

Thermography to monitoring of Sports Training: an Overview

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Abstract — Thermography measures have been increasingly used as a preventive resource and control method in the sports training monitoring. The purpose of this study was to present an overview of applications and analysis of thermal images in sports training, as well as presenting the parameters and standards for its use in the sports training monitoring. This is a narrative review of the literature. The results of studies with thermography have shown different responses in body temperature regulation with the exercise practice, which in turn has been linked to the exercise prescription characteristics, such as type of exercise, intensity, among others. The application of thermography has been used also as a strategic resource in the monitoring of high-level athletes, which has been reduced, significantly, the number of sports injuries, by the use of the tomographic image analysis. For this purpose, technical parameters and standards for carrying out the thermographic images must be carefully observed in order to maintain the reliability of the data. Thus, through a suitable design methodology, it is possible to perform a physiological monitoring to sports training with the use of thermography, maximizing strategies to prevent possible injury.

Keywords: thermography, sports training, body temperature regulation, injuries, exercise.

Resumo — Medidas termográficas têm sido cada vez mais utilizadas como recurso preventivo e de controle de atletas no treinamento esportivo. O objetivo do presente estudo foi apresentar uma visão geral das aplicações e análises das imagens termográficas no treinamento esportivo, assim como apresentar os parâmetros e padronizações para a devida coleta e uso das imagens termográficas no treinamento esportivo. Para tanto, foi realizado uma revisão narrativa da literatura sobre o tema. Os resultados de estudos realizados com a termografia têm demonstrado diferentes respostas na regulação da temperatura com a prática do exercício, que por sua vez, tem sido relacionada as características da prescrição do mesmo, como tipo de exercício, intensidade, dentre outros. A aplicação da termografia vem sendo utilizado também como recurso estratégico na monitoração de atletas de alto nível, onde redução significativa do número de lesões no esporte tem sido observadas com o implemento destas análises de imagens termográficas. Para tanto, os parâmetros técnicos e padronizações para a realização das imagens termográficas precisam ser atentamente observadas a fim de manter a fidedignidade dos dados obtidos. Assim, por meio de um planejamento metodológico adequado, é possível realizar um monitoramento de respostas fisiológicas ao treinamento esportivo com o uso da termografia, maximizando as estratégias para a prevenção de possíveis lesões.

Palavras-chave: termografia, treinamento esportivo, regulação da temperatura corporal, lesões, exercícios.

1. BASIC CONCEPTS

Three major factors determine the degree of heat production: basal metabolic rate (hypothalamus); specific organic activity (eg. hormones or digestion); and muscle activity (physical activity)(1, 2).

In human body, the heat loss is a function physiologically regulated and controlled by cutaneous vasomotor activity of the vascular network. The heat dissipation physical mechanisms are four: Conduction (contact); Convection (vascular system); Evaporation (lungs and sweat); and Radiation (skin). The higher thermal loss mechanism of the human body is the radiation that accounts for 60% of the total loss(1).

2. THERMAL IMAGE ACQUISITION PROTOCOL

There are three main groups of factors involved in thermal image acquisition protocol: technical factors; human factors; and environmental factors.

Regarding to the first one, the equipment has the major importance. It is recommended the usage of thermal imagers that operate in the far-infrared range between 7-15 microns, having a resolution of 320 x 240 pixels and thermal sensitivity 0.05 °C, and also having special programs for the thermogram analysis(2, 3).

In human factors, we can cite: age; body fat distribution; muscle mass; metabolic rate; emotions; body position; medical history; intake factors; and physical activity (4-6). And, as the environmental factors: the wind, relative humidity, others sources of radiation, and the room temperature(7).

3. DISCUSSING THE HUMAN FACTORS

In order to be able to monitoring the physiological responses induced by exercise, using thermography, it is necessary understand the skin temperature behavior with exercise. This behavior depends on the exercise intensity, duration, recruited muscle mass, muscle density and subcutaneous fat layer(5, 6).

High-intensity exercise can cause an increase, or decrease, in skin temperature during rest period, according to the ratio muscle mass / subcutaneous fat layer, however, in normal weight people, an increase in temperature is expected due physiological responses in the

muscle recovery process. Although, low-intensity exercise induces a decrease in skin temperature, returning to the baseline values in the recovery days(2). This behavior was also observed by Neves et al.(3), the authors investigated the relationship between the volume/intensity and thermal responses during resistance training exercises.

The heat dissipation from active muscles to the skin surface can cause an increase in body parts temperature during exercise. Nevertheless, an interesting fact is the decrease in skin temperatures in the first moments during the exercise (8).

The skin temperature variations, on post exercise period, may also be useful to understand the muscle recovery processes. Neves et al.(3), founded that a temperature increase in both arms, after resistance training, is directly related to the muscle volume increase. The studied group that has achieved an increase in muscle volume also got a significant temperature increase. The thermal response remained high during the exercise as immediately, 48, 72 and 96 hours after exercise. The authors reported than the rise in skin temperature is associated with the inflammatory process and tissue repair.

Hani et al. (9) founded a correlation between skin temperature and the delayed onset muscle soreness (DOMS). The authors reported an increase on skin temperature of the exercised arms 24 hours after exercise, compared to pre-exercise temperatures. Hemodynamic variations influence directly the skin temperature.

Hemodynamic variations are directly related with changes in skin temperature. Prior et al.(10) reported that the temperature behaviors can act differently according to the age of the athletes. In the rest period after exercise, the temperature decrease more slowly in older subjects than young subjects. The older subjects probably have lower heat dissipation due the blood circulation limitations.

Under normal circumstances (with no clinical disease) few physiological instances can induce angiogenesis, however, there are evidences that exercise can induce new blood vessels formation. McCall et all. (11) evidence an increase in capillary numbers proportionally with the increase in muscle fiber.

Authors (2, 6) claim that the subcutaneous fat layer can increase the difference between core and skin temperatures. This study identified significant correlations between muscle areas and

the temperature variations. The study identified significant correlations between muscle areas and the temperature variations for biceps but the same was not observed in the triceps; the arm vascularization and the fat layer over of each muscle could explain this difference.

The injury detection by thermal imaging is based on standard temperature and thermal asymmetry patterns. The thermal asymmetries normally not exceed values as 0.25°C . Studies show that larger asymmetries (more than 0.60°C) may correspond to musculoskeletal injuries (4, 6, 12).

4. APPLICATIONS IN MONITORING THE SPORTS TRAINING

Currently, there are several reports in the literature that indicate the possibility of using thermography to: muscle recovery assessment(3); training planning (13); release for training(14); VO_2max estimation (15); edema identification (7); varicose veins identification; ischemic identification (16); and muscle injury identification (4).

Recently Carmona (17) investigated thermography as a preventive method for soccer player injuries. On this study, the injuries of a professional football team were registered on 2008 ($n=24$) and 2009 ($n=24$) preseasons. In addition, during 2009 preseason, infrared thermography was used to achieve information about the assimilation of the training load. This information was used to rethink the specific protocols to injury prevention that were used in the previous season. The results showed a significant reduction (60%) in the injuries frequency during 2009 preseason, and also a decrease in the overall injuries incidence, from 8.3 injuries per 1000 hours of exposure in 2008, to 3.4 in 2009. Furthermore, the percentage of players that have suffered injury in 2008 decrease from 85% to 26% in 2009, like muscle injuries that fell 70% compared to 2008. In addition, it was found a 91.8% decrease in the stop days caused by injury.

Thermography has been applied in injury prevention but also as a method to monitoring the modalities of muscle recovery after exercise, such as cryotherapy (Figure 1).

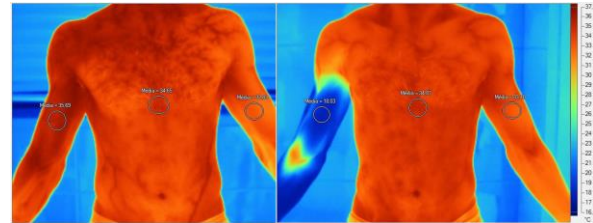


Figure 1. Illustration of the thermography usage in monitoring of cryotherapy.

Cryotherapy has been used for immediate soft tissue treatment, applied by doctors, physiotherapists and coaches. According to the recent PRICE guidelines, by The Association of Chartered Physiotherapists in Sports and Exercise Medicine, a reduction in skin temperature of at least 5°C - 15°C is necessary in order to achieve the optimal physiological responses to reduce the recuperation period. In order to monitoring the cryotherapy application on clinical and sport treatments, skin temperature seems to be a relevant and clear parameter to take under consideration (18). Hardeker et al (19) found a negative quadratic relationship among intramuscular and skin temperatures, reporting that the amount of an object's heat is proportional to its volume, meaning that internal tissue temperature can be accessed by dissipation of the subjacent tissue volume.

Although it is usual to use subjective and contact devices in order to access skin temperature, like Thermocouples (20), Ingestible Temperature Sensors (21) and Point Thermal Sensors(22). Nevertheless, there is evidence in literature that supports the use of thermal images to access skin temperature during cryotherapy. Being a non-contact method is an extremely important advantage over other methods, due to the natural dynamics of skin temperature. The use of contact and other subjective methods to access skin temperature can lead to data errors, particularly in repeated trials (23). Also Ingestible temperature sensors seem to have some disadvantages compared to thermal imaging, especially when studies aim to evaluate isolated body parts.

5. CONCLUSIONS

Through an appropriate methodological planning, you can conduct a monitoring of physiological responses to sports training with the use of thermal imaging.

ACKNOWLEDGMENT

We would like to thank Brazilian Army and Brazilian Counsel of Technological and Scientific Development (CNPq) by the Eduardo Borba Neves scholarship, and Coordination for the Improvement of Higher Education Personnel (CAPES) by the Raphael M Cunha Scholarship, process n. BEX 8048/14-2.

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