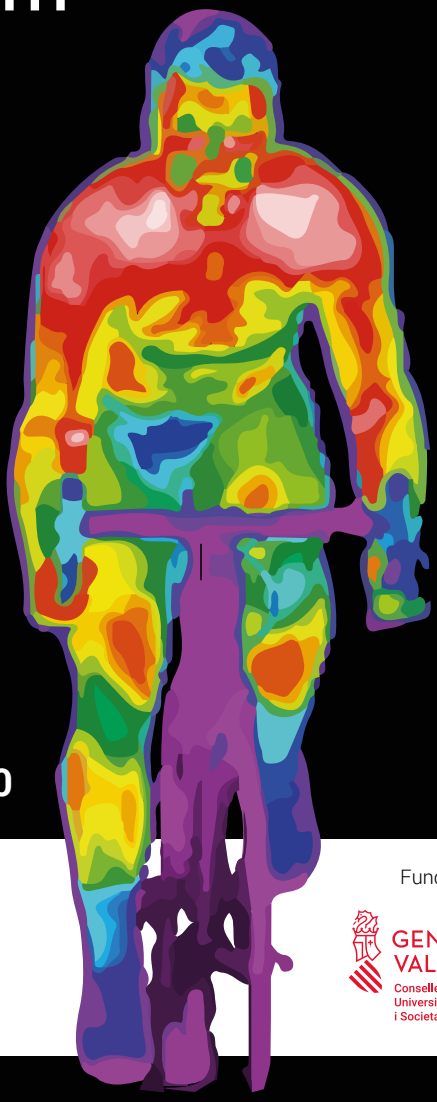
BOOK OF ABSTRACTS

I INTERNATIONAL CONGRESS ON **APPLICATION OF INFRARED THERMOGRAPHY IN SPORT SCIENCE**

V CONGRESS OF THE RESEARCH GROUP IN SPORTS BIOMECHANICS | **GIBD** |



ONLINE
19-20 NOVEMBER **2020**

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V CONGRESS OF THE RESEARCH GROUP IN SPORTS BIOMECHANICS | GIBD |
ONLINE 19-20 NOVEMBER 2020
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PROGRAMME

19 Nov. 2020

17:00 - 17:15 Opening ceremony: presentation of the congress by the authorities.

17:15 - 18:00 Opening lecture I: Prof. **George Havenith** (University of Loughborough, UK): Infrared thermography for mapping skin temperature profiles for thermophysiological research and evidence based clothing design.

18:00 - 18:15 Questions

18:15 - 19:00 Opening lecture II: Prof. **Lisa R. Leon** (US Army Research Institute of Environmental Medicine, USA): Heat Stroke: Risk Factors and Mechanisms of Susceptibility.

19:00 - 19:15 Questions

20 Nov. 2020

9:30 - 11:00 Application of Infrared thermography on sports field.
Chair: Prof. **Maria Soroko** (Wrocklaw University, Poland)

- 9:30 - 9:50 Invited lecture: Prof. **Jose I. Priego-Quesada** (University of Valencia, Spain): Assessment of skin temperature to control physiological stress.
- 9:50 - 10:10 Invited lecture: Prof. **Manuel Sillero** (Universidad Politécnica de Madrid, Spain): Present and future of thermography as an injury prevention tool.
- 10:10 - 10:30 Invited lecture: Prof. **Maria Soroko** (Wrocklaw University, Poland): Application of infrared thermography in equestrian sport.
- 10:30 - 11:00 Questions

11:15 - 12:45 Methodologies and other applications.
Chair: Prof. **Manuel Sillero** (Universidad Politécnica de Madrid, Spain).

- 11:15 - 11:35 Invited lecture: Prof. **Damiano Formenti** (Università Degli Studi Dell'Insubria, Italy): Thermal images analysis: procedures and new perspectives.
- 11:35 - 11:55 Invited lecture: Prof. **Inmaculada Aparicio** (University of Valencia and AITEX, Spain): Use of infrared thermography for the evaluation of textiles and sports accesories.
- 11:55 - 12:15 Invited lecture: Prof. **Nicola Gerrett** (VU Amsterdam, Netherlands): Skin temperature and sweat gland function.
- 12:15 - 12:45 Questions

12:50 - 13:20 Closing lecture: Prof. **Arcangelo Merla** (University of Chieti-Pescara, Italy): From thermoregulation to stress and cognitive activity during exercise. What thermography has still to say.

13:30 - 13:30 Questions

13:30 Closing ceremony and awards

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Opening lecture: Infrared thermography for mapping skin temperature profiles for thermophysiological research and evidence based clothing design

George Havenith

University of Loughborough, UK.

In this talk I will provide examples of the research in the Environmental Ergonomics Research Centre at Loughborough University in which we used infra-red measurements to assess the development of skin temperature and to assess moisture accumulation in clothing.

In this process I will touch on the techniques used and consider issues with the use of infra-red cameras for such measurements. Further I will show how the information obtained can inform clothing design.

Opening lecture: Heat Stroke: Risk Factors and Mechanisms of Susceptibility

Lisa R. Leon

US Army Research Institute of Environmental Medicine, USA.

Dr. Leon's presentation discussed heat stroke risk factors and recent studies that were conducted to identify mechanisms of increased heat stroke susceptibility or severity. Studies were conducted in a mouse model of classic heat stroke. A small acute dose with a non-steroidal anti-inflammatory drug (NSAID; indomethacin) was shown to increase gut hemorrhaging and provided no advantage during heat exposure. Prior illness, in the absence of overt clinical symptoms at the time of heat exposure, caused a significant increase in heat stroke severity. Coagulation and inflammatory pathways are implicated in the response to prior illness and may be treatment targets. These studies indicate that NSAIDs and prior illness should be taken into consideration prior to heat exposure as they may increase heat stroke susceptibility.

Invited lecture: Assessment of skin temperature to control physiological stress

Jose I. Priego-Quesada

University of Valencia, Spain.

Skin temperature assessment has attracted attention in recent years as a possible internal load and muscle damage measurement. Its possible application is based in the idea to register a peak in basal skin temperature related with the training load of the previous trainings. However, the results of the literature are contradictory, and more research is necessary for this specific application. In this lecture, Dr. Priego-Quesada will present the studies that he performed about this topic assessing the effects after an exercise protocol to induce calf damage, a half marathon, a marathon, or during a triathlon training camp.

Invited lecture: Present and future of thermography as an injury prevention tool

Manuel Sillero-Quintana

Sports Department, Faculty of Sciences for Physical Activity and Sport (INEF), Universidad Politécnica de Madrid, Spain.

The work with start analyzing the results of a search with the expressions "thermography" and "(sports or exercise) and thermography" on two free access databases, which will allow understanding the evolution and current situation of the Sports Thermography, including the fast analysis of the more relevant articles in literature. Later, they will proposed new research lines and strategies for future development of sport thermography, and it will be presented a new model for explaining, from the thermography point of view, the physiological responses of skin temperature to the exercise in humans.

Invited lecture: Application of infrared thermography in equestrian sport

Maria Soroko

Wrocklaw University, Poland.

The presentation includes application of thermography in performance horses as a complementary diagnostic tool in veterinary medicine, in: thermoregulation, athletic performance, evaluation of welfare and in physiotheraphy. First paper, on application of thermography in veterinary medicine was presented by Smith in 1964. In this paper the author using thermographic camera detected clinical injures of horses limbs associated with: inflammation of flexor tendon, splints, joints injury.

Invited lecture: Thermal images analysis: procedures and new perspectives

Damiano Formenti

Università Degli Studi DellInsubria, Italy.

Thermal image analysis is usually performed by averaging temperature values of pixels within a selected region of interest. However, this methodology does not take into account for the distribution of temperature patterns, thus not fully exploiting the potentialities of thermal imaging for studying thermal responses to physical exercise. Literature, methodologies and new perspectives are examined and presented."

Invited lecture: Use of infrared thermography for the evaluation of textiles and sports accesories

Inmaculada Aparicio

University of Valencia and AITEX, Spain.

The different fabrics and materials used in sports garments and equipment could affect the transfer of heat between the skin and the environment. In this sense, assessing the response of skin temperature in the use of these materials is interesting with the aim of increasing thermal comfort and improving thermoregulatory efficiency. AITEX is a research textile institute that investigates new materials and sports equipment. Dr. Aparicio will present the studies carried out in the last year in which infrared thermography has been used in compression clothing, and foot orthoses, among others.

Invited lecture: Skin temperature and sweat gland function

Nicola Gerret

VU Amsterdam, Netherlands.

The evaporation of sweat from the skin, helps attenuates the rise in skin and core temperature during thermally challenging conditions. Whilst this may suggest that sweat controls skin temperature, it is not a one-way street. Skin temperature plays an important role in the initiation sweating and strongly affects the sensitivity of the sweat glands to rising body temperature. Local skin temperature has recently been shown to regulate the rate of ion (e.g. sodium and chloride) reabsorption in the straight duct of sweat glands. As a result, skin temperature may affect the content of our sweat. In this presentation, Dr. Nicola Gerrett will discuss the relationship between skin temperature and sweat gland function.

Closing lecture: From thermoregulation to stress and cognitive activity during exercise. What thermography has still to say.

Arcangelo Merla

University of Chieti-Pescara, Italy.

Using thermography for assessing skin thermoregulatory processes is one of the most immediate use of the methodology. However, since the skin temperature is controlled by the autonomous nervous system, which activity in turn is intimately connected the emotional state of the individual, thermography may provide an useful method for investigating the emotional dimension, even in the framework of sport activity. In this lecture, potentialities and limits of thermography based methods for assessing emotional states are presented, togetehr with their implications to sport science.

ABSTRACTS
POSTERS

Coplanar arrangement of shortwave diathermy is the most efficient in skin temperature change

Benincá, Inaihá (1); De Estéfani, Daniela (1); De Avelar, Núbia (1); Haupenthal, Daniela (2); Silveira, Paulo (2); Haupenthal, Alessandro (1)

(1) Federal University of Santa Catarina, Araranguá, Brazil; (2) The Universidade do Extremo Sul Catarinense, Criciúma, Brazil.

Introduction

Continuous shortwave diathermy (SWD) is commonly used as a therapeutic modality in sports rehabilitation setting. This modality efficacy relies on change in temperature, which had been evaluated by previous studies. However, these studies are not comparable enough to determine which of SWD capacitive technic arrangements is the most efficient.

Objective

To analyze which capacitive technique arrangement of SWD is the most efficient in skin temperature change.

Methods

A randomized, single-blinded crossover trial. Twenty health male subjects received 20 minutes of SWD application to the anterior aspect of the thigh on coplanar, contraplanar and longitudinal arrangement. Skin temperature was collected under the proximal electrode and at the thigh center before the application (after 20 minutes of acclimatization), immediately after application and in each minute over 25 minutes after electrodes removal. In order to collect temperature change, we used an infrared thermography camera that was positioned vertically 1 m from the thigh.

Results

Twenty subjects were randomly allocated, we had two losses to follow up, remaining 18 subjects for analysis (age = 21.4 ± 2 years, BMI = 23.6 ± 2.4 kg/m2). Under the electrode all arrangements achieved vigorous heating (coplanar = 7.9 ± 1.7°C; contraplanar = 6.5 ± 2.6°C; longitudinal = 7.4 ± 1.8°C) immediately after electrodes removal and temperature decreased with a similar rate across arrangements (<0.1°C each 5-minute interval). At the thigh centre, coplanar arrangement achieved mild heating (1 to 2°C) until seventeen minutes after electrodes removal, meanwhile, the other arrangements did not increase temperature sufficiently for post intervention therapeutic effects.

Conclusions

Coplanar arrangement increased skin temperature the most, heated the greatest area, and had the lowest temperature decay. Therefore, if the body part accommodates any of the capacitive technic arrangements, coplanar should be used to treat superficial tissues.

Effects of 24-h use of compression stockings with menthol and camphor on skin temperature following running

Kunzler, Marcos Roberto (1); Carvalho, Jean da Silva (1); Priego-Quesada, Jose Ignacio (2,3); Aparicio, Inmaculada (2,4); Pérez-Soriano, Pedro (2); Machado, Álvaro Sosa (1); Carpes, Felipe Pivetta (1)

(1) Applied Neuromechanics Research Group, Laboratory of Neuromechanics, Federal University of Pampa, Uruguaiana, Brazil; (2) Research Group in Sports Biomechanics (GIBD), Department of Physical Education and Sports, University of Valencia, Valencia, Spain. (3) Biophysics and Medical Physics Group, Department of Physiology, University of Valencia, Valencia, Spain.; (4) AITEX (Textil Research Institute), Alcoy, Spain.

Introduction

The manipulation of compression and temperature are often discussed as strategies to improve performance and recovery in sports. Objective - To determine the effects of compression stockings made with fabric combined or not with substances eliciting heating and cooling on skin temperature and comfort after consecutive running efforts.

Methods

Ten amateur competitive runners with mean (SD) age 45 (11) years old and without experience in using compressive stocking participated in the study by completing 8 running sessions. They worn control, compression, compression impregnated with camphor, and compression impregnated with menthol stockings 24 h continuously after running 10 km at competitive pace (day 1). At the end of the 24 h they ran again for 5 km at competitive pace (day 2). Each block [10 km – 24 h compression - 5 km] was repeated 4 times being the stocking conditions randomized. On day 2, after 24 h of compressions or control conditions, skin temperature parameters and comfort were evaluated. Skin temperature was determined before and immediately after running using an infrared thermal camera aimed at anterior and posterior thigh and lower leg from both lower limbs. The general perception of comfort, perceived calf compression, tissue comfort, humidity and perceived temperature in wearing the stockings were assessed by analogue visual scale. Data were compared between the different compression garments.

Results

Different types of compression stockings used for 24 h before exercise did not affect skin temperature parameters (p=0.09). During exercise, the different stockings conditions did not change perception of comfort (p=0.13; mean of 7/10 points).

Conclusions

In general there were no effects of pre-exercise 24 h lower leg compression including menthol and camphor applications on skin temperature and comfort perception in athletes performing consecutive running efforts.

Effects of a single session of high intensity continuous exercise on skin temperature at different times of day

Kunzler, Marcos Roberto (1); Pereira, Matheus Dotto (1); Azevedo, Renato Ribeiro (1); Machado, Álvaro Sosa (1); Da Silva, William (1); Carpes, Felipe Pivetta (1)

(1) Applied Neuromechanics Research Group, Laboratory of Neuromechanics, Federal University of Pampa, Uruguaiana, Brazil.

Introduction

The body temperature of humans fluctuates throughout the 24 hours of a day, and such variation may influence sports performance. However, it is unclear if skin temperature in response to exercise also varies along the day, and therefore influence measures performed before and after exercise. Objective - To determine whether skin temperature changes in response to physical exercise performed at different times of day.

Methods

Twenty-six adult men visited the laboratory in the morning (07:00-10:00AM, light period) and evening (06:00-09:00PM, dark period) with 48 h of interval between the visits. On each visit, skin temperature was determined using an infrared thermal camera aimed at anterior and posterior thigh from both lower limbs, before and after performance of 30 seconds of a continuous maximal jumping exercise. During the exercise, performance was monitored by determination of jump height. Data were compared between pre and post exercise and between the different times of the day.

Results

Skin temperature did not show an effect for time of the day (F=4.079; p=0.055 anterior thigh; F=4.209; p=0.155 posterior thigh) and exercise (F=0.455; p=0.507 anterior thigh; F=3.424; p=0.077 posterior thigh). Jump height did not differ between morning and evening (t=-0.825; p=0.418).

Conclusions

Skin temperature did not change at different times of the day, even after a high intensity short duration exercise session.

Skin temperature measurement in people with spinal cord injury during exercise: systematic review.

Sánchez-Jiménez, Jose Luis (1); Romero-Ávila, Jose Luis (2); Aparicio-Aparicio, Inmaculada (1); Priego-Quesada, Jose Ignacio (3)

(1) Research Group in Sports Biomechanics, Universitat de València, Valencia, Spain; (2) Department of Physiotherapy, Universitat de València, Valencia, Spain; (3) AITEX (Textil Research Institute), Alcoy, Spain.

Abstract

People with spinal cord injury have a dysfunction in the nervous system which impairs their thermoregulatory response and the heat exchange with the environment. Specifically, the sympathetic branch dysfunction below the level of the injury has as consequence the lost of vasomotor control and the sweat capacity. Skin temperature assessment during exercise could therefore be an interesting application of this population with the aim to avoid heat stroke.

Objective

To analyse the scientific literature about the skin temperature assessment during or after exercise in people with spinal cord injury.

Methods

Three database were checked: Pubmed, Web of Science and Scopus. Experimental human studies and papers published after year 2000 were some of the inclusion criteria.

Results

The results of the search were 241 articles. After removing duplicate articles and applying the inclusion/exclusion criteria, 20 articles were selected. 6, 9 and 5 articles presented evidence levels of II, III and IV, respectively. The 90% of the studies employed during the measurement of skin temperature instruments that are in contact with the skin, and only one research used infrared thermography (level of evidence IV) [1]. People with spinal cord injury increased their skin temperature during exercise, and they had great rises in hot environments. People with paraplejia decreased their skin temperature during the rest, in contrast to people with tetraplejia who did not reduce their skin temperature and they increased the heat storage.

Conclusions

People with spinal cord injury increase their heat production during the exercise, and they may have some difficulties to exchange the heat with the environment. Infrared thermography could be a great tool to control the thermoregulatory response and prevent heat related illness in people with spinal cord injury.

References

1. I.Rossignoli, I. Fernández, P.J. Benito, A.J. Herrero, Infrared Physics and Technology 76 (2016) 251-58.

Thermovision assessment of surface temperatures changes following the cryostimulation in football players

Lubkowska, Anna (1); Klejdysz, Robert.

(1) Chair and Department of Functional Diagnostics and Physical Medicine, Faculty of Health Sciences, Pomeranian Medical University in Szczecin, 54 Zoł.

Introduction

The cryostimulation treatment (CT) is associated with short exposure to low temperatures, most often in the range from -120 to -140 ° C for a 2-3 minutes. The beneficial effects of CT on delayed onset muscle soreness (DOMS), well-being sensations and muscle strength recovery after exercise are documented. In professional sport it is important to precisely control the time and temperature of the procedure as well as mobility of the devices according to its efficiency. Method of visualizing the thermal effects of CT is thermographic evaluation.

Objective

To determinate the changes in temperature of selected body surfaces in football players in response to open system cryostymulation treatment applied directly after football match.

Methods

15 footballers, aged ± 26; BMI= 23,5 kg/m2, underwent a CT procedure after a football match. Each player was subjected to anthropometric characteristics including body composition and blood pressure. Thermographic analyzes of anterior and posterior surfaces of upper and lower extremities as well as the trunk areas was performed before and immediately after the treatment. Results and

Conclusions

After CT a highly significant decreases in temperature of all analyzed areas was observed, most marked in the lower extremities, especially the anterior thigh area (ΔT = 10.65 °C) and the least in the upper back area (ΔT = 6 ° C). A number of significant correlations between the range of temperature changes and values of body composition indicators (fat and muscle mass) and blood pressure, varied in areas, have been shown. Maintaining a constant body temperature during CT occurs at the expense of thermoregulation mechanisms leading to a decrease in body surface temperature. The stronger cooling effect is observed in lower extremities. The range of temperature changes of the analyzed areas indicate a strong stimulus effect of the treatments in mobile cryogenic chamber in an open system.

The effect of sweat after running on skin temperature: infrared thermography vs thermal contact sensors

Machado, Álvaro (1); Gil-Calvo, Marina (2); Jimenez-Perez, Irene (2); Cibrián Ortiz de Anda, Rosa Maria (3); Salvador Palmer, Rosario (3); Pérez-Soriano, Pedro (2); Priego-Quesada, Jose Ignacio (2)

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It has been observed higher skin temperature with the use of thermal contact sensors than with infrared thermography, possibly due to the drop in evaporative cooling efficiency produced by sweat accumulation in the fixation method (1).

Objective

The aim of the study was to define a methodology to assess the effect of sweating on infrared thermography and thermal contact sensors, after moderate intensity running.

Methods

Nine male recreational runners performed a laboratory test consisted in 35 minutes of continuous running with 1% of slope on a treadmill (Excite Run 900, TechnoGymSpA) at a self-selected speed (10.0(0.5)km/h) at a RPE of 12 points in 6-20 Borg scale. Skin temperature (infrared thermography, Flir E60bx; four thermal contact sensors, IButton DS1923 Hygrochron) and relative humidity (thermal contact sensors) were measured in the anterior thigh at both lower limbs before and after running. Two thermal contact sensors were located at each lower limb, and in each lower limb one of them was attached throughout the complete protocol (fixed) and the other just 5 min before to each data acquisition (non-fixed) Laboratory environmental conditions were: air temperature 23.2(0.9)°C and relative humidity 27.9(5.1)%.

Results

Non-fixed sensors presented lower skin temperature than fixed sensors and thermography before and after running (before: 28.3(3.3) vs 31.8(1.4) vs 31.3(1.3)°C, respectively; after: 31.8(1.8) vs 33.2(1.4) vs 33.9(1.3)°C, respectively), and fixed sensors presented higher skin temperature than thermography after running. Fixed sensors presented higher relative humidity than non-fixed sensors after running (101(2) vs 83(16.2)%).

Conclusion

The mean relative humidity of the fixed sensor suggests the saturation of sweat provoked by the fixation method. For further research, the attachment of the non-fixed sensors should be 10 minutes before the acquisition of the data.

The clinical evaluation of an accidental injury of skin in Athletes

Kolosovas-Machuca, Eleazar Samuel (1); Martínez-Jiménez, Mario Aurelio (2); Ramirez-García Luna, José Luis (3); Arriaga-Caballero, Jesús Emmanuel (4)

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Introduction

The clinical evaluation of a Skin Disease in Athletes alone may not be adequate to predict the severity of the injury nor to guide clinical decision making. Infrared thermography provides information about soft tissue viability and has previously been used to assess burn depth.

Materials and methods

We describe one case.

Results

Male 23 years old Mexican erfusiónl football player, suffered burn wound after cook and present a erfu burn on the dorsum of the right foot was transferred to our hospital in less er 1 h. In the emergency room; looking clinical second superficial degree, and The thermographic image showed a ΔT value of 1.8 (B), so conservative management with outpatient management and daily visits to the emergency department to monitor the wound was advised. After seven days of treatment, the wound showed signs of re-epithelization and adequate tissue erfusión. The patient evolution was satisfactory and was discharged from the burn clinic two weeks after the injury. Being able to return to the playing field.

Conclusion

Infrared thermograms obtained at first contact with a wounded patient can be used to accurately predict the definitive treatment modality for burn patients. This method can be used torationalize treatment and streamline early wound closure.and as well as many accidentally caused skin wounds to optimize management and return to sports activities.

Reference

1. Medina-Preciado JD, Kolosovas-Machuca ES, Velez-Gomez E, Miranda-Altamirano A, González FJ. Noninvasive determination of burn depth in children by digital infrared thermal imaging. J Biomed Opt. 2013 Jun; 18(6):061204.

Wellness perception in young high-performance rugby players correlates with thermal physiological response after training

Del Estal Martinez, Alejandro (1); Correa Wirgues, Amanda (2); Fernández, Ana (3); Torralba-Estellés, Javier (3)

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Rugby is a contact sport with an epidemiology similar to other long duration intermittent sports, such as football1. It seems that an increase in the time and intensity of exposure to the training increases the

incidence of injuries in rugby, the vast majority being muscle and tendon injuries in the lower limbs due to overuse2. Thermography is a tool that helps improve load control3.

Objective

To assess the relationships between thermal results and wellness perception of young highperformance rugby players.

Methods

36 rugby players from the Spanish Under-18 Rugby Team [15.8±0.88 years; 80±13.6kg; 1.80±0.08m; BMI 24.5±2.5] were evaluated with thermal analysis and Wellness Questionnaire (WQ), during a three-day national meeting. Data collection was performed under controlled temperature and humidity conditions with a FLIR T335 and analyzed with Thermohuman Software. Shapiro-Wilk test was used to verify data normality. A 1-way ANOVA with repeated measures and Tukey post-hoc comparisons were used to locate the significantly different means. Pearson's correlation was performed to identify the relationship between WQ and ROIs of the leg.

Results

WQ decreased (day 1 to day 3; $p<0.05$). There was difference for the group in the morning and afternoon ($p <0.05$), where we can observe a drop in XT with the exception of joint regions (knee and ankle) in the morning. There was correlation between WQ values and that of the morning XT of the whole leg (,016-,008), leg-ankle-foot set (,012-,017) and Achilles tendon (,006-,006) and a positive trend in the knee (,144-,055), but there was not for those in the afternoon. After three days, athlete's wellness perception and whole leg thermal analyses decreased during the morning collections having significant statistical correlation, but not during the afternoon ones. With load-control purposes, we highly recommend data collections to be performed rather during the mornings than in the afternoons.

EFFECT OF A HIGH-INTENSITY INTERVAL TRAINING SESSION ON THE SKIN TEMPERATURE OF THE THIGH

Pinheiro, Ramon (1); Uchoa, Paulo (1); Borba Neves, Eduardo (2); Scipião, Lino (1); Cavalcante, Jurandir (1); Vilaça-Alves, José (3); Pinheiro, Bruno (1)

(1) University Center UNIFAMETRO, Fortaleza, Brazil; (2) Brazilian Army Sports Commission, Rio de Janeiro, Brazil; (3) Research Center in Sports, Health and Human Development, Vila Real, Portugal.

Introduction

Resistance training (RT) variables for strength training prescription such as the intensity, load, number of repetitions and sets, interval between sets, the order of the exercises and the cadence of execution, have to be manipulated in order to enhance strength and muscle hypertrophy.

Objective

To analyze the effect of a high-intensity interval training session (HIIT) on the Tsk of the anterior and posterior thigh faces.

Methods

Thirteen participants physically active of both sexes were selected. Thermal images were captured using a thermographic camera E8 from Flir®, with a measurement range of -20 to +120°C, accuracy of 2%, sensitivity of ≤ 0.05°C and infrared resolution of 320 x 240 pixels. The exercise protocol had 4 running blocks (240s each) on a treadmill, structured with 8 series of 20 seconds of running for 10 seconds of rest among each series, per each block. The interval between the blocks was 2 minutes, and the heart rate was measured at the end of each block. The exercise effort level was established through subjective perception of effort, using the OMINI scale, on a scale from zero to ten, where the individual would need to correspond to scale nine. After the training session, TSK was measured before intervention (T0), immediately after (T1), 24 hours (T2) and 48 hours (T3) after intervention.

Results

Considering T0 as reference, TSK increased (p<0.05) in T2 and T3 in the anterior face of the thigh (31.91±1.68Cº; 33.67±0.68Cº), and on the posterior face (32.34Cº±1.29; 34.14±01.15Cº). There were no significant differences between the Tsk of the anterior and posterior face, considering the same moment of evaluation.

Conclusions

Based on the results of this study, a HIIT session provides an identical increase of TSK in the anterior and posterior thigh faces from 24h to 48h after the intervention in both sexes.

Low-Cost Infrared Thermography to Evaluate Rectus Abdominis Muscle Activation After Exercise

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Introduction

Skin temperature variation can change during exercise due to increased neuromuscular activation, muscle fatigue or vasomotor behavior (1).

Objective

To evaluate Low-Cost Infrared Thermography (LC-IRT) to measure rectus abdominis muscle activation in different exercises and between genders.

Methods

The study group consisted of 20 university students, 16 men (age: 22.29 ± 1.44 years, height: 1.72 ± 0.04 m, weight: 70.80 ± 11.15 kg) and 4 women (age: 21 ± 0 years, height: 1.62 ± 0.05 m, weight: 63.66 ± 9.84 kg). The proposed exercises were to work the rectus abdominis muscle. Three groups were formed. Abdominal crunches on Swiss ball were performed by first (eight men) and second (four women) group. Third group (eight men) carried out leg lifts. Three sets of sixteen repetitions per exercise were performed, with a 1-minute rest between each set. A thermal image was taken pre – post exercise.

Results

First group, a higher temperature ($p < 0.05$) at pre-exercise ($\bar{x} = 24.39$) compared to post-exercise ($\bar{x} = 20.97$) was observed. Second group, a higher temperature ($p < 0.05$) at pre ($\bar{x} = 21.16$) compared to post ($\bar{x} = 19.43$) was found. Third group, a higher temperature ($p < 0.05$) at the pre ($\bar{x} = 21.52$) compared at the post ($\bar{x} = 20.89$) was observed. Conclusion: LC-IRT is a tool for evaluating the activation of the rectus abdominis muscle. The degree of activation depends on the exercise that is performed, in addition, it occurs in different intensity according to gender.

ABSTRACTS
ORALS

Injuries identification under different load control models: A case of the Clube de Regatas do Flamengo Youth Football Team

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Introduction

During 3 months of training, Clube de Regatas do Flamengo monitored and controlled the injuries with infrared thermography (IRT) and training loads of its U-20 team players in 2019. It was observed 38 situations of medical department intervention need with IRT, understood as prevention and following-up, which 8 of those were confirmed as injuries.

Objective

Injuries identification with acute: chronic (AC) ratio and IRT.

Methods

31 players, 18.7 ± 0.7 years, 75.9 ± 7.2 kg, 179.7 ± 6.4 cm, and body fat of 8.3 ± 4.2%, VO2max of 53.9 ± 2.5 mL/kg/min. For injuries, we consider a player being unable to fully participate in training/match. Cox regression analysis was applied on IRT for missing days and was based on the identification of temperature variation of at least 0.7 °C. A total of 80 measurements were diagnosed as such. IRT was able to detect 6–8 injuries (75%) and to censor 72 cases: muscular (33%), articular (23%), trauma (25%), and tendinous (19%). The AC ratio of the training workload was calculated by the rolling averages, as follows: coupled AC ratio (AC-AC), uncoupled AC ratio with 3-week duration (AC-NAC3), and uncoupled AC ratio with 4-week duration (AC-NAC4), with the following ranges: very light: ≤ 0.49, light: 0.50 – 0.99, moderate: 1.00 – 1.49, high: 1.50 – 1.99, and very high: ≥ 2.00.

Results

The AC ratio average presented the total values of AC-AC: 1.00 ± 0.32; AC-NAC3: 1.06 ± 0.48; and AC-NAC4: 1.07 ± 0.49. No significant statistical differences were observed in the AC ratio. The greater relation is among the AC-AC and AC-NAC3 (R2 = 94%) methods. IRT was very accurate on the injuries prevention as the Physiology and Medical teams intervened with a 75% sensibility.

Conclusion

combined AC and IRT represent useful strategies for reducing injuries among U-20 football players.

Skin temperature is not related to front crawl performance in young swimmers

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Introduction

In competitive swimming there is a transition phase between the end of the warm-up and the competition start, in which there is an expected drop in core and muscle temperature that affect swimmers' performance (1). This possibly might be also reflected on skin temperature.

Objective

To assess skin temperature evolution between a standardised warm-up and a 100m maximum front crawl test in transition phases of different duration and its effects in swimming performance.

Methods

nine young competitive swimmers (15(1)YY, 62.31(6.80)kg; 1.74(0.1)m) performed three maximal randomised bouts of 100-m front crawl after a standardised 1200-m warming-up, with different durations of transition

phase (10, 20 and 45 min) in different days. Thermograms (Flir E60, Flir Systems Inc.) of the whole body were taken before and after warming-up and every 5 min during transition phase. Mean skin temperature of the body and temperature variations were calculated. Time-trial performance was obtained using a manual stopwatch (3X–100 model, Finis).

Results

No differences were found in time-trial performance among the three conditions (P=0.48). Variation of mean skin temperature pre-test was lower in 10 than in 45 min condition (P<0.001), but no-differences were found with 20 min condition (P=0.14; P=0.11). No correlations were found between time-trial and variation of mean skin temperature pre-test in any condition. During transition phases, variation of mean skin temperature showed a log increment over the time with differences between first min vs all other instants (P<0.001), min 5 vs every instant from min 15 (P<0.01) and min 10 vs every instant from min 30 (P<0.05).

Conclusion

There is no relationship between mean skin temperature and 100 m front crawl swimming performance. During transition phase, around minute 15, stabilization of the skin temperature occurs.

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Relationship between plantar pressure and temperature of the sole of the foot or the footwear outsole

Jimenez-Perez, Irene (1); Gil-Calvo, Marina (2); Salvador Palmer, Rosario (3); Cibrián Ortiz de Anda, Rosa Mª (2); Pérez-Soriano, Pedro (2); Priego-Quesada, Jose Ignacio (3)

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Introduction

The evidence about the relationship between plantar pressure and sole of the foot is not clear (1). Foot temperature has a multifactorial dependence, so the footwear outsole would explain plantar pressure distribution better (2).

Objective

To determine if plantar pressure after a prolonged run could be explained by sole of the foot temperature or footwear outsole temperature.

Methods

30 recreational runners carried out 30-min running on a treadmill. Thermographic images (Flir E60bx, Flir Systems Inc., USA) of the sole of the foot and the footwear outsole were taken before and after running, and dynamic plantar pressure (F-Scan, Tekscan, USA) was measured after running. Foot was divided in 3 regions: forefoot, midfoot and rearfoot. Pearson correlations were performed.

Results

A moderately significant correlation ($P < 0.01$, $r = 0.40–0.73$) between plantar pressure percentage and absolute temperature percentage after running and temperature variation percentage (both sole of the foot and footwear outsole) were found in forefoot and rearfoot. However, the correlation coefficient was always greater with footwear outsole than with sole of the foot ($r = 0.52–0.73$ vs $r = 0.40–0.61$, respectively).

Conclusions

Footwear outsole temperature can better explain plantar pressure distribution than sole of the foot temperature, in the forefoot and rearfoot. However, the midfoot temperature does not seem to have any relationship with plantar pressure.

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Infrared thermography applied to professional athletes of pelota valenciana

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Introduction

Playing "pelota valenciana" sport is associated with a high injury risk in the hands. Striking the ball with the hands over time may produce physiological changes with an effect on skin temperature.

Objective

To analyze if playing pelota valenciana results on physiological alterations at the hands that can be quantified by infrared thermography.

Methods

13 professional players of a modality of pelota valenciana ("raspall") and 10 control participants (physically active) participated in the study. Infrared images (FLIR E60) were taken in both groups at basal conditions. During the image acquisition, important methodological aspects of infrared thermography were taken into account (1) and a TISEM checklist was used (2). Skin temperatures of professional players were also assessed after a real competition. A cold thermal stress was applied for them to the palm of the hand using a metal plate during 2 minutes before and after the competition, and skin temperature recovery was assessed.

Results

Control participants showed same skin temperatures for both hands ($p>0.05$). Dominant hand of professional players presented lower basal temperatures than non-dominant hand ($p<0.05$). Asymmetries were increased and observed in all regions after the match with lower skin temperatures for the non-dominant hand ($p<0.05$). After competition, a higher recovery rate was found than before competition. The analysis of all results highlighted the importance to follow-up the following regions of the dominant hand: index finger, middle finger, ring finger and palm.

Conclusions

Infrared thermography can be used as a method to prevent injuries in players of pelota valenciana, considering that their lower temperatures may be the consequence of injury or a vascular adaptation.

Influence of waterproofing level on thermal comfort of men's trekking footwear

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Introduction

Thermal comfort is becoming increasingly important in technical footwear, for instance in trekking footwear. It depends on different factors such as temperature and humidity inside the shoe, its design, and thermal properties of the materials from which it is made. In this sense, waterproofing features of trekking footwear can affect shoe perspirability and therefore foot microclimate – related to inside temperature and humidity levels.

Objective

This study is aimed to determine the influence of footwear materials water resistance level on shoe microclimate generated during its use, since this property can affect sweat evacuation through perspirability. For the objective evaluation of thermal comfort in footwear, the infrared thermography technique was used.

Method

Testers panel consisted of a group of five male users with amateur trekking experience. Participants performed a 30 min exercise walking on a treadmill with a 10% gradient at a constant speed, with ambient conditions of 22±0.5 oC, 50±3 % RH. Two kinds of waterproof trekking footwear with different water resistant level were evaluated. Infrared images pre and post trials were recorded to assess foot skin temperature, while users' subjective perceptions were recorded using a seven-point thermal scale. Standardised clothing and socks were used.

Results and conclusion

Qualitative results were obtained by checking the thermal maps. The overall quantifiable results were drawn by calculating the average temperature increase occurred in the areas under study of the user's feet while performing exercise, correlating these results with the perceptions obtained. The greater the capacity of heat evacuation through the shoe, the less sweat condensation was produced on the foot surface and, therefore, the better the thermoregulation capacity of footwear.

Deep learning based segmentation of uncovered body parts in thermal images during dynamic exercise

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Introduction

Computer vision and machine learning (ML) enable a deeper insight into large data sets. In sports science, Infrared Thermography (IRT) is applied to investigate skin surface radiation during dynamic exercises like endurance exercise testing [1]. Current research focuses on non-moving phases and non-continuous measurements, which introduces inconsistencies due to dynamically changing surface radiation temperature from moving to resting. Furthermore, clothes, other skin covering objects and the background should not be included in region of interest analysis.

Objective

We developed a new ML-based method to automatically segment relevant and uncovered body parts in an IRT image without a body model, during dynamic movement.

Methods

Relevant body parts in a thermal image were segmented by an artificial neural network (ANN) based on Fully Convolutional DenseNets [2]. This ANN detects uncovered body parts pixelwise. We trained our model with a set of 249 hand-labeled thermograms. Our dataset contains thermal images of both legs' backside while standing or moving during treadmill exercise testing. The subjects wore shoes, socks and short pants.

Results

The ANN can automatically segment body parts from the background and hidden body parts during dynamic movement. We achieved a Jaccard index (mean intersection over union) of 96,87% for a test set of 84 additional, unseen thermograms.

Conclusions

The results of our ANN can improve thermogram analysis in means of objectivity and sensitivity. Moreover, this method outperforms a manual analysis strategy by saving time and costs. Further improvements of

our model include the application to different camera models and various laboratory conditions. Additional, recurrent ANN architectures could boost results in terms of computational load and frame-to-frame refinements.

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Low-Cost Infrared Thermography to Evaluate Rectus Abdominis Muscle Activation After Exercise

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Introduction

Skin temperature variation can change during exercise due to increased neuromuscular activation, muscle fatigue or vasomotor behavior (1).

Objective

To evaluate Low-Cost Infrared Thermography (LC-IRT) to measure rectus abdominis muscle activation in different exercises and between genders.

Methods

The study group consisted of 20 university students, 16 men (age: 22.29 ± 1.44 years, height: 1.72 ± 0.04 m, weight: 70.80 ± 11.15 kg) and 4 women (age: 21 ± 0 years, height: 1.62 ± 0.05 m, weight: 63.66 ± 9.84 kg). The proposed exercises were to work the rectus abdominis muscle. Three groups were formed. Abdominal crunches on Swiss ball were performed by first (eight men) and second (four women) group. Third group (eight men) carried out leg lifts. Three sets of sixteen repetitions per exercise were performed, with a 1-minute rest between each set. A thermal image was taken pre – post exercise.

Results

First group, a higher temperature ($p < 0.05$) at pre-exercise ($M = 24.39$) compared to post-exercise ($M = 20.97$) was observed. Second group, a higher temperature ($p < 0.05$) at pre ($M = 21.16$) compared to post ($M = 19.43$) was found. Third group, a higher temperature ($p < 0.05$) at the pre ($M = 21.52$) compared at the post ($M = 20.89$) was observed.

Conclusion

LC-IRT is a tool for evaluating the activation of the rectus abdominis muscle. The degree of activation depends on the exercise that is performed, in addition, it occurs in different intensity according to gender.

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Infrared thermography during graded exercise testing in patients with cystic fibrosis, including two retests

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Introduction

Contactless and non-invasive Infrared Thermography (IRT) has the potential to measure acute physiological adaptations during exercise [1]. Investigations of the IRT-measured surface radiation temperature (Tsr) in patients with chronic diseases have been rare. The reliability of IRT measurements has been continually discussed.

Objective

The purpose was to examine the Tsr in patients with cystic fibrosis (CF) during a graded walking exercise test (XT) and Tsr reproducibility of two retests.

Methods

Eight CF-patients performed three treadmill-XT, including breath-analysis and lactate measurement, to determine VO2peak and individual anaerobic threshold (IAT). T1 was twelve weeks and T2 was 52 weeks after T0. CTsr(°C) was measured at rest (PRE), IAT, maximum exhaustion (POST) and after three-minute recovery (REC). We executed rmANOVA and Spearman's rho correlation for statistical analysis.

Results

CTsr (°C) at T0, T1, T2 was PRE: 30.8, 31.5, 31.1; IAT: 30.2, 30.8, 30.3; POST: 30.0, 30.6, 30.2; REC: 30.6, 31.1, 30.9; ΔPRE-IAT: -0.6, -0.7, -0.8; ΔIAT-POST: -0.2, -0.2, -0.1; ΔPOST-REC: +0.6, +0.5, +0.7 and ΔPRE-POST: -0.8, -0.9, -0.9. There was a slight but not significant mean increase of VO2peak T0:28.5, T1:29.4, T3:30.0 ml/min/kg. An overall statistically significant difference of CTsr was revealed between the increments ($p<.001$;h2p = 0.468). No significant difference was identified between tests ($p = 0.605$). There were high correlation coefficients of CTsr for T0/T1, T0/T2, T1/T2 of rs = 0.81, 0.88, 0.73 ($p<.001$).

Conclusions

CTsr decreases in patients with CF during XT. The CTsr changes overall increments are only middle reproducible, but Δ-values appear to be more robust. Further investigations are needed to verify these observations. The Δ-extend of CTsr during XT can be a robust IRT-parameter in the future and is promising tool in non-invasive detection of individual physical effort, for example in patients with CF. 1. Hillen, B., Pfirrmann, D., Nägele, M., Simon, P. Sports Med. 50(2) (2020) 263-282.

Infrared thermography in exercise testing: Comparison between cystic fibrosis patients, trained and untrained

Hillen, Barlo (1); Pfirrmann, Daniel (1); Etzel, Jakob (1); Mertinat, Katrin (1); Wolz, Florian (1); Poplawska, Krystyna (2); Simon, Perikles (1)

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Introduction

During graded exercise testing (XT), surface radiation temperature (Tsr), measured by infrared thermography (IRT), has been observed decreasing until individual voluntary exhaustion, and immediately increasing again after the termination of movement. IRT measurement non-invasively reveals acute vasomotor adaptation during XT [1].

Objective

The purpose was to compare Tsr changes between patients with cystic fibrosis, trained and untrained during XT.

Methods

16 patients, 11 trained and 16 untrained performed a treadmill XT. Patients conducted a modified walking protocol, whereas trained and untrained absolved a running protocol. IRT captured the subjects' calves

(C). CTsr was measured at rest (PRE), maximal exhaustion (POST) and after three-minute recovery (REC). RmANOVA was executed for statistical analysis.

Results

We identified a mean CTsr(SD) of 30.9°C(1.3) PRE, 29.9°C(1.6) POST and 30.4°C(1.5) REC for the patients. A mean CTsr of 32.2°C(0.6) PRE, 30.4°C(1.2) POST and 32.5°C(0.7) REC was detected in trained. Untrained had a mean CTsr of 30.5°C(1.0) PRE, 28.9°C(1.1) POST and 30.2°C(1.1) REC. Patients had the lowest ΔPRE/POST(-1.0°C) and ΔPOST/REC(+0.5°C). Trained had the highest ΔPRE/POST(-1.8°C) and ΔPOST/REC(+2.1°C). Untrained had a ΔPRE/POST of -1.6°C and ΔPOST/REC of +1.3°C. We identified an overall statistically significant difference between time points (PRE, POST, REC) ($p<.001$; h2p 0.772) and groups ($p<.001$; h2p 0.293). Posthoc comparisons revealed this difference to be significant between patients and trained (pbonferroni = 0.02) and trained and untrained (pbonferroni<.001), but not between patients and untrained (pbonferroni = 0.367).

Conclusions

Acute vasomotor adaptations during XT are higher in trained than in untrained and CF-patients. CF-patients also seem to have lower vasomotor adaptability than untrained. Factors such as XT-duration, protocol and intensity or sex, must be considered. The detection of different acute physiological adaptability, training level, or disease-related limitations indicated by CTsr changes appears feasible.

1. Hillen, B., Pfirrmann, D., Nägele, M., Simon, P. Sports Med. 50(2) (2020) 263-282.

Pain as a mediator of thermal response to plyometric training on ankle strain rehabilitation: case study

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Introduction

Pain is a nervous system response that causes different acute physiological outputs, such as an acute decrease in body temperature1. Plyometric training is a strategy in advanced phases of ankle strain rehabilitation in athletes2. Training on a pain threshold has been seen as an effective strategy to improve strength values in less time than no-pain training3. Infrared Thermography (IRT) has been used to monitor the optimal load to assess thermal responses, as an adaptation for the subject4.

Objective

To evaluate the thermal response to two plyometric training protocols: Low-volume training in a pain level of 1-2/10 of Visual Analogue Scale (VAS) and High-volume training in a pain level 5/10 VAS.

Methods

One professional soccer player (22 years; 1.68m; 59.8kg; BMI 21.19) with grade 3 lateral ligament strain in his right ankle was evaluated during his rehabilitation process. In the twelfth day, he performed 120 jumps, exceeding the pain threshold up to 5/10. The day after, he performed only 50 jumps (VAS below 1-2/10). Thermal data collection was done following a standardized protocol5 with a FLIR T335 thermal camera and analyzed with the ThermoHuman software.

Results

Low-volume training increased post-exercise temperature on the right foot region of interest (ROI) in 0.96ºC (Pre-training: Right Mean Temperature (RMT)=27.56ºC, Left Mean Temperature (LMT)=26.76ºC; Post-training: RMT=28.42ºC, LMT=27.10ºC). While, high-volume painful training, decreased post-exercise temperature on the right foot in 0.6ºC (Pre-training: RMT=27.45ºC, LMT=25.60ºC; Post-training: RMT=26.85ºC, LMT=24.98ºC).

Conclusions

In a ligament injury, training stimulus with or without pain seems to vary the thermal behavior of the foot ROI. Thus, when the stimulus does not exceed 4/10, the response is hyperthermic. However, when training is painful, a hypothermic response seems to appear immediately after stimulus. Local thermal behavior analysis could be a useful tool in load control in injured athletes.

Thermal and girth assessment after total knee replacement

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Introduction

Knee osteoarthritis is a pathology that involves tissue changes and cartilage degeneration, generally related to age, genetics and overuse, limiting movement and causing pain1. When functionality and symptomatology become severe, surgical intervention by means of total knee replacement (TKR) is recommended1. Infrared thermography consists of the measurement of skin temperature (Tsk), generally associated to the physiological state and inflammation2. Assessment of thermal and inflammation symmetry are usually employed to categorize the severity of the process2.

Objective

To assess thermal asymmetry in postoperative knee prosthesis patients, evaluating the relationship with tests and questionnaires of knee severity and functionality.

Methods

24 patients, 18 women (65.71 ± 12.55 years; 82.51 ± 15.9kg; 1.67 ± 0.09m; BMI of 29.8 ± 5.66; 63.9 ± 32.39 days after TKR), were submitted to thermal tests, knee range of motion (ROM), knee anthropometric measurements (girths) and a patient's perspective of outcome after TKR questionnaire (OKS). Thermograms of the anterior lower limbs where recorded with a FLIR T335 thermal camera and under controlled conditions. The selection of the replaced knees (RKnee) and non-repleaced knees (NRKnee) was made with FLIR Tools software. Differences (D) between NRKnee-RKnee were calculated.

Results

The T-test for paired samples shows as RKnee Tsk has always significantly higher ($p<0.001$) (DTsk-average = +2.08 ± 0.87 oC, DTsk-maximum = +1.70 ± 0.88 oC, DTsk-minimum = +1.66 ± 0.92 oC). The Dknee-girth difference was also significantly wider +2.74±0.26 cm. No significant correlations were found between ROM, OKS and Tsk, only between OKS and ROM ($r=0.864$; $p<0.001$)

Conclusions

It seems there is no relationship between Tsk, functionality and pain tests and questionnaires. However, patients undergoing a TKR have a higher Tsk and girth on the operated side, due probably to the inflammation.

Correlation between external (GPS) and internal load (Infrared Thermography) in professional soccer players

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Introduction

Monitoring training load is a fundamental mechanism to prevent injury risk1. GPS has been widely used to measure and analyze external load, mainly in soccer2. Infrared Thermography (IRT) helps us to detect changes in skin temperature (Tsk) that are related to the internal load3. The combination of GPS and IRT might be a key factor getting a better control on training loads and therefore a less injury incidence.

Objective

To search on the relationship between the external load measured by GPS and the internal load variables by IRT.

Methods

28 professional soccer male players (26.6 ± 3.6 years, 73.5 ± 7.42 kg, 1.80 ± 0.06m) were evaluated before 6 training sessions (one of them 48 hours after match). Thermal images were taken before training using a FLIR T530 following a standardized protocol4, and analyzed using ThermoHuman software. GPS data from the previous training/competition session were extracted from OptimeEyeX4. We performed an ANOVA repeated measures test with a Turkey post hoc test to check the differences between variables ($p < 0.05$) and Pearson's bivariate analysis to search for correlations.

Results

A negative correlation between the variable of total distance measured with GPS and the Tsk of the non-dominant posterior thigh were obtained with IRT in data collected 48 hours after match ($r = -0.795$; $p<0,01$). Likewise, we found positive correlations between thigh Tsk and maximum speed variables ($r=0.806$; $p<0,01$), which would be correlated not only with the internal load, but also with the subject's capabilities.

Conclusions

Correlations between GPS and IRT variables are stronger 48 hours after competition, not during week training sessions. Total distance is inversely related to thigh Tsk and the maximum speed of the players is directly related with the thigh Tsk 48 hours after competition. However, larger samples and more evaluations are necessary to confirm these results.

Thermal profile description of most common soccer injuries by Infrared Thermography: case studies

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Introduction

Infrared Thermography (IRT) allows us to measure in a fast, non-invasive and objective way skin temperature (Tsk)[1]. The persistent problem of injuries in high performance sports boosts the search of technologies to reduce injury incidence[2]. Lately, IRT has been shown as a useful tool to prevent, support diagnosis and follow up injuries in soccer[3].

Objective

To describe thermal profile before, during and after the most common soccer injuries. To establish references in order to better guide prevention, diagnosis support and injury monitoring with IRT in professional soccer players.

Methods

38 soccer male players (27.6 ± 4.6 years, 73.6 ± 6.42 kg, 1.81 ± 0.26m) from different European professional teams were assessed before, during and after suffering most common soccer injuries: ACL, hamstring muscle tear, ankle sprain, fasciitis, bone fracture, nerve issue, contusion and tendinopathy. Thermal images

were taken before training using a FLIR T530 following a standardized protocol4, and analyzed using ThermoHuman software. Borg's CR-10 scale was used to measure pain perception.

Results

Thermal profile before injuries were symmetrical (0,07ºC±0,51ºC). Depending on the injury, the thermal profile was different during and up to 30 days after injury (muscle, nerve and tendinopathy were hypothermic and ACL, ankle sprain, fasciitis, contusion and bone fracture hyperthermic). After 30 days, thermal profile general tendency was mostly symmetrical (0,37ºC±0,89ºC) but showing bigger variability depending on the kind of injury.

Conclusions

Without pain and injury, the tendency is to keep a thermal balance. Once injuries occur, the thermal profile can help to support diagnosis based on hyper or hypothermic responses. During recovery period the tendency is to slowly get back to symmetrical profiles, which might help to quantify recovery and to take return to play decisions. Thermal asymmetries are a solid method to determine healthy status, support diagnosis and monitor injury recovery in soccer.

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Keywords

Thermal profile, soccer, injury, diagnosis support, injury monitoring.

Comparison of thermoHuman automatic software and manual analysis for assessing foot temperatura

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Introduction

A disadvantage of infrared thermography is the long time required to analyse images due to the manual definition of the regions of interest (ROIs). Automatic software could reduce this time required and the human factor during measurements. However, there is a lack of evidence about the differences between the manual method and the automatic definition of the ROIs.

Objective

The aim of the study was to evaluate an automatic thermographic software package (ThermoHuman) for assessing skin temperature on the soles of the feet before and after running.

Methods

120 thermal images (Flir E60bx, Flir System Inc.) of the soles of the feet of 30 participants (20 males and 10 females), at two conditions, before and after running 30 min, were analyzed on two different days. Two different models of thermographic image analyses were used to obtain the mean temperature of 9 regions of interest (ROIs): automatic definition of ROIs using ThermoHuman software (ThermoHuman), and manual delimitation of ROIs trying to replicate the regions of ThermoHuman using ThermaCAM researcher pro 2.10

software (Manual-TH).Laboratory environmental conditions were: air temperature 21.4(2.0)°C and relative humidity 40.6(10.1)%.

Results

ThermoHuman resulted in an 86% reduction in time involved compared to manual delimitation. 12% of the images presented some error in one or more ROIs delimitations. ThermoHuman and Manual-TH presented significant overestimation of the temperature in the 47% of the comparisons performed, nevertheless, all differences had a small effect size or lower (ES<0.4). Bland-Altman plots showed similar 95% agreements between both procedures before and after running. Intraclass correlation coefficients analysis of both procedures presented excellent reliability (ICC>0.8).

Conclusion

ThermoHuman software was time-saving for image analysis with an excellent reliability. These results suggest that ThermoHumanand manual methods are both valid by themselves, nevertheless, combining them is not recommended due to the differences observed between them.

Skin temperature asymmetries in archery

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Introduction

Archery is a sport in which asymmetrical loads act on the body throughout the draw, aiming, and release phases. It makes interesting to analyse skin temperature asymmetries in archers, since most of the injuries are produced by a large number of repetitions with high asymmetric loads.

Objective

To analyse skin temperature asymmetries in archers before and after a simulated training session.

Methods

30 archers (12 females, 23±8 years, 1.76±0.09 m, 83.7±9.3 kg, 7±4 experience years) were analysed. Skin temperature was measured with an infrared camera (Flir E60bx) in three different moments: before (Pre), immediately after (Post), and 10 min after (Post10) a simulated training session (18 warm-up shots and 72 qualifying round shots according to the FITA rules). 11 regions of interest (ROIs) were defined on the trunk and upper limbs. Relative (difference between draw side and bow side) and absolute asymmetries were calculated in each measurement moment.

Results

Relative asymmetries were lower (higher skin temperature of the bow side), with a moderate or large effect size, in the Post than in the Pre moment in the upper back (CI95% [0.1, 0.4ºC]), posterior shoulder (CI95% [0.0, 0.5ºC]), posterior arm (CI95% [0.0, 0.6ºC]) and posterior elbow (CI95% [0.4, 0.9ºC]). Absolute asymmetries were higher, with a large effect size, in the Post than in the Pre moment in the chest (CI95% [0.1, 0.4ºC]), upper back (CI95% [0.1, 0.3ºC]), posterior shoulder (CI95% [0.1, 0.5ºC]) and posterior elbow (CI95% [0.2, 0.7ºC]). An approximation to the Pre values in these ROIs was observed at the Post10 moment for relative and absolute asymmetries.

Conclusions:

The asymmetry data obtained with the present study allows us to know which level of asymmetries can be considered due to the archery technique. Higher asymmetries could need more attention due to its possible association with injury.

Effect of strength fatiguing exercise on skin temperature response after a cold stress test: preliminary study

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Introduction

Dynamic thermography allows analyzing the response of vascularization after apply thermal stress to the skin to alter deeper structures. Strength exercise can induce muscle damage, which may alter the rewarming process after the application of cooling stress.

Objective

To assess changes in anterior thigh skin temperature in response to a cold stress test after a strength exercise fatiguing protocol.

Methods

4 active adults performed a familiarization session and two strength exercise sessions with an intervention and control leg (previously randomized), separated by one week. Subjects performed bouts of 10 concentric and eccentric contractions of leg extension with 1' rest at 120°/s in an isokinetic device until reaching around a 30% of force loss. Infrared thermographic images (Flir E60bx, Flir Systems Inc.) were taken the familiarization day (basal condition) and after the fatigue level from both thighs after being cooled using a cryotherapy system (GameReady GRPro 2.1; CoolSystems Inc) during 3 min (Temperature: 0-3°C; pressure: moderate). Skin temperature rewarming was assessed 15, 30, 45, 60, 90, 120, 150 & 180 s after the cooling process in a 23°C room. Logarithmic equations of each ROI, leg and condition were adjusted and slope and constant coefficients were obtained.Differences between basal, intervention and control condition were analyzed using Cohen effect size (ES).

Results

Intervention leg presented higher slope and lower constant coefficients than basal condition in vastus lateralis (ES=1.06; 0.88), rectus femoris (ES=1.2; 0.98) and adductor (ES=0.92; 0.74) meanwhile no differences were observed in vastus medialis neither in slope (ES=0.34) nor in constant (ES=0.05) coefficients. Control leg presented lower slope and higher constant in vastus lateralis, rectus femoris and abductor (ES>0.40), and similar in vastus medialis (ES<0.15) than intervention leg. Conclusion: Strength loss in anterior thigh seems to produce an increment in slope and a reduction in constant coefficients in rewarming process.

AWARDS

AWARDS

Best communication

Irene Jimenez-Perez et al.

Relationship between plantar pressure and temperature of the sole of the foot or the footwear outsole.

Honourable mention

Oral comunication

Ismael Fernandez-Cuevas et al.

Correlation between external (GPS) and internal load (Infrared Thermography) in professional soccer players.

Honourable mention

Oral comunication

Daniel Andrés López et al.

Deep learning based segmentation of uncovered body parts in thermal images during dynamic exercise.

Best poster

Marcos Kunzler et al.

Effects of 24-h use of compression stockings with menthol and camphor on skin temperature following running.

Honourable mention

Poster

Barlo Hillen et al.

Infrared thermography during graded exercise testing in patients with cystic fibrosis, including two retests.

Honourable mention

Poster

Anna Lubkowska & Robert Klejdysz

Thermovision assessment of surface temperatures changes following the cryostimulation in football players.

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