

Seasonal Variation of Skin Pigmentation

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We measured skin pigmentation by skin reflectance monthly from May 1992 to April 1993 in 36 healthy Caucasians. Pigmentation was measured at four UV-exposed sites at the forehead, the upper chest, the inside of the upper arm, and at the upper back. The pigmentation and UV sensitivity were simultaneously measured at UV-protected buttock skin. The results showed a considerable seasonal variation for skin pigmentation at the UV-exposed sites. Buttock skin had a pigmentation and UV sensitivity that varied only marginally.

We recommend that measurements of genetically controlled skin pigmentation and constitutive UV sensitivity should be performed at UV-unexposed skin on the buttocks, except in persons that expose this site to artificial or natural sunlight. **Key words:** minimal erythema dose; skin pigment; skin reflectance; UV.

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In 1954 Lasker (1) investigated seasonal changes in skin colour by measurements of skin reflectance at the forehead and the palms of the hands and the upper arm and found a darkening of the forehead and the arm in the spring and summer periods. Brodthagen (2) in 1969 studied the UV sensitivity of the inside of the forearm by exposing the skin to artificial sunlight and found a seasonal variation with lowest UV sensitivity in the summer months and maximal sensitivity in the late winter.

The aim of our study was to measure skin pigmentation objectively in several anatomic regions on a monthly basis for at least 1 year and quantify the magnitude of the seasonal variation. The regions under study should be highly UV-exposed regions as well as less exposed regions and also unexposed. The study should elucidate which region was least affected by seasonal variation and therefore best suited for measurement of the UV sensitivity of UV-unadapted skin, i.e. the constitutive UV sensitivity.

MATERIAL AND METHODS

Thirty-six healthy Caucasians from the staff at the Department of Dermatology, The National University Hospital in Copenhagen, were recruited as volunteers after informed consent. There were 6 males and 30 females, with a mean age of 46.2 years (SD = 10.6 years, range 20–65 years). The study was performed from May 1992 to April 1993 and in February 1994.

Skin type

All subjects were initially skin-typed according to the Fitzpatrick skin type (FST) classification (3) by a short interview on their tendency to sunburn and ability to tan after initial sun exposure for 2 h at noon in the spring or early summer, which in Copenhagen, situated at 56 degrees latitude north, is equivalent on a sunny day to a UV dose of 93.6 mJ/cm² (erythemally weighted at 296 nm). Skin type was defined

as FST I: always burn and never tan; FST II: usually burn and tan less than average; FST III: sometimes mild burn and tan as average; FST IV: rarely burn and tan more as average. Two subjects were classified as FST I, 10 subjects as FST II, 19 subjects as FST III, and 5 subjects as FST IV.

Skin pigmentation

For the measurements of skin pigmentation a skin reflection apparatus (UV-Optimize, Model 550/660, PBI, Ringsted, Denmark) was used. Based on skin reflection spectroscopy of wavelength bands with peaks at 555 nm and 660 nm the skin pigmentation and skin redness are calculated independently (4) and given on a continuous scale from 0 to 100%. Zero per cent pigment is the degree of pigmentation seen in an extremely white person on buttock skin that has not previously been UV-exposed. One-hundred per cent pigment represents the pigmentation of skin with no reflection at all, as in an extremely black person. The apparatus is portable and one measurement takes less than 10 s and is without any discomfort to the person being measured.

Skin pigmentation was measured monthly in a standardized way from May 1992 to April 1993 in the 36 subjects and repeated in February 1994 in 30 of the 36 subjects. Measurements were performed in skin at the forehead just above the glabella area, at the upper chest over the upper part of the sternum, at the upper back just lateral to the spine and above the scapula, at the inside of the middle of the upper arm, and at the medial and upper quadrant of the buttocks.

UV sensitivity

The UV-Optimize apparatus enables a prediction of the UV sensitivity at buttock skin that has not been exposed to UV. From independent measurements of skin pigment and skin redness the apparatus software programme calculates the predicted UV sensitivity (4, 5). The UV sensitivity was measured monthly at the buttocks in connection with measurements of skin pigmentation at the exposed sites.

Statistics

To evaluate the differences in monthly measurements of pigmentation and UV sensitivity we used repeated measurements analysis of variance (ANOVA). To compare skin pigment and UV sensitivity measured with an interval of 1 year the paired *t*-test was used.

RESULTS

Skin pigmentation at UV-exposed sites and season

For UV-exposed skin a close connection between pigmentation and season was found with pigmentation reaching a maximum in July (Fig. 1). Statistical analysis of site variation by repeated measurements ANOVA for the 12 months showed significant differences in pigmentation for all four sites: the forehead $p = 0.03$, the chest $p < 0.01$, the back $p < 0.01$, and the arm $p < 0.01$. The greatest pigment increase of 85% was found for the chest in persons of FST III and of 83% on the back for persons of FST II, while the forehead showed less pigment increase (Fig. 2). The least increase of 33% was found for the inside of the upper arm and for persons of FST I, but the seasonal variation was as pronounced for the inside of the upper arm as for the forehead.

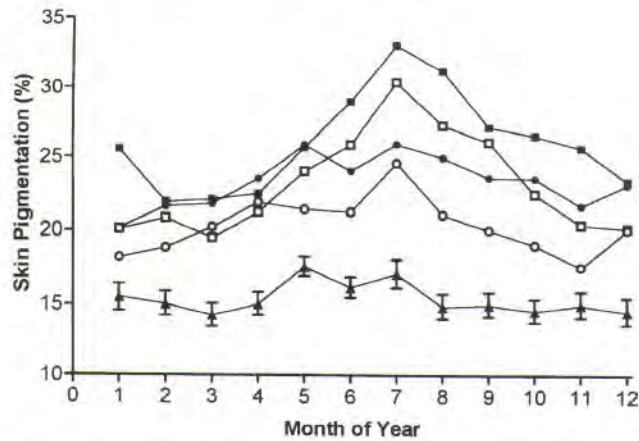


Fig. 1. Seasonal variation of skin pigmentation at UV-exposed and unexposed sites. Skin pigmentation in 36 healthy Caucasians was measured monthly from May 1992 through April 1993 at the forehead, the upper chest, the upper back, the inside of the upper arm, and at the buttocks. For each month the mean % pigmentation is indicated. Error bars for SEM are shown for the buttocks; the other sites had SEMs of similar magnitude. Back: ■; chest: □; arm: ●; forehead: ○; and buttock: ▲.

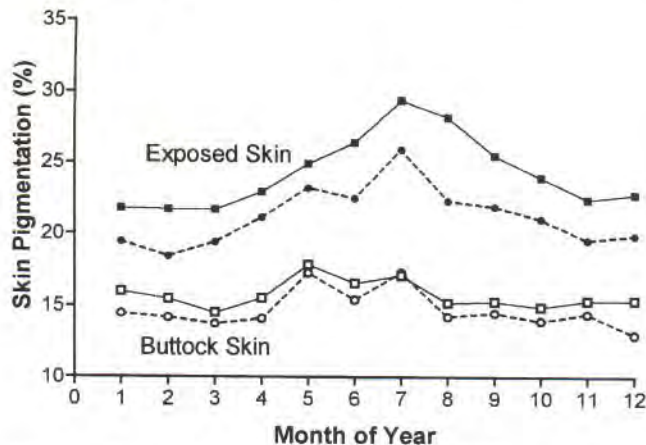


Fig. 2. Skin pigmentation in fair-skinned versus dark-skinned Caucasians in UV-exposed and unexposed skin. Skin pigmentation for the 12 subjects of FST I or II and for the 24 subjects of FST III or FST IV for each month from May 1992 to April 1993. Exposed skin is indicated as the mean value of the sum of the four exposed sites at the forehead, the upper chest, the upper back, and the inside of the upper arm. FST III+IV: ■; FST I+II: ●, (exposed); FST III+IV: □ and FST I+II: ○, (buttock).

Buttock skin

For buttock skin we found a slight increase in pigmentation of approximately 10% during the summer months of May through July (Fig. 1) but for the rest of the year the pigmentation remained very constant ($p=0.05$). Four persons used sunbeds or practised nude sunbathing, which might have raised their buttock pigmentation substantially, but the same summer increase in skin pigmentation was found for the remaining 32 subjects.

Skin pigmentation and skin type

The seasonal variation in skin pigmentation according to skin type is shown in Fig. 2. There was only little difference in

pigmentation at the buttocks between fair-skinned Caucasians and dark-skinned Caucasians, with a slight increase in the summer months. A greater difference in pigmentation between fair- and dark-skinned persons was found for the UV-exposed sites.

Skin pigmentation in February 1993 and February 1994

To examine if persons who participated in the study developed a special behaviour that influenced their UV exposure, we performed re-measurements 1 year after stopping monthly measurements. In 30 persons it was possible to get new measurements in February 1994 and to compare these to measurements from February 1993. Surprisingly similar values for pigmentation at the forehead, the chest, and the buttocks were recorded ($p>0.05$ for all sites by paired t -test), and only pigment at the back and the arm differed approximately by 2%. However, only the difference for pigmentation at the upper back was significant ($p<0.01$, paired t -test).

UV sensitivity at the buttocks

The mean value for UV sensitivity measured by skin reflectance increased marginally by 6 mJ/cm² to 59 mJ/cm² during the months of May to July ($p=0.03$, repeated measurements ANOVA). For the remaining 9 months of the year the levels for UV sensitivity were identical with a mean value of 53 mJ/cm². For the 30 subjects measured after an interval of 1 year the mean UV sensitivity at the buttocks was 53 mJ/cm² in February 1993 and 50 mJ/cm² 1 year later ($p=0.37$, paired t -test).

DISCUSSION

Our measurements of skin pigmentation in healthy Caucasians have objectively quantified the well-known seasonal variation of UV-exposed sites that are related to solar UV exposure. The variation was most pronounced for the back and the chest, but for the inside of the upper arm, which is commonly regarded as a relatively UV-shielded site, we also found a considerable seasonal variation. This corresponds to UV dosimeter studies on the anatomical distribution of sunlight, showing the shoulder and chest regions to receive higher UV doses than the face and the arm (6, 7). Somewhat surprisingly, we found a lesser degree of pigmentation at the forehead than at the inside of the upper arm. The forehead is often UV-shielded by hair and hats (8) and during outdoor work in direct sunlight we often tilt the head, which significantly reduces exposure of the forehead (9). This may be reflected in the lower incidence of skin cancer in the forehead than in the temple areas and the cheeks.

Repeated measurements of skin pigment in February, with an interval of 1 year, gave nearly similar results for all sites except for the back, which is most UV-exposed and therefore more influenced by personal sun exposure and travel habits and year-to-year variations in solar UV irradiance.

We observed the same pattern of seasonal variation for fair-skinned persons of FST I and FST II as for dark-skinned persons of FST III and FST IV (Fig. 2), probably because the study sample consisted of few subjects of FST I and FST IV, while the majority of subjects were of FST II and FST III with tanning abilities that are not markedly different.

Skin at the upper and medial quadrant of the buttocks showed only marginal seasonal variation, with a slight increase in pigmentation in May through July and then remaining at a constant level for the rest of the year. The UV-protective effect of some synthetic textiles is very low (10), and the pigment increase at the buttocks may be caused by UV passing through thin summer clothings and bathing suits. Stierner et al. has in an interesting study on humans showed that UV-B exposure in 10 of 21 subjects increased the melanocyte density also in covered skin, and in "a few cases" the degree of pigmentation in the covered area increased by visual inspection (11). An endogeneous circulating melanocytic factor originating from the irradiated skin has been suggested to account for the melanocyte increase in covered skin (12) being able to activate silent melanocytes or stimulate melanocyte proliferation. If a such factor exists and if this stimulation also leads to increased pigmentation by exposure to sunlight, this may offer a further explanation for our observation of increased pigmentation in covered buttock skin during the summer months.

Since buttock skin is shielded from direct UV exposure in most persons and the observed summer increase in pigmentation was only marginally and transitory, we believe that UV-protected buttock skin is best suited for measurements of constitutive pigmentation, as has also been proposed by Rhodes & Friedmann (13). The lateral part of the buttocks may, however, in some persons and especially in younger women wearing diminutive bathing suits in the summertime be UV-exposed, and so the lateral parts of the buttocks are also to be regarded as an exposed area in some persons. Our measurements were performed on the UV-protected medial part of the buttocks and were therefore not influenced by the sex distribution of the study subjects. Outside the summer period constitutive UV sensitivity can be measured at the upper and medial part of the buttocks, except in persons whose buttocks are exposed to artificial or natural sunlight.

In contrast UV-exposed skin will have a pigmentation that changes seasonally as a result of sun-induced tanning, which increases the pigmentation above the level of genetically determined pigmentation. Therefore, the inside of the upper arm or the back cannot be used for measurement of constitutive pigmentation or constitutive UV sensitivity.

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