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Correlation between skin temperature and heart rate during exercise and recovery, and the influence of body position in these variables in untrained women

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HIGHLIGHTS

- Skin temperature decreases during and after anaerobic exercise in untrained women.
- There were no differences in thermal response to exercises in 70% or 85% of 10RM.
- There were significant negative correlations between skin temperature and heart rate.
- The body posture influences the skin temperature in untrained women.

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ABSTRACT

It was known that the thermal response varies according to some variables. Until now, there are no studies that have investigated the relationship of skin temperature and heart rate during and after the workout, either the thermal behavior during postural changes. *Objective:* the aim of this study was to evaluate the behavior of skin temperature and heart rate, during exercise and up to an hour of recovery (with postural change), performed in two different intensities sessions (70% and 85% of 10 repetitions maximum) and observe the correlation between them. *Method:* This was a short longitudinal study, carried out with women aged from 18 to 30 years. A sample of 31 untrained women, aged 18 and 30 was used. The volunteers were randomized into two groups: Biceps Group (BG), with 15 women, and Quadriceps Group (QG) with 16 women. *Results:* During and after completion of the exercise session, there was a significant reduction in skin temperature on the active muscles in both groups (BG and QG), with similar thermal responses for the two intensities studied (70% and 85%) to the minute 15 (which marks the end of the recovery in the standing position). From minute 15 to minute 20–60, the skin temperature increases abruptly and significantly, returning to levels close to those observed before exercise. *Conclusion:* There were no statistical differences in thermal response to exercises in 70% or 85% of 10RM. There is a negative correlation between heart rate and skin temperature when untrained women perform anaerobic exercise. It was observed that after a change of posture (from a standing position to a sitting posture) skin temperature increased abruptly and significantly.

1. Introduction

The search for reliable methods for the exercise prescription, intensity control and monitoring of the exercise at a low cost and easy applicability has always been a constant concern of physical exercise professionals [1]. According to Graef and Kruel [2] there

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are several physiological indicators used to evaluate the exercise intensity in land and water.

Among the most common methods to monitoring the physical activity during the exercise session are: the percentage of one repetition maximum (% 1RM) or the percentage of ten repetitions maximum (% 10RM) [3], Heart Rate (HR) and the Perceived Exertion Rating Scale (RPE) [4]. After session, we can use ways as determination of serum creatine kinase isoenzymes (CK) and Infrared Thermography (IT) [5,6]. According to Bandeira et al. [5], IT is a tool that can be used to assess the level of muscle damage, inflammation and intensity of muscular work. The IT captures the infrared electromagnetic energy emitted by the skin [7] presenting applications in diagnosis of musculoskeletal injuries and evaluation of muscle recovery after competition and training [8].

IT is an innocuous, non-invasive, non-ionizing and without contrast agents, capable of measuring the skin temperature at distance with high precision, providing high-resolution images. The technique involves detection of infrared radiation that can be directly correlated with the temperature distribution in a specific body region [9–11]. Body heat is generated by the metabolism and muscle contraction, and transported throughout the body by the cardiovascular system. The main control of the core temperature is done by the hypothalamus. When occurs the core temperature increase, neural responses lead to heat loss by vasodilation, or transpiration, or by reduction in metabolic rate [12].

Specifically about physical exercise, temperature behavior appears to differ comparing aerobic and anaerobic exercise, during and after exercise [5,13–16]. Merla et al. [17] studied 15 men which performed a progressive protocol of aerobic exercise and evaluated the body temperature before, immediately after reached a maximum heart rate and during the recovery period. The results showed a decrease of the temperature during every exercise, with a guidance to used muscle, but returning to increase in recovery moment; another study, Neves et al. [13] performed anaerobic exercises for upper limbs showed that the temperature decreases in the first minute of exercise in both limbs (exercised and not exercised). In the other moments during exercise, increases in the exercised limb and decreases in the non-exercised limb.

Interestingly, the front of the arm and forearm seems to be better than back when the objective is to evaluate the variations of temperature in the upper limbs. This fact probably is related to the distribution of fat in these areas, which acts as a heat insulating in the body [15].

It was known that the thermal response varies according to some variables [18]. There are few studies which aimed to evaluate the temperature behavior during anaerobic exercise (as the resistance exercise). To the best of our knowledge, there are no studies that have investigated the relationship of skin temperature and heart rate during and after the workout, either the thermal behavior during postural changes. In this sense, the aim of this study was to evaluate the behavior of skin temperature and heart rate, during exercise and up to an hour of recovery (with postural change), performed in two different intensities sessions (70% and 85% of 10 repetitions maximum) and observe the correlation between them.

2. Methods

This was a short longitudinal study, carried out with women aged from 18 to 30 years. The study was performed according to the Declaration of Helsinki and was approved by a Research Ethics Committee. All subjects read and signed the informed consent before participation in the study.

2.1. Sample

The volunteers were selected among the students of the University of Tras-os-Montes and Alto Douro, Vila Real, Portugal. A sample of 31 untrained women, aged 18 and 30 was used. The volunteers were randomized into two groups: Biceps Group (BG), with 15 women, and Quadriceps Group (QG) with 16 women.

The inclusion criteria were: be between 18 and 30 years-old, not participate in any kind of systematic physical activity, systolic blood pressure (SBP) < 140 mmHg and diastolic blood pressure (DBP) < 90 mmHg, Par-Q test negative. Exclusion criteria were: obesity (BMI < 30 kg/m^2), diabetes mellitus, cardiovascular disease, use of drugs that could influence responses to exercise, orthopedic impairments or any physical or mental limitation that disturbed the exercises performance.

The volunteers were asked to follow some recommendations during the study, such as: do not ingest thermogenic substances that may influence the collection and interpretation of data; not smoking before the collection of data (exercise sessions were held in the morning); not performing physical activity from 72 h before the tests of 10RM up to the end of the experimental procedures of this study.

2.2. Experimental protocol

This study conducted four meetings with the volunteers, as illustrated in Fig. 1. In the first meeting, the experimental protocol has been presented and filled the Parq-*q* test and the informed consent. At the second meeting were collected data on height, age, body weight and skinfold according to the protocol by Jackson and Pollock [19], as shown in Table 1. At the same meeting, the volunteers were randomized into 2 groups: Biceps Group (BG) or Quadriceps Group (QG). Thus, it was performed the test to 10RM in the biceps curl exercise for BG volunteers and in the back half squat at 90° for QG volunteers. After 72 h, the participants performed the retest of 10RM in order to perform the necessary calculations for the required loads by the exercise protocol. These tests followed the recommendations proposed by Kraemer et al. [20].

Seven days after the completion of the retest, groups (BG and QG) held the first exercise session (SE1), whose load was randomized (70% or 85% of 10RM). A week after SE1 was performed the second exercise session (SE2). BG volunteers have only conducted the unilateral biceps curl exercise and QG volunteers have only performed the back half squat at 90° exercise.

2.3. Exercise sessions

Before the exercise sessions, the volunteers wore light clothing, put the heart rate monitor in their chest, and remained sitting at rest in a room with temperature adjusted to 22 °C during 15 min for acclimatization purposes.

The performed exercises were: the unilateral exercise biceps curl [21,22] and the back half squat at 90° [23]. Both were performed in four sets, with 10 repetitions in each set, and with 30 s to rest between them. The HR and skin temperature in the biceps and quadriceps were recorded at the same time in all moments evaluated.

In BG, all women were right-handed, so it was established that the right arm as exercise arm (Experimental Biceps – EB) and left arm as control (Control Biceps – CB).

In experimental protocol was used a chronometer to control the timeline of data acquisition. The exercise was initiated at the second 30 and ended at minute four. Data relating to skin temperature in the brachial biceps and quadriceps were captured by an Infrared camera FLUKE® model Ti32, at each 30 s up to the minute 10 of experimental protocol; at each minute from the minute 10 to the minute 15; at each 5 min from the minute 15 to the minute 60.

All data were acquired in standing position, but the volunteers remained only the first 15 min of protocol in it. From the minute 15 to the minute 60, all volunteers remained in sitting position and