Original Article

To determine irradiance of ultraviolet A in ambient sunlight and optimum exposure time for PUVAsol in a North Indian location

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Abstract

Background: Psoralen with ultraviolet A is an effective photochemotherapeutic modality. A subtype of this, PUVAsol, uses sunlight as the natural source of ultraviolet A. The amount of sunlight received and the consequent ultraviolet A exposure vary according to the month in the year, time of the day and geographical location of a place.

Aim: The aim of this study is to determine irradiance of ultraviolet A in ambient sunlight and optimum exposure time for PUVAsol.

Materials and Methods: This was an observational study carried out at Postgraduate Institute of Medical Education and Research, Chandigarh (30.7333°N, 76.7794°E), India using a photometer. Ultraviolet A irradiance was recorded at a fixed place at 10 AM, once weekly for a period of 12 months.

Results: The irradiance of peak ultraviolet A was found to be 3.1 mW/cm^2 in June 2016 while irradiance of 0.64 mW/cm^2 was recorded in January 2017. The exposure time needed for therapeutic dose of 2 J/cm^2 was 11 min 6 s in June 2016 while exposure time for achieving therapeutic dose of 2 J/cm^2 was 52 min 5 s in January 2017. The duration of exposure was found to be significantly longer in the winter months.

Limitation: The limitation of the study is not determining ultraviolet B radiation and infrared exposure. Other limitation of this study is that the irradiance was measured only at 10 am. This data cannot be used to determine irradiance at different time points in the day as the patient may expose himself/herself to sunlight anytime depending on his/her convenience.

Conclusions: The study demonstrates the mean exposure time required for a given therapeutic dose of ultraviolet A in different months. The wide variation in ultraviolet A irradiance in natural sunlight over the year in different months also suggests that exposure times for PUVAsol should be based on the season and geographical location at the site of therapy and not based on uniform guidelines.

Key words: Psoralen with ultraviolet A, PUVAsol, ultraviolet A irradiance

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Introduction

Psoralen with ultraviolet A is a type of photochemotherapy, effective in dermatological conditions such as psoriasis and

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vitiligo.[1] It involves systemic or topical administration of exogenous photosensitizers, known as psoralens, followed by exposure to ultraviolet A. PUVAsol is the subtype in which exposure to sunlight acts as the source of ultraviolet A. In a tropical country like India, PUVAsol is an effective, convenient and cost-effective method of administering therapy with better compliance. This does not require installation of any special ultraviolet A chamber and the patient does not need to visit healthcare facility for exposure to ultraviolet A, thus being cost-effective. PUVAsol requires sufficient sunlight exposure to allow adequate ultraviolet A exposure. As ultraviolet A irradiance in sunlight varies with month, time of the day and topographical location, the present study tried to determine irradiance of ultraviolet A in ambient sunlight as well as the optimum exposure time needed for PUVAsol at that irradiance in a north Indian location of Chandigarh (30.7333°N, 76.7794°E).

The aim of this study was to determine irradiance for ultraviolet A in ambient sunlight during morning at 10 AM as well as to calculate the optimum exposure time for PUVAsol therapy at that irradiance.

Materials and Methods

This was an observational study carried out at Postgraduate Institute of Medical Education and Research, a tertiary care hospital in the north Indian city of Chandigarh (30.7333°N, 76.7794°E). A photometer (Waldmann GmbH, Germany) [Figure 1] with data-logging capabilities was used at a fixed place to record the irradiance specifically for ultraviolet A in the spectrum range of 320–380 nm, with maximum sensitivity at 360 nm. The data were recorded at a fixed time of 10 AM once a week on Monday for a period of 12 months (from April 2016 to March 2017). The photometer was placed horizontally on a flat surface in the east to west orientation with the sensors directed vertically upwards avoiding any shade overhead. The data so collected were transferred to a structured database and the charts of data were analyzed. In the factory, ultraviolet sensor was calibrated to meet the standard requirements. Exposure time needed to deliver energy of 2 J/cm^2 was calculated for each day.

Figure 1: Waldmann GmbH variocontrol used in the study

All values of irradiance and exposure times were expressed as mean ± standard deviation. Statistical tests were applied as applicable and all statistical calculations were made using Statistical Package for the Social Sciences software, version 19. Student's *t*-test was used to compare mean exposure times for winter and summer months. All statistical values with $P < 0.05$ were taken as statistically significant.

Results

During the study period, peak ultraviolet A irradiance was found to be 3.10 mW/cm^2 in June 2016 while irradiance of only 0.64 mW/cm^2 was recorded in January 2017. The mean ultraviolet A irradiance over the study period was 2.057 mW/cm^2 and the median irradiance was 2.14 mW/cm^2. These data appear to be skewed because North India has four seasons and the variation in natural sunlight across the year is expected to generate a skew. The duration of exposure to sunlight needed for 2 J/cm^2 was calculated for each day of reading and the mean values of exposure time for each month were also calculated [Table 1]. The mean exposure time during the study period was calculated to be 19 min 38 s and the median exposure time was 15 min 32 s. The minimum exposure time needed for 2 J/cm^2 was 11 min 6 s in June 2016 and maximum exposure time was 52 min 5 s in January 2017. Using Student's *t*-test, the duration of exposure was found to be significantly longer ($P = 0.04$) in the winter months (November, December, January and February), as compared with summer months (April, May, June and July) [Table 2].

Discussion

Use of psoralen with ultraviolet A therapy is an established and effective first line therapy in the management of psoriasis as well as other conditions such as widespread vitiligo, eczema, cutaneous T-cell lymphomas and so on. Most of the currently followed international guidelines favor the use of artificial ultraviolet light chambers or fluorescent ultraviolet A lamps as the source of ultraviolet A.[2] Use of these artificial sources is because of weather considerations and limited daylight exposure in some countries. However, there are limitations in the widespread use of such artificial sources in resource-limited settings owing to higher cost and the need for administration in an institutional setting. PUVAsol, which involves the use of sunlight exposure as source of ultraviolet A, is an effective alternative and can be administered either as topical PUVAsol or systemic PUVAsol. Aggarwal *et al*. compared efficacy and cost-effectiveness of psoralen with ultraviolet A versus PUVAsol in a randomized controlled trial in patients of chronic plaque psoriasis and concluded that although psoralen with ultraviolet A and PUVAsol had equal efficacy, PUVAsol had double the cost-effectiveness as psoralen with ultraviolet A.[3] In a retrospective study, Handa *et al*. concluded that topical PUVAsol was the most efficacious therapy for localized vitiligo, whereas for generalized vitiligo, topical PUVAsol, systemic PUVAsol and PUVA therapy were equally efficacious.[4]

Table 1: Mean ultraviolet A irradiance (I), dose administered and exposure times at 10 AM for a period of 1 year

Month, year	Ultraviolet A irradiance (I) (mW/cm²)	Dose at 1 min (D1)	Dose at 5 min (D5)	Exposure time (T) for 2 J/cm²
April, 2016	2.695	0.152	0.773	12 min 54 s
May, 2016	2.585	0.241	0.779	12 min 50 s
June, 2016	3.10	0.181	0.900	11 min 6 s
July, 2016	2.71	0.162	0.83	12 min 2 s
August, 2016	2.65	0.152	0.76	12 min 48 s
September, 2016	2.1	0.126	0.630	15 min 52 s
October, 2016	1.61	0.097	0.483	20 min 42 s
November, 2016	1.32	0.070	0.390	25 min 38 s
December, 2016	1.26	0.076	0.382	26 min 10 s
January, 2017	0.64	0.038	0.192	52 min 5 s
February, 2017	1.82	0.110	0.546	18 min 18 s
March, 2017	2.19	0.131	0.657	15 min 13 s
Mean	2.057	0.128	0.61	19 min 38 s
Median	2.14	0.128	0.643	15 min 32 s

Table 2: Comparison of mean exposure time during summer and winter months

Parameter	Summer months (April-July) (4-month period)	Winter months (November-February) (4-month period)
Mean exposure time for UVA dose of 2 J/cm²	12 min 13 s	30 min 33 s
P	0.048	

UVA: Ultraviolet A

Use of sunlight as the source of ultraviolet radiation in PUVAsol has some inherent disadvantages. The total amount of ultraviolet A reaching skin shows variation according to the location, time of the day, season, latitude, as well as atmospheric conditions.[5] Patient may be exposed to ultraviolet B as well as infrared rays in sunlight, which may be undesirable. There may be concerns regarding privacy and cultural inhibitions in case of female patients in some societies. From a therapeutic point of view, appropriate exposure time for PUVAsol still needs to be addressed. As per the commonly followed regimen in India, the initial treatment dose for ultraviolet A for both psoriasis and vitiligo is 2–3 J/cm² and is to be increased by 0.5 J/cm². Psoralen such as 8-methoxypsoralane is administered orally, followed by sun exposure for 10 min after 2 h. Time of exposure is increased by 5 min weekly for a maximum of 30–45 min.[6] The initial starting exposure time of 10 min has been extrapolated from select small studies. This general approach may not be suitable for all geographical locations.

In the Indian study by Balasaraswathy *et al*., UV irradiance of sunlight was recorded from January to December 1999, between 8 AM and 5 PM in the town of Coimbatore in South India (11.0168°N, 76.9558°E).[7] The authors reported irradiance of ultraviolet A to be higher during summer months and best time for PUVAsol to be between 9:15 AM and 11:15 AM; 2:30 PM and 3:30 PM due to minimal exposure to ultraviolet B and infrared rays during this period. The sun exposure time for therapeutic efficacy was calculated by authors to be between 5 and 9 min. However, a fixed time duration irrespective of season may not ensure desired exposure to ultraviolet A.

In our study, irradiance was measured at 10 AM, the time corresponding to best time reported for PUVAsol as per studies quoted earlier. Our study revealed that spectral irradiance for ultraviolet A showed significant variation, from as low as 0.64 mW/cm² in January to as high as 3.1 mW/cm² in June 2016. The duration of exposure required for optimum ultraviolet A exposure was found to be significantly longer in the winter months. The exposure time in our study is higher than that reported in other studies. This can be explained by the difference in the geographical location (30.7333°N, 76.7794°E). At the place of our study, the weather conditions and consequent sunlight exposure vary greatly throughout the year, with sunlight exposure being much less during the winter season (November to February), whereas places such as Coimbatore experience ample sunlight throughout the year, with much less variance in exposure.

Not determining ultraviolet B and infrared exposure is a limitation of the study. Because reading of irradiance were taken only at 10 am, this study does not provide data for irradiance at other time points during the day. Patients according to their convenience may opt for sun exposure at other times (between 10 am to 3 pm).

Conclusion

The study demonstrates the wide variation in ultraviolet A irradiance in natural sunlight over the year in different months. As spectral irradiance and total duration of exposure to sunlight in a session are important determinants of efficacy of PUVAsol, the study suggests that following strict exposure times based on extrapolation from select studies may be

fallacious. Studies are needed to determine the appropriate exposure time for PUVAsol in different seasons in different parts of the country. Dermatologists in North India may follow the mean spectral irradiance and exposure time in our study in different months while giving instructions to patients for optimum exposure to ultraviolet A.

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Conflicts of interest
There are no conflicts of interest.

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