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Variation of melanin levels in the skin in areas exposed and not exposed to the sun following winter and summer

Variação dos níveis de melanina da pele em áreas expostas e não expostas ao sol após inverno e verão

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ABSTRACT

Introduction The pigment mainly responsible for the color of the skin, melanin is directly influenced by exposure to sunlight.

Objective: The present study assessed the effects of solar radiation on the levels of melanin in areas exposed and not exposed to the sun, taking into consideration the seasonality of exposure.

Methods: Melanin levels were evaluated on the forehead, sacral region, and forearm, in the post-summer and post-winter periods, using spectrophotometry.

Results: The levels of melanin after winter were lower than those after summer in the forehead (168.1 vs. 177.0), sacral region (132.0 vs. 140.4), and forearm (218.7 vs. 260. 4), with a statistically significant reduction only in the forearm ($p<0.0001$). Additionally, erythema was significantly less intense in the forearm and forehead ($p<0.0001$ and $p=0.002$) after winter than after summer.

Conclusion: The significant reduction of melanin levels in the forearm after winter reinforces the influence of seasonality on skin pigmentation changes to body areas exposed to the sun without protection. The small variation in the levels of melanin found in the unexposed area (sacrum) confirms that the effect of exposure to the sun on the levels of melanin is predominantly local. Increased production of melanin is directly related to local exposure to UV rays.

Keywords: melanins; erythema;solar radiation; pigmentation.

RESUMO

Introdução: *A melanina, principal pigmento responsável pela cor da pele, sofre influência direta da exposição aos raios solares.*

Objetivo: *Este estudo avaliou os efeitos dos raios solares nos níveis de melanina em áreas expostas e não expostas à radiação solar, considerando a sazonalidade.*

Métodos: *Os níveis de melanina foram avaliados na fronte, região sacra e antebraço, nos períodos pós-verão e pós-inverno, através de espectrofotometria.*

Resultados: *Os níveis de melanina após o inverno foram menores que após o verão na fronte (168,1 vs. 177), região sacra (132 vs. 140,4) e antebraço (218,7 vs. 260,4), sendo a redução estatisticamente significativa apenas no antebraço ($p<0,0001$). O eritema foi significativamente menor no antebraço e na fronte ($p<0,0001$ e $p=0,002$) após o inverno do que após o verão.*

Conclusões: *A redução significativa dos níveis de melanina após o inverno no antebraço reforça a influência da sazonalidade na pigmentação da pele nas áreas de exposição solar sem uso de proteção. A pequena variação dos níveis de melanina verificado na área não exposta (sacro) confirma que a repercussão da exposição solar nos níveis de melanina é predominantemente local. O aumento da produção de melanina é diretamente relacionado à exposição local aos raios UV.*

Palavras-chave: *melaninas; eritema; radiação solar; pigmentação.*

INTRODUCTION

Skin color results from the presence of pigments, such as hemoglobin, carotenoids, and especially, melanin.[1] The quality and amount of melanin produced by melanocytes are the main determinants of cutaneous pigmentation.[2] Melanin is a protein whose main role is to protect DNA from the harmful action of solar radiation, absorbing and diffusing ultraviolet rays (UV).[1,3] There are two types of melanin: the constructive (determined by genes and not dependent on the exposure to the sun), 4 and the optional (produced by the body after exposure to UV rays).[1]

The increase in melanin production after exposure to UV rays is a photoprotective response of melanocytes and keratinocytes, achieved through a cascade of chemical reactions that result in, among other things, the increased expression of hormones, especially the melanocyte stimulating hormone melatonin. [5] When excessive, exposure to the sun can cause or worsen some important alterations in pigmentation, such as melasma,[6] post-inflammatory hyperpigmentation,[7] solar lentigines,[8] and can also lead to the development of cutaneous neoplasms.

The dose of UV rays that reaches the skin depends on the change of the seasons, among other factors. The irradiation of UVB rays, for instance, is much higher in summer than in winter.[9] Moreover, parameters like latitude also influence the intensity of the UV rays that reach the surface of the earth. 9 The city of Porto Alegre (RS), Brazil, where the study was carried out, experiences well-defined seasons, making it a favorable location for obtaining accurate results regarding the seasonal variation in the levels of melanin.

It is known that activation of melanocytes in order to produce melanin, which is caused by exposure to sunlight, occurs in body sites where there has been direct solar incidence. It is unknown however, whether the cutaneous expression of melanin remains restricted to the exposed locations or if it also occurs in areas where there was no direct solar incidence, as a result from increased serum levels of hormones, such as melatonin. The present study was developed to evaluate the effects of solar radiation on the levels of melanin in body areas exposed and not exposed to solar radiation, taking into account the specific season of the year.

METHODS

A prospective observational study was conducted in 2009 and 2010. Patients were recruited from a pre-existing Centro Brasileiro de Estudos em Dermatologia—CBED's (Brazilian Center for Studies in Dermatology) database. Prior written consent regarding participation in the study was obtained from all patients. The protocol of the study was approved by the Ethics Committee of the Hospital Moinhos de Vento, in Porto Alegre (RS), Brazil.

The main inclusion criteria were: individuals older than 18, Fitzpatrick skin phototypes I to IV, and absence of prior exposure to artificial sources of UV radiation. Exclusion criteria included: pigmentation disorders, topical treatments that might interfere with skin pigmentation, or having undergone other cosmetic treatments or surgeries in the assessed sites.

The patients attended the research center on two occasions, with one visit during the months of March and April (post-summer period) and another in September or October (post-winter period). The interval between visits was six months for all researched individuals. On both visits, skin pigmentation was assessed using a spectrophotometer (Mexameter®, Courage-Khazaka, Cologne, Germany), a device that provides objective measures of the levels of melanin and erythema in the skin.

Three areas were evaluated in each patient:

- the anterior part of the forearm, 8 cm above the wrist, measured from the styloid process of the ulna (an area exposed to direct sunlight only during the summer)
- the forehead, 4 cm below the hair's implantation line (an area exposed to direct sunlight throughout the year)
- the sacral region, located 10 cm below the midpoint between the posterior iliac crests (an area not exposed to direct sunlight at any time of year)

Statistical Analysis

The data were described using mean value and standard deviation for continuous variables and as percentages for categorical data. The data for melanin and erythema were compared over time through a paired t-test. The correlation between the values of melanin and erythema levels was calculated through the Pearson's correlation coefficient. The statistical analyses were performed using the SPSS 16.0 software (Chicago IL).

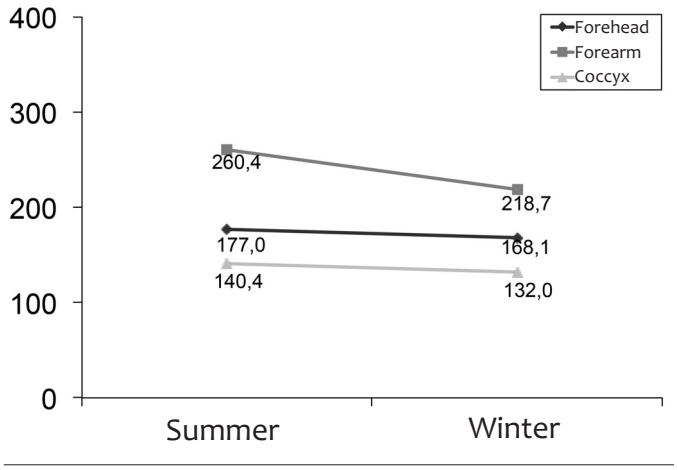
RESULTS

Thirty-four female patients were included in the study. Most patients were classified as phototype III (38.2%) and the mean value of their ages was 38.4 ± 11.6 years. The objective evaluations of pigmentation indicated that the levels of melanin decreased after the winter as compared to those seen after the summer, in all body areas (Graph 1). However this reduction was statistically significant only in the forearm ($p < 0.0001$), an area that is exposed to the sunlight especially in the summer.

Regarding the levels of erythema, there was also a statistically significant reduction in the forearm and forehead ($p < 0.0001$ and $p = 0.002$, respectively) when comparing the results obtained after the summer and after the winter. The sacral region showed a slight increase in erythema after the winter, nevertheless with an absence of a significant difference when this value was compared to that presented after the summer (Graph 2).

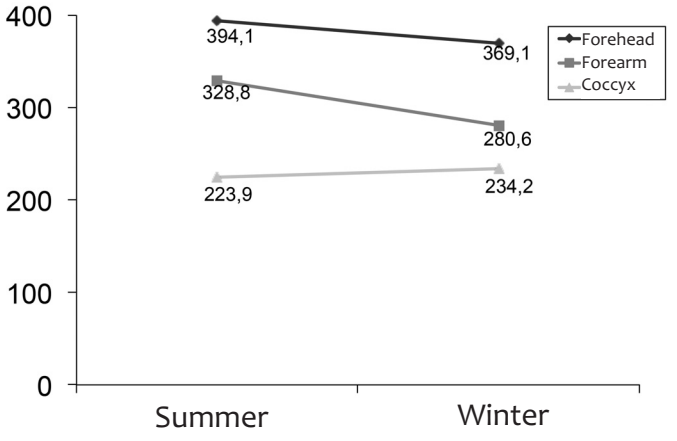
After the summer, a positive correlation between the amounts of melanin and erythema in the forehead ($r = 0.512$; $p = 0.002$), and a strong positive correlation between the values for melanin and erythema in the forearm and sacrum were verified ($r = 0.744$; $p < 0.0001$ and $r = 0.835$; $p < 0.0001$ respectively). After the winter, the same correlation pattern was observed: there was a positive correlation between the values for melanin and erythema in the forehead ($r = 0.485$; $p = 0.004$) and a strong positive correlation between the values for melanin and erythema in the forearm and sacrum ($r = 0.809$; $p < 0.0001$ and $r = 0.719$; $p < 0.0001$ respectively).

Graph 1: Melanin levels



Melanin levels after the summer and after the winter, evaluated in the forehead, forearm, and coccyx

Graph 2: Erythema levels



Erythema levels after the summer and after the winter, evaluated in the forehead, forearm and coccyx

DISCUSSION

Studies evaluating the response of melanin production after UV exposure have already been carried out.[10-12] Nevertheless, the present study is the first that objectively evaluates through spectrophotometry whether there is a systemic expression of melanin after the exposure to or in the absence of direct sunlight, taking into account seasonal variation.

As expected, the present study revealed lower values for melanin levels after the winter as compared to those observed after the summer, with those values showing to be significantly lower in the forearm, a body site that is usually exposed to the sunlight during the summer and protected during the winter. An interesting finding was that although the face has also presented lower melanin levels after the winter (177.0 vs. 168.1), this reduction was not statistically significant. This might be due to the fact that the face is always exposed to the sunlight and the patients have maintained the same habits of using or not using sunscreen throughout the year. These results are similar to those found by Roh et al.,[10] who have also observed significant seasonal variation of melanin in the arm, as well as have Lock-Andersen and Wulf,[11] who observed considerable seasonal variation in skin pigmentation of body areas exposed to the sun.

Another important finding was that there was no significant variation in the levels of melanin in the sacral region, a body site that is not usually exposed to direct sunlight anytime of the year. This supports the idea that increased levels of melanin are, above all, a predominantly local effect of exposure to sunlight. Regarding the levels of erythema, there was a significant decrease at the end of winter, in the forearm and forehead, which are body sites with greater seasonal exposure. The levels of melanin and erythema were positively correlated in this study, indicating that the higher the values of melanin, the higher the values observed for measurements of erythema.

The device used in the study's evaluations (Mexameter®) allowed for the objective checking of the levels of melanin and erythema, since it quantifies those two components that are responsible for the color of the skin on a scale from 0 to 999. The narrow-band reflectance spectrophotometry is a sensitive, reproducible, and specific method for taking objective measurements of the color of the skin, allowing the quantification of small differences.[13,14]

CONCLUSIONS

The increase in production of melanin is directly related to local exposure to sunlight. The same effect was not observed in areas that were not directly exposed to sunlight.

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