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Visualisation of ankle injury using a thermal imaging camera

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ABSTRACT

Purpose: This paper is dedicated to the study of the impact of multiple ankle injuries on blood flow in the lower limb.

Design/methodology/approach: The study was performed using a thermal imaging camera which by differentiating temperature between the uninjured and injured leg enabled checking and comparing blood flow between both limbs.

Findings: The patient subjected to the examination had suffered multiple ankle injuries. The images were taken before and after rehabilitation procedures so as to compare the temperature.

Research limitations/implications: By using thermal imaging, the temperature differences within structures can be observed, which in turn attests to limited blood flow. Improper trophic might have had an influence on a slow recovery process.

Practical implications: Analysis of image taken using a thermal imaging camera facilitates localizing damaged structures and planning the treatment process that aims at normalizing temperature differences between limbs. Moreover, the analysis of further images, taken during the treatment process enables us to evaluate the effectiveness of the selected method of treatment and to change the method if needed. The evaluation is entirely objective and it enables eliminating reliance on patient's feedback, which is often subjective and unreliable.

Originality/value: The study shows possibility of usage thermal imaging camera in traumatology.

Keywords: Thermal imaging camera; Ankle injuries; Rehabilitation

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METHODOLOGY OF RESEARCH, ANALYSIS AND MODELLING

1. Introduction

Thermography is commonly used in medicine, not only in orthopaedics, but also in cardiology, laryngology, pulmonology, and other fields. It is a non-invasive and contactless method which enables measuring temperature distribution in human body. The basis for drawing conclusions from examining a patient using a thermal imaging camera is the fact that the human body is homeothermic and keeps a constant temperature regardless of the external conditions. However, the temperature largely depends on where it is measured at, the time of the day, and the physical activity level of a given person. Contrary to popular belief, there is no single and fixed body temperature value applicable to everyone. It depends on what body part the temperature is measured at. Rectal temperature is from 0.3 to 0.6°C higher than oral temperature. Axillary temperature is from 0.3 to 0.6°C lower than oral temperature. Among children from India aged 6-12 the average difference between oral and axillary temperature was only 0.1°C (while the standard difference is 0.2°C). Among children from Malta aged 4-14 this difference was also slight, a 0.56°C, whereas the difference between rectal and axillary temperature among children aged less than 4 was 0.38°C. The analysis of temperature changes may be an evidence of pathologies occurring within the study area. Pathologies conducive to high temperature are characterized by inflammatory state in the body, caused inter alia by injury. And fever is a consequence of general inflammation processes. It is caused by excreting endogenous pyrogens, such as IL-1 and TNF excreted by leukocytes, accompanied by inducing of the sympathetic nervous system (catecholaminemia) and increasing of adrenal glucocorticoids. Thermography also enables monitoring and evaluating the progress of treatment. In the described case, temperature lowering occurs in the area of the injured ankle joint, while the proper blood flow resembling the one in the uninjured leg is restored after rehabilitation [1-11].

2. Assumptions (case presentation)

The performed examinations are aimed at showing differences between the uninjured and injured leg, while also presenting the influence the rehabilitation processes had on the achieved results. The female patient had suffered multiple ankle sprains and was referred by a physician to rehabilitation. The joint was aching and unstable, impeding the patient's ability to move. The following rehabilitation methods were selected for the patient: muscle massage (gastrocnemius, soleus), iontophoresis, ultrasounds, transverse massage of ligaments (calcaneofibular ligament and anterior ligament) and shock waves.

Before commencing the treatment process, the patient was examined using a thermal imaging camera. Weaker blood flow was observed in the injured limb, as compared to the uninjured limb. After a series of treatments, 10 sessions that included the aforementioned rehabilitation methods, equalization of temperature in both limbs was observed, a sign of a proper blood flow returning to the injured limb. Regulating the temperature and enhancing the blood circulation might have had a substantial impact on accelerating the treatment process of the affected ligaments by nourishing them. After the treatment, the patient stopped complaining about the pain and commenced the next phase of the rehabilitation process – strengthening the treated limb.

2.1. Materials and methods

The study was performed at the MESIR Rehabilitation Centre in Zabrze. At the office where the measurements were performed the temperature was a constant of 21°C. The patient was a dancer who had suffered from multiple injuries of the right ankle joint. The patient came to the office with pain of the aforementioned joint occurring during walking and during dance practice. The treatment of previous injuries involved mainly immobilizing and resting the damaged structure, with no rehabilitation treatment performed. During the treatment at the office, the following were performed: calf massage, transverse massage of ankle joint ligaments, iontophoresis and shock wave. Before having the image taken, the patient waited for 30 minutes at the office for the temperature to stabilize. The measurements were performed during winter and despite the long stabilization time, the temperature shown at the presented images is slightly lower than the actual temperature. However, the purpose of this paper is to show the temperature difference connected with different blood flow in the uninjured and injured leg. Therefore, the actual body temperature was not determined accurately.

The study was performed using a thermal imaging camera Flir T335 which is equipped on the Institute of Engineering Materials and Biomaterials of the Silesian University of Technology in Gliwice. The thermal image resolution of this camera is 320 x 240 pixels. The thermal sensitivity in the FLIR T335 is < 50 mK. The range of measured temperature is from -20°C to +650°C. Images were analysed using the Research IR software.

3. Results

In the image taken using the thermal imaging camera prior to commencing the treatment, differences of temperature in lower limbs were observed, which is an evidence of different blood flow in the limbs. A treatment process was commenced, comprising of gastrocnemius massage, transverse massage of ankle joint ligaments, iontophoresis and shock wave. It was assumed that calf muscle contractures occurring in the leg subject to multiple injuries have constrained the patency of blood vessels, which in turn constrained transportation of blood to the damaged structures, slowing down their regeneration. Limited blood flow was observed using the thermal imaging camera (Tab. 1, Fig. 1, Fig. 2, Fig. 3). The images show clearly that within the injured joint the temperature is lowered, caused by limited blood supply in the joint. It was presumed that this was a factor which slowed down the treatment process due to abnormal nourishment of the structures [12,13]. After a series of 10 rehabilitation sessions performed daily, further images were taken using the thermal imaging camera. In the images (Fig. 4, Fig. 5), equalization of the temperature in both limbs was observed. After the therapy, the patient reported significant improvement, the pain was being relieved and mobility of the joint was being increased. Therefore, it can be inferred that the administered treatment, through normalizing the gastrocnemius tension, has improved the blood flow. As a result, the treatment process has been accelerated thanks to the structures being properly nourished and regenerating at a faster pace.

4. Discussion

The results can suggest that observing tissues by using a thermal imaging camera enables localizing damaged structures. In the images the damaged structures are of a significantly lower temperatures, which is an evidence of their improper blood flow (Fig. 1, Fig. 2). Thanks to providing a correct rehabilitation process, the proper limb temperature has been restored, meaning that the trophic of this area has been improved (Fig. 3, Fig. 4). Proper blood flow enables regeneration and nourishment of the damaged structures, accelerating the treatment. However, in order to achieve more reliable results, the study group needs to be broadened, the treatments focusing solely on pain relief need to be eliminated, and only those treatments that focus on improving the trophic of the tissue need to be administered.

Table 1.
Measurements before the treatment

Nazwa	Typ	Maks.	Min.	Średnia	Odch. st.	Zakres	Suma	Emisyjność	Odległość (m)	Temp. odbita (°C)
IR_0980.jpg (°C)										
Image		32°C	21.6°C	26.7°C	2.9°C	10.4°C	2047038.9°C	0.98	1	25
Sp1		31.2°C	31.2°C	31.2°C	-	-	-	0.98	1	25
Sp2		29.6°C	29.6°C	29.6°C	-	-	-	0.98	1	25
Sp3		30.9°C	30.9°C	30.9°C	-	-	-	0.98	1	25
Sp4		29.5°C	29.5°C	29.5°C	-	-	-	0.98	1	25
Sp5		31.7°C	31.7°C	31.7°C	-	-	-	0.98	1	25

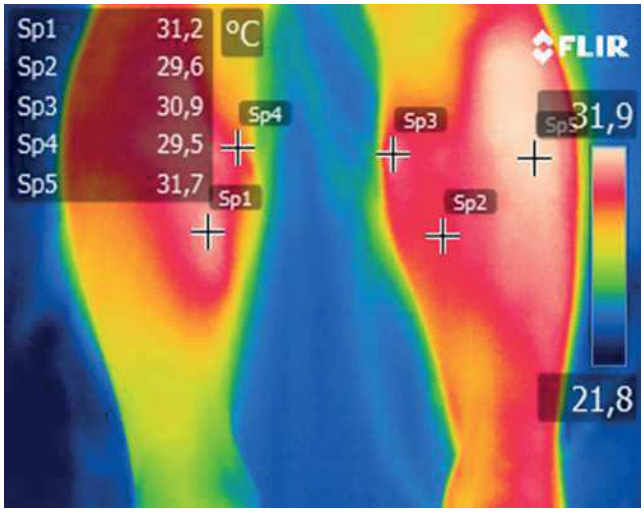

Fig. 1. Before the treatment – posterior image, calves

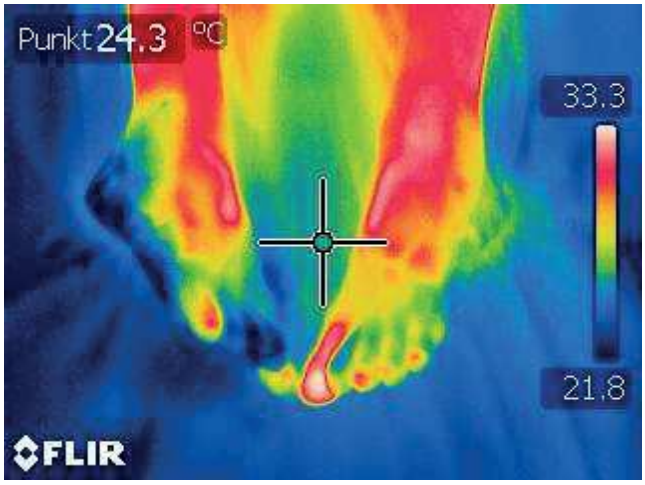

Fig. 2. Before the treatment – anterior image

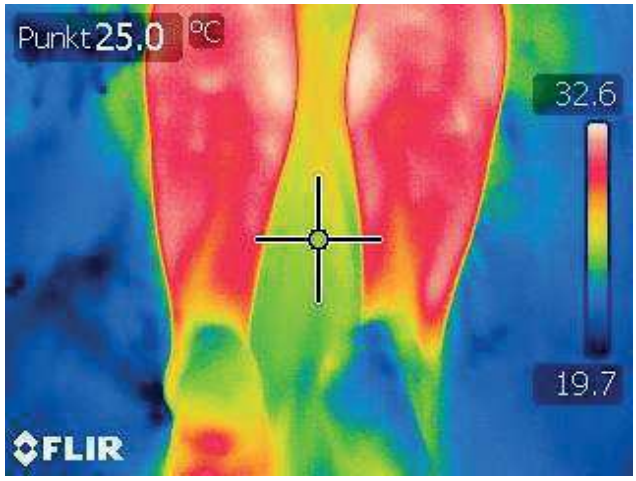

Fig. 3. Before the treatment – posterior image

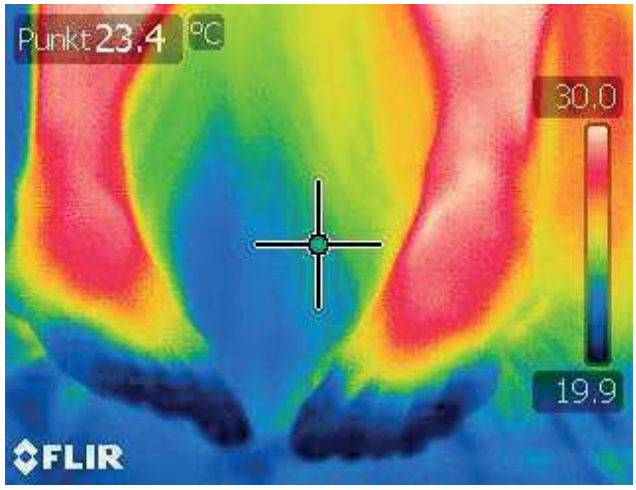

Fig. 4. After the treatment – anterior image

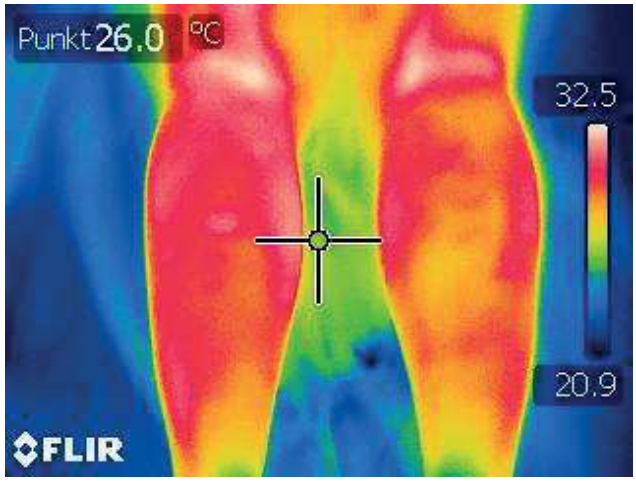

Fig. 5. After the treatment – posterior image

5. Conclusions

By using thermal imaging, the temperature differences within structures can be observed, which in turn attests to limited blood flow. Improper trophic might have had an influence on a slow recovery process. Analysis of image taken using a thermal imaging camera facilitates localizing damaged structures and planning the treatment process that aims at normalizing temperature differences between limbs. Moreover, the analysis of further images, taken during the treatment process enables us to evaluate the effectiveness of the selected method of treatment and to change the method if needed. The evaluation is entirely objective and it enables eliminating reliance on patient's feedback, which is often subjective and unreliable.

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