Possibilities of thermovision application in sport and sport rehabilitation

Mogućnosti primene termovizije u sportu i sportskoj rehabilitaciji

Vukašin Badža*, Vojin Jovančević†, Franja Fratrić‡, Goran Roglić§, Nenad Sudarov†

*Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia; †Provincial Secretariat for Sport, Novi Sad, Serbia; ‡University EDUCONS, Novi Sad, Serbia; §Electromedical, Novi Sad, Serbia

Abstract

Introduction. Infrared thermography or thermovision is increasingly applicable in sport and sport rehabilitation. Thermic forms, thermic imprints, temperature and isotherm distribution, temperature gradient change are the terms that are more and more often met in sport medicine and medicine, in general. Case report. We presented two examples of thermovision application: in detection of muscle injury and changes of the feet exposed to low temperature. In the first example the thermovision method was used for analysing heat distribution in an athlete with back muscles injury. With a special original method of local cooling the place and degree of injury was precisely localized and determined, respectively, regardless high environmental temperature. In the second case the thermovision method was for the first time applied in a runner whose feet was exposed to low temperature. Significant hypothermia of the feet was detected by the method and appropriate treatment was performed. Thanks to this the athlete had no harmful consequences. Conclusion. Thermovision is fast and efficient in detecting different kind of injuries, so its increased use in the future can be expected.

Key words: sports medicine; rehabilitation; athletic injuries; thermal conductivity; treatment outcome.

Introduction

Body temperature is determined by heat production generated in metabolic processes and mechanisms that enable the process of thermoregulation. The skin is particularly important as a barrier between the outside and the inside of the body. Normal temperature of the body is between 36.2 and 37.8 ºC. In normal conditions the inside body temperature is several degrees higher than on the skin surface. Temperature starts dropping about 2.5 cm deep into the skin creating a temperature dissipation gradient. Peripheral tissues, like muscles, fat, skin, are able to function in a wider temperature range (20ºC to 40ºC), than inner organs that need lower temperature variation, ie. more stable temperature. Temperature changes on the skin have influence on blood circulation, on the receptors for heat in the skin and in the hipotalamus. Heat is lost through the following mechanisms: 60% through radiation in infrared (IR) spectar, 25% through an evaporation, 12% through air circulation, and 3% through conducting.
In 1977, Clark et al.\(^1\) reported temperature changes on the skin during running. Infrared thermography was used for skin temperature visualization in two athletes during stillness and during running at the air temperature of 20°C and 11°C, respectively. Temperature distribution was recorded on the film and analyzed. Parallely, a method of measuring temperature with thermopar was used. It was concluded that during running the average skin temperature above muscles is significantly different from the average skin temperature during stillness. Both methods of measurement were identical within 1°C–5°C. In 1979, Veghte et al.\(^2\) did thermovision measurements of temperature changes during training sessions. That study analyzed dynamic temperature changes on the skin connected to vascular changes following running and other exercises. They noticed rising in temperature (with maximum increase by 1.7°C) with the increasing difficulty during the exercise, as well as a significant increase in the temperature of the skin on the challenged leg in comparison with the rested leg. Furthermore, Torri et al.\(^3\) and Nakayama et al.\(^4\) noticed an increase in temperature when intensity of the exercise was increased by 20%, 50% and 80%, as well as a significant increase in the temperature of the leg skin that was challenged in comparison with the rested leg. They did studies to determine increase and drop of temperature in different sports, such as running, swimming, and cycling. The initial temperature drop was analyzed on the bicycle in ten healthy males. The examination was done under the weight of 50W–150W in the ambience of a chamber with the temperature ranging from 10°C to 40°C and relative air humidity from 45% to 55%. Temperature was measured thermographically and with a thermopar. A drop in temperature during the exercise did not depend on the season of the year, although perspiration was greater at 40ºC than at 30ºC. They concluded that the temperature drop was not influenced by perspiration but by vasoconstriction, probably caused by non-thermic factors.

First articles on thermovision application to injuries monitoring and treatment were published about thirty years ago.\(^5\),\(^6\) Their authors concluded that injuries can be recognized as a local hypothermia, if an injury is not deep in the tissue.

## Case report

We presented two examples of thermovision application: in detection of muscle injury and changes of the feet exposed to low temperature.

The applied protocol included control of room temperature and humidity before thermal recording, as well as 20 min rest and thermal body equilibrium (during thermal recording, patient must be without movement).

Basic functions of thermal camera M3 were: All the pictures presented in LCD in black and white or in the pallette of 256 colours; picture performances; Spectral range: 8-14 µm; Thermal sensitivity ≤ 120 mK, 30°C; Temperature range -20°C - +250°C; Resolution: 0.1 °C

Modes of measurement were: auto hot-spot trace, spot, area, line profile, and isotherms.

---

**The first case**

Thermovision measurement was done on a 19-year-old athlete, 181 cm high, weighing 75 kg. The athlete, a javelin thrower, was chosen after he had injured back during training in the gym, when he had been lifting weights.

The athlete was still after he had taken off his T-shirt so that the body temperature became balanced. Air humidity was 45%, and the air temperature was 28.5°C. *Musculus erector spinae* was injured. In order to measure the degree of back injury in the acute phase of the injury, pictures were taken immediately and there was no waiting in order to lower the temperature in the room, because the precious time would have been lost.

We applied an original, new method of local cooling of the back region by using spray for cooling injuries, and in that way the first therapy was done. With even movements at the distance of twenty centimeters cooling spray was applied. The technique of even spray application can be easily trained using autospray, where even colour application was practiced. The same technique was applied for local cooling of the body. Soon after the application of cooling spray, regions that were warmer heated the lower temperature of the spray and clearly pointed out the temperature contrast between the injury and the surrounding tissue. It was necessary to determine the extent of injury as soon as possible and locate it precisely in order to start the therapy, as with this type of injury the most important period is several hours in the acute phase.

There were successive thermal pictures made in the time intervals of 1 minute after applying the cooled spray (Figure 1). Application of cooled spray enabled us to use the method of local cooling at the high temperature conditions of 28.5°C. In that way we were able to precisely localize and determine the extent of muscle injury, and at the same time immediately apply the first therapy.

![Thermal presentation after the application of cooling spray](image)

Gradual heat domingering of the injured muscle that points out the traumatized area (light blue region along the backbone). A temperature region that is light blue, surrounding

---

the cooled area, is a normal phenomenon of heating of the borders of both the cooled and the non-cooled region. We are interested in the light blue region that appears within the treated region. It shows localization and the extent of injury.

Thermic picture was the same as the clinical picture of the athlete. Figure 2 shows a graph of thermal distribution along the lines L1 and L2 (black and red lines). On the line L1 there is a temperature difference of symmetrical points on the muscle of 0.5°C, and on the line L2 of 1.2°C. At the same time it shows the direction of the injury that extends into the lower part of the back where the focus of the injury is. In recording 6 (Figure 1) there is the thermal picture of temperature distribution after 30 minutes. The injury is still clearly noticed.

**The second case**

In second case, termovision was applied after running. Thermovision measurement was done in a 45-year-old half-marathon runner, 182 cm high, weighing 78.5 kg. The trainers for running made by a branded manufacturer were used. The socks were made from special materials chosen for running, so-called "dry-fit". The procedure was as follows: expose feet at room temperature after running, rest 5 min in sitting position, take thermovision photos. Measurement was done after 10 km of running at the temperature of -2°C. Fresh, wet snow had fallen before. Immediately after the run, there was a measurement with thermovision camera, done inside. Checking and making photos for comparison were done at one of the following days in the ambience at similar temperatures, but in dry weather, when feet were not wet.

In this case, a thermovision camera registered hypothermia on the feet, especially on the toes, mostly on the thumb on the right foot. This type of measurement was also new, and had been never recorded before. Thermal picture when feet were exposed to the temperature of -2°C and humidity, is given in Figure 3. The coolest point was registered at the top of the toe-thumb (14.8°C). Set squares on thermal pictures automatically find the coolest points. In Figure 4, a temperature gradient along the line L1 from Figure 3 is given. Figure 5 represents a histogram with temperature distribution in the marked square. It can be seen that there was a significant hypothermia in that region. This hypothermia was quickly sanated and did not leave any consequences, except redness and numbness feeling in the next 48 hours. Figure 6 shows a termal picture of the feet, that were dry, at the temperature of -2.5°C. A significant difference can be seen in the foot temperature (the lowest registered temperature was 25.2°C).
It is interesting that again the upper part of the right toe-thumb was the coolest point. It can be concluded again that there was a modest disturbance in peripheral circulation in the right foot in this runner, the same as was noticed in his medical history (the runner had modestly varicose veins on the right leg, as a consequence of operation on the vermiform appendix). Besides, in the left leg there was also a significant local hypothermia of 16.8°C.

**Discussion**

In the first case thermovision measurement of back injury (*musculus erector spinae*) determined the extent and localization of the injury. A new original method was applied, a method of local cooling that enabled the measurement although the environmental temperature was high. In such a situation measurement must be applied quickly. That is a limitation of the method. Other limitations include conditions when an injury is deep inside the tissue, or when it is impossible to get appropriate environmental condition.

In the first case presented, thermal picture, distribution of the temperature gradient and clinical picture of the injured athlete were completely the same. The thermal pictures clearly show that the injury was asymmetrical (the injury was localized on the right part of the backbone). Local cooling provided the first therapy and also allowed recording in the high temperature conditions.

In the second case, the method detected local hypothermia of the feet exposed to the temperature of -2°C and humidity. Under the same ambiental conditions, but with dry feet, there was no hypothermia. The feet were again cooler, but the impact of lower temperature was insignificant. Graphical representation of topology and thermal distribution on the upper part of the right foot point out that at the temperature below zero and if feet are wet, during the long runs (half-marathon, marathon) frostbites of the first degree would occur. The wind influence would additionally aggravate the situation because, according to the chilly scale with the wind blowing at the speed of 10 m/s, it would feel the temperature like that of -10°C. At the same speed of the wind and temperature of -8°C, chilly temperature would be -18°C. Additionally, thermal disbalance was detected, as a direct consequence of the difference in peripheral circulation of the left and right runner’s leg, which was the same as in the runner’s existing history.

**Conclusion**

Thermovision is a fast and efficient method in detecting different kind of injuries. Using a new cooling method it is possible to record thermovision pictures even in high environmental temperatures. Increased use of this method can be expected in the future.

**References**


Received on March 11, 2011.
Revised on October 12, 2011.
Accepted on October 24, 2011.