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Effectiveness of heliotherapy for psoriasis clearance in low and mid-latitudinal regions: A theoretical approach

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ABSTRACT

The action spectrum for psoriasis clearance is reconstructed taking into account the results obtained in the early 1980s. The antipsoriatic action spectrum is used for weighting the medical cabinet UV spectra, and the solar spectra measured in San Diego (USA) and Belsk (Poland). The mean cumulative antipsoriatic effective dose of 450 mJ cm^{-2}, due to TL-01 (UVB narrowband) tubes, is taken by a patient with skin phototype II during routine 20 phototherapy sessions carried out in a phototherapy cabinet in the Medical University of Łódz. Thus, the daily mean dose of value 22.5 mJ cm^{-2} is proposed as the threshold for daily solar dose for numbers of out-door exposures to clear psoriasis. We assume that the heliotherapy will last a whole month with every day 2 h exposition to the direct sunlight around local noon. The heliotherapy will be successful if weather conditions permit at least 20 days with the daily exposure over the threshold. The minimum cumulative ambient erythemal dose, necessary for psoriasis clearance, is estimated as 144 standard erythema dose (SED) for the whole heliotherapy period. We find that heliotherapy could be effectively used in March through October (San Diego) and in June through August (Belsk). Thus, the heliotherapy against psoriasis is possible not only at southern resorts but even at the mid-latitude sites.

1. Introduction

Phototherapy with artificial ultraviolet (UV) radiation due to fluorescent tubes is widely used to treat psoriasis [1]. Previous empirical studies showed effectiveness of heliotherapy offered to psoriatic patient especially at low latitudinal resorts [2–4] and at high altitude sites such as Davos [5]. In 19th century there were psoriasis treatment centers on the seaside resorts in England and Germany [6]. However, nowadays the climate therapy has been systematically carried out only at a very few places [3,4].

The major psoriasis therapeutic effects are in the UVB range. UVA light therapy is also possible but a patient needs to take psoralen, a medication increasing the skin's sensitivity to UV light, prior to the cabinet irradiation. Two kinds of UVB fluorescent tubes are commonly used in irradiation cabinets, i.e., broad band UVB (BBUVB) with ~50 nm of the full width at half maximum, and narrow band UVB (NBUVB) with a peak emission at 311 nm ± 2 nm (see Fig. 1). In present day dermatology, NBUVB tubes are more frequently used in the psoriasis treatment than other sources of artificial UV radiations [7]. However, some authors claimed that therapeutic effectiveness of BBUVB [8] or psoralen UVA [9] is at least comparable with the NVUVB phototherapy. Side effects of the UV phototherapy are mainly development of erythema and photocarcinogenesis. Using BBUVB may be safer option than NBUVB as erythema effects were similar for both lamp types but NBUVB appeared to be 50% more carcinogenic for equal erythemal doses [10].

This paper proposes a theoretical basis to estimate an effectiveness of the solar UV radiation for psoriasis clearance in different sites and seasons of the year. A mathematical formula for the antipsoriatic action spectrum (AAS) is estimated based on the previous studies on the action spectrum for the psoriasis clearance [11,12]. The long-time series of the solar UV spectra, which have been taken by the UV spectrometers at selected sites: low-latitudinal (San Diego USA, for the period 1996–2008), and mid-latitudinal (Belsk, Poland, for the period 2000–2010), are analyzed. The measured spectra are weighted by the proposed AAS to calculate the antipsoriatic effective doses. These are used to find the number of cases, for selected calendar month, with fractional daily doses exceeding the threshold for psoriasis clearance.

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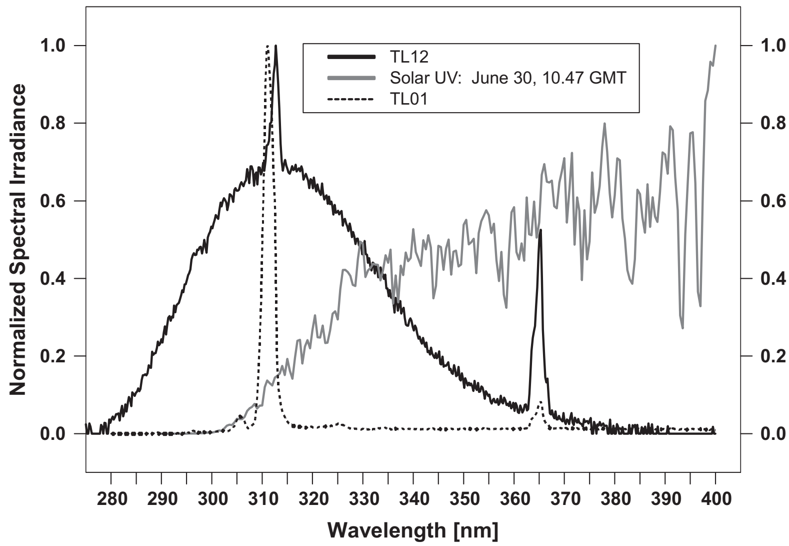

Fig. 1. The irradiance spectra of UVB lamps (in arbitrary units) for the psoriasis clearance in medical cabinets and the solar spectrum (in absolute units) in the UV range measured at Belsk, Poland, in summer 2010.

2. Methods

2.1. Cabinet doses

The UV doses, which are used to determine the cumulative dose threshold value for psoriasis clearance, are based on the phototherapy schedule applied in the Medical University of Łódź, Poland [13]. The whole body irradiation was performed in the MEDISUN 2800 PC-AB phototherapy chamber containing twelve NBUVB fluorescent tubes (TL-01 type manufactured by Philips Lighting B.V., Roosendall, The Netherlands) surrounding the irradiation space. Cabinet software allows to estimate non-weighted UVB dose (J cm^{-2}) received by a patient during a single exposure session in the cabinet. Patients routinely take 20 exposure sessions with 2–3 treatments weekly starting with the dose of 0.2–0.3 J cm^{-2} (non-weighted) up to the maximum dose 1.5 J cm^{-2} with the mean daily dose of ~0.7 J cm^{-2} (range 0.5–0.9 J cm^{-2}) [13].

The cabinet standard in Poland is to express the doses in terms of non-weighted doses according to output of the cabinet built-in jouletimer. Uncertainty of the doses, assigned by technical staff according to medical doctor recommendation, is estimated less than 20% when compared with the independent UV meter measurements inside the cabinet during every half-year calibration session. It is worth mentioning that the last exposure is about six times greater that the initial one. Such increase is possible because of the photoadaptation of patient's skin to supra-erythemal exposures attained during numerous irradiation sessions.

The cabinet daily mean dose, 0.7 J cm^{-2} (non-weighted), will be used to calculate a threshold value for a single open-air exposure session. The solar and tubes spectra are very different from each other (Fig. 1), so the antipsoriatic effective doses need to be calculated for a comparison of healing effects of ultraviolet solar and tube radiation. Thus the threshold value has to be expressed in the antipsoriatic effective doses. This value will represent the minimum daily dose for psoriasis clearance that is equal to the mean daily exposure attained during a single phototherapy session in the medical cabinet.

2.2. Antipsoriatic action spectrum

Action spectrum studies on psoriasis clearance were rather limited and carried out in the 1980s [11,12]. These studies built the theoretical basis supporting construction of a new brand UVB tubes with a narrow peak around 310 nm (NBUVB). It appeared that both the UVC and UVA wavelengths were relatively ineffective for psoriasis clearance. The major therapeutic wavelengths were in the 295–313 nm range with rapid fall of in the effectiveness below 295 nm and above 320 nm.

AAS differs significantly with the erythema action spectrum in the short UV wavelength range, as a stronger burning effect appears for shorter UV wavelengths. To the authors knowledge, an analytical formula for AAS does not exist and the antipsoriatic effective UV irradiances (or doses) have never been calculated. Using the AAS pattern shown by Bolognia et al. [1] on page 2054, which is based on the effectiveness of psoriasis clearance reported previously in the 1980s [11,12], we propose the following analytical formula:

$$Antipsoriasis(\lambda) = \begin{cases} 0.6504 \times 10^{-0.6304*(296-\lambda)} & \lambda < 296\ \text{nm} \\ 1.0000 \times 10^{-0.0467*(300-\lambda)} & 296 \leqslant \lambda < 300\ \text{nm} \\ 1.0000 \times 10^{-0.1067*(\lambda-300)} & 300 \leqslant \lambda < 304\ \text{nm} \\ 0.3743 \times 10^{-0.1571*(\lambda-304)} & 304 \leqslant \lambda < 313\ \text{nm} \\ 0.0144 \times 10^{0.08233*(313-\lambda)} & 313 \leqslant \lambda < 330\ \text{nm} \\ 00057 \times 10^{0.00937*(330-\lambda)} & 330 \leqslant \lambda < 400\ \text{nm} \end{cases} \quad (1)$$

The antipsoriatic action spectrum (1) is normalized to 1 at 300 nm and it is used for calculation of the antipsoriatic weighted doses due to solar (or tube) radiation in the period beginning at t_1 and ending at t_2 as follows:

$$Dose_{ANTIPSOR}(t_2, t_1) = \int_{t_1}^{t_2} \left(\int_{280\ \text{nm}}^{400\ \text{nm}} Irradiance(t, \lambda) \times Antipsoriasis(\lambda) d\lambda \right) dt \quad (2)$$

where solar (or tube) spectral irradiance at λ wavelength for time t, $Irradiance(t, \lambda)$, is weighted by AAS described by formula (1).

The antipsoriatic effective doses are calculated in a way corresponding to the commonly used erythemal weighting of the UV spectral irradiance to obtain the erythemal exposures:

$$Dose_{ERYTHEMA}(t_2, t_1) = \int_{t_1}^{t_2} \left(\int_{280nm}^{400nm} Irradiance(t, \lambda) \times Erythema(\lambda) d\lambda \right) dt \quad (3)$$

where $Erythema(\lambda)$ is the CIE (1987) reference action spectrum for erythema in the human skin [14].