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Thermal maps of young women and men

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HIGHLIGHTS

- The use of thermography as an effective tool in creating a thermal map of people.
- The manuscript can be a valuable diagnostic value in medicine, physiotherapy, sports.
- Significant differences in the surface temperature of the body between men and women.
- In the women and men, the highest T_{mean} temperatures were found on the trunk.
- T_{mean} in the chest, abdomen, back were mainly correlated with BMI and PBF.

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ABSTRACT

The objective was to use thermal imaging (ThermaCAM SC500) as an effective tool in establishing a thermal map of young participants, with a high diagnostic value for medicine, physiotherapy and sport. A further aim was to establish temperature distributions and ranges on the body surface of the young women and men as standard temperatures for the examined age group, taking into account BMI, body surface area and selected parameters of body fat distribution.

The participants included young, healthy and physically active women ($n = 100$) and men ($n = 100$).

In the women and men, the highest T_{mean} temperatures were found on the trunk. The warmest were the chest and upper back, then the lower back and abdomen. The lowest T_{mean} were found in the distal parts of the body, especially on the lower limbs.

The results showed that only in the area of the chest was T_{mean} significantly higher in women than in men. In the areas of the hands (front and back) T_{mean} were similar for women and men. In the other analyzed body surface areas, T_{mean} were significantly lower in women.

Research showed significant differences in body surface temperature between the women and men.

Among the analyzed characteristics, T_{mean} in the chest, upper back, abdomen, lower back (both in women and men) were mainly correlated with BMI and PBF; the correlations were negative.

Difficulties in interpreting changes in temperature in selected body areas in people with various conditions can be associated with the lack of studies on large and representative populations of healthy individuals with normal weight/height parameters. Therefore, it seems that this presented research is a significant practical and cognitive contribution to knowledge on thermoregulation, and may therefore be used as a reference for other studies using thermal imaging in the evaluation of changes in body surface temperatures.

1. Introduction

In contrast to the core temperature of the human body (constant at about 37 °C ± 0.5 °C), the body surface temperature can be described by a complex map of isotherms with a very wide range of temperatures changing under the influence of endo- and exogenous factors. For example, the distal parts of the body have a lower mean surface temperature than internal parts, with temperatures decreasing along the longitudinal axis of the extremities, producing both axial and radial temperature gradients. The picture is made even more complex due to local differences in internal heat production, insulation and evaporation, convective heat transport via the blood, and diurnal and other periodic variations. A

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local increase in internal body temperature may influence the surface temperature.

Thermology is an important branch of medical diagnostic imaging as the increased temperature of tissues is frequently the first symptom of pathological changes, even before the occurrence of structural or functional changes [1]. Therefore, abnormal thermograms can indicate a condition even before the appearance of clinical symptoms. One of the methods used to measure body surface temperature is infrared thermography, where infrared cameras record the heat present on the human skin. This method allows quantitative and objective analysis of body surface temperature distribution [2], while its visualization provides precious diagnostic information. If used in accordance with measurement standards, it can reflect the processes taking place inside the body.

Due to the high cost of the necessary instruments, thermal imaging is not popular, and literature contains few papers on this subject. There is a lack of comprehensive results showing body surface thermal maps in young healthy individuals based on representative groups, which could be used as references in medical and physiological diagnostics. The few existing papers concern only small groups of participants [3–6].

2. Aims of the study

The aims of the study were:

To establish the use of thermal imaging as an effective tool in establishing a thermal map of young, healthy and physically active women and men, with a high diagnostic value as a reference in medicine, physiotherapy and sport.

Establishing the temperature distribution and range on the body surface of young women and men as standard temperatures for the examined age group, taking into account BMI, body surface area and selected parameters of body fat distribution.

3. Materials and methods

Each participant provided a written assent before participation in the study according to the Declaration of Helsinki. The study was approved by the local Ethics Committee (Pomeranian Medical University Ethics Committee, KB-0012/151/12).

3.1. Study group

The test was performed in October and November 2012. The participants included women ($n = 100$) and men ($n = 100$), aged 20–23 years, students of Physical Culture at the University of Szczecin. The participants were professionally involved in competitive sports (volleyball, basketball, futsal, football or handball), were of similar age, with a BMI in a normal range of 18.5–24.99 kg/m^2.

The tests were only performed on healthy individuals with no injuries and with a valid athlete's card (with a physician's approval to participate in the league).

3.2. Methods

The women and men were subjected to measurements of body height (using an anthropometer) and body mass. BMI (Body Mass Index) ratio was also calculated.

The body surface area was determined based on the Dubois formula (associating the body surface area with weight and height) [7].

The bioimpedance method and a Jawon Medical X Scan Plus II multifrequency segmental body composition analyzer were used to determine the composition of the body, including body mass [kg], percentage of body fat (PBF) [%], skeletal muscle mass (SMM) [kg], and subcutaneous fat mass (SFM) [kg]. SFM/body mass ratio was also calculated [%]. The paper used the following indicators: PBF [%] and SFM/body mass [%].

In order to eliminate the effects of the menstrual cycle phase on the temperature ranges in the women, temperature measurements were performed during each participant's follicular phase for women not using hormonal contraceptives. It is known that a number of the physiological processes in a woman's body are related to the different phases of the ovulatory cycle. The most important of these include changes in the levels of gonadotropins, estrogens and progesterone in the blood, differences in water balance, and fluctuations in body temperature, which is approximately 0.4 °C higher in the luteal phase than in the follicular phase of the cycle [8–11]. Among the examined women who used hormonal contraceptives, the phase of the menstrual cycle was not that significant for body temperature, as reports document a leveling of temperature over the entire cycle. The use of hormonal contraceptives results in the appearance of quasi-phases of the cycle which show no differences in body temperature [12,13,8].

Thermography was performed in a standing position for each participant, with the use of a ThermaCAM SC500 thermal imaging camera (FLIR System), providing longwave (7.5–13 μm) imaging with a thermal sensitivity of 0.1 °C. The study was conducted according to standards set by the European Thermographic Association [14]. A reliable visualization of temperature distribution over the body requires prior acclimatization, and therefore the participants were dressed in underwear (panties and bra) and earflaps, and remained for 20 min at a room temperature of 25 °C and 60% relative humidity before imaging. Thermal images were then obtained at a distance of 3 m.

The room (area of approximately 12 m^2) was closed, with a constant ambient temperature and humidity over the period of the measurements. There were no draughts or influences of air conditioning. There was low intensity natural lighting.

Measurements were always performed in the afternoon (after 4 pm). The similar times of tests and the same season were important to exclude the effect of circadian rhythms on body temperature fluctuations.

Measurement analysis used Agema Report 5.4.1 and Agema Report Viewer 5.4.

Quantitative analysis of thermal images was performed for 12 areas of the body taken from the front and the back in a standing position (Fig. 1).

A mean surface temperature, T_{mean}, was obtained for each chosen area, and was more representative of the area than minimum and maximum values.

3.3. Statistical analysis

Temperature data were found to be normally distributed (Shapiro–Wilk tests). The results were presented as arithmetic means with standard deviations (SD). In order to check the homogeneity of the examined groups of women and men, we calculated coefficients of variation (C_V) for each of the analyzed parameters and T_{mean} of the selected body areas. Differences between the arithmetic means of morphological characteristics, body components, and mean surface temperature (T_{mean}) of the women and men were tested using a two-sample Student's t test. We calculated the Pearson's correlation coefficient and performed regression analyses for T_{mean} of the analyzed areas of the body, as well as BMI, body surface area and body composition indicators: PBF% and SFM/body mass%. Calculations were performed using Statistica 10 software (StatSoft).

4. Results

Comparative analysis of the temperatures of the right and left side of the body of the selected body areas showed differences