Pigment Protection Factor as a Predictor of Skin Photosensitivity – A Polish Study

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ABSTRACT Assessment of individual photosensitivity by determining the minimal erythema dose (MED) is commonly accepted. MED objectively describes a single individual response to the irradiation of skin with a particular wavelength (UVB, UVA). Pigment protection factor (PPF) is an objective value to measure skin type. The aim of the project was to analyze PPF values in the population of Lodz and the relationship between PPF, skin phototype, and individual MED. The study was conducted on the group of 270 volunteers: 130 men and 140 women, mean age 28.5 years (OS $\pm$ 9.66) with either skin phototype II or III, as defined by Fitzpatrick Skin Phototype Classification. Phototesting of each volunteer was undertaken with an increasing dose series (UVB radiation) on six squares (1×1 cm) on the skin of the back. The MED was defined as a perceptible erythema 24 hours later. Starting dose was determined by history, physical examination, and phototype ranged from 0.03-0.07 J/cm^2. PPF was measured by a skin reflectance meter UV Optimize 555. The mean MED value was 0.15 J/cm^2 and the PPF value was 6.15. A positive correlation between the MED value and PPF (R=0.38; P<0.001), and a positive correlation between phototype and MED and PPF (P< 0.001) were found. Both determination of MED and PPF are objective methods of photosensitivity assessment, but PPF determination is an easy and non-invasive method.

KEY WORDS: pigment protection factor, photosensitivity, minimal erythema dose

INTRODUCTION

Exposure to ultraviolet radiation (UVR) from the sun is undoubtedly common, but due to the fact that the ozone layer is permanently decreasing, UVR is expected to rise in the future. Furthermore, in the Polish population a healthy suntan has become fashionable. Unfortunately, most people are still unaware of the detrimental impact of UVR (1).

Although it has recently been shown that sun exposure has a beneficial influence on vitamin D synthesis and mood improvement, the adverse influence of UVR cannot be denied. Excessive skin penetration by UVR can lead to erythema, sunburn, and photoageing. It can cause DNA damage and repairing processes impairment leading to carcinogenesis. Tendency

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Table 1. Skin phototypes

Skin phototype	Sunburn	Suntan
I	always	never*
II	always	sometimes
III	sometimes	always
IV	never	always
V	never	always**
VI	never	always***

- *Mainly Celtic population
- **Dark-skinned, Mediterranean ancestry
- ***Afro-Americans, Blacks

towards sunburns is a well-known predisposing factor to melanoma (2).

Increased levels of vulnerability to UV is the one of the diagnostic criteria of many skin diseases, e.g. polymorphic light eruption, chronic actinic dermatitis, erythropoietic protorfiria, and solar urticaria (3,4). This environmental factor plays a key part in connective tissue diseases, particularly in cutaneous forms of lupus erythematosus (LE) – subacute cutaneous LE (SCLE) and discoid LE (DLE) (5).

Before beginning phototherapy for psoriasis and atopic dermatitis, it is vital to determine individual photosensitivity (6). The higher the individual UVR sensibility, the bigger the potential risk of excessive sun exposure. In clinical practice, the most common methods of skin UVR sensibility assessment are MED and skin phototype according to Fitzpatrick (Fitzpatrick Skin Phototype Classification, FSPC). A new objective method is determining pigment protection factor (PPF) which is an objective measurement of skin sensitivity in all skin types after single exposure. PPF is measured by diffuse remittance spectroscopy with a dedicated instrument, Optimize Scientific 555 (Chomo-Light, Naerum, Denmark). It measures the photoprotection provided by skin pigmentation and stratum corneum. It predicts the UV dose (number of SED) to produce 1 MED and thereby indicates how easily a person will get a sunburn after a single exposure on the measured spot. PPF successfully estimates both constitutive and facultative UV sensitivity, when erythema is the endpoint. According to recent data, PPF is a better predictor of individual photosensitivity than skin photypes (7).

MED is defined as a dose of UV in a particular spectrum which induces a barely perceptible erythema 24 hours after skin irradiation. Establishing MED in the surveyed group should be carry out in the same circumstances, the same body area, and using the same calibrated source of UVR.

Only a few studies analyzed the correlation between values of objective pigment protection factor, values of MED, and skin phototype according to the Fitzpatrick scale, although PPF was mentioned in the methodology (8).

The aim of our study was to analyze PPF values in the population of Lodz and the relationship between PPF, skin phototype, and individual MED.

PATIENTS AND METHODS

The study group consisted of 270 healthy volunteers with a mean age of 28.5 years (OS $\pm$ 9.66), with skin phototype II or III, as assessed by the Fitzpatrick score (9) (Table I). They were without any skin or other diseases and were not receiving any medications. People exposed to sunlight or sunlamps two months prior the study were also excluded. To decrease the influence of natural solar radiation, all the procedures were performed between November 2012 and February 2013. Each volunteer gave written informed consent before entry into the study, and the experimental plan was approved by the local ethics committee.

The volunteers did not take any medications. Before the beginning of the study, each of them was examined. Aiming to eliminate the influence of solar radiation, the study was carried out during the winter season. Skin diseases, sun-sensitizing medication, and exposure to artificial tanning 2 months prior to the study were exclusion criteria.

As the aim of the study was to define the minimal

Table 2. Detailed PPF results in patients with phototype II and III

	II	III
Number	142	128
Minimum	4.4	4.5
25% percentile	5.35	6.7
Median	6.75	7.85
75% percentile	8.1	9.35
Maximum	10.9	12.0
Mean	6.769	7.852
Std. deviation	1.648	1.773
Std. error	0.1383	0.1567
Lower 95% CI of mean	6.496	7.541
Upper 95% CI of mean	7.042	8.162

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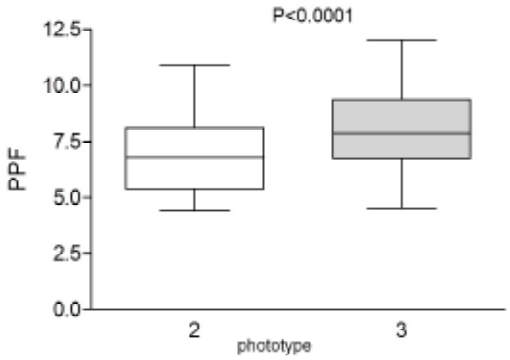

Figure 1. Correlation between pigment Protection Factor and skin phototype.

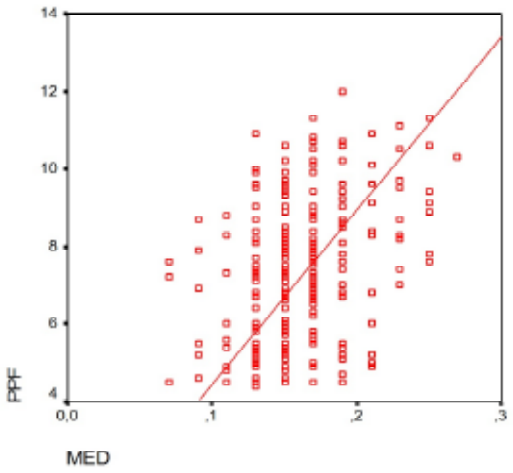

Figure 2. Correlation between pigment Protection Factor and minimal erythema dose.

erythema dose (MED), several irradiation procedures with rising doses of UVB were performed on six 1×1 cm areas on the skin of the back. The initial dose was defined based on interviews, clinical research, and skin phototypes. Its value was between 0.03-0.07 J/cm^2.

The skin pigmentation, measured by reflectance spectroscopy (UV-Optimize 555, Matic, Naerum, Denmark) (10) is directly related to the melanin content of the skin (8). Erythema and pigmentation were quantified using the UV Optimise 555 device (ChromoLight, APS, Denmark). This patented device is used in dermatological practice to optimize UV treatments. The probe consists of two light emitting diodes, a photodetector, and the circuitry necessary to collect and transmit data regarding the skin's reflection of red and green light to a microprocessor. The results obtained are a percentage of the reflection of 558 and 660 nm light. PPF measurement was performed on the upper arm of each volunteer. PPF was determined from the readings and calculated automatically. The mean values of the three readings were calculated. Relative spectroscopy can be used to asses both pigmentation and erythema response to UV (8,11).

STATISTICAL ANALYSIS

Statistical analysis included assessing the arithmetic mean, extreme values, standard deviation, and the Mann-Whitney test. *P* values <0.05 were considered statistically significant.

RESULTS

Mean value of MED in 240 volunteers was 0.15 J/cm^2 (median 0.15; SD±0.033).

A statistically significant difference (*P*<0.0001) was found between mean MED in patients with skin phototype II (mean MED 0.141 J/cm^2; SD±0.02) and mean value of this parameter in individuals with skin type III (mean MED 0.177 J/cm^2; SD±0.03) (*P*<0.01 for both comparison).

The mean value of the PPF factor was 7.30 for the whole group. A statistically significant difference (*P*<0.0001) was found between mean PPF in subjects with skin phototype II (mean PPF 6.769) and the mean value of this parameter in individuals with skin type III (mean value 7.852) (Figure 1) (Table 2).

A positive correlation between the PPF value and MED value was found (R=0.38; *P*<0.001) (Figure 2). There was no correlation between PPF and patient gender (*P*>0.05) (Figure 3).

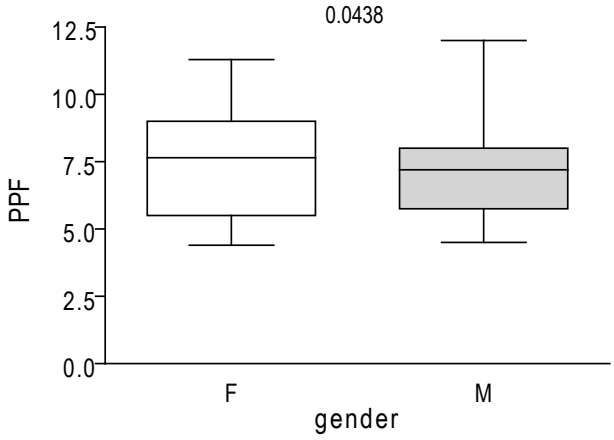

Figure 3. Correlation between pigment Protection Factor and gender.

DISCUSSION

Phototesting, an easy and quick procedure, is widely used in dermatological practice for assessment of photosensitivity and establishing the initial dose of UV in phototherapy.

Our study is the first, to our knowledge, in which PPF was determined in a Polish population. The standard of individual photosensitivity determination is minimal erythema dose and phototype according to the Fitzpatrick Scale. Introducing PPF as one of these standards is considered to be reasonable, as recent studies confirm (12). Ravnbak described skin pigmentation in the research participants using skin reflectance measurements. At the same time, he carried out MED and *minimal melanogenic dose* (MMD) measurements classifying the participants according to the Fitzpatrick skin phototype. He proved that PPF is a reliable predictor of skin phototype, both in people before sun exposure and after it. In his research, a higher positive correlation has been observed for patients after numerous exposures into UV radiation in comparison with sole exposure. As expected, PPF correlated strongly with SED/MED and even more distinctly with phototype according to the Fitzpatrick scale.

Description of individual photosensitivity could play a key role in sunburn prevention. A correlation between hazardous exposure (sunbaths) and applying sunscreens was found. Recent studies indicate that sunscreens (SPF creams) are commonly used as a protection against sunburn. Women use much more sunscreen, but, on the other hand, engage in much more risky behaviors and more frequently have sunburns (13,14). The amount of sunscreen applied is dependent on the skin phototype. The higher the phototype, the lower the sunscreen use. Thieden *et al.* showed that subjects with phototype I received a much lower dose of UV radiation, and subjects with phototype IV a much higher dose of UV than those with phototype II or III (15). There is a need for studies which explain the usefulness of individual UV sensitivity assessment in personal decisions on sunscreen application. In recent years, there have been awareness campaigns concerning sun protection and the necessity of dermatological controls to diagnose the cancer early. The public should be informed that the higher the skin sensitivity, the greater the risk of sunburns and carcinogenesis.

So far, studies have focused on determining correlation between MED and skin phototype. The majority of studies found statistical differences in MED values for particular skin phototypes, which is in line with our observations (16,17).

In the literature values of MED may be observed different depending on the photobiological laboratory (18). It may be caused by different photosensitivity of the population and different equipment used in phototesting (10). Clinical determination of skin erythema is not a completely objective method. That is why some authors point out the usefulness of skin reflectance meters (f.e. Dia-stron erythema meter, Optimize 555) for determining other markers such as PPF (15,19).

CONCLUSION

The results obtained confirm that pigment protection factor (PPF) is a predictor of individual photosensitivity as it correlates positively both with MED and skin type. PPF is preferable to the subjective Fitzpatrick skin type in predicting individual UV-sensitivity. We suggest that PPF measurements should be considered instead of MED assessment because of the safety, simplicity, and non-invasiveness of PPF.

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