Infrared Physics & Technology 78 (2016) 209–213

Contents lists available at ScienceDirect

Infrared Physics & Technology

journal homepage: www.elsevier.com/locate/infrared

Changes in body surface temperature during speed endurance work-out in highly-trained male sprinters

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HIGHLIGHTS

- A homogenous group of highly trained sprinters has been thermally monitored.
- Thermovision has been used to observe body temperature changes during outdoor training.
- Legs temperature symmetry was established during all training phases.

ARTICLE INFO

Article history:
Received 2 June 2016
Revised 13 August 2016
Accepted 15 August 2016
Available online 17 August 2016

Keywords:
Thermography
High-intensity interval exercise
Outdoor training session
Lower limbs

ABSTRACT

The mechanism of thermoregulatory adaptation to exercise cannot yet be fully explained, however, infrared thermography (IRT) seems to have potential for monitoring physiological changes during exercise and training. It is a non-contact and easy to use technology to measure heat radiation from the body surface.

The objective of the study was to examine the temperature changes over time on lower limbs in sprinters during speed endurance training session.

Eight sprinters, specialized in distances 100 m and 200 m, aged 21–29 years, members of the Polish national team, were evaluated during an outdoor speed endurance work-out. Their track session comprised of warm-up, specific drills for sprinting technique, and speed endurance exercise. The surface temperature of lower limbs was measured and thermal images were taken using infrared camera after each part of the session.

The speed endurance training session brought about specific time course of body surface (legs) temperature. The warm-up induced a significant decline in surface temperature by ~2.5 °C, measured both on the front and back of lower limbs ($p < 0.001$), followed by a temperature stabilization until the end of the session. No significant asymmetry between the front and back sides of legs was observed.

Body surface temperature may help identify an individual optimal time to terminate warm up and start the main part of the training session. It may also be useful for the assessment of muscle activity symmetry in cyclical activities, such as sprint running. This is of particular relevance when a training session is performed outdoors in changeable weather conditions.

1. Introduction

One of the essential mechanisms to maintain constant human core body temperature is the thermoregulatory control of blood flow in the skin [1,2]. It depends mainly on the sympathetic neural control of adrenergic vasoconstrictor and cholinergic vasodilator systems [1]. The degree of blood circulating in the skin is, in turn, the major determinant of the changes in body surface temperature [3]. These processes are modified by many acute (exercise, hydration) and long-term (aging, chronic diseases, reproductive hormones) factors [4].

Infrared thermography (IRT) is a non-contact, safe, and easy to use method, intended to measure heat radiation from the body surface, viewed as an expression of all physiological processes affecting skin temperature [2] including physiological

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http://dx.doi.org/10.1016/j.infrared.2016.08.003
1350-4495/

thermoregulation responses to body cooling and heating [5,6]. IRT has already been used in sport practice for some years, primarily for diagnosis of post-traumatic states [2,7]. Kenney and Johnson [8] and Johnson [9] showed that skin blood flow reflects the thermodynamic response to exercise. Therefore, IRT seems to have potential for monitoring physiological changes during exercise and training, however, only a few studies can be found in the literature [3,10–14].

Speed endurance is a crucial ability for a sprinter because it ensures that high running speed is maintained or only slightly reduced in the final stage of a 100-m or 200-m distance. High peak blood lactate levels and a rapid transient cardiorespiratory response are characteristic of this kind of exercise [15,16]. The classic method to develop speed endurance is so called "anaerobic lactic training" that usually consists of several sprints (80–150 m) performed at submaximal and maximal intensity (90–100% of maximum speed), separated by recovery periods lasting 5–15 min [16,17]. During such an exercise, anaerobic energy sources for muscle activity are estimated to deliver as much as 82–95% of the total energy demand [18–23]. However, the contribution of aerobic metabolism may increase from ~10% to ~40% of the whole energy delivery with each successive sprint when separated by very short recovery intervals [24].

Previous research, based on IRT, depicted skin temperature changes induced by prolonged continuous exercise with increasing intensity until volitional exhaustion [10–13,25], constant endurance exercise at various work intensities [26], and resistance exercise [3]. Research performed as yet included untrained participants [3,12], semiprofessional trained individuals [10–13,25] or single cases [7]. Importantly, all above studies were conducted in laboratory conditions, using cycle ergometer [3,10,25] or computerized treadmill [12]. Body surface temperature was measured in few sites on the upper part of the body [26], on the forehead [25], in the anterior body regions [13], in the upper limbs [11], and above working muscles [3,10,12].

So far, no research has been reported concerning highly-trained athletes, conducted during actual specific maximal-intensity speed-endurance work-out performed on outdoor track. Therefore, the aim of our study was to examine the temperature changes over time on lower limbs during a typical speed-endurance session in highly-trained male sprinters.

2. Methods

2.1. Experimental approach to the problem

The study was performed using the IRT method in accordance with Glamorgan Protocol [27]. For the temperature analysis, regions of interest (ROIs) were established. Mean surface temperature of the front and back side of legs was calculated. As shown in Fig. 1, the front ROI covers the area between the inguinal ligament and the talocrural region. The ROI of the back side covers the area between the gluteus sulcus and the talocrural region. The difference in mean surface temperature between right and left leg was calculated. It has been suggested that the temperature between contralateral extremity areas in healthy athletes, measured at rest, should be similar [28].

The thermographic camera (FLIR Systems Inc., model SC640, Sweden) was placed in a special tent near the training track to isolate the measure stand from sunlight and wind. The camera was positioned on a tripod 1 m above the ground and 4 m from the subject. There was a non-reflecting background behind the subject. In the tent, there were stable temperature conditions with temperature of 22 °C and humidity of 50%.

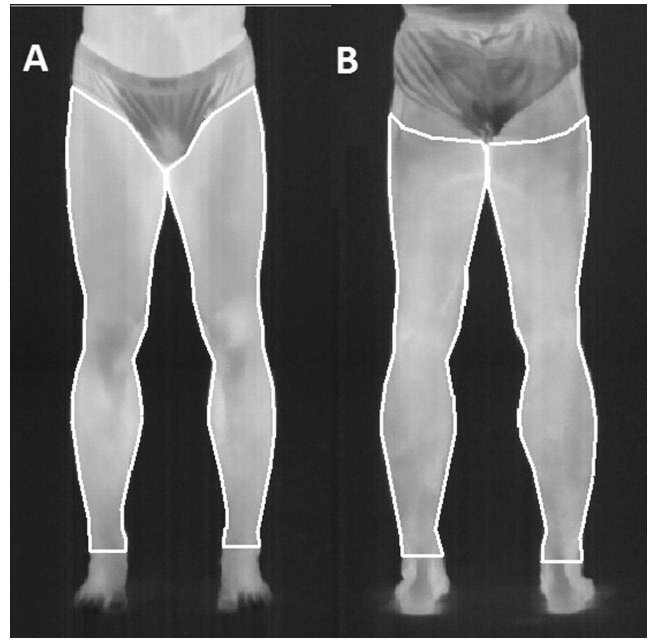

Fig. 1. Region of Interest (ROI) established for temperature analysis of front (A) and back (B) side of legs.

Heart rate (HR) was continuously measured during the whole training session using Polar device (Polar Elektro, Finland). Additionally, legs body fat (BF) was assessed using dual-energy X-ray absorptiometry method (DXA) (Lunar Prodigy device, GE Healthcare, USA).

2.2. Subjects

Eight male Caucasian sprinters, specialized in distances 100 m and 200 m, aged 21–29 years, members of the Polish national team, participated in the study. Basic characteristics of the group are shown in Table 1. All participants received detailed explanation about the aim of the research and gave their written informed consent prior to the examination. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethical Committee at the Poznan University of Medical Sciences.

2.3. Procedures

The day before the training session participants were instructed on how to prepare for the measurement procedure. On the day of the measurements they were not allowed to drink coffee and use other stimulants. Legs had to be washed and grease-free, and using skin cream or ointment was not allowed. There was no clothing worn on the scanned body area. The measurements were performed during the taper phase, before the main competition, on a standard 400-m running track at a windless weather, air temper-

Table 1
Characteristics of the studied group.

Parameter	Mean	SD	Min–Max
Age (years)	24.6	3.0	21.2–28.8
100-m performance (s)	10.54	0.28	10.31–11.00
200-m performance (s)	21.23	0.39	20.89–21.91
Weight (kg)	81.5	7.7	73–91.6
Height (cm)	184.5	5.6	179.2–196.6
BMI (kg/m^2)	23.8	1.2	22.0–25.7
Leg BF (% of total)	11.6	1.7	8.9–14.0

Abbreviations: BF, body fat; BMI, body mass index.