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Thermographic profile of soccer players' lower limbs

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ABSTRACT

Objective. The objective of this study was to establish the thermographic profile of the lower limbs in elite young soccer players.
Method. One hundred soccer players from the U-19 categories of a first division Brazilian football club (15.5 ± 1.37 years; 67.93 ± 9.62 kg; 177.49 ± 8.67 cm) participated in the study. Two thermograms allowed us to record maximum and average skin temperatures (T_{SK}) in four body regions of interest (ROIs) of the lower limbs corresponding to the anterior and posterior view of the leg and thigh. The Wilcoxon test was used to compare bilateral T_{SK} differences with a significance level of $\alpha < 0.05$.
Results. Average values of T_{SK} in the anterior view were as follows: right thigh 30.2 ± 1.9°C, left thigh 30.2 ± 1.9°C, right leg 29.8 ± 1.8°C, and left leg 29.9 ± 1.8°C. In the posterior view, the values were as follows: right thigh 30.3 ± 1.8°C, left thigh 30.2 ± 1.8°C, right leg 29.6 ± 1.9°C, and left leg 29.4 ± 1.9°C. The statistical analysis did not show significant differences between sides in the selected ROIs for average or maximum temperatures. A histogram of T_{SK} frequencies for each ROI allowed establishment of values for hyper-and hypothermia.
Conclusion. The elite young soccer players analyzed showed contralateral thermal symmetry. The average T_{SK} differences for paired ROIs were each ≤ 0.2°C. Each ROI exhibited a specific thermal profile. The registered T_{SK} indicated a normal thermal profile of the athletes.

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Palabras clave:
Fútbol.
Termografía.
Temperatura de la piel.
Termorregulación.

RESUMEN

Perfil termográfico de los miembros inferiores en jugadores de fútbol

Objetivo. El objetivo de este estudio es establecer el perfil termográfico de los miembros inferiores en jóvenes jugadores de fútbol de élite.

Método. En el estudio participaron 100 jugadores de fútbol de categorías sub-19 de clubes de fútbol brasileños de primera división (15,5 ± 1,37 años; 67,93 ± 9,62 kg; 177,49 ± 8,67 cm). Mediante dos termogramas se obtuvieron las temperaturas máximas y medias de la piel (T_{SK}) de cuatro regiones corporales de interés (RDI) correspondientes a la vista anterior y posterior de la pierna y del muslo. Se empleó el test de Wilcoxon para comparar las diferencias de la T_{SK} bilateral, con un nivel de significación $\alpha < 0,05$.

Resultados. Los valores medios de la T_{SK} en la vista anterior fueron los siguientes: muslo derecho 30,2 ± 1,9°C, muslo izquierdo 30,2 ± 1,9°C, pierna derecha 29,8 ± 1,8°C y pierna izquierda 29,9 ± 1,8°C. En la vista posterior, los valores fueron los siguientes: muslo derecho 30,3 ± 1,8°C; muslo izquierdo 30,2 ± 1,8°C; pierna derecha 29,6 ± 1,9°C y pierna izquierda 29,4 ± 1,9°C. El análisis estadístico no mostró diferencias significativas en las temperaturas medias o máximas tomadas en las RDI elegidas. Un histograma de las frecuencias de T_{SK} para cada RDI permitió establecer valores para hiper e hipotermia.

Conclusión. Los jóvenes jugadores de fútbol de élite analizados mostraron simetría térmica contralateral. La T_{SK} media para pares de RDI era para cada uno ≤ 0,2°C. Cada RDI mostró un perfil térmico específico. La T_{SK} mostró un perfil térmico normal de los atletas.

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INTRODUCTION

The development of new technologies applied to sport has allowed better understanding of the physiological responses to training and competition, has helped to determine the appropriate training load and has provided information about the physical condition of athletes. There have been published studies monitoring heart rate[1-2], controlling creatine kinase[3] or global positioning system (GPS)[4]. Recently, infrared thermography (IRT) has been proposed as a tool to be employed[5-8], with interesting applications both in sports medicine[9-10] and physical therapy[11] or as a way of determining training load[12].

IRT is a technique that records the radiant heat of a body by recording infrared emission, which lies in a range of the electromagnetic spectrum that the human eye is unable to identify[9,13]. This technique allows visualization of the temperature of the body surface in real time with sensitivity up to 0.025°C and precision reaching 1 %, non-invasively and without any physical contact with the subject[14]. Other advantages of the technique are that it is fast and harmless, highly reproducible, and does not involve the emission of radiation[14-16]. These characteristics enable scientists to obtain the general and local thermal profile of the subject and, if performed routinely, to conduct real-time monitoring of skin temperature (T_{SK}), gathering information about the complex thermoregulatory system of the human body[13].

In the medical field, IRT has been used to identify a number of problems related to different types of pain syndromes[17], changes in the skin[18], vascular defects[19], neurological defects[20], muscle and tendon injuries[9-10], all of which have direct applications to sports.

The use of IRT has also been linked to the prevention of orthopedic injuries[21-22]. Under normal conditions, T_{SK} is similar between the sides of the body[23]. T_{SK} differences greater than 0.7°C between contralateral limbs or body areas have been associated with structural or physiological abnormalities in athletes[6,9]. Thus, IRT can be an important tool in preventing injuries when bilateral thermal differences are identified.

To allow meaningful interpretation of thermographic data, it is necessary to establish a normal profile in different population groups without any pathology. Studies to this end are few, but there is some research that has established thermal profiles in populations of non-athletes in groups of Chinese[24], Finnish[25], Portuguese[26], Thai[27], and even in Mexican children[28]. These data allow us to evaluate thermal normality in different body segments and to observe bilateral differences.

No reference baseline study has been performed to characterize the epidemiological thermography profile of athletes, especially in soccer players. The construction of these T_{SK} normative data can help establish normal patterns in different parts of the body, with a focus on the lower limb, allowing skin assessment of general or local hyperthermic or hypothermic conditions. T_{SK} differences between hemispheres may indicate the presence of a problem and may reduce the subjectivity of the assessment. Establishment of normal values at rest may also contribute to the understanding of changes in T_{SK} and allow the use of IRT as an exploratory analysis tool in clinical settings including physical therapy or physical training. Thus, the aim of this study was to establish thermographic profiles of the lower limbs in young soccer players, which will serve as a starting point for future applications of this technique in soccer.

METHOD

This cross-sectional study analyzed 100 soccer players in the basic categories of a Brazilian first division soccer club aged between 15 and 19 years (age: 15.5 ± 1.37 years, body mass: 67.93 ± 9.62 kg and height: 177.49 ± 8.67 cm). Leg dominance was right-sided in 77 and left-sided in 23 cases. The subjects performed systematized training five times a week, 90 minutes per session, during the preparatory period of the season.

The study was approved by the Ethics Committee of the Federal University of Viçosa (UFV), with registration number 40928260540, following all of the criteria set forth by the Brazilian legislation for human studies, in accordance with National Health Board Resolution 196/96. Because the study subjects were minors, permission for them participate was given by their parents; all subjects were volunteers and received no reward.

Considering that T_{SK} measurements are prone to multiple sources of interference, the following exclusion criteria were applied: a) history of kidney problems; b) performing physical therapy in the past two days; c) consuming any diuretic or antipyretic drug and any food supplement such as creatine that could interfere with water or body temperature homeostasis in the last two weeks; d) smoking; e) skin burns; f) topical treatments with creams, ointments or lotions; g) pain symptoms in any region of the body; h) fever in the last seven days; i) sleep disorders; and j) musculoskeletal injuries meeting the criteria of the Fédération Internationale de Football Association Medical Assessment and Research Centre (F-MARC)[29]. These injury criteria include any physical complaint reported by a player due to training or during a football game, regardless of needing medical attention or stopping the football activity. All subjects reported the absence of any type of sports injury according to these criteria.

Thermographic images were collected using a thermal imager IRT-25 (Fluke®, Everett, USA) with a measurement range of -20 to +350°C, an accuracy of ± 2°C or 2 %, a sensitivity of ≤ 0.1°C, an infrared spectral band from 7.5 to 14 microns, a refresh rate of 9 Hz and an FPA (Focal Plane Array) of 160 x 120 pixels. The distance between the subject and the camera was 4 m, and the index of human skin emissivity was set to 0.98.

Data collection followed the standards proposed by the European Association of Thermology[30]. The images were taken in the morning before performing any intense physical exercise or training in the previous 24 hours. The temperature during data collection was maintained at 21 ± 1°C, and the acclimation period was set at 15 minutes, surpassing the minimum time of 8 minutes of stabilization proposed in 2012 by Roy et al.[31]. Prior to and during the procedure, the subjects were asked to avoid any sudden and intense movement, or rubbing, scratching or crossing their legs.

Two thermograms were taken for each evaluation (anterior and posterior); body regions of interest (ROIs) analyzed included the thighs and legs. These regions were selected by a rectangle bounded by the software (Smartview 3.1 - Fluke®, Everett, USA), which provided us with the average and maximum temperatures from each analyzed ROI.

To configure the ROI, we followed the recommendations of Moreira[32], who proposed drawing rectangular areas referenced by the following anatomical landmarks: for the thigh, 5 cm above the upper border of the patella and groin line, and for the leg, 5 cm below the lower border of the patella and 10 cm above the malleolus. The points corresponding to the posterior regions were marked parallel to the ground with a mea-

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