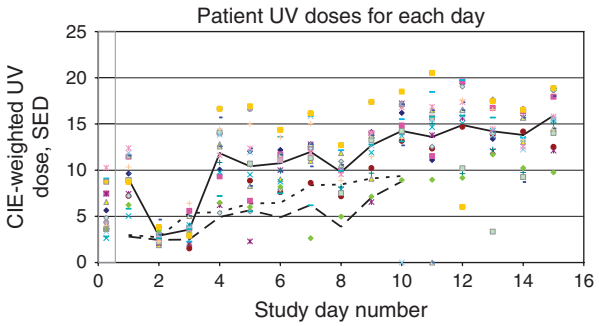

Fig. 2. CIE-weighted ultraviolet (UV) doses estimated for each patient for each day of the study period. UV doses to each patient are set equal to the ambient doses divided by two. The rectangle marking the data points before day 1 shows the doses excluding exposure time under the application of sunscreen. The daily mean dose is shown as the black solid-drawn line, and the doses corresponding to the prescribed exposure schedule are shown for the real weather situation (- - -) and for a clear sky (. . .).

Table 2. Estimated cumulative ultraviolet (UV) doses to the patients after 15 days of sun exposure*

	UV doses after 15 days of exposure	
	Including all sun exposure time, also when sunscreen is used ($n = 20$)	Excluding sun exposure time when sunscreen is used on day 1 ($n = 20$)
UVB (J/cm^2)		
Mean	11.8	11.5
(95% CI)	(11.0, 12.6)	(10.7, 12.3)
UVA (J/cm^2)		
Mean	464	452
(95% CI)	(432, 496)	(420, 485)
CIE-weighted UV (SED)†		
Mean	170	166
(95% CI)	(158, 181)	(154, 177)

*UV doses to each patient are set equal to the ambient doses divided by two, since only half the body can be exposed at any time.

†CIE-weighted UV dose is given as standard erythema dose (SED). 1 SED = 100 J/m^2 = 0.01 J/cm^2.

(only two patients) and 169 ± 21 SED for the patients with skin type II and III, respectively. For females, the dose was 160 ± 14 SED and for males it was 168 ± 28 SED. If sunscreen use on the first day was included, the mean dose was 170 ± 24 SED for all subjects combined. The patients reported using sunscreen mostly on parts of the body that could easily be burned, and the amount of sunscreen varied between 30 and 700 ml for the whole period. The variation between minimum and maximum patient doses each day was large (Fig. 2), and the accumulated doses varied by a factor 2 for the whole treatment period (Table 2). For the whole treatment period, the coefficient of variation was 15%.

PASI reduction in relation to UV exposure

All patients experienced an overall reduction in the PASI score of $72.8 \pm 18.0\%$ (median 77.8%, 95% CI 64.4–81.2), from a mean PASI score of 9.8 ± 4.5 before treatment to 2.4 ± 1.7 (range 0.4–6.9) after treatment. The percentage reduction in the PASI score was $51.8 \pm 30.4\%$ and $75.1 \pm 15.8\%$ for patients with skin type II and III, respectively. Fifty-five per cent of the patients achieved a 75% improvement in the PASI score and 90% achieved a 50% improvement. Pearson's correlation coefficients between the percentage improvement in the PASI score and the SED, the spectral UVB dose and the spectral UVA dose for the whole treatment period were 0.21, 0.21 and 0.2, and were not significant. Pearson's correlation coefficient between the percentage improvement in the PASI score and the mean exposure time per day was 0.19 and was not significant (Fig. 3).

Discussion and conclusion

The detailed patient diaries were used to calculate the UV dose only for the time each patient had spent in the sun. Studies have shown good agreement between diary records of time spent

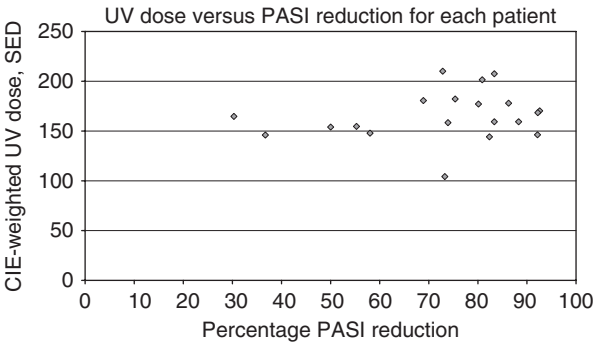

Fig. 3. The cumulative CIE-weighted ultraviolet (UV) dose with respect to the percentage improvement in the psoriasis area severity index (PASI) score.

outdoors and personal dose measurements at SZAs similar to our study (23–25). However, there is always some uncertainty regarding registration of exposure time, e.g. whether a 5–10-min walk to and from the nearby beach is included or not. This yields an uncertainty of $\pm 20\%$ on the first day of sun exposure (restricted time in the sun) and $\pm 7\%$ at the end of the study (high exposure/long time in the sun). However, to evaluate sun exposure, it is insufficient to calculate only the exposure time. On days 3, 8, 13 and 14 of this study, the patients spent relatively long periods in the sun (Fig. 1), but due to cloudy weather the UV doses on these days were low (Fig. 2).

Our method to measure and estimate UV doses is easier compared with using personal UV dosimeters, but is affected by greater uncertainties. UV intensities were measured only once an hour, yielding about a 20% uncertainty due to the application of possibly incorrect weather corrections in cases of rapidly changing weather. The reflection and thereby the UV intensity differs depending on the environment. Sand reflects more than water, loam, grass, concrete and rocks, whereas limestone, for instance, reflects at a level similar to the former (26, 27). The nearby beach consisted of fine sand, with high stone buildings on one side and the sea on the other side. The treatment centre is located nearby and at the entrance of a desert-like valley with sparse vegetation, but with white-coated concrete buildings. The reflection at these two sites should therefore be comparable, causing a maximum 5% uncertainty in the UV dose estimates.

The predominant uncertainty concerns the assumption that the skin dose equals half the ambient dose. Measurements using personal dosimeters in other studies support this assumption (7, 28–30). However, the UV doses are reported to be higher for the extremities, lower for various activities and vary more than during sun bathing (7, 30, 31). For the abdomen and the back, the assumption of receiving half the ambient UV can be appropriate as a first approximation during sun bathing (almost horizontal surfaces) and assuming the patients turned to expose these body areas in equal amounts. However, the assumption is weak and constitutes a limitation for the study. Future studies may consider using personal dosimeters, in particular placed near a psoriatic plaque, if local therapeutic effects are to be studied.

The calculated UV doses after 1 day of sun exposure (Fig. 2) are mostly lower than those needed to induce erythema, if

exposure time when using sunscreen is excluded. In order to illustrate this point, Harrison and Young (32) indicated moderate sunburn to occur for doses of 5–8 SED and painful, blistering sunburn at 10 SED, for the whitest skin categories. The declared SPF factor requires a uniform application of sunscreen with a thickness of 2 mg/cm^2 (16), i.e. totally 40 ml for an adult body (33). Most of our patients used roughly this amount after lunch on the first day of sun exposure. It is therefore reasonable to estimate doses for the first day of exposure using only the time without sunscreen (Table 1, second column). Nonetheless, 14 patients reported erythema. The explanation can be variation in doses over the body, such as the extremities, that they exposed different body parts unequally or that some patients have used less than the prescribed sunscreen on the first day.

For the remaining days of sun exposure, the patients reported using small amounts of sunscreen and mostly on the upper extremities, i.e. areas that may receive more than 50% of the ambient UV (7, 28, 30, 31) and are more susceptible to be sunburned. Therefore, it seems reasonable to calculate UV doses for the psoriatic skin for all reported hours spent outdoors for these days, disregarding sunscreen use.

Our patients clearly exceeded the prescribed exposure schedule (Fig. 2). If they had followed this schedule, the mean skin dose would have been 105 SED (ambient dose 210 SED) instead of 166 SED for the 15-day treatment period. Also, in a study involving 2-week climate therapy at the Dead Sea (14), 83.5% of the patients exceeded the prescribed exposure schedule of a maximum of 3h of daily sun bathing. These patients actually achieved better therapeutic results. Some of our patients have expressed their belief that more sun exposure leads to better therapeutic results. Also, the presence of clouds may incorrectly give the impression of much lower UV intensities. Thereby, the exposure times are prolonged to receive what the patients believe to be the necessary UV exposure.

The mean percentage reduction in the PASI score for our patients (72.8%), as well as for the 2-week Dead Sea regime (70.9%) (14), is lower than for patients receiving 4-week therapy at the Dead Sea with only 3h of daily exposure, i.e. $>$ 80% reduction in the PASI score (9–11). One of the studies obtained such results for treatment in the months March to August, with an ambient dose of 170 SED in March and 310–390 SED in the period from April to August (indicated in Fig. 4) (11). In the period from September to November, the reduction was around 70% for doses between 170 and 250 SED. The Dead Sea treatment site is at a latitude similar to the Canary Islands, although the former lies around 400 m below sea level. Therefore, the UV radiation and particularly the UVB radiation (280–315 nm) is attenuated compared with the levels at sea level and more attenuated as the sun elevation is reduced (towards winter) (34).

The full treatment period in Gran Canaria was 3 weeks, and our patients also continued sun exposure after finishing the study period of 15 days. UV doses for the whole period can be estimated by adding 6 days with doses equal to the average of the last 5 days of sun exposure (days 11–15). The resulting skin and ambient dose would be around 250 and 500 SED,

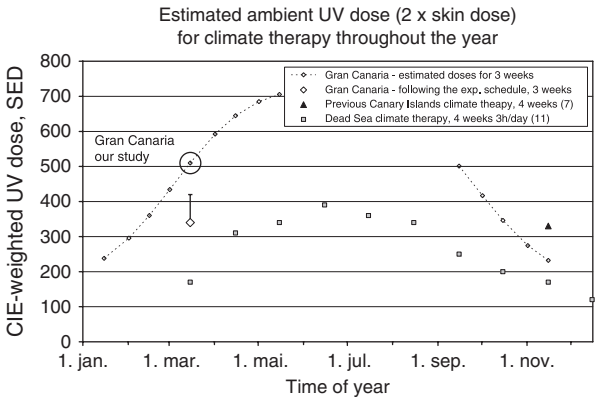

Fig. 4. Ambient CIE-weighted ultraviolet (UV) doses estimated for a full treatment period of 3 weeks with respect to time of the year of the treatment. The doses are estimated using the exposure schedule, weather conditions and ozone values as for our study in March 2006. The doses corresponding to the prescribed exposure schedule are indicated for the actual weather situation (open diamond) and in the case of a clear sky (top of upward line). Ambient doses from other studies are given in the figure (7, 11).

respectively, i.e. much higher than for the Dead Sea treatment. If the exposure schedule had been followed, however the skin and ambient doses would have been 170 and 340 SED for the actual weather situation and 210 and 420 SED in case of clear sky conditions. These doses are comparable to the Dead Sea treatment doses. For comparison, UV doses measured during a 4-week treatment in the Canary Islands in November showed a mean ambient dose of 330 SED or an average skin dose of about 130 SED (7).

Psoriasis patients undergoing climate therapy also seem to exhibit marked improvement for other months and with approximately the same sun exposure hours. Figure 4 shows estimated doses for the months in which patients are sent to Gran Canaria using the average sun exposure pattern established in our study. A factor 3 difference in UV dose between January and June is observed. The patients are, however, supposed to follow exposure schedules with more sun hours during the winter months (December–February) and less during the summer months (late April–June and September). Compared with the Dead Sea results (11), as well as the exposure schedule they should have followed, patients treated in June may therefore receive doses higher than needed to achieve good therapeutic improvement. Even our patients treated in March may all have received high enough UV doses with respect to the therapeutic response. This corresponds well with the fact that our results showed no correlation between reduction in the PASI score and the UV dose, i.e. the spectral UVB and UVA doses or the CIE-weighted UV dose. Other factors may be of importance for the therapeutic outcome and these should be explored in future studies.

In conclusion, this study has estimated UV doses for patients receiving climate therapy in Gran Canaria. The mean UV dose to the skin is estimated to 166 SED for the 15-day study period and 250 SED for a full treatment period of 3 weeks. The climate

therapy resulted in a 72.8% reduction in the PASI score. The individual percentage reduction in the PASI score did not seem to depend on the UV dose. The patients exceeded the prescribed exposure schedule and they received higher UV doses compared with climate therapy patients treated at other locations. It seems beneficial to focus on the prescribed exposure schedules to avoid erythema and large accumulated UV doses.

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