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Skin temperature during sunbathing – relevance for skin cancer

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Abstract

It has been found that exposure to heat and infrared radiation (IR) can be carcinogenic, and that a combination of ultraviolet radiation (UVR) and IR possibly amplifies carcinogenesis.

To investigate how the skin temperature is affected by sunbathing, we measured the skin temperature on 20 healthy volunteers over 6 days' sun holiday in Egypt. Temperatures were measured with an infrared thermometer gun at 8 skin sites on the volunteers while they were indoors in the morning and when sunbathing during the day. Skin temperatures were higher during sunbathing (33.5ºC ± 2.1ºC) (mean ± SD) than when indoors in the morning (32.6ºC ± 1.4ºC) (mean ± SD) ($P < 0.0001$). The average skin temperature for men was higher than for women by 0.40°C in the morning ($P = 0.02$) and by 0.44°C during sunbathing ($P < 0.0001$).

Our results show that sunbathing has an impact on skin temperature, which possibly by activation of the heat shock response, is likely to contribute to the immediated and delayed effects of UV in a way that has to be found out in future studies.

Introduction

Infrared radiation (IR) constitutes about 50 % of the total solar irradiance and induces molecular vibrations and rotations. Humans are therefore exposed to a considerable amount of IR when sun exposed. IR is divided into IRA (760–1440nm), IRB (1440–3000nm) and IRC (3000nm–1mm); the latter is completely absorbed in the epidermis and may cause an increase in skin temperature.[1]

It has been shown in guinea pigs that IR (heat) causes some of the same skin changes as UVR does both causing epidermal hyperplasia and an increased amount of modified elastin in the dermis. When UVR and IR were given in combination, the effect on elastin was amplified.[2]
In murine keratinocytes pre-treatment with IRA reduced DNA damage and UVR-induced apoptosis[3]. In a consecutive study it was found that pre-treatment with IRA delayed tumour formation but tumours were shifted into a more aggressive phenotype.[4]
Another study showed that the formation of tumours in UV-irradiated mice was significantly more pronounced at 35–38 °C than at a room temperature of 23 °C when analysing the time to a 50 % tumour incidence.[5] These results are supported by other mouse experiments showing that mice living in a heated environment under ultraviolet-light exposure developed more tumours at a higher rate than mice living in a temperate environment did. They also showed that elevated skin temperature enhanced some of the acute effect of UVR exposure as the mice developed more intense erythema and more crusting.[6]

To our knowledge, nobody has measured skin temperatures during sunbathing; behaviour associated with an increased risk of skin cancer. With this study, we therefore aimed to investigate the effect of sunbathing on skin temperature.

Method

Location

The study was performed during the first week of December 2010 at a costal holiday resort of Hurghada, Egypt (27.2° N, 33.5° E).

Volunteers

We recruited 20 volunteers (10F; 10M, mean age 44.3 years [range 20–63]) through the intranet at our Hospital. The inclusion criteria was: sun-seekers of Scandinavian ancestry defined as those who had been on at least 5 sun-seeking holidays in the previous 10 years. The volunteers were slightly suntanned before the study. No instructions on how to behave or on use of sunscreen were given to the volunteers. The volunteers determined their skin type according to Fitzpatrick[7], resulting in: skin type I = 0, skin type II = 12, skin type III = 6 and skin type IV = 2. A written informed consent was obtained from all volunteers.

Measurements

We measured the volunteers' skin temperature on 8 skin sites representing face, trunk and limbs (forehead, chest, midriff, right shoulder, right back, left back, left wrist, right wrist) when indoors each morning and while sunbathing during the day. We encountered the volunteers 1 to 3 times each day on the beach or by the pool, where we measured the skin temperature on those skin sites exposed to the sun for minimum the last 10 minutes, if they had just turned around or had been to the water, we came back after 10 minutes. If the skin temperature on any skin site on a volunteer was measured more than once during sunbathing on the same day, the average of these measurements was used in the data analysis. We used a Fluke 62 mini infrared thermometer gun

(Fluke Corporation, Everett, WA 98206, USA) to measure the temperature. Repetitive measurements on the same spot resulted in a deviation of ± 0.25 °C. We equipped the thermometer gun with a cardboard tube (length = 25 cm, diameter = 6 cm) to measure at a standardised distance and to avoid interference of IR from sunlight (Fig. 1). The cardboard tube fitted the thermometer gun, wherefore no fixation was necessary, and the tube made exclusive recordings of the skin surface possible. The air temperature was provided by a stationary air thermometer placed in the shadow.

Statistics

SPSS Statistics 19 (IBM, New York, United States) was used for data analysis. The Wilcoxon Signed Ranks Test was used to test for differences between temperatures measured in the morning and during sunbathing, and the Mann-Whitney test was used to test for differences between genders. We used an analysis of variance (ANOVA) to analyse for intra-individual variability of skin temperatures adjusting for skin-site, day-number and mean individual skin temperature. We used the residuals of this model as a measure of the intra-individual variability. The significance level was $P < 0.05$.

Results

The outdoor air temperature during day-time varied between 25 °C and 28 °C during the study period. The average skin temperatures for each skin site are presented in table 1. When analysing all skin sites together the average skin temperatures during sun bathing was 33.5°C ± 2.1°C (mean ± SD), which was statistically significantly higher than the average skin temperature in the morning 32.6 °C ± 1.4°C (mean ± SD) ($P < 0.0001$). There was a significant increase in skin temperature on all skin sites ($P < 0.003$), except on the forehead ($P = 0.934$) and on the shoulder ($P = 0.230$). The intra-individual variation was 1.0°C in the morning and 2.0°C during sunbathing. There was a significant difference in skin temperature between genders. The average skin temperature for men was higher than for women by 0.40°C in the morning ($P = 0.02$) and by 0.44°C during sunbathing ($P < 0.0001$).

Discussion

Our results show that there is an effect of sunbathing on skin temperature, even with the rather low environmental temperatures during winter in Egypt. This is relevant as UVR exposure itself has a known carcinogenic effect[8], and previous studies have shown that IR (heat) not only causes dermal changes similar to those caused by UVR, but also potentiates UV-induced elastosis and carcinogenesis, and alone also has a malignant potential.[1,2,5,6,9,10] Accordingly, it is probable that the harmful effect of the sun is more pronounced at locations with higher temperatures, often accompanied by intensive UVR. As a result, an additive or multiplicative effect is possible, and potentially high temperatures worsen the UVR induced skin damage caused by holidaying in the sun.

A previous study measured skin temperatures and found that skin temperatures after sunbathing were lower than before sunbathing, probably due to the cooling effect of sweat.[11] We measured skin temperatures at skin sites directly exposed to the sun for the last 10 minutes. We found that skin temperatures were significantly higher while sunbathing than when indoors in the morning. Notably, we found that men had a significantly higher skin temperature than women, both in the morning and when sunbathing. It is possible that differences in thermal regulation can explain the difference in skin temperature between men and women; however, this has to our knowledge not yet been shown. In a previous publication based on data from the same study [12], we found that men received greater (but statistically non-significant) UVR doses and were more frequent sunburned than women, which may both be parameters with a possible influence on skin temperature.

Our hypothesis that there is an increased risk of skin cancer with increased skin temperatures under high intensity sun can be supported by several reports of pre-malignant and malignant changes inclusive squamous-cell carcinomas developing in erythema ab igne[10]; a well-known skin condition

caused by continuous direct heat exposure.[9] Cells are protected from heat stress by the heat stress response that prevents apoptosis by induction of heat shock proteins (HSPs)[13], however, this response can also prevent cancer cells from apoptosis and thereby the heat shock response may become a risk factor for skin cancer[14]. In contrary, it has been found that hyperthermia (45–48 ºC) induces impairment of HSPs leading to apoptosis in melanoma and non-melanoma cancer cells[15], and in general hyperthermia may have a role in the treatment of cancer.[16] These contrary reports tell us that the effect of heat stress, good or bad, is complex and still needs further investigations.

We conclude that the skin temperature is affected by sunbathing and suspect that the influence of high environmental temperature on skin temperature, possibly by activation of the heat shock response[14], is likely to contribute to the immediated and delayed effects of UV in a way that has to be found out in future studies.

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Skin site	Skin temperature (ºC)						P- Value
	Morning Indoors	Sun-bathing	Paired measurements (number)*	Increase (mean)	Interquartile range		
					25%	75%	
Forehead	33.6±0.9	33.8±1.7	73	0.1	-1.6	1.4	0.934
Chest	33.3±1.1	34.5±1.6	72	1.2	0.2	2.4	<0.0001
Midriff	32.4±1.2	34.2±2.2	66	1.6	-0.2	3.4	<0.0001
Right shoulder	33.6±1.1	33.9±2.5	31	0.6	-1.2	2.4	0.230
Right back	32.6±1.4	33.9±2.1	30	1.4	-0.2	3.6	0.003
Left back	32.7±1.0	34.2±2.4	31	1.5	-0.2	3.8	0.002
Right wrist	31.4±1.2	32.5±1.6	78	1.0	-0.1	2.2	<0.0001
Left wrist	31.2±1.2	32.4±2.0	78	1.1	0.0	2.4	<0.0001

Table 1. Skin temperatures indoors in the morning and during sunbathing (mean ± SD) on 8 different skin sites. The mean increase in skin temperatures for days when paired data (*skin temperatures when indoors in the morning and during sun-bathing from the same day) were available are presented with interquartile range. The increases were tested with the Wilkoxon Signed Ranks test.

Legends

Figure 1

Photos showing the thermometer gun with and without cardboard tube. The cardboard tube has a length of 25 cm and a diameter of 6 cm, and was used to avoid interference of infrared radiation from sunlight, and to measure at a standardised distance.

Figure 1