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Skin Temperature in a Group of Students at Peradeniya

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Abstract : Skin temperature was measured with a radiation thermometer at 20 points on the body surface in an atmosphere of 24.4°C (76°F) in 26 young adult Sri Lankan males. The surface temperature was different at different points on the body. The warmest regions were the forehead and hypogastrium. The trunk was warm. The coolest regions were the hand and foot. This pattern of regional variation of the body temperature is essentially the same as has been described elsewhere in the world.

1. Introduction

Cullumbine[4] reported findings on the body temperature of Ceylonese (former name for Sri Lankan) persons. His sample consisted of more than 400 male and more than 50 female university students aged 18 to 25 years. The arithmetical mean and standard error for oral temperature in males were 98.9 ± 0.03°F, females 99.4 ± 0.04°F; rectal, males 99.9 ± 0.02°F, females, 100.2 ± 0.05°F ; axillary, males 98.6 ± 0.07°F, females, 98.7 ± 0.11°F. Earlier, Castellani[3] had stated that there was no difference in the body temperature of healthy natives and resident Europeans in Ceylon, "with due allowance for individual and seasonal differences and the effects of exercise and clothing". There has been no report on skin temperature in Sri Lanka.

The purpose of the present work was to get some idea of skin surface temperature in persons in Sri Lanka. It was done as a student project during the third term of the physiology course in the Peradeniya medical school in 1978. The sample consisted of 26 male medical students of average age 21 years.

Skin surface temperature (T_{sk}) varies in different parts of the body. Generally speaking, the head is warmest and the feet coolest. There being no such thing as *the* skin temperature, it becomes convenient or necessary to invent the concept of a *mean* skin temperature ($\bar{T}_{sk}$). It is convenient because we can use a single representative figure for skin temperature instead of having to use a number of separate figures. It is necessary when we wish to calculate the heat gain or loss from the body as a whole. In estimating T_{sk} we can measure $\bar{T}_{sk}$ at many different points on the body surface and calculate a weighted mean value. Hardy and DuBois[8] introduced a standard method in which skin temperature was measured at 20 different points on the body surface and a mean value calculated by giving a weight of 7% for the head skin temperature, 35% for the trunk ; arms 14%, hands 5%, thighs 19%, legs 13% and feet 7%. These weightings corresponded to the relative surface areas of the body regions as determined by DuBois and DuBois.[6]

2. Materials and Methods

The thermometer used was an instant-reading radiometric skin thermometer marketed by Messrs Heimann GMBH, Wiesbaden, West Germany.[17] It consists of a bolometer, which the operator holds in his hand and which he places on or close to the skin, and a recording box. The bolometer receives the heat radiated from the skin and converts it into electricity. The electrical change is amplified and converted into a movement of a lever over a temperature scale in the recording box. The instrument was calibrated with a Leslie cube ; the temperature of the water in the cube was taken with a certified mercury-in-glass thermometer ; the bolometer was placed on or near the black surface of the cube and the temperature read on the recording box. It was assumed that the cube surface should have the same temperature as the water within the cube.

The skin temperature measurements in the 26 students were made at 9 to 10 a.m. in an air-conditioned room. It was necessary to fix a time of day because body temperature, including skin temperature, shows a marked diurnal variation.[11,12] The dry bulb temperature of the room was 24.4°C (76°F), the wet bulb temperature 21.1°C (70°F) and the effective temperature 22.2°C (72°F). A dry bulb temperature of 24.4°C was chosen because this is the mean annual temperature of Peradeniya.[18] This is several degrees lower than the air temperature at 9 a.m.

The subject entered the room and sat for 20 minutes. He then changed clothes ; he wore a cotton sarong (a cylindrical tubular garment hanging down from the waist over the legs), leaving his trunk, upper limbs and most of his lower limbs bare. Skin temperature measurements were made immediately thereafter at the 20 sites specified in the Hardy-DuBois method.[5,8]

Mean skin temperature for each person was calculated by the same method using the following steps :— (a) for each of the seven body regions (head, trunk, arms, hands, thighs, legs, feet) the mean of all readings for that region was calculated ; (*b*) this regional mean value was multiplied by the appropriate weighting factor ; (*c*) the weighted mean values were added up, as shown in the formula—

$$\bar{T}_{sk} = 0.07\ T_{head} + 0.35\ T_{trunk} + 0.14\ T_{arm} + 0.05\ T_{hand} + 0.19\ T_{thigh} + 0.13\ T_{leg} + 0.07\ T_{feet}.$$

3. Results and Conclusions

The results are shown in the Table.

TABLE 1. Skin temperature of 26 male medical students in an air-conditioned room with a dry bulb temperature of 24.4°C (76°F), effective temperature 22.2°C (72°F)

Body No.*	Region	Skin temperature		Coefficient of variation	Difference from mean skin temperature
		Mean (°C)	Standard deviation (°C)	(%)	(°C)
—	Skin as a whole (mean skin temperature)	32.9	0.76	2.31	—
1	Forehead	35.8	0.43	1.20	+ 2.9
6	Abdominal, iliac	35.2	0.64	1.82	+ 2.3
5	Chest, over liver	34.6	0.46	1.32	+ 1.7
2	Cheek	34.2	0.61	1.78	+ 1.3
18	Trunk, back of shoulder	34.0	0.71	2.08	+ 1.1
3	Chest, front upper part	33.8	0.59	1.74	+ 0.9
15	Shoulder	33.8	0.50	1.48	+ 0.9
16	Trunk, over scapula	33.8	0.54	1.61	+ 0.9
17	Trunk, loin	33.8	0.48	1.42	+ 0.9
9	Back of knee	33.3	0.59	1.77	+ 0.4
11	Shin	33.3	0.86	2.58	+ 0.4
4	Chest, front middle	33.1	1.16	3.51	+ 0.2
7	Thigh, front	32.3	0.61	1.88	— 0.6
10	Calf	32.3	0.99	3.06	— 0.6
14	Forearm	31.9	0.84	2.63	— 1.0
8	Thigh, back upper end	31.5	0.83	2.64	— 1.4
13	Palm	31.5	1.73	5.66	— 1.4
13*b*	Hand, dorsum	30.8	1.31	4.25	— 2.1
12*b*	Ankle	30.4	3.22	10.59	— 2.5
12	Sole	30.0	1.55	5.16	— 2.9

*The numbers are those in the Hardy-DuBois method of numbering the body regions for skin temperature determination.

The mean skin temperature for the 26 subjects was 32.9°C. The scatter of mean skin temperature values was : range, 30.0°C to 35.8°C, standard deviation 0.76°C, coefficient of variation 2.3%.

A regional variation in skin temperature in different parts of the body was apparent. The warmest region was the forehead (35.8°C) while the coolest was the sole of the foot (30.0°C). In the limbs, a pattern of falling of temperature in a proximodistal direction was observed. The extensor surface was cooler than the flexor surface.

Sites of the body where skin temperature was closest to the mean skin temperature were *a)* the chest near the nipple *b)* the front of leg, and *c)* the back of the knee. Individual variation was greatest in the ankle, sole of foot, dorsum of hand and palm of hand.

4. Discussion

It is well known that the temperature of the skin surface shows marked differences in different parts of the body in a cool or cold atmosphere. The warmest part is the head, the coolest is the foot, and the trunk is warm. A graph that is frequently reproduced in textbooks shows the results for J. D. Hardy in a range of room temperatures from 23°C to 34°C.[9] In a warm environment, the regional variation in skin temperature practically disappears ; the temperature in all parts becomes about 35°C. The present work shows that the skin temperature in a cool room shows the usual pattern of regional variation : the forehead was warmest (mean value 35.8°C), the foot coolest (sole 30.0°C); the difference between the two was 5.8°C. The trunk was warm ; the warmest point on it was the abdominal iliac region (35.2°C).

The body can be divided into three main regions on the basis of surface temperature :—[11]

A, a region of greatest warmth with a small range of temperature : forehead, chest, abdomen.

B, a region of moderate warmth and a larger range of temperature : arm, thigh.

C, a region of least warmth and greatest range of temperature : hands, lower part of the leg, foot.

This three-region concept is supported by the present work, except in certain points of minor detail. *Region A* consisted of the forehead and parts of the abdomen and chest. The mean temperature was 35.8°C to 34.0°C. The inter-individual variation of skin temperature was lower for the forehead than for any other site (coefficient of variation 1.2%). The variation in the other sites of Region A were of the order of 1 or 2 per cent. *Region B* consisted of the rest of the trunk and the limbs down to the forearms and legs (with the exception of the upper end of the back of the thigh, near the buttock, which falls into the next category). The mean temperature was 33.8°C to 31.9°C. Inter-individual variation was of the order of 2 per cent, ranging from 1.4% for the loin to 3.5% for the chest (breast). *Region C* consisted of the hands and feet and the upper end of the back of the thigh near the buttock. The mean temperature was 31.5°C to 30.0°C. Inter-individual variation was of the order of 7%, going up to 10.6% in the ankle region.

Mean skin temperature ($T_{\bar{sk}}$) is an artificial and elastic quantity. With so much difference of skin temperature in different parts of the body, the calculated $T_{\bar{sk}}$ will depend on (*a*) the points on the body surface at which the temperature was measured, (*b*) the weightage given to the temperature at the different points. The number of regions and points at which skin surface temperature (T_{sk}) has been measured in

order to estimate $T_{\bar{sk}}$ has ranged from about 3 to 25. Burton[2] used three points (chest, calf, lower arm), Newburgh and Spealman[14] 4 points (chest, thigh, leg, lower arm) ; Miller and Blyth[13] 5 (forehead, arm, chest, back and thigh) ; Palmes and Park[15] 9 ; US Quartermaster Corps[19] 10 ; Iampietro *et al*[11] 10 ; Hale *et al*[17] 15 points in 7 regions ; Adams and Covino[1] 16 ; Hardy and DuBois[9] 20 ; Mali[11] 24. The weighting of the temperature from the various body regions has usually been on the basis of the contribution which the surface area of the region makes to the total body surface area, as in the Hardy-DuBois method. Ramanathan[16] proposed a simpler weighting system where :

$$T_{\bar{sk}} = 0.3\ T_{chest} + 0.3\ T_{arm} + 0.2\ T_{thigh} + 0.2\ T_{leg}.$$

For each of the four regions represented in the formula, he took the mean of 10 readings from thermocouples placed in various places in the front, back and sides of the body region, which makes 40 readings in all.

It has been noticed by Teichner[19] and Ramanathan[16] that the temperature of the medial aspect of the thigh corresponds to the mean skin temperature of the body. The present work used entirely the Hardy-DuBois method with regard to the sites at which the skin temperature was measured and the weightings used to calculate the mean skin temperature. This was found to be 32.9°C with a standard deviation of 0.76°C, at a room temperature of 24.4°C (76°F). This seems to be much the same for an environmental temperature of 24.4°C as in other studies in other parts of the world. Accordingly, it seems that the skin vasoconstrictor mechanism which reduces skin temperature in a cool environment at 24.4°C is not more sensitive in these tropical subjects than in others.

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