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Preditive Thermography for Sport Injuries - Brazilian Current Studies.

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Thermography measures have been increasingly used as a preventive resource and control method in the sports training monitoring.

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 thermographic 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.

Since muscle injuries trigger inflammatory processes and inflammation generates heat due to increased local metabolism, hence the level of inflammation can be measured by the temperature gradient.

The training level and intensity of each training session promote differences in muscle mass level and skin temperature. Some studies conducted by us concluded that trained subjects have a higher cutaneous blood flow than others. This response could be related with several physiological changes (e.g., increased muscle metabolism, anaerobic energy reserve, density of capillaries and nerve conduction rate). Also, age difference could provoke changes in skin temperature in soccer players. A study conducted in soccer players from the U-19 categories (age: 15.5 ± 1.37 years) observed mean values of skin temperature of 30.2ºC in anterior and posterior thigh and 29.6ºC in legs. Thus, comparing mean values of skin temperature between elite soccer players and U-19 categories, a difference of 1.67ºC and 1.5ºC in thighs and legs, respectively could be noted. These skin temperature changes can be related to higher workout intensity, maturation, increase capillary density and morphological changes in muscle tissue by modifying the cross-sectional area of the muscle.

Thermal symmetry of the human body is similar between the sides of the body which are identical in shape and size, being taken at the same angle. On the other hand, acute injuries lead to vasodilatation and increase of inflammatory mediators in the area, which result in an increase of the metabolism and blood flow in the region, consequently, increase local body temperature and disturb this normal symmetric pattern. Thus, differences greater than 0.7°C between contralateral limbs or body areas have been associated with structural or physiological abnormalities in athletes. This way, IRT is now seen as a helpful technology that may help athletes, coaches, physicians and physical therapists in cases of injuries for prevention, early detection and therapy assessment.

Study #1

A study was conducted with adolescent athletes of soccer Club (Curitiba, Brazil), who were divided into two groups, namely control and experimental. The control group attended a training session of low intensity (run 50 and 60% of maximum heart rate) and the experimental group a high intensity one (above 60% of VO_2 maximum). First, a thermographic image of the anterior thigh (rectus femoris; adductor longus; vastus medialis) of each athlete was acquired before the training session. After the training session, a blood sample was collected to check the level of serum lactate of each athlete. Subsequently, 24 hours after training, an extra blood sample was performed to check the level of serum CK of each athlete. Another individual thermographic image of the quadriceps was acquired at that stage. The comparison of the temperature variation (24h post-training - pre-training) in each three muscles analyzed within each group (control and experimental), indicated that there was temperature difference statistically significant solely in the experimental high intensity group.

Study #2

The study 2 included 30 healthy male professional soccer players (25.4 ± 4.7 years; 179.5 ± 6.7 cm; 78.3kg ± 7.5 kg; body fat 10.2 ± 4.2 %) from a club of the Brazilian first division soccer league that participates in national and international competitions organized by the Brazilian Soccer Confederation (CBF) and South American Soccer Confederation (CSF). The current training frequency was 6.3 ± 0.7 days/week and the training programs consisted of jumps, ball fights, sprints, accelerations and decelerations. Exclusion criteria included: 1) smoking history during the previous 3 months, 2) presence of any cardiovascular or metabolic disease, 3) systemic hypertension (≥140/90 mmHg or use of antihypertensive medication), 4) use of anabolic steroids, drugs or medication with potential impact in physical performance (self-reported), or 5) recent presence of musculoskeletal injury, 6) pain symptoms in any region of the body. The study was approved by the local institutional Ethical Committee for Human Experiments, and was performed in accordance with ethical standards in sport and exercise science research. All data collection was carried out in the beginning of the training season.

Body weight was measured using a calibrated physician's beam scale (model 31, Filizola, São Paulo, Brazil), with the men dressed in shorts. Height was determined without shoes using a stadiometer (model 31, Filizola, São Paulo, Brazil) after a voluntary deep inspiration. Body fat percentage (%) was estimated using the seven-site skinfold procedures, and performed twice, in circuit. The mean technical error of measurement for skinfold value was 0.31. All biometric measurements were carried out in a climatized room (22±1° C). No clinical problems occurred during the study.

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Blood creatine kinase (CK) concentration was assessed by reflectance photometry at 37°C using the Reflotron Analyser Plus (Reflotron Plus; Roche, Germany), previously calibrated. After the finger asepsis, by using 70% ethyl alcohol, a lancet device with an automatic trigger was used for puncturing finger and the blood was drained into a strips for specific analysis (heparinized capillary strips). Blood sample (32 µl) was immediately pipetted into a CK test strip which was inserted into the instrument. Absolute values of CK were used for analysis.

All thermographic images were performed between 8:00 and 9:00 A.M. with an acclimatized room with temperature of 23ºC with a relative humidity of 65%. The acclimation period to evaluate skin temperature was set at 15 minutes. Thermal images sequences of lower limbs (thighs and legs) were acquired in an anteroposterior manner (i.e., frontal and dorsal views) by a digital infrared thermo-camera (Flir Systems Inc®, model T1030sc, USA) accuracy of ± 1°C or 1 %; sensitivity of ≤ 0.03°C, an infrared spectral band from 7.5 to 14 microns, a refresh rate of 60 Hz and an FPA (Focal Plane Array) of 640x420 pixels. The distance between the subject and the camera was standardized at 3 m and the index of human skin emissivity was set to 0.98.

Analyze of the body regions of interest (ROI) were selected by a drawing rectangular areas by the software (ResearchIR, FLIR, USA), which provided the average and maximum temperatures from each analyzed ROI. Selection of the ROI utilized 5 cm above the upper border of the patella and groin line for the thigh, and for the leg, 5 cm below the lower border of the patella and 10 cm above the malleolus.

Coffee, tea and alcohol intake was prohibited for 4 hours and subjects avoided formal and strenuous exercise for 48 hours before testing. The subject not use physiotherapy before the test (e.g. massage, electrotherapy, ultrasound, heat treatment, cryotherapy, hydrotherapy) and without cosmetics products before the measurements to obtain thermal images most meaningful of skin temperature. All subjects reported the absence of any type of sports injury according to these criteria.

Considering that CK levels increase after exercise or soccer matches, applying two methods for muscle activity are more accurate. CK levels increase up to 24h after matches, and thermal images could measure muscle activity immediately after exercise. Since the athletes should recover not only for matches but also for training, the response of thermal images analysis could provide a rapid feedback for coaches during training phases.

The evaluated elite soccer players showed contralateral thermal symmetry the difference between both sides in most players and all the ROI is not greater than 0.2°C. The symmetry obtained indicates that athletes have a normal thermography pattern which does not suggest the presence of injury. Thermal response between two contralateral body parts is expected to be symmetrical and thermal monitoring comparing bilateral body parts that indicate differences surfaces temperature < 0.5°C are deemed negligible.

However, difference > 0.5°C is considered asymmetry of temperature distribution which may be related with pathological conditions in tissues in non-athletes. On the other hand, values > 0.7ºC are considered asymmetry between contralateral body parts in athletes. When observed difference > 0.7ºC is important verifying if some external factor influenced the result, observe environmental and training conditions and increase the frequency of monitoring. Moreover, differences contralateral >0.7ºC can contribute to decrease of quadriceps power in 7.9%

Thermographic images can be used with creatine kinase (CK), in order to determine the intensity and location of post-training muscle damage, since the CK biochemical marker cannot determine the anatomic location of the muscle injury.
The use of infrared thermography and CK plasma level can together determine muscle damage, because only biochemical markers do not show the anatomic location of the muscle injury. Few studies evaluated the profile of infrared thermography in lower limbs of the elite soccer players.