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The role of infrared thermal imaging and sonography in the assessment of patients with a “painful elbow”

Quantification of skin blood flow with medical infrared thermography following the application of a newly developed regenerative device

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Quantification of skin blood flow with medical infrared thermography following the application of a novel regenerative device

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SUMMARY

Medical Infrared Thermography (MIT) makes it possible to quantify regulatory processes of the skin blood flow based on the amount of heat dissipated on the skin surface. The aim of the study was to assess the acute effect of the regenerative device Wobbler® on peripheral blood flow by using the non-invasive technology of MIT. The temperature distributions of the lower limbs of 31 subjects (23.3±2.6 years of age) were analyzed before and after a 12-minute application of the Wobbler® in a sitting position. To test the differences between both legs before and after the application, the non-parametric Wilcoxon test was applied. The quantitative evaluation of the data showed a significant increase in temperature of the treated leg after the application of the Wobbler®, in the area of the lower legs, both anterior (p= 0.003) and posterior (p= 0.002). In the area of the thigh, highly significant increased temperature differences were detected for the anterior part (p= 0.001), while significant temperature differences were found for the posterior section of the thigh (p= 0.004). The present study demonstrated that passive leg movements on the Wobbler® lead to a temperature increase at the skin, thus a treatment effect resulting in an increased blood circulation can be supposed.

KEY WORDS: infrared thermography, Wobbler®, regeneration, skin blood flow

QUANTIFIZIERUNG DER HAUTDURCHBLUTUNG MITTELS MEDIZINISCHER INFRAROT- THERMOGRAPHIE IM ANSCHLUSS AN DIE ANWENDUNG EINES NEUARTIGEN REGENERATIONSGERÄTES

Das nicht-invasive und strahlungsfreie Verfahren der Infrarotthermografie (IRT) ermöglicht die Quantifizierung physiologischer Prozesse basierend auf Abstrahlungsmuster der Hautoberfläche. Das Ziel dieser Studie war, aufbauend auf den physiologischen Grundlagen, die Überprüfung einer mittels IRT quantifizierbaren Veränderung der Abstrahlungsmuster der unteren Extremitäten nach der Anwendung des Regenerationsgerätes Wobbler®. Analysiert wurden Veränderungen der Abstrahlungsmuster an der unteren Extremität nach einer 12 minütigen, einseitigen Wobbler®-Anwendung in einer sitzenden Position. Zur Überprüfung signifikanter Unterschiede wurde der Wilcoxon-Test angewendet, wobei das Signifikanzniveau auf p = 0.05 für signifikant und p = 0.01 für hoch signifikant festgelegt wurde. Die quantitative Auswertung zeigte eine signifikante Temperaturzunahme am belastetet Unterschenkel, sowohl anterior (p= 0.003), als auch posterior (p= 0.002). Im Bereich des Oberschenkels ergaben sich hochsignifikante Temperatursteigerungen im anterioren Bereich (p= 0.001) sowie eine signifikante Zunahme der Abstrahlung im posterioren Bereich (p= 0.004). Die nach der Intervention erhöhte Temperatur an der Hautoberfläche legt einen Behandlungseffekt im Sinnen einer vermehrten Durchblutung nahe.

SCHLÜSSELWÖRTER: Infrarotthermografie, Wobbler, Regeneration, Durchblutung

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Introduction

The constantly developing technology of Infrared Cameras makes the Medical Infrared Thermography (MIT) a useful additional diagnostic tool in the field of human physiology. Most of the diagnostic imaging modalities in medicine utilizes portions of the electromagnetic spectrum, however in contrast to other medical devices, MIT can provide non-invasive, non-radiating, real time and large area measurements of the skin temperature. Since the temperature distribution across the body surface is symmetrical [1], it is possible to draw conclusions about physiological changes and thermal abnormalities of the human body based on the infrared radiation patterns [2]. Meanwhile the MIT has proven useful in various fields of medical application, such as dermatology [3], surgery [4], neurology [5] and in the assessment of different vascular diseases [6]. Beyond, thermography can record the early detection of diabetic neuropathy and vascular disorders [7]. Varices can also be depicted well by MIT, as the affected veins run close to the skin surface. Based on these results, the non-invasive measuring method of the MIT enables a fast and smooth use in the field of human medicine as well as the quantification of changes in blood flow. However, in the field of sports medicine, research on the application of MIT is still lacking [8]. Quesada and Vardasca pointed out that there are a number of aspects for future research to increase it´s widespread in the area of sports science [9]. Recently, MIT has been successfully utilized in the field of preventative sports medicine [10, 11]. However, the application in the field of regenerative procedures is lacking. The examination of enhanced vascular capacity and supply of peripheral blood flow is important to understand the physiological magnitude of regeneration in athletes. A fast regeneration is especially crucial in high-performance sport and helps avoid overloading and injuries. Beyond, to guarantee high performance, an optimal proportion between training and regeneration must be ensured [12]. There are a number of regeneration interventions that aim to reduce exercise-induced muscle damage to optimize regeneration by removing blood lactate and to support injury prevention. The most commonly used passive method is the massage treatment, which is used, frequently in the training cycle of elite athletes. It is believed that among an increased level well-being there are a number of further benefits that contribute to an improved regeneration initiated by massage [13]. Possible mechanisms of massage are related to biomechanical, neurological, psychological and physiological effects. Using MIT makes it possible to describe changes of skin temperature based on variations of skin perfusion. A theoretical model of the expected mechanism of massage is an increased muscle blood flow, skin blood circulation and parasympathetic activity. Besides well-known measures such as massage, sauna and sleep, there are also sports medical devices that passively move the body and therefore support the process of regeneration.

The Wobbler® is an example of passive regeneration, by simulating a 3-dimensional movement for activating and relaxing relevant muscle groups. The Wobbler® was previously used in uncontrolled observational study, that examined the influence of a passive foot and lower leg movement on the regulation of the blood pressure and blood gas parameters. Following a ten-minute application of the Wobbler® they showed a significant decrease of systolic blood pressure in both healthy subjects (n=11) and hypertonic subjects (n=13) as well as a concomitant fall in blood pH. They concluded that the application of the Wobbler® influenced the autonomic nervous system resulting in a dominance of vagal activity [14]. However, to interpret physiological changes we need to understand the different physiological responses during regeneration. Therefore, the aim of the present study was to assess the acute treatment effect of the regenerative device Wobbler® based on changes in skin temperature by using MIT.

2. Methods

Participants

The study was undertaken on 31 sport science students of the University of Innsbruck (10 female, 21 male) with an average age of 23.3 (±2.6) years and an average BMI of 21.6 (1.3) for the female subjects and 22.6 (1.3) for the male participants. Before data collection, subjects received an information letter about the aim of the study, the conditions, the instruments as well as the implementation. All subjects gave their written consent. The following criteria for exclusion were pre-screened using a questionnaire:

- injuries of the lower extremities in the last three months prior to the study
- operation of the lower extremities in the last twelve months
- strenuous exercise two days prior to the measurements
- illnesses including fever three days prior the measurements

In addition, the physical activity profile of all subjects was analyzed. They had to indicate in which sports they were currently practicing in order to classify them into the following 4 categories: strength, endurance, speed/agility and coordination. The mean number of training sessions per week was 4.7 (±2.1).

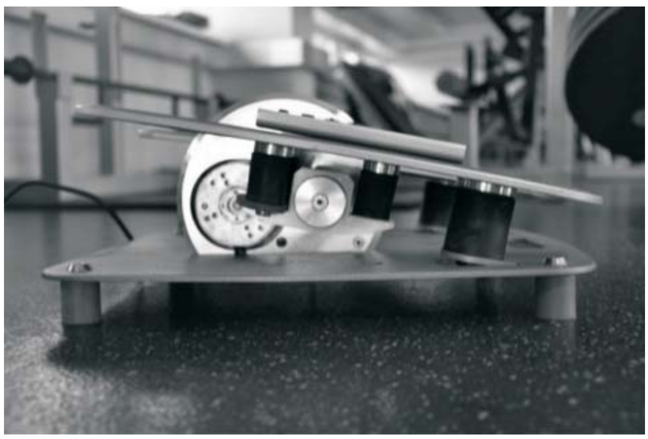
Two days before the measurements, subjects were advised to consume no alcohol, no coffee or cigarettes and were asked to refrain from the use of cosmetics, ointments or lotions at the relevant measure points on the skin. To avoid the influence of circadian rhythm, all subjects were measured between 10 a.m.- 11 a.m. This study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of the Department of Sport Science as well as the Board for Ethical Issues (BfEI) of the University of Innsbruck.

Regenerative device

Investigations were done by using the Wobbler® which simulates a 3-dimensional motion (Figure 1,2). This is a newly developed mobilization device that passively moves the joints by imitating the movement of walking, by com-

Figure 1
Wobbler® plan view

Figure 2
Wobbler® side view



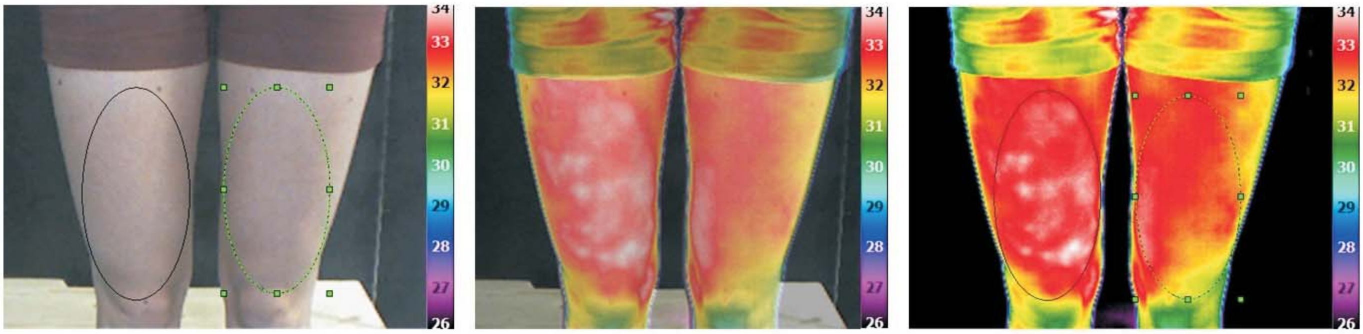


Figure 3
anatomical image- superimposed image- infrared image

bining a vertical and horizontal displacement. Subjects were instructed to sit in a relaxed position and not to resist the passive movement. Instructions were given that active leg movements were not allowed.

Even though the Wobbler® can be applied to different parts of the body in different fields of application, this study is limited exclusively to the regenerative aspect of the product and its impact on the lower extremities, which is why the Wobbler® was applied only in a sitting position. To compare the physiological changes within the subjects (treated leg versus untreated leg), only one leg was subjected to the intervention. This leg was positioned on the Wobbler®, while the other leg was standing next to the device. On both feet, the participants wore shoes during the intervention. The device has different intensity levels, which can be adjusted with remote control. The frequency can be adjusted in a range between 1.5 Hz - 11 Hz and an amplitude of about 12 mm (±6 mm). For the present study, the highest intensity level (11 Hz) was set for a period of 12 minutes.

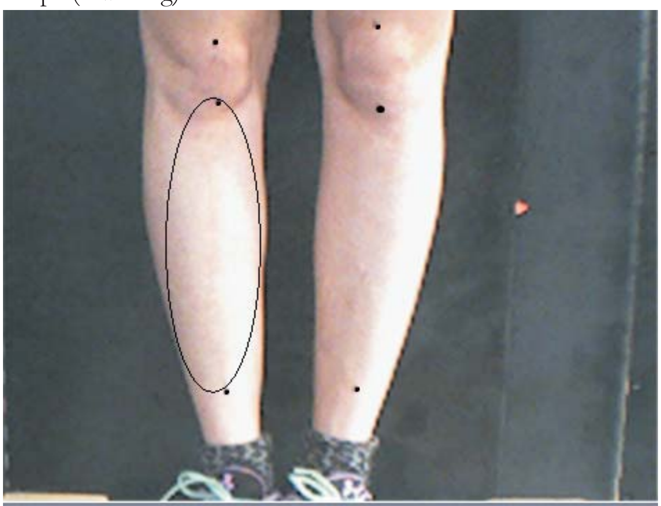
Thermal images

The thermal images were taken using the VarioCAM high resolution of InfraTec (Dresden, Germany), which is especially sensitized for medical use. It is based on an uncooled microbolometer FPA detector, which operates in the spectral range of 7.5 µm - 14 µm. The temperature resolution is at values below 0.05 K at 30 °C with an accuracy of measurement of ±1.5 K (between 0 and 100 °C) or ±2 % of the overall reading. The camera was turned on at least 60 minutes before testing to stabilise the electronic. All data were stored and analyzed with the software EXAM5. It allows the adjustment of the temperature range and temperature level as well as the adjustment of the background contrast. It also has a function of image fusion, whereby the anatomical and the infrared image can be superimposed to insert pre-defined shapes based on the anatomical markers to enable a standardized temperature analysis (Figure 3). Based on the pixels within the specified forms a thermographic mean value, the minimum and the maximum were calculated for the heat distribution in the region of interest (ROI). The thermographic averages were finally used for the detailed analysis of the change in the radiation pattern. All images were corrected using an emissivity factor of 0.98.

Experimental design

MIT measurements were conducted in a room with no external influences to maintain constant temperature. The room was temperature-controlled (23.3 °C ±0.7 °C) and temperature was checked every 30 minutes. The humidity showed relatively stable values over time (33-38%). To avoid interferences caused by background radiation or airflow, a self-constructed background (black mat surface) was used. Subjects were required to comply with an acclimatization time of 15 minutes in shorts. To avoid interferences between surface temperature of the legs and other parts of the body, the participants sat on a chair with their arms on the sides. Prior to the acclimatization period, the participants were asked to complete the questionnaire and to sign the consent form. This was followed by the labeling of the anatomical markers of the lower extremities. The knee, the upper edge of the patella and the tibial tuberosity were used as anatomical landmarks. Since the most significant effects were assumed in the area of the large muscle groups, the points were determined in such a way that the upper and lower margin of the inserted ovals were in agreement with the particular anatomical landmarks (Figure 4). On the thigh, the anterior superior iliac spine was used as an indicator and two points were marked on a line 15 cm towards the thigh. At the ankle the lateral malleolus of the fibula and malleolus medialis of the tibia were palpated and

Figure 4
Region of interest according to anatomical landmarks and oval shape (lower leg)



a marker was set 10 cm proximal on the tibia and the fibula. All points that had been applied in the anterior aspect were transmitted along a line on the posterior aspect of the leg and the upper and lower limits of the inserted shapes could thus be determined.

All subjects were assessed twice with four thermal images taken in a standing position. The first set of images defined the baseline data (anterior and posterior view of the upper and lower leg). Following a 12 minute session on the Wobbler® a second set of infrared images were taken in the same position. The distance between the camera and the subjects were adjusted in accordance to the alignment of the anatomical landmarks, ranging from 79-98cm. To allow the reliability of the data recommendations of previously published literature were followed [15, 16].

Statistical analysis

To test the measured thermographic averages of both legs before and after the intervention and for all views, the arithmetic mean and standard deviation were calculated. The Shapiro-Wilk test was used to assess the distribution of the data. Differences at baseline between the two untreated legs were tested using the t-test for paired samples. To analyze statistical significance of the temperature changes of the treated leg, the non-parametric Wilcoxon test was applied, with the levels set for significant at p= 0.05 and highly significant at p= 0.01. All statistical tests were calculated using the statistic software IBM SPSS 23.

Results

Based on a qualitative evaluation of the thermal images, 94 % showed symmetrical pattern of thermal radiation between the two legs. Only one person showed a deviation of thermal pattern. This symmetrical pattern was supported by the quantitative analysis of the thermographic images. Prior to intervention, the temperature differences of the thermographic averages between the right and the left side were tested and showed no significant differences independent of the ROI. In the anterior aspect of the lower legs, the differences were on average 0.14 ±0.19 °C, and 0.0 ±0.20 °C on the posterior aspect. In the area of the thighs the medium values of the differences between the left and right side were 0.0 ± 0.17 °C for the anterior thigh, and 0.12 ± 0.18 °C for the posterior part. Following the intervention, a highly significant increase of skin temperature of the lower leg was observed for both, the anterior and posterior aspects, with an average value of 0.47 °C ±0.54 °C, (p= 0.003) and 0.45 °C ±0.55 °C, (p= 0.002) respectively (Figure 5).

Figure 6 represents an example of the thermal changes within the ROI between the untreated (left side) and the treated (right side) in the posterior surface of the lower leg. Before the intervention, symmetrical pattern and equal heat distribution between both legs could be found. Following intervention, there was an increased heat distribution at the treated leg and a clearly asymmetrical heat pattern between both sides.

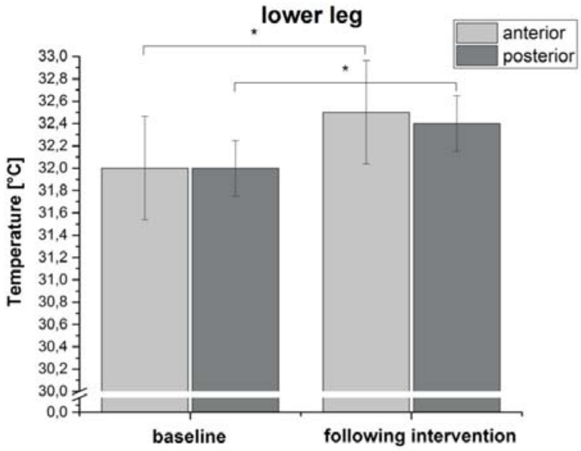


Figure 5
Temperature of the lower leg - posterior view at baseline and following intervention

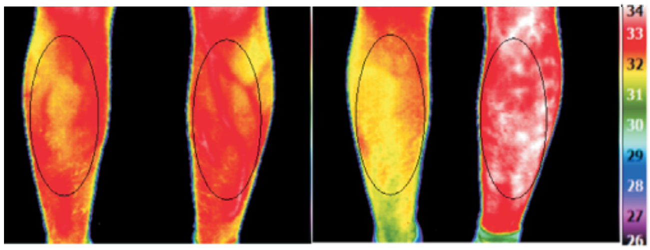


Figure 6
lower leg - posterior view at baseline and following intervention

The temperature differences before and after the intervention in the thigh showed a highly significant temperature increase in the anterior aspect of the thigh with a mean value of 0.34 °C (±0.19 °C, p= 0.001) and a significant increase of the temperature at the posterior aspect with a mean value of 0.25 °C ±0.35 °C, (p= 0.004) (Figure 7).

Temperature differences were also detectable at the untreated legs after the application of the Wobbler® within a temperature range of minimum -0.22 °C and a maximum of 0.31 °C. However, there was no tendency to be found in regards of either an increase or a decrease. Results of the

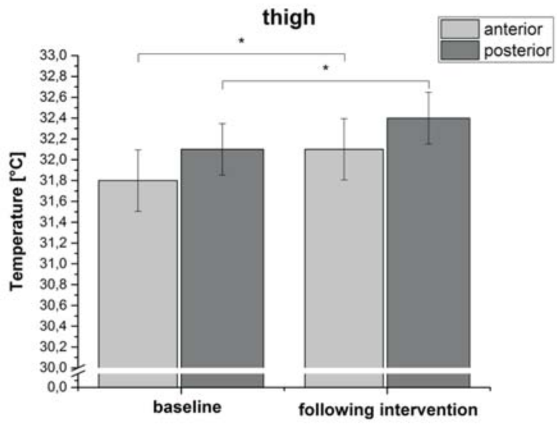


Figure 7
Temperature of the thigh anterior/posterior view at baseline and following intervention

Wilcoxon-Test showed no significant changes in the untreated limb.

In addition to the measured temperature values, all thermal patterns could be classified into three groups of different temperature distribution. These three groups were named 1. "uniform pattern", 2. "spotty pattern" and 3. "vascular pattern" and are illustrated in the following figures 8,9 and 10. The thermal changes of the posterior aspect of the lower legs within the ROI in the untreated leg (left leg) and treated leg (right leg) are shown.

For a more precise interpretation of these peculiarities, the questionnaires were used and the factors BMI, training volume and other characteristics were evaluated in all three groups of radiation patterns (Table 1).

The majority of participants (45%) could be classified in the group of "uniform pattern". These were exclusively men with an average BMI of 23.0 ±1.3 kg/m², which corresponds to a normal weight for men of this age group. Concerning sports, no classification in terms of the five basic motor skills, strength, endurance, speed, agility and coordination could be seen. In the group of "uniform pattern" the average number of training hours per week was 7.7 ±4.9. Of all participants, 32% could be assigned to the group of subjects with the marking "spotty pattern", which consisted to 90% of women. The average BMI in this group was 22.5 ±1.4 kg/m², which also corresponds to the normal weight of the people involved. In addition, one male subject in this group had a BMI of 23.9 kg/m². Again, no tendency could be recognized relating to sport and the hours of training per week were on average 5.2 ±3.1 hours/week. The remaining 23% were classified in the group "vascular pattern". The majority in this group was male participants and the average BMI was 21.0 ±1.3 kg/m². In terms of sports, no classification was possible, at an average training time of 7.6 ±3.5 hours of training per week. The subjective well-being of all the participants was evaluated based on a survey after the application. Only one person had applied the Wobbler® before the tests several times. The feeling following the intervention was described as "tickle" by 94%, 32% also indicated a relaxation of the treated leg and further 16% perceived this leg as subjectively heated. The application and the level of intensity were perceived as comfortable of all participants and 80% indicated they would like to repeat it if possible.

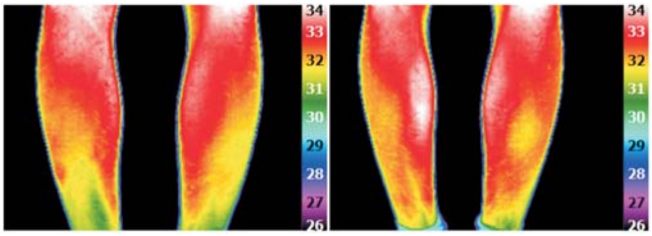


Figure 8: "uniform pattern" (baseline/following intervention)

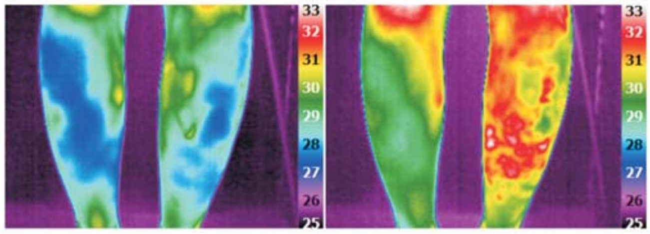


Figure 9: "spotty pattern"(baseline/following intervention)

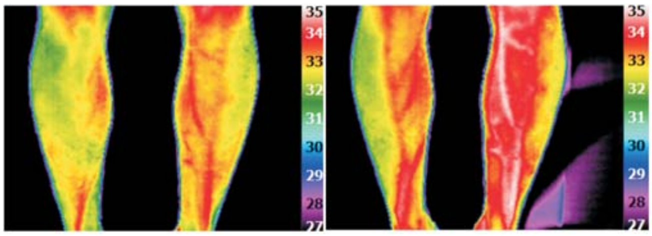


Figure 10: "vascular pattern"(baseline/following intervention)

Discussion

To be able to draw conclusions about physiological changes in the body, MIT must be analyzed critically, based on the physiological basics of blood circulation. The goal of this study was the examination of temperature distributions of the leg using MIT following the application of the regenerative device Wobbler®. In the ROI the temperature of the lower limbs increased after the application of the Wobbler®. This temperature rise was mainly seen over the M. gastrocnemius. Physiologically, the dependency of the blood flow rate on the autonomic nervous system must be considered. If the temperature influence stays in the area of so-called indifferent temperature, i.e. between 27 °C - 32 °C, which is perceived as pleasant under basal metabolic conditions the heat regulation is only controlled by the skin perfusion [14]. An increase of room temperature can be excluded as a factor for an increased skin temperature. In addition, the temperature differences prior the intervention ranged between -0.3 °C and 0.2 °C. According to the literature these differences can be regarded as physiological [1,17]. Temperature changes following intervention were less in the area of the posterior thigh compared to all other ROIs. This can be explained by the sitting position of the subjects. Due to standardization procedures, it is only al-

Table 1
Interpretation of the temperature patterns according to gender, BMI, training hours/week and special characteristics

temperaturepatterns	gender	BMI (± SD) kg/m²	training-hours/week	characteristic
"Uniform pattern"	14 ?	23.0 (±1.3)	7.7 h/week	exclusively male
"Spotty pattern"	9 ?, 1 ?	22.0 (±1.4)	5.2 h/week	highest BMI on average
"Vascular pattern"	1 ?, 6 ?	22.0 (±1.3)	7.6 h/week	lowest BMI on average

lowed to analyse body parts with MIT, which had no direct skin contact with other objects. Therefore, in the area of the posterior thigh a smaller ROI was selected due to the sitting position leading to a consequent contact to the chair.

In the present study, measurements were done in a sitting position with the legs positioned on the Wobbler®. Due to the wobbling, warming can be also explained based on the movement of tissue and muscles, which is likely to be coupled with mechanical factors. This is similar to a study by Cochrane et al. [18], who described the increase in muscle temperature after the application of a whole-body vibration plate. The muscles near the moving joints are in the area of the ankle and the lower leg posterior, the triceps surae muscle, which consists of the three muscles medial and lateral gastrocnemicus, and soleus muscles. All three muscles have a common tendon, the achilles tendon, which connects the muscles to the calcaneus and transmit the force of the muscles to the skeletal system. Following the application, the subjects reported their wellbeing, which could be analyzed as comfortable for all participants and corresponds with the objectively determined results. The application of the Wobbler® is of course not limited to the legs, it can also be applied to other body regions. However, it should be noted that these results cannot be transferred to other type of devices or other body parts without further research. Changing postures, intensities and implementations can greatly influence the physiological effect and lead to different results.

Thermal imaging enabled a simple and non-invasive measurement of the surface temperature of the lower extremities, allowing a quantitative and qualitative analyses. From a qualitative point of view all thermal patterns were classified into either a "uniform", "spotty" or "vascular pattern". Most of the participants were classified to the uniform pattern (45.0%), which seems to be the most common heating pattern following aerobic exercises [8]. Previous research has shown the influence of subcutaneous adipose tissue on heat radiation of the skin [19]. The typical spotty pattern was only found in females with an increased BMI. Even though the thermal conductance across a fat layer is reduced, we cannot provide information about the thickness of the fat layer and the temperature at interface between muscle and fat. In contrast the vascular pattern were only found in male athletes with the lowest BMI 21±1,3 kg/m^2. Perforator vessels have a straight course to the skin where they connect with the subdermal plexus. It can be therefore assumed that the vascular pattern is common in skinny persons with a small layer of subcutaneous adipose tissue.

It should be noted that there are some limitations. Using MIT, it is not possible to define exact causes leading to increased blood flow. The lack of information regarding thermoregulatory processes in deeper tissues limits the accurate interpretation of the results. A sensible way for a detailed evaluation of the blood flow could be the utilization of a high frequency ultrasound. This technique has the advantage of a deeper penetration, allowing measurements of both, epidermis and dermis [20]. Using two different imaging modalities it would be possible to better observe the cutaneous circulation accurately and to assess causes of physiological changes according to various factors.

Conclusion

The present study investigated temperature changes of the skin following the application of a passive lower limb movement on the Wobbler®. The results showed an increase of the skin temperature following a 12-minute intervention. However, to provide physiological relevant findings, further research into the effect of the Wobbler® on blood flow changes, mental well-being and the response of the autonomic nervous system are possible considerations for future research. Beyond, investigations with subjects that have an injury are desirable to provide clinically information about the regulatory processes following a passive leg movement.

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The Role of Infrared Thermal Imaging and Sonography in the Assessment of Patients With A Painful Elbow

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SUMMARY

BACKGROUND: The human elbow is the compound of 3 articulations: the humeroradial, the proximal radioulnar and the humeroulnar articulation. The joint capsule has recesses and synovial folds, and is reinforced by ligaments. Fourteen bursae have been described in the elbow region, and seventeen muscles are crossing the elbow joint. All these structures are potential sources of pain. The most common causes of elbow pain include medial and lateral epicondylitis.

AIM OF THE STUDY: To investigate the value of infrared thermography and sonography for the differential diagnosis of elbow pain and to define the prevalence of causes of elbow pain in a group of patients referred for treatment to a private practice of rehabilitation medicine.

METHOD: Retrospective chart review was conducted of patients with a painful elbow who were referred for treatment between January 2013 and December 2015, and underwent a complete clinical, musculoskeletal, thermographic and sonographic examination.

RESULTS: In total 43 patients underwent a complete examination, 35 subjects of them had problems on one side only. 5 exhibited pain on both arms, either on the medial or lateral site and 3 patients had symptoms at the medial and lateral site of both elbows. Any painful finding on the elbow was defined as case, and the 43 subjects comprised in total 57 cases. The following clinical diagnosis were made: 21 cases with lateral epicondylitis, 13 cases with medial epicondylitis, 4 cases with bursitis, 14 cases with sequelae of injuries and 5 unclear cases. Thermal imaging detected 51 cases with increased temperature, 4 cases with decreased temperature and 5 cases exhibited normal temperatures. 45 sonographic examinations were positive and 12 were negative. Diagnostic sensitivity of thermal imaging for clinical diagnosis was 91%. The rate of true positive sonograms for clinical diagnosis was 71%.

CONCLUSION: Epicondylitis is considered as the primary cause of elbow pain. In private practice of rehabilitation medicine, however, they only represent slightly more than 50% of all the cases. Slightly less than half of all elbow pain show very different causes and their exact specification is difficult without the use of imaging techniques. Infrared imaging is highly sensitive in the case of epicondylitis, and can supplement morphology based imaging with information on the acuteness of morphological changes.

KEYWORDS: painful elbow, thermal imaging, sonography, epicondylitis

DIE BEDEUTUNG VON INFRAROTTHERMOGRAPHIE UND SONOGRAPHIE IN DER BEURTEILUNG VON PATIENTEN MIT SCHMERZEN AM ELLBOGEN

HINTERGRUND: Der menschliche Ellenbogen ist die Verbindung dreier Gelenke: des proximalen radioulnaren, des humeroradialen und des humeroulnaren Gelenks. Die Gelenkkapsel zeigt synoviale Falten, hat Recessi und wird durch Bänder verstärkt. Vierzehn Schleimbeutel sind in der Ellbogen-Region beschrieben worden, und siebzehn Muskeln das überqueren Ellenbogengelenk. Alle diese Strukturen sind mögliche Schmerzquellen. Als häufigsten Ursachen für Ellbogenschmerzen gelten die mediale und laterale Epikondylitis.

DAS ZIEL DER STUDIE war es einerseits den Wert der Infrarot-Thermografie und Sonographie für die Differential Diagnose von Ellbogenschmerzen zu untersuchen und andererseits die Prävalenz der Ursachen von Ellbogenschmerzen in einer Gruppe von Patienten zu definieren, die zur Behandlung in eine Privat-Ordination für Rehabilitationsmedizin überwiesen worden waren.

METHODE: Retrospektive Auswertung von Patientenkarteien, die wegen Ellenbogenschmerzen im Zeitraum zwischen Januar 2013 bis Dezember 2015 behandelt worden waren und eine vollständige klinische, muskulo-skelettale-, thermografische und sonographische Untersuchung absolviert hatten.

ERGEBNISSE: Insgesamt 43 Patienten unterzogen sich einer vollständige Untersuchung. Von diesen hatten 35 Personen Probleme auf nur einer Seite. 5 boten Schmerzen an beiden Armen entweder auf die mediale oder laterale Seite und 3 Patienten hatten Symptome in der medialen und lateralen Seite beider Ellenbogen. Jede Schmerzmanifestation am Ellenbogen wurde Fall definiert und die 43 Personen umfassten insgesamt 57 Fälle. Folgende klinische Diagnose wurden gestellt: 21 Fälle mit lateraler Epikondylitis, 13 Fälle mit medialer Epikondylitis, 4 Fälle mit Schleimbeutelentzündung, 14 Fälle mit Folgeerscheinungen von Verletzungen und 5 unklare Fälle. Die Wärmebildtechnik fand 51 Fälle mit erhöhter Temperatur, 4 Fälle mit verminderter Temperatur und 5 Fälle zeigten normale Temperatur. 45 sonographische Untersuchungen waren positiv und 12 waren negativ. Die diagnostische Sensitivität der Wärmebildtechnik für die klinische Diagnose lag bei 91 %. Die Rate der richtign positiven Sonogramme für die klinische Diagnose betrug 71 %.

SCHLUSSFOLGERUNG: Epicondylitis gilt als die primäre Ursache von Schmerzen im Ellbogen. In einer Privat- Ordination für Rehabilitationsmedizin erklären sie jedoch nur etwas mehr als 50 % aller Fälle. Etwas weniger als die Hälfte aller Ellbogenschmerzen zeigen sehr unterschiedliche Ursachen und ihre genauen Spezifikation ist ohne den Einsatz von bildgebenden Verfahren schwierig. Infrarot-Thermographie hat bei Fällen von Epicondylitis eine hohe diagnostische Sensitivität und kann die Morphologie basierte Bildgebung mit Informationen über die Akuität morphologischer Veränderungen ergänzen

SCHLÜSSELWÖRTER: Ellbogenschmerz, Thermographie, Sonographie, Epikondylitis

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Table 1
Articulations in the elbow region

articulation	articulating bones	motion
humeroradial	articulation between the spherical shaped humeral capitellum and the concave surface of the cylindrical shaped radial head.	pivoting joint allowing rotation.
proximal radioulnar	articulation between the cylindrical shaped radial head and the radial notch of the ulna.	pivoting joint allowing rotation.
humeroulnar	articulation between the humeral trochlea and the greater sigmoid notch,	hinge joint with motion of flexion and extension.

Introduction

The human elbow is a complex anatomical structure, composed of 3 articulations (table 1) which are enclosed in a common capsule that consists of two layers, an outer fibrous capsule and an inner synovial lining. On the radius, the capsule extends as the sacciform (annular) recess beneath the annular ligament [1]. Recesses at the posterior and the anterior capsule have been described in arthrography [2] and magnetic resonance imaging [3], but can also be detected by sonography [4].

Prominent folds of synovial membrane are called plicae, which are remnants of the normal embryonic development of articular synovial membranes. An anterolateral and a posterolateral plica have been described in arthroscopy [5,6] or magnetic resonance imaging [4]. The posterior plica is a crescent shaped synovial fringe with a meniscus-like appearance. These folds may become impinged, predominately in the posterior part of the humeroradial articulation, causing snapping in the joint and locking during motion. Such symptoms may raise the suspect of intra- articular loose bodies. The associated disabling pain at the lateral elbow can imitate symptoms of lateral epicondylitis [6].

The annular ligament completes the humeroradial joint and controls passively the rotation of the radial head. Several ligaments reinforce the joint capsule. There are two collateral ligaments, a fan shaped at the medial site and ligamentous complex at the lateral site. The radial portion of the lateral collateral ligament originates from the lateral epicondyle and inserts to the annular ligament while the ulnar portion runs between the lateral epicondyle and the tubercle of the supinator crest of the ulna. These ligaments can be imaged by sonography [7] or magnetic resonance imaging [8]. The ligaments may become partially or totally torn when the elbow is exposed to external forces; strain injuries of the medial collateral ligament are common in throwing sportsmen [9].

Bursae are structures closely related to tendon sheaths [10]. The bursal lining is a poorly vascularized synovial membrane that has a lowcoefficient of friction, thereby facilitating gliding of tissues adjacent to the bursa [11]. Although fourteen bursae have been described in the elbow region, the official anatomic terminology [12] lists only five bursae: the subcutaneous and the intra-tendinous olecranon bursa, the sub-tendinous bursa of triceps brachii, the bicipitoradial bursa and interosseous cubital bursa. A complete list of all fourteen bursae is provided in table 2. These bursae are

Table 2
Bursae in the elbow region [13-17].

A. Bursae mucosae cubitales anteriores

1. Bursa bicipitoradialis: between the tuberositas radialis and supinator muscle. Between the distal biceps tendon and the radial tuberosity. The smaller bursa is superior to m. supinator and m. brachialis.
2. Bursa musculi brachii interni: between the inner edge of m. brachialis and the capsule on the inner border of the trochlea of humerus.
3. Bursa musculi flexoris digitorum communis sublimis: between the m. flexor digitorum superficialis tendon and pronator teres.
4. Bursa musculi tensoris ligamenti annularis radii anterior: under the insertion of the tensor of the annular ligament of the radius or in the capsule itself and the insertion on the radial neck.

B. Bursae mucosae cubitales posteriores

1. Bursa subcutanea olecrani: under the skin over the olecranon, below it being the adjunctive bursa subolecrani - proximally over the rear of the ulna.
2. Bursa subtendinea musculi tricipitis brachii: between m. triceps brachii and the olecranon apex over the insertion of the tricep.
3. Bursa intratendinea olecrani - in the middle of the triceps tendon itself. 4. Bursa humerotricipitalis - between the triceps and the fat pad that is above the distal part of the humerus.
5. Bursa retro-epitrochlearis - dorsally between the medial head of the tricep with the ulnar nerve dorsal and the most posterior surface of the medial humeral condyle.
6. Bursa musculi anconei quarti - between the beginning of m. anconeus and the joint capsule.

C. Bursae mucosae cubitales laterales externae

1. Bursa subcutanea condyloidea humeri externa - between the skin and the outer part of the humeral condyle.
2. Bursa musculi extensoris carpi ulnaris - between the m. extensor carpi ulnaris tendon and the articular capsule.
3. Bursa cubitalis musculi extensoris carpi radialis brevis - between the beginning of m. extensor carpi radialis brevis and the supinator.

D. Bursa mucosa cubitalis lateralis interna

1. Bursa subcutanea condyloidea humeri interna - between the skin and the medial humeral condyle.

E. Bursa mucosa cubitalis interossea.

1. Bursa cubitalis interosaea s. ulnoradialis - between the fat pad in the fossa cubiti, the biceps and chorda obliqua (tranversalis) membranae interosseae [13,14].

dered by their location following the anatomical coordinate system.ween the skin and the medial humeral condyle.

Olecranon bursitis is commonly caused by direct trauma or repetitive stress, but may be associated with rheumatoid arthritis, gout, or crystal deposition disease and may develop local infection [11,18,]. Only single case reports or small case series exist for bicipitoradial [19, 20] and interosseous cubital bursitis [21]. Both bursae may become infected, or compress nerve fibres in their vicinity.

There are seventeen muscles crossing the elbow joint. Three of them, the biceps, the brachialis and the brachioradialis function as primary elbow flexors. However, only the brachialis is pure flexor, the brachioradialis acts as an elbow flexor solely with the forearm in neutral rotation and the biceps is also a strong supinating muscle. Elbow extension is principally caused by contraction of the triceps muscle inserting at the olecranon.

Pronation is induced by two muscles: the pronator quadratus, located on the distal forearm, and the pronator teres. The latter originate with one head from the medial epicondyle and second head from the coronoid process of the ulna and both insert on the lateral and posterior surface of the proximal third of radius. In elbow flexion, supination is the result of contraction of the biceps, but the two-headed supinator muscle contributes to forearm rotation in any flexion/ extension position. The origins of extensores carpi radialis brevis and longus at the lateral epicondyle are the usual site of pain in 'lateral epicondylitis'. Both muscles are weak elbow flexors but principally extend the wrist. The common tendon insertion at the medial epicondyle (for pronator teres, flexor carpi radialis, palmaris longus, and flexor carpi ulnaris) is, similarly, the site of pain in 'medial epicondylitis' [1].

Nerves that pass through the elbow region can become compressed at multiple sites during their course by rigid fibrous structures. The median nerve can be entrapped under lacertus fibrosus in the cubital fossa,or between the ulnar and humeral head of m. pronator teres, which forms a tendinous bridge of the humero-ulnar and radial head of m. flexor digitorum superficialis = sublime bridge [22].

Just anterior to the lateral epicondyle, the radial nerve bifurcates into the sensory or superficial branch of the radial nerve and the motor or deep branch entering the radial tunnel immediately after its origin. The floor of this space is built by the anterior capsule of the humeroradial joint together with the deep layer of the supinator muscle. The roof is constituted by the arcade of Frohse, defined by the fibrous adherence between the brachialis and brachioradialis muscles in front of the radial head, the medial edge of the extensor carpi radialis brevis muscle, and the superficial layer of the supinator muscle [23]. Five potential sites of radial nerve entrapment have been described of which the arcade of Frohse is the most frequent [24]. In case that the bicipitoradial bursa becomes enlarged, it may get in contact with adjacent branches of the radial nerve [19].

The ulnar nerve may be exposed to pressure at the entrance of the cubital tunnel. The roof of cubital tunnel is formed by aponeurosic attachment of the two heads of flexor carpi ulnaris, which spans in arcade like manner from medial epicondyle of humerus to the olecranon process of the ulna (also known as Osborne's ligament). Entrapment of the ulnar nerve at the elbow is the second most common compression neuropathy after carpal tunnel syndrome [25].

The elbow is a region which was early included in thermographic evaluation of diseases of the locomotor system. Francis Ring used elbow thermograms in the database for the definition of the Thermal Index [26]. The Heat Distribution Index, developed by thermographers in Cambridge, was also partially based on elbow thermograms [27]. An early standard paper listed the lateral elbow as one of the most frequently used thermographic views in locomotor diseases [28]. Binder et al used thermography as diagnostic tool and as outcome measure in patients suffering from lateral epicondylitis [29]. A hot spot above the lateral epicondyle was confirmed as typical thermographic finding by Ammer, who found also evidence that these hot spots show a lower threshold in pressure algometry [30]. Thermal imaging can detect chronic lateral epicondylitis in a similar way as isotope bone scanning [31].

Mayr proposed an axial view for imaging both elbow tips simultaneously in one image [32] and published elbow thermograms from patients with rheumatoid arthritis, primary and secondary elbow osteoarthritis. In patients with medial epicondylitis, hot spots over the medial epicondyle are rare findings [33]. However, in the case of lateral epicondylitis thermal imaging was successfully used as responsive outcome measure [34,35].

Tauchmannová reported a significant coincidence of thermographic findings with the physical signs of patients with clinically diagnosed enthesopathy of the humeral epicondyle. Using thermographic methods, a group of female rehabilitation workers showed a severe forearm hyperthermia of right-hand-side, which may be due to uneven muscle load during the work performance. Obtained findings suggest the possibility of a preventive use of thermography to detect soft tissue defects. Symmetrical uniform hyperthermia of both forearms was detected in the group of elite athletes (weight lifters), suggesting symmetrical muscle loads in sports performance. This finding is the basis for monitoring temperature changes in the exposed muscle groups by thermography for the timely adaptation of the training load [36].

The most common causes of elbow pains include lateral and medial epicondylitis. Symptoms at the lateral elbow are often referred as tendinopathy with a typical sonographic finding of distal hypoechoic gap in a tendon leading from the bone attachment. Other causes of lateral elbow pain include entrapment of the posterior interosseous and lateral antebrachial cutaneous nerves, posterolateral rotatory instability, posterolateral plica syndrome, Panner's disease (an avascular necrosis of the ossification core of the capitellum humeri following an injury) osteochondritis dissecans of the capitellum, radiocapitellar overload syndrome, occult fractures and chondral-osseous impaction injuries, and radiocapitellar arthritis [37].

Causes of pain at the medial site of the elbow include ulnar collateral ligament injury, valgus extension overload syndrome, cubital tunnel syndrome (entrapment of the ulnar nerve) and medial epicondylitis [38]. The latter presents more often as enthesopathy than as tendinopathy.

Anterior elbow pain may be due to distal biceps rupture, biceps tendonitis, cubital bursitis entrapment of lateral antebrachial cutaneous nerve, and posterior interosseous nerve syndrome [38]

The posterior side may show signs of olecranon bursitis, olecranon stress fracture, posterior impingement of the olecranon tip in the olecranon fossa, which may cause osteophyte formation and a fixed flexion or triceps tendinopathy [38].

Other rare causes of the painful elbow include

- ganglia and cysts, which may result in compression of branches of the radial nerve [39] or the ulnar nerve [40]
- Parosteal lipomas [41], lipoma arborescens [42] and fibrolipomas [43] may also affect nerves passing through the elbow region
- epitrochlear lymphadenopathy in the medial elbow area, also called the cat scratch disease (caused by the Gram negative bacteria of Bartonella Henselae) [44]
- inadequately consolidated fracture - e.g. head or neck of the radius, missed Monteggia fractures [45],
- ulnar nerve luxation from the sulcus ulnaris [46]
- snapping tricep syndrome caused by medial dislocation of the medial head of the triceps over the medial epicondyle during flexion[47]
- Os supratrochleare dorsale in the olecranon fossa [48].

Facing the variety of disorders that can result in elbow pain, we wanted to get an idea of the prevalence of causes of elbow pain in a group of patients referred for treatment to a private clinic of rehabilitation medicine located in Trencin. The second aim was to investigate the value of infrared thermography and sonography for the differential diagnosis of elbow pain.

Method

A retrospective study was perfomed based on charts reviews of patients with a painful elbow, referred for treatment between January 2013 and December 2015. In some patients the referring physician had organised blood tests and/or radiography or magnetic resonance imaging (MRI). Inclusion criteria were elbow pain, normal serology, and report of a complete clinical, myoskeletal, thermographic and sonographic examination. Exclusion criteria were recent splinting or surgery in the elbow region, patients suffering from fibromyalgia, patients with rheumatoid or other forms of inflammatory arthritis.

Physical examination

The clinical examination included a record of each patient´s medical history, especially focusing on pain characteristics: when and at what site pain started at first, the direction in which the pain spread, what conditions aggravate or reduce the pain such as rest, movement, work, stress, relaxation and so on. At the end of this interview, externally realised investigations such as blood tests, radiographs or MRIs were collected.

The physical examination include inspection with a particular focus on abnormal vascular findings and superficial skin lesions Palpation of the elbow joint included testing for tenderness of insertions of ligaments and tendons, assessment of swelling, thickened synovial folds and effusions. Functional tests were performed including range of motion, assessment of joint play, joint stability and joint stiffness. Muscle tone and muscle strength were also tested.

Thermal imaging

Ti32 Fluke thermal imager (US production) with a temperature resolution of 0.05°C was used for the thermographic examination. The patient naked to the waist was equilibrated in a darkened room at 25° ± 1.0°C for 20 minutes.

In addition to standard positions specified in the Glamorgan protocol [49], we used additional projections to capture thermal images of elbows in:

1. Anterior projection with full extension in the elbow and maximal supination of the forearm to obtain a thermal image of the cubital fossa

2. Posterior projection with the elbow totally extendend and the forearm in maximum supination to obtain a thermal image of the olecranonof the posterior site of the elbow

The qualitative evaluation of thermal images of the elbow was based on the description of deviations from the pattern of temperature distribution found in subjects free of symptoms in the examined body region. We compared the location of vascular abnormalities and skin lesions found during inspection, with suspicious findings in the thermograms for avoiding false positive temperature readings. After exclusion of potentially false positives, thermal findings were related to to the anatomical details of the investigated region.

For quantitative analysis, we described mean (Tmean), maximum (Tmax) and minimum (Tmin) temperatures in regions of interest (ROI). These circular ROIs covered either the total skin area over the elbow joints or enclosed an anatomical structure such as the muscle insertions at the epicondyles or the tip of the olecranon. Similar ROIs were defined at the corresponding collateral site. Mean temperatures of ROIs over defined anatomical structures were compared to the temperature in the vicinity of the ROI or to the corresponding measurement area at the contralateral side. Temperature findings with temperature difference $\Delta t \geq 0.5°C$ were regarded as positive.

Sonography

The MyLabGold platform (Esaote, Italy) equipped with a linear-array transducer working in frequency band between 7.5 to 12 MHz has been used in our workplace for ultrasound examinations. We examined the whole elbow in each patient, dividing it into four sections - frontal, lateral, medial, posterior.

- Examination of the front of the elbow was conducted in a patient with the extended elbow resting on the arm of a deckchair.
- The medial section of the elbow was examined with the patient in supine position. The patient leaned toward the examined side of the body to allow for a maximum outward forearm rotation.
- The lateral part of the elbow was examined in two positions. During the elbow extension the thumb is turned upwards in one position, in the other position the forearm is in pronation.
- Posterior aspect of the elbow was examined in elbow flexion of 90° with the palm resting on the deck chair.

Table 3 shows the criteria defining true positive cases of epicondylitis, bursitis and sequelae of injury related to physical examination, thermography and sonography.

Results

In total 43 patients underwent a complete examination, 35 of them had problems on one side. 5 exhibited problems on both arms, either on the medial or lateral site and 3 patients had symptoms at the medial and lateral site of both elbows. The total number of painful elbow findings in 43 subjects was 57.

15 patients provided externally realised radiographic or magnetic resonance imaging, with positive findings in 12 cases. In each evaluation approach a total of 97 elbow sites have been assessed, i.e. 57 painful sites and 40 control sites.

Physical examination

21 elbows fulfilled the clinical criteria of lateral epicondylitis, 13 elbows were diagnosed as medial epicondylitis. 4 elbows showed signs of bursitis, 14 elbows with sequelae of injuries were diagnosed by radiography or MRI. The pain could not be explained by a medical condition in the remaining 5 elbows.

Sonography

Of the 57 sonographic examinations, 45 were positive and 12 negative. In cases with clinically confirmed lateral epicondylitis, 14 true positive and 7 false negative sonographic

Table 3
Diagnostic criteria

Diagnosis	Physical examination	Thermography	Sonography	Absence of
lateral epicondylitis	tenderness of the lateral epicondyle plus pain at resisted dorsiflexion of wrist and fingers	hot spot (0.5°C warmer than the surrounding) at the lateral epicondyle temperature difference to the contralateral side =0.5°	tendinopathy: hypoechogenic cleft in tendon distal from its bony insertion	inflammatory arthritis fracture, osteochondritis dissecans, tendon rupture, joint instability, severe joint stiffness, bursitis, local oedema, tumours entrapment of peripheral nerves, radiculopathies C6 -Th1
medial epicondylitis	tenderness of the medial epicondyle plus pain at resisted flexion of wrist and fingers	hot spot (0.5°C warmer than the surrounding) at the medial epicondyle or temperature difference to the contralateral side =0.5°	enthesopathy: proximal part of the tendon enlarged with alterations in echogenicity	
bursitis	tenderness at the site of bursa plus palpable synovial thickening and effusion	hot spot (0.5°C warmer than the surrounding) at the site of bursa or temperature difference to the contralateral side≥0.5°	hypoechoic rims and fluid	inflammatory arthritis fracture, osteochondritis dissecans, joint instability; severe joint stiffness epicondylitis, bursitis local oedema, tumours entrapment of peripheral nerves radiculopathies C6 -Th1
Sequelae of injury	pain appearing after exposure to external forces and/or radiographic signs of injuries of bone or cartilage	total area above the elbow joints presented with temperature difference to the contralateral side ≥0.5°	disruption of the cortical bone eventually step formation and axial deviation	inflammatory arthritis joint instability, severe joint stiffness epicondylitis, bursitis local oedema, tumours entrapment of peripheral nerves radiculopathies C6 -Th1

Table 4
Positive and negative cases, diagnostic sensitivity and specificity of sonography related to clinical diagnosis

	Physical examination positive	Physical examination negative	
Sonography positive	40	5	
Sonography negative	12	40	
	Estimated Value	95% Confidence Interval	
		Lower Limit	Upper Limit
Prevalence	0.54	0.43	0.64
Sensitivity	0.77	0.63	0.87
Specificity	0.89	0.75	0.96

results were obtained. For medial epicondylitis the number of true positive sonographies was 8, but also 5 false negative sonograms were recorded. False negative ultrasound images were not found in all other causes of elbow pain. Consequently, the cause of pain in the 5 elbows with inconclusive clinical symptoms was clearly identified by sonography. Table 4 shows the number of positive and negative findings comparing physical examination and ultrasound imaging. Calculation of sensitivity and specificity of sonography for the clinical diagnosis obtained 77 % sensitivity and 89% specificity.

Thermal imaging

Typical temperature distributions at lateral, medial and dorsal site of the elbow recorded in subjects free of symptoms are presented in figure 1a, 1b and 1c.

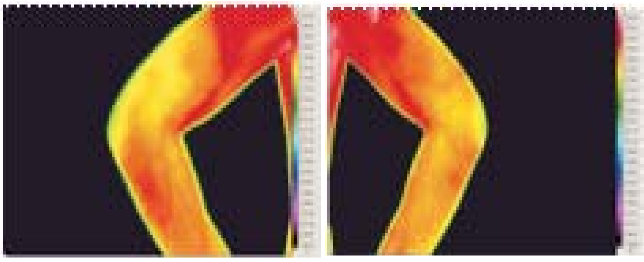

Figure. 1a
Normal thermal images of

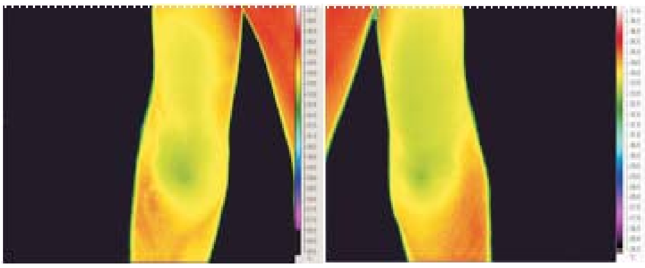

Figure. 1a
Normal thermal images of the dorsal elbow

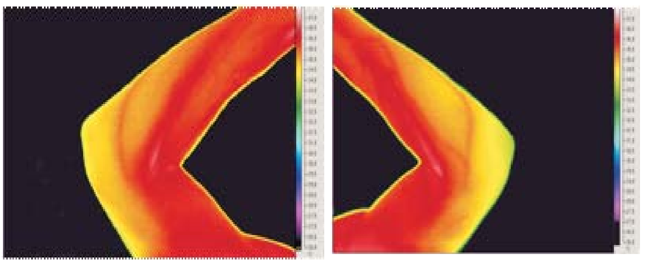

Figure. 1c
Normal thermal images of the medial elbow

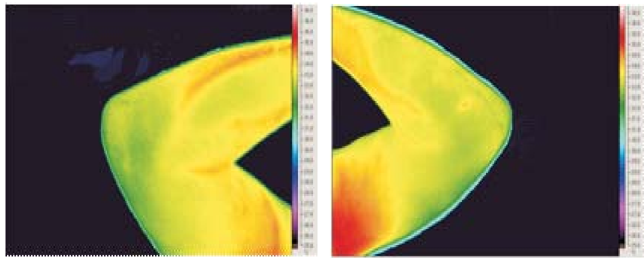

Fig. 2a
Normal thermograms of the elbows,. medial view

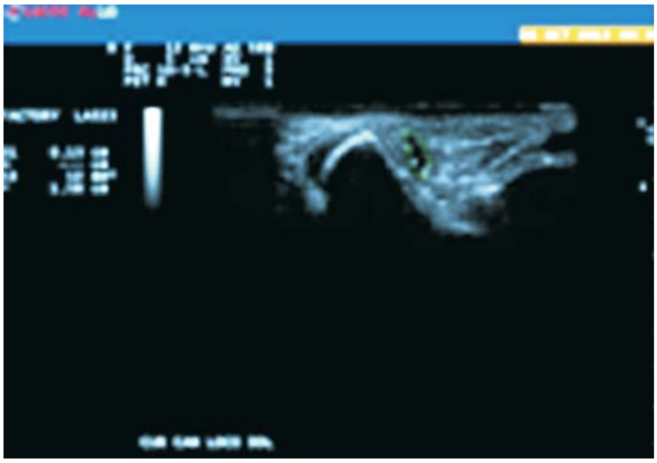

Fig. 2b
Sonogram showing a cyst in the cubital canal at the right side

Diagnostic temperature differences were detected at 55 elbows, in 4 of them the painful site presented with a lower temperature than the corresponding site. Non significant temperature differences were detected in 2 patients who did not suffer from epicondylitis. Figure 2a shows a normal temperature distribution in the medial view of a painful elbow at the right side. The corresponding sonogram detected a cyst located in the cubital canal (figure 2b).

All 21 elbows clinically diagnosed as lateral epicondylitis showed increased temperature at the symptomatic lateral epicondyle (figure 3a). Medial epicondylitis presented with a higher temperature at the symptomatic elbow in 12 cases (figure 4a) and a temperature decrease in the remaining case. The corresponding sonographic images of lateral and medial epicondylitis are shown in figures 3b and 4a. The thermal image of a large bursitis olcranon is shown in figure 5a, with corresponding sonographic findings in figure 5b.

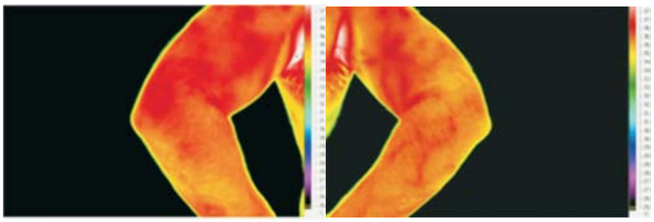

Figure 3a
Hot spot at the lateral epicondyle, right side

Figure 3b
Sonographic image of lateral epicondylitis

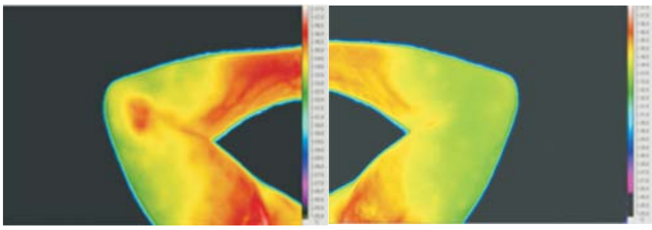

Figure 4a
Hot spot at the medial epicondyle, right side

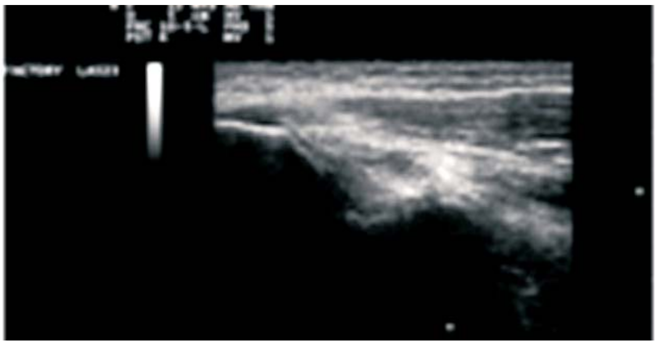

Figure 4b
Sonographic image of lateral epicondylitis

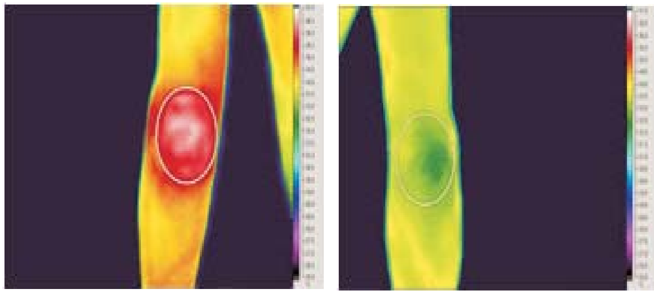

Figure 5a
Local hyperthermia at the left olecranon in a patient with bursitis

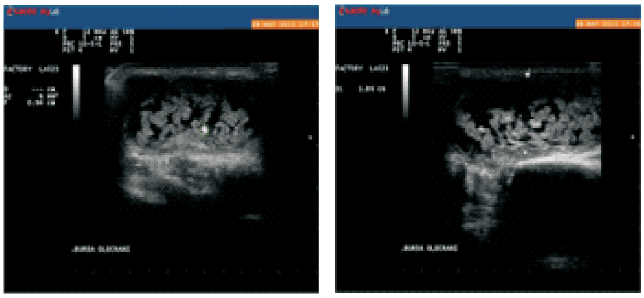

Figure 5b
Corresponding sonographic finding of the thermal image in figure 5a

Calculation of diagnostic accurracy of thermal imaging for clinical symptoms obtained 91% sensitivity and 95% specificity (table 5).

Discussion

The causes of elbow pain are manifold. It is a common belief that epicondylitis is the most frequent cause of elbow pain. In this retrospective study based on patient´s charts collected from a private clinic for Rehabilitation Medicine, the most frequent diagnosis in painful elbows was lateral epicondylitis (21/57) followed by medial epicondylitis (13/57). A swollen bursa was the source of pain in 4 elbows. The remaining 19 cases were explained by sequelae of injury affecting bone, cartilage or tendons. Although most pain problems can sufficiently be diagnosed when based on medical history and findings from the physical examination, in five cases of our sample the clinical findings were non conclusive for a destinct diagnosis. Sonography found an clear explanation for the pain in these clinical unclear cases.

Table 5
Positive and negative cases, diagnostic sensitivity and specificity of thermal imaging related to clinical diagnosis

	Physical examination positive	Physical examination negative	
Thermal imaging positive	50	5	
Thermal imaging negative	2	40	
	Estimated Value	95% Confidence Interval	
		Lower Limit	Upper Limit
Prevalence	0.57	0.46	0.67
Sensitivity	0.91	0.79	0.97
Specificity	0.95	0.83	0.99

Thermal imaging and sonography capture different information of the human body. While sonographic images are able to detect small anatomical details, thermography depicts the temperature distribution on the body surface which reflects physiological processes associated with skin blood flow, which depends on the nutritional demands of metabolically active tissues and the state of body heat balance.

Temperature can be understood as an indicator of the acuteness of lesions, as on-going tissue repair or inflammatory processes are associated with blood flow changes leading to possible changes of skin temperature. Almost all injury sequelae in our sample presented with increased local temperature values. It would be of interest to know, whether a relationship exist between temperature and the time passed since the onset of injury.

In 4 cases, the painful elbow was slightly, but significantly colder than the corresponding site.. Previously we thought that the coincidence of pain and reduction of local skin temperature might be the manifestation of a sympathetically maintained pain-syndrome. Although local temperature might be the result of increased acitivity of adrenergic autonomous nerve fibers, the evidence of sympathically maintained pain requires the application of sympathetic blocks which are followed by pain relief and increase in local skin temperature. As the involvement of the autonomous nerve system was not evaluated in the 4 cases with decreased elbow temperature, we decided to remove sympathetically maintained pain from the list of thermographic assisted diagnoses.

Thermal imaging showed a slightly higher rate of true positives related to clinical diagnosis than sonography. This can be explained by the superior performance of thermography in identifying epicondylitis cases, while sonography had a better rate of true positives in detection of morphological changes such as osteophytes, calcifications, abruptions, fractures, loose bodies, tendon ruptures, cysts, bursas.

Conclusion

Epicondilitis is considered to be the most common cause of elbow pain. However, in a cohort collected in a private clinic over 2 years, epicondylitis explained only slightly more than half of all elbow pains. The cause of elbow pain not due to epicondylitis varies to a great extent and their exact specification without the use of imaging methods is difficult. Infrared imaging is highly sensitive in the cases of epicondylitis, and can supplement morphology based imaging with information on the acuteness of morphological changes.

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Programme

Saturday, April 22st, 2017

09:00 - 10.50 Session I: **Chair:** Prof Kurt Ammer, Dr Kevin Howell

1. *Ammer K.* (Austria)
Can the source of metabolic heat be seen by infrared thermal imaging?
2. *Mercer J.B., Weerdt L.*(Norway)
Passively induced mild hyperthermia- a novel approach to the thermographic evaluation of the circulatory status of the hands .Seixas A., Hausler V., Monteneiro J.,
3. *Seixas A, Ammer K, Carvalho R, Vilas-Boas JP, Vardasca R Mendes* J. (Portugal/United Kingdom)
Do clinical signs of peripheral artery disease in the posterior tibial artery influence skin temperature? preliminary results
4. *Petrova NL, Tang W, MacDonald A, Lomas C, Ainarkar S, Bevans J, Allen J, Plassmann P, Kluve B,* Rogers L, McMillan J, Whittam A, Simpson R, Machin G, Edmonds ME. (United Kingdom)
The use of thermal imaging in thre follow-up of healed diabetic foot ulcers

5.. *Vardasca R, Mendes J (Portugal)*
The reliability and repeatability of low cost infrared camera for clinical use.

10.50-11.10 Coffee break

11:00 - 12:45 Session II Chair: Prof. James Mercer; Prof Ricardo Vardasca

1. *Cholewka Agnieszka; Kapek L, Szlag M, Wojcieszek P, Kellas-Sleczka S, Stanek A, Sieron-Stoltny K, Slosarek K, Biawas B, Cholewka Armand* (Poland)
   The use of thermal imaging in evaluation of brachytherapy effcts in basal cell carcinoma
2. *Trzyna M, Cwierz A, Szczesniak A; BiernatM, Jung A* (Poland)
   Evaluation of the diagnosticefficacy of liquid-crystal thermography in breast cancer detection. Prospective observational study-ThermaAlg
3. *Englisz B, Cholewka A, Firganek E, Baic A, Knefel G, Lizka G, Kawecki M; Nowak M;*
   Effect of hyperbaric oxygen therapy on delayed wound healing evaluated by thermal imaging and planimetry
4. *Urakov AL, Urakova NA, Reshenikov AP, Kopylow VV, Gabdrafikov RR* (Russia)
   Thermal imaging predicts the eruption of the first milk tooth in infants
5. *Kasprzyk T, Balamut K, Stanek A, Sieron-Stoltny K, Kaszuba M, Kopczynska E, Cholewka A, Morawiec T.* (Poland)
   The application of thermal imaging in dentistry - a pilot study

13:00 - 14:15 Lunch

14:00 - 15:00 Session III Chair: Prof Manuel Silero-Quintana, Prof Armand Cholewka

1. *Gabrhel J, Poraciva Z, Tauchmannova H (Slovakia)*
   Painful elbow syndrome in thermal and musculoskeletal sonographic imaging
2. *Wysoczanski B.*
   Effects of magnetotherapy on peripheral circulation in elderly women(60+) complaning of cold hand syndrome
3. *Moreira DG, Sillero-Quintana M*
   The delphi protocol applied to the consensus document "Thermographic imaging in sports and exercise medicine (TISEM)
4. *Kasprzyk T, Wojcik M, Sieron-Stoltny K, Stanek A, Cholewka A.*
   Quantitative thermal evaluation of the influence of thermo-active baselayers tops on heat transfer between body and environment in sportsmen-pilot study
5. *Binek M, Drzazga Z, Pokora I*
   Thermal mapping of ski-runners during endurance training
6. *Colodron AS, Moreira DG, Sillero-Quintana M*
   Effect of anti-inflammatory cream on soccer players skin temperature.

16:00 - 16:15 Coffee break

16:15 - 18:15 EAT committee meeting

Abstracts

THE RELIABILITY AND REPEATABILITY OF LOW COST INFRARED CAMERAS FOR CLINICAL USE

Ricardo Vardasca, Joaquim Mendes

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INTRODUCTION: Thermal camera suppliers have introduced in spring of 2014 low-cost infrared cameras in the market with interesting features and at an appellative price. Two years later, a second generation of those devices was launched with most of the issues addressed and improved characteristics. This have attracted researchers and enthusiasts in the world of clinical thermography to perform applications using such devices. Despite of the technical specifications provided by the manufacturers, limited knowledge exists about the thermal performance of this gadgets. The present research aimed to test the three most common low-cost IR cameras available in the market actually and investigate parameters such as start-up and temperature drift.

METHODOLOGY: A standalone FLIR C2 (array size 80x60 and NETD < 100mK), and two FLIR ONE 2nd generation (array size 160x120 and NETD < 100mK) attached to an Android tablet (LG V400) and an iOS tablet (iPad mini 2) were used against a calibration source reference (Blackbody Isotech Hyperion R Model 982). All cameras were placed 30cm away from the target in an acclimatised room (mean temperature of 23±0.8ºC, relative humidity of 47±2%, absence of incident lightning and air flow over the target). For reference, two IR cameras (FLIR A325sc and FLIR E60) that meet the minimal requirements (array size 320x240 and NETD < 50mK) for clinical applications were also tested. The first test consisted in one hour assessing the calibration source set at 30º C, with every capture at 5 minutes' interval after switching on the camera. The second test consisted in recording every temperature set in the blackbody beween 20 and 38º C with all cameras.

RESULTS:Examples of images obtained with the different IR cameras from the calibration source are presented in figure 1. The results of the start-up drift test are shown in figure 2, where it can be observed that the IR camera FLIR A325sc got stable after 10 minutes, FLIR C2, FLIR E60 and FLIR ONE for iOS after 20 minutes and FLIR ONE for Android after 25 minutes. The minor difference in temperatures recorded after getting stable was found in the E60 (average: 0.39; min: 0.2; max: 0.7), followed by A325sc (0.62; 0.5; 0.7), C2 (1.15; 0.8; 1.6), One for iOS (1.28; 0.8; 1.9) and One for Android (1.81; 1.3; 2.6). In the second test, E60 and A325sc presented a correlation with the blackbody of 0.999 and the other cameras of 0.972 in the temperature range of 20-38ºC, which is the range of the human body skin. The minor temperature drift found between the recording of the IR camera and temperature set at the calibration source was found in the E60 (average difference: 0.36; min: 0.1; max: 0.5), followed by A325sc (0.59; 0.3; 1), C2 (1.15; 0.7; 1.5), One for iOS (1.3; 0.8; 1.6) and One for Android (1.6; 1.1; 2.0).

DISCUSSION: All of the used cameras had uncooled detectors, only the FLIR A325sc did not run on battery. The batteries of low cost IR cameras (FLIR C2 and FLIR ONE 2nd generation) last for ± 1 hour. Based in the obtained results for the start-up drift, the C2 camera had a similar performance in stabilization when compared with E60 and A325sc, although with a higher reading error. The cameras attached to mobile devices despite of allowing short periods of stable recordings, presented a reading error higher than 1.2 ºC. Observing the temperature reading drift over the selected range the low-cost cameras,it was found that these systems have a reading error higher than one degree in average, which is considerable when compared with equipment that fulfil the minimal requirements for clinical use. From this experiment, it can be concluded that despite these systems being attractive in price and manufacturer provided features, their operational performance does not comply with required standards for clinical use. The information should only be taken in account for monitoring proposes and not as an input for diagnose judgments.

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CAN THE SOURCE OF METABOLIC HEAT BE SEEN BY INFRARED THERMAL IMAGING?

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A common interpretation of temperature distribution of the human skin is that it represents the thermal signature of metabolic heat. For understanding, whether this concept is appropriate, some basic facts of thermal physics and physiology must be considered.

Heat is a form of energy and have both volume and intensity. Heat is absent at zero Kelvin, but ubiquitousabove zero temperature.The 3-dimensional thermal expansion follows the distribution of its intensities or in other words heat flow is directed from high towards low temperature levels until equilibration is reached. In case of a permanent heat source and an ambient temperature below the heat source, equilibrium is characterised by an established temperature gradient between heat source and surface.

In homoiotherms a physiological system exists that keeps the variation of temperature of core tissues within a narrow range. The temperature shell, represented by tissues surrounding the core, acts as insulation layer varying in expansion in dependence

Table 1
Heat Capacity, Thermal Conductivity and Heat Generation Rate of various tissues

Tissue	Heat Capacity (J/kg/°C) mean ± standard deviation	Thermal Conductivity (W/m/°C) mean ± standard deviation	Heat Generation Rate (W/kg) mean ± standard deviation
Blood	3617 ± 301	0.52 ± 0.03	0.0
Blood Vessel Wall	3306 ± 158	0.46 ± 0.02	2.32 ± 0.00
Muscle	3421 ± 460	0.49 ± 0.04	0.93 ± 0,03
Tendon/Ligament	3432 ± 96	0.47 ± 0.04	0.45 ±0.00
Fat	2348 ± 372	0.21 ± 0.02	0.51 ± 0.02
Skin	3391 ± 233	0.37 ± 0.06	1.65 ± 0.03
Brain	3630 ± 74	0.51 ± 0.02	11.37 ± 0.20
Heart muscle	3686 ± 62	0.56 ± 0.04	39.45 ± 1.18
Thyroid gland	3609	0.49 ± 0.02	87.10 ± 2.17
Small intestine	3595	0.52 ± 0.00	15.89 ± 0.52
Water	4178	0.60 ± 0.01	0.0

of ambient temperature. Skin blood flow defined by the ratio of blood volume to tissue volume is a major determinant of the insulative properties of shell tissues. Under resting conditions and in a constant-state, the temperature gradient between deep tissue and skin of extremities should be smaller than the temperature gradient between core and mean skin temperature, although the velocity of heat flow from the core to shell may be affected by differences in thermal conductivity of tissues and combined mass and heat transport in blood vessels.

In thermal physiology metabolism invariably relates to the transformation of chemical energy into work and heat. Not included in this definition are other changes in the state of chemical energy such as the transformation of storage compounds to readily available compounds, including the energy transferring polyphosphates. Obligatory thermogenesis refers to the minimal heat produced by all the processes that maintain the body in a basal state (fasting) at thermo-neutral temperature. The standard metabolic rate and the heat generated during digestion, processing and storing of energy in the organs of the gastrointestinal tract including the liver and white fat, contribute to obligatory heat production.

Table 1 provides an overview on heat capacity, thermal conductivity and heat generation rate of defined tissues. Heat capacity of all tissues, but notof subcutaneous fat, is in a similar range of magnitude indicating an almost equal potential for heat storage. Distinct differences in thermal conductivity exist between skin, fat and muscle, but conductivity of blood, muscle and inner organs such as brain, small intestine, heart muscle and endocrine glands is similar in magnitude. Heat generation rate varies in wide range from zero (blood) to 87.1 ± 2.17 W/kg.

Measurements of heat generation by cancer cells are difficult to find, but a change in intracellular glucose metabolism was often described as marker of cancerous transformation. However, it remains unclear how much of this extra energy is lost as heat.

In a steady state, temperature differences in body regions are determined by the temperature gradient between core and shell, despite differences in heat conductivity and heat production. Total metabolic heat produced by the human body, can be measured by calorimetry, but only estimated by thermometry. Neither method can be used for the detection of the source of metabolic heat.

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DO CLINICAL SIGNS OF PERIPHERAL ARTERY DISEASE IN THE POSTERIOR TIBIAL ARTERY INFLUENCE SKIN TEMPERATURE? PRELIMINARY RESULTS

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Diabetes isone of the most frequent causes of lower-limb amputation, due to the commonly associated foot complications, with significant burden and increased mortality. The International Working Group on the Diabetic Foot defines this condition as the presence of infection, ulceration or destruction of tissues of the foot, associated with the presence of neuropathy and/or peripheral artery disease in the lower extremity of diabetic patients [1].The presence of peripheral artery disease is common in patients with established diagnosis of diabetic foot and is a predictor of non-healing and a risk factor for ulcer recurrence and amputation [2]. Thermal imaging may play an important role in the assessment of patients with diabetes [3], but studies comparing the skin temperature of patients with diabetic foot with and without peripheral artery disease are lacking in the literature.

The aim of this study was to compare skin temperature in patients with established diagnosis of diabetic foot, with and without peripheral artery disease.

Twelve patientswith diabetic foot (2 females), aged 42-76 were recruited from a specialized foot care centre, 6 with neuropathy and peripheral artery disease affecting the posterior tibial artery and 6 only with neuropathy. The analysis was done at the foot level, 24 feet were available. Examination room conditions (ambient temperature, humidity and air flow) were controlled to avoid experimental bias.Before thermal data was acquired, all participants followed a 10-minute acclimatization period. Thermograms were obtained with a FLIR E60 camera with resolution of 320 x 240 pixels, thermal sensitivity <0.05ºC and ±2ºC of accuracy. Images were obtained from the plantar surface of the foot and regions of interest were defined in the plantar surface. Thermograms were analyzed with FLIR ResearchIR Max software.

Thermogram analysis revealed significant differences in skin temperaturein the medial plantar artery angiosome (p=0.042), with higher values in patients with no peripheral artery disease, but not in the remaining angiosomes of the plantar foot (p>0.05).

These are preliminary results of an ongoing research but even with a small sample size it was possible to detect skin temperature differences between the groups of diabetic foot patients. The results of this study suggest that skin temperature in the foot may be dependent on arterial blood supply

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PASSIVELY INDUCED MILD HYPERTHERMIA- A NOVEL APPROACH TO THE THERMOGRAPHIC EVALUATION OF THE CIRCULATORY STATUS OF THE HANDS.

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Thermal provocation tests are often used in the thermo- graphic evaluation of the circulatory state of the hands. The pattern and/or speed of change of the thermal signal from the skin surface, especially the dorsal surface, provide valuable information on skin perfusion dynamics. Specific guidelines and recommendations for thermographic examinations are well described and range from patient preparation to environmental conditions of the imaging environ- ment and equilibration time. A common recommendation is that patient should be sitting or lying in a comfortable positions at a room temperature of 22°C and should be equilibrated to the environmental conditions of the examination room for at least 15 minutes.

The majority of patients referred to our thermography laboratory already have a diagnosis with different underlying pathologies. We have experienced that when patients with a vasospastic disorder like Raynaud's syndrome are examined using cold provocation tests following the above mentioned guidelines the information obtained may be limited. This is especially true when these patients are examined in a phase when the peripheral vessels are constricted or partially constricted. Based on the physiological concept that a mildly hyperthermic state would normally produce a vaso- dilatory response of peripheral blood vessels in their hands wehave started to use a new approach that involves making the patients mildly hyperthermic prior to their thermographic examination. To achieve this patients are requested to wear their outside clothing, including headwear and gloves, after entering the hospital and while waiting to be examined. Patients are instructed to adjust their clothing as best as they can to avoid sweating and the majority of the patients are able to do comply in an adequate manner. The air temperature in the laboratory is maintained at about 24°C. On entering the laboratory, a thermal image of the face and dorsal aspect of the hands are taken. The majority of patients subjectively report feeling warm following the pre-warming protocol and were observed to have open arteriovenous anastomoses in the nose (warm nose).

It is assumed that in this mildly hyperthermic state the central controller of body temperature in the hypothalamus is receiving a warm sensory thermal input that should evoke a heat loss thermoregulatory effector response (peripheral vasodilation of the hands). The response to this mildly hyperthermic state provides us with important information on the severity of the vasospastic state of peripheral vessels.A mild cold provocation test is then applied to both hands using a desk top fan blowing air at room temperature for a period of 2 minutes. The rewarming is recorded for a 3 minutes period using thermography. In selected cases, a stronger provocation test is used in which both hands covered with a plastic bag are placed for 1 minutes in a water bath with a temperature of 20°C. The skin rewarming following the cold provocation provides us further information of their vaso- spastic state. In addition, we noticed that a difference in the vasospastic state between fingers as well as the level of the vasospasm becomes more clearly visible using this approach.We have not only used this novel approach to obtain insight in the severity of the vasospastic disorder but also to evaluate treatment of the vasospastic disorder. Some case studies will be presented to illustrate the use of this novel approach for thermographically examining perfusion of the hands.

THE USE OF THERMAL IMAGING IN THE FOLLOW-UP OF HEALED DIABETIC FOOT ULCERS

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INTRODUCTION: Infrared thermal imaging has attracted attention as a possible useful modality for early detection of incipient tissue damage in high-risk diabetic foot patients. Previous studies using an Infrared Camera have shown that areas with a temperature of 2.2°C or greater than the corresponding contralateral site are at risk of an ulcer.

The aim of this study was to determine skin temperatures at sites of previously healed ulcers in diabetic foot patients in comparison to healthy volunteers.

METHODS: Plantar, dorsal, medial and lateral images of the right foot and left foot the diabetics were captured after 10 minutes of acclimatisation in a temperature controlled room (temperature range 22-24°C) using a thermal imaging device designed and constructed by Photometrix Imaging Ltd (1).

The thermal images were uploaded onto a computer and skin temperatures at the sites of healed foot ulcers and their corresponding contralateral sites were measured and the temperature difference (ΔT) was calculated. The images were then assessed for the presence of hot spots using the aforementioned 2.2°C temperature difference indicator.

RESULTS AND DISCUSSION: Eight diabetics had a history of bilateral symmetrical ulcers and a ΔT greater than 2.2°C was not applicable. Fifty-eight healed ulcer sites in 39 patients were analysed. Twenty-eight ulcer sites were warmer than their contralateral sites (ΔT range 0°C to 2.1°C). Twenty two ulcer sites were cooler than their contralateral sites (ΔT range -0.1°C to -2.1°C at 20 sites and ΔT below -2.2°C at 2 sites). However, at eight healed ulcer sites, ΔT was greater than 2.2°C (ΔT range 2.5°C to 8.6°C) and these sites were classified as hot spots on the thermal images. These hot spots were offloaded as per local standards and none had ulcerated at the next clinic visit (2-4 weeks).

CONCLUSION: This study shows the potential role of thermal imaging in the assessment and prevention of diabetic foot ulcers. In high-risk diabetic foot patients, a full thermal imaging sequence of both feet (plantar, dorsal, medial and lateral) should be considered for early detection of areas at risk.

THE USE OF THERMAL IMAGING IN THE EVALUATION OF BRACHYTERAPY EFFECTS IN BASAL CELL CARCINOMA

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The aim of the study was to determine the influence of whole cycle of brachytherapy on temperature changes of skin lesions and surrounding tissue. The study group consisted of 22 patients suffering from basal cell carcinoma localized on the face. Patients were treated by High-Dose-Rate (HDR) brachytherapy at the Maria Sklodowska- Curie Memorial Cancer Center and Institute of Oncology in Gliwice. The therapy cycle was divided into 9 sessions of irradiation. In each session a dosage of 5 Gy was delivered to the tumour area. A costum made mould applicator for brachytherapy was produced for each patient.

Digital photographs were made from the face of each patient and thermal images were recorded with the thermal camera E60 Flir Systems. Individual digital images and treatment plan were correlated with the thermal images to assure the dimensions of treated and studied lesions. All regions of interest were carefully defined on the affected site . Similar areas were described on the corresponding healthy site of the face.

The differences between mean temperature of lesion area, mean temperature of surrounding tissues and the healthy similar areas before first treatment fraction and one month after last one as well as the differences of mean temperature in all regions of interest in chosen stage of treatment were taken into account for statistical analysis.

Obtained results showed that the difference between mean temperature of lesion and its surrounding studied before treatment is significantly higher than one month after the end of treatment. Similar effects were obtained in analyzing of thermal parameters derived from lesion and the symmetrically healthy side.

Such temperature changes suggest that planned and performed treatment lead to cancer cells necrosis what might be seen as slower metabolism due to lower temperature in treated region. Such effects may proved proper radiotherapy effects on tissue and may also point that thermal imaging could be used in brachytherapy effects evaluation.

EFFECT OF HYPERBARIC OXYGEN THERAPY ON DELAYED WOUND HEALING EVALUATED BY THERMAL IMAGING AND PLANIMETRY

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Hyperbaric oxygen therapy (HBO) is a treatment option in physical medicine that applies a higher than atmospheric pressure of air or pure oxygen to the human body. The increased oxygen pressure has an influence on many healing processes in the organism due to reduction of edema, a broad antibacterial effect and facilitation of neovascularization and restoration of normal extracellular matrix what leads to healing.

Usually planimetry and oximetry are used for the quantified evaluation of hyperbaric oxygen therapy effects in the case of delayed wound healing. However, a non-invasive, easy to perform and quick method of evaluation of treatment effects is not yet available. The same is true for the asssement of the patient's health condition. The objective of the presented work was to evaluate the hyperbaric oxygen therapy effects in patients with delayed wound healing by infrared thermal imaging and to compare the results to planimetry. Research were performed at the Centre of Burns Treatment in Siemianowice Slaskie. The studied group consisted of 8 patients (3 female with mean age 69±13 years, 5 male with mean age 70±7 years) who suffered from delayed wound healing on the lower extremities. Thermal images were recorded at three stages of the treatment cycle, always before entering and after leaving the hyperbaric chamber. (I: 0-10 sessions, II: 10 to 20 and III: more than 20 sessions of HBO)

The results obtained indicate that the combination of thermal imaging and planimetry may provide the physician with additional information related to diagnosis and obtained treatment effects. The wound surface decreased with increasing number of completed treatments which might be an indicator for the effectiveness of HBO. Moreover, it seems that temperature differences between selected regions of interest in the vicinity of wound are changing with time of therapy, indicating that temperature parameters may be useful in the evaluation of therapy effects.

THERMAL IMAGING PREDICTS THE ERUPTION OF THE FIRST MILK TOOTH IN INFANTS

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INTRODUCTION: The central lower incisor is the first milk tooth that erupts; typically, at an infant-age between 6 and 8 months. At that age, when the child appears suddenly malaise and in a febrile state, dentition may be suspected. It is hypothesized that a local temperature increase of the gum precedes the eruption of the milk tooth caused by the onset of a local inflammation in that area. In such a situation, it might be helpful to monitor the local temperature dynamics in the region of the lower gum, daily and repeatedly for several days. The value of temperature monitoring for the prediction of milk tooth eruption was tested in a small case series consisting of 5 infants.

METHODS: The dynamics of the local temperature of both gums were studiedin the open mouth of a child (6 months old boy) for several days in normal body temperature and in fever (general hyperthermia of unknown disease, the appearance of which was associated with the possibility of eruption of the first tooth). In parallel, studies were undertaken of the dynamics of the local temperature of the gums by applying convective cooling with a stream of dry air at room temperature using a household hair- dryer. Infrared monitoring of gum's temperature was performed with infrared camera Thermo Tracer TH9100XX (NEC, USA). Ambient temperature of the examination room was 24 - 25°C, the temperature window of the thermal camera was set to the range of 25 to 39°C [1, 2]. Both parents of the child gave informed consent.

RESULTS: At an early age, it is very difficult to diagnose the cause of the sudden worsening of mood, decreasing appetite, increasing irritability and fever. As children at this age do not speak and have only non verbal means to express their condition, results in the situation that child cannot clearly specify the body site where from the feeling of pain is emanating.

The appearance of local hyperthermia zone on the surface of gums may be considered as a diagnostic symptom for the development of local inflammation. Once discovered, this early sign of an erupting milk tooth can be confirmed by recording an infrared video after short-term cooling of oral surfaces. The transient decrease in the local gum temperature by several degrees Celsiu intensifies the temperature contrast between areas of healthy and inflamed tissue, thereby improving the accuracy of diagnosis of early local inflammation in the area, where the first tooth seeks to cut through the soft tissue (Fig. 1). The results obtained in follow-up the boy's condition, confirmed the hypothesis that local hyperthermia of the gum preceeds the eruption of milk tooth.

Infrared thermography proved to be a completely safe and very sensitive technique, suitable for early detection of local complications in oral cavity caused by eruption of teeth. Our experience has shown that monitoring by thermal imaging should be done repeatedly and on daily basis as the technique can be effectively used in the clinic and at home. Thermal imaging provide information enabling us identify the onset of local inflammation.

As described above, we managed to develop a novel method of immediate diagnosis of milk tooth eruption [3]. In evaluation of thermal images, the uniformity of gingival temperature distribution indicates that an early penetration of a tooth is unlikely. However, the detection of local hyperthermia at the gum is as sign of high probability for imminent dentition.

CONCLUSION: The process of eruption of milk tooth can trigger the development of local hyperthermia in the gums. Such hyperthermic areas can be identified by infrared thermography, particularly in combination with convective cooling.

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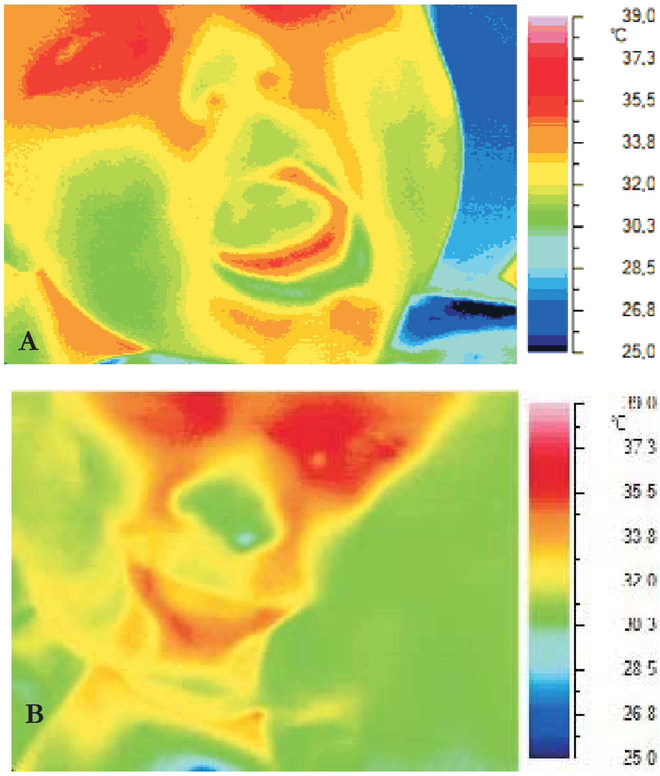

Figure 1.
Infrared image of the gingival tissue in open mouth of boy, aged 6 months (A) non febrile condition (B) after the onset of fever

EFFECTS OF MAGNETOTHERAPY ON PERIPHERAL CIRCULATION IN ELDERLY WOMEN (60+) COMPLAINING OF COLD HAND SYNDROME.

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INTRODUCTION: Numerous studies have demonstrated that the human body is influenced by magnetotherapy which has been used for long in rehabilitation. The magnetic field affects calcium-potassium channels in biological membranes through the resulting cyclotron effect, leading to an accelerated ion transport during the treatment.

Much attention has been devoted to the influence of magnetic fields on the circulatory system, particularly the response of blood components and also the action of blood vessels itself. Other discussed therapeutic targets are the myocardium and the stimulation of angiogenesis. However, the vast majority of the study were focused on changes in intracerebral circulation of laboratory animals. Studies on the influence of magnetic fields blood supply of the extremities are few and the report often, but not exclusively, treatment effect in Raynaud's disease.

One of the problems faced by the elderly people is the feeling of cold hands, leading to a deterioration in the quality of life. This existing problem is mostly reported by women. Although the problem has been discussed by various authors, it has not yet been sufficiently explored and the underlying cause of the "cold hands syndrome" remains unkown.

METHODS: The study group consisted of 47 women aged 60-76 years. Patients did not report accompanying illnesses in their medical history, and subjectively determined their general condition as "good".

Before the procedure the patients were sitting 30 minutes in the study room. A questionnaire about possible accompanying illnesses, pain in hands and cold sensation has been written. It was also the basis for the qualification of patients to the survey.

The main part of the survey consisted of: checking the radial and ulnar arteries with the Doppler Ultrasound; measurement of oxygen saturation with a pulseoximeter; innervations of the hand with WEST device, measuring the quality of feeling (QF) and a sensory threshold (ST); thermographic examination of the dorsal part of the hand with FLIR A325 Camera.

Then the patients' dominant hand was immersed for one minute in 14°C cold water. One minute later, another thermogram was taken. After a series of 10 treatments using magnetic field (MF) (50Hz, 10mT, 15 min.), the whole test procedure was repeated.

RESULTS: In almost all subjects with cold hands syndrome, both the ST and the QF were reduced. Before the treatment 35 subjects had a ST level of 0.2g, while 10 presented with a ST of 2.0g and only 2 subjects had a normal sensory threshold (felt pressure 0.07g). After the 10 day treatment ST was increased by 1 grade in 41 patients. There were no change in 6 cases regarding ST, but 3 of those patients has increased of their QF.

The difference in hand temperature measured before and after cooling was on average 1.84°C. After surgery, the difference has decreased to 0.91°C. In one case the temperature after cooling the hand was lower by 2.1°C compared to the period before the treatment.

There were no significant changes in the results of Doppler ultrasound or oxygen saturation after MF.

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APPLICATIONS OF THERMAL IMAGING IN DENTISTRY - PILOT STUDY.

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Changes in body surface temperature can providesome interesting information about tissues metabolism so thermal imaging may be use not only in diagnostic but also in monitoring of different therapy effects.

The aim of this study was use the infrared thermography in chosen stomatology procedures. Researchers also tried to use thermal imaging in dentistry inflammation and in monitoring the healing processes after the extraction or surgical ablation of tooth.

Ten patients participated in study. The first group contain 7 subjects for whom the surgical ablation of block-out third grinder was done. Second group contain 3 subjects with extraction of third grinder. Thermal imaging were performed before, after and

1, 4 and 7 days after the procedure. In addition, the not affected side of face was measured as a control area.

Obtained results show some differences in temperature changes between extraction group and surgical ablation group. Also the temperature changes in the period of healing after the dentistry procedures were observed in both studied groups.

Performed studies suggest that thermal imaging may bes useful in some dentistry procedures. However further measurements are needed to check and confirm obtained results.

THE DELPHI PROTOCOL APPLIED TO THE CONSENSUS DOCUMENT FOR "THERMOGRAPHIC IMAGING IN SPORTS AND EXERCISE MEDICINE" (TISEM).

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No consensus guidelines exist to address the methods for collecting skin temperature (TSK) data in Sports and Exercise medicine. The main aim of this work is introducing the Delphi protocol used to develop a checklist to collect T using Infrared Thermography (IRT) in sports and exercise medicine settings after the final document has been submitted for publishing.

The panelists members and coauthors of the work (n=24), their nationalities and their research areas will be represented. The general characteristics of the items and the evolution of the 3-rounds consensus agreement process will be introduced; however, the final results and the checklist entitled "Thermographic Imaging in Sports and Exercise Medicine (TISEM)" will be divulged only in the article published in a scientific journal high with impact factor.

It is intended that the TISEM will standardize the collection and analysis of TSK data using IRT and will be also applied to evaluate bias in thermographic studies and to guide practitioners and thermologists in the appropriate use of this technique.

QUANTITATIVE THERMAL EVALUATION OF THE INFLUENCE OF THERMO-ACTIVE BASELAYERS TOPS ON HEAT TRANSFER BETWEEN BODY AND ENVIRONMENT IN SPORTSMEN - PILOT STUDY

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It is known that during exercises the human body is under influence of external as well internal environment. The magnitude of body heat loses is function of body core heat production so the level of effort (heat energy produced in muscles) as well as the environmental's conditions (temperature, humidity...). The heat transfer take place through the skin so mentioned factors have to change the thermal map of the external layer of the body. That is why the most important for sportsmen is kept the thermal balance in body core, which is needed to avoid the overheating. Sports clothes are usually made from special fabric to provide the thermal comfort for sportman body and support the biological thermoregulation processes.

The purpose of this study was to find new method which can bring information about thermal parameters of baselayer tops. Nowadays to measure and characterize sport clothes only the structural and biophysical parameters are used (e.g. air or water vapour permeability, hygroscopy).

Six difference models of baselayers were measured in presented studies. Thermal imaging was done before, during and after the progressive cycling test, which were performed on training simulator Elite Real Turbo Muin B+ with power measurement possibilities. Thermal measurements were done always on the same sportsman in the same stage of his traning cycle (always in the middle of week) and similiar environment conditions.

In result some dependences between training parameters and body core temperature were found. Moreover important information are obtained not only from internal temperature, but also from temperature distribution changes observed on the tops. It seems that thermal imaging can be helpful in sport clothes assesment. Results may give some new information, which will be useful for sportsmen to choose the best top and protect organism thermoregulation mechanisms.

PAINFUL ELBOW SYNDROME IN THERMAL AND MUSCULOSKELETAL SONOGRAPHIC IMAGING

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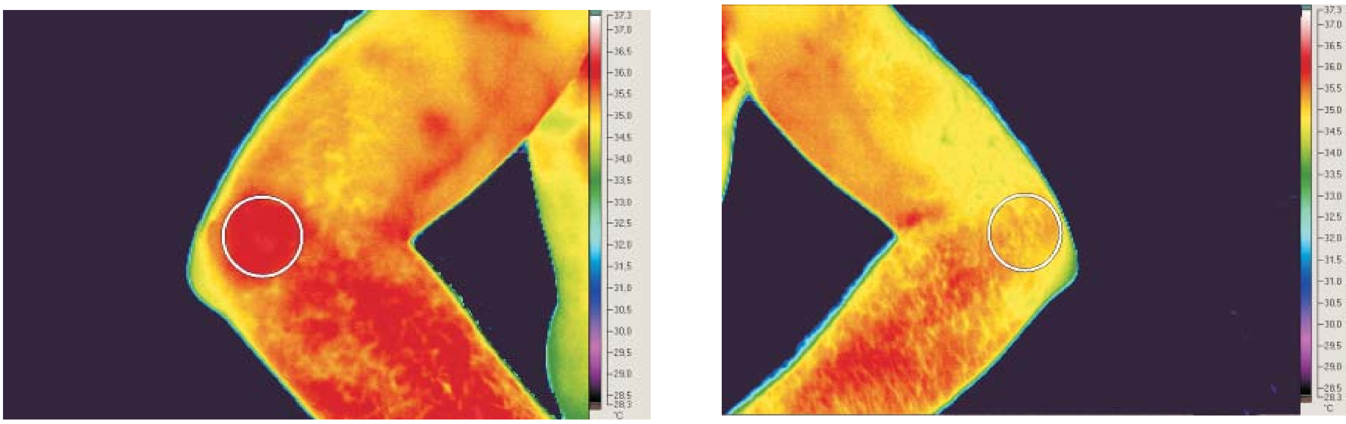
INTRODUCTION: The human elbow is the compound of 3 articulations: the humeroradial articulation - spherical shape, the proximal radioulnar articulation - cylindrical shape, and the pivot-like humeroulnar articulation. There are seventeen muscles crossing the elbow joint. The articular capsule has several recessi: posterior, anterior, anular (periradial), under the lateral ligament, and under the medial ligament. Furthermore, there are two plications - plica humeroulnaris, plica humeroradialis = lateral synovial fringe has a moon-like shape - encroaches the joints, has a meniscus-like appearance, imitates radial epicondylitis, and can cause disabling and cracking in the joint. Ligaments: lig. collaterale laterale, lig. anulare radii, lig. collaterale mediale, lig. epitrochleoradiale, lig. quadratum, chorda obliqua. There are fourteen bursae described within the elbow area. Some of these are constantly present, some only occur in a certain percentage of cases:

A. bursae mucosae cubitales anteriores - 4.
B. bursae mucosae cubitales posteriores - 6.
C. bursae mucosae cubitales laterales externae - 2.
D. bursa mucosa cubitalis lateralis interna - 1.
E. bursa mucosa cubitalis interossea - 1.

The most common causes of painful elbow syndrome include medial epicondylitis and lateral epicondylitis. Other causes of elbow pain: ganglia, cysts, epitrochlear lymphadenopathy (medial elbow), paraosteal lipomas, improperly consolidated fracture, partial tendon rupture of the m. biceps brachii, m.brachialis, m. triceps brachii, ulnar nerve instability, snapping triceps syndrome, os supratrochleare dorsale, osteochondritis dissecans capitulum humeri, Panner's disease, hidden fractures, entrapment syndromes caused by compression of n. medianus, n. radialis, n. ulnaris.

COHORT AND METHODOLOGY: Our work presents a retrospective study, which only included the patients with the painful elbow syndrome who were admitted for therapeutic purposes

Figure 1
Typical thermal image of lateral epicondylitison the right side, normal findings on the left side



between January 2013 and December 2015, and underwent a complete clinical, myo-skeletal, thermal imaging and sono- musculo-skeletal examination. Total number of patients who underwent a complete examination cycle was 43, of whom 8 patients had problems on both sides and 3 of them were affected medially and laterally. Thus, results in the total of 60 painful findings in the elbow region.

RESULTS: Of the total number of thermal imaging findings, 51 were cases of increased thermal activity, 4 were findings of decreased thermal activity, and 5 cases exhibited normal thermal activity. Thermal imaging sensitivity exhibited 91.7% efficiency. Of the total number of musculoskeletal sonogram imaging examinations, 45 were positive and 15 were negative. Musculoskeletal sonographic imaging exhibited 75% efficiency. Topographic anatomy findings: epicondyles: 34 cases = 56.6%, other findings (osteophytes, calcifications, arthroses, cysts, bursae, ruptures, abruptions, corpora libera, fractures...): 26 cases = 43.4%. In the case of epicondylitis, the thermal imaging methods showed higher sensitivity than sonogram imaging methods. In the case of other findings (osteophytes, calcifications, arthroses, cysts, bursae, ruptures, corpora libe2ra, fractures...), sonographic imaging showed higher sensitivity compared to thermal imaging.

CONCLUSION: Epicondylitis is considered as the primary cause of elbow pain. In reality, however, they only represent a little over 50% of all the cases. Less than half of all the elbow pain syndrome cases point to a highly variable cause and their exact specification without the use of imaging methods is difficult. Thermal imaging diagnostics is highly sensitive; nevertheless, further specifications require additional sonomusculoskeletal examinations, or using other imaging diagnostic methods.

EFFECT OF ANTI-INFLAMMATORY CREAM ON SOCCER PLAYERS SKIN TEMPERATURE (T_{SK}.)

Alberto Serrano Colodrón[1], Danilo Gomes Moreira[1,2,] Manuel Sillero-Quintana[1].

1 Faculty of Physical Activity and Sports Sciences (INEF). Technical University of Madrid, Madrid, Spain.
2 Federal Institute for Education, Science and Technology of Minas Gerais, Campus Governador Valadares, Brasil;

Infrared thermography (IRT) is a technology currently used for injury prevention in sports and to evaluate the effects of exercise in the athletes. The usage of creams is considered as one of the influence factors of thermography.

The objective of this work is to study the effect of the anti-inflammatory cream Traumeel on the lower limb of soccer players using IRT.

The sample consisted on 18 amateur soccer players of the team Santa María Caridad from Madrid. The anterior side of the lower extremity was measured by thermography using anti-inflammatory cream (Traumeel) on one, both or none of the players' knees. Thermograms were analysed by the software Thermohuman and ThermacamReporter. After testing the normality of the data, ANOVA was used to check the temperature of the skin (Tsk) of the different registered variables to prove the effect of the cream. Student - t analyses were run to check the acute effect of the cream and the training.

Results showed that the use of Traumeel did not decrease the Tsk after 10 minutes of its application, that the soccer training decreased the knees' temperature on 0.7°C and that decrease of the temperature was compensated by both monolateral or bilateral application of the cream.

THERMAL MAPPING OF SKI-RUNNERS DURING ENDURANCE TRAINING.

Mariusz Binek [1,2], Zofia Drzazga[1,2], Ilona Pokora [3]

1 Department of Medi-cal Physics, Institute of Physics, University of Silesia, Katowice ul. Uniwersytecka 4.
2 Department of Medi-cal Physics, Silesian Intercollegiate Center for Education and Interdisciplinary Studies, Chorzów ul. 75 Pulku Piechoty 1A
3 Department of Physiological and Medical Science, Academy of Physical Education in Katowice, Katowice ul. Mikolowska 72A

This work presents thermal mapping of ski-runners during endurance training for efforts on threshold strength taking into account the muscles the working the most intensively while running. These sportsmen used the wellness treatments consisting of taking a bath in a Finnish dry sauna 3 times a week for two weeks in the preparatory period.

Thermograms of 7 ski runners (students of the Katowice Physical Education Academy) were registered before and after one hour running on the treadmill on a threshold load. The thermograms of chest, back as well as upper and lower limbs were performed in conditions suitable for thermographic imaging. The mean temperature for selected muscles zones were analyzed using program Statistica 12.

Thermal analysis showed the higher temperatures for the trunk muscles, especially for the pectoralis major, than the leg muscles with the lowest values for the knees. In general, an endurance training reduced the body temperature of the trunk muscles in the range of 0.5-2 ° C and lower limb muscles about 0.2-0.7 ° C, what is probably due to sweating of the athletes. Statistically significant differences between mean temperatures before and after training were found only for the trunk muscles, that is: trapezius muscle, deltoid muscle, pectoralis major, serratus anterior, biceps brachii, trapezius muscle (back), latissimus dorsi. In the lower limb muscles a slight decrease of temperature was observed except the knees, where even a slight increase in temperature could be observed after training.

It is worth to note that the biggest negative changes of temperature were observed in the upper part of the body of ski runners, probably because of a larger amount of sweat glands than in low limbs. It seems that there is no clear correlation between the temperature changes of muscles and use them during exercise running. Further research and deeper analysis is required

Letter to the editor

THERMOLOGY IS THE BASIS OF MEDICINE SINCE ANCIENT TIMES

Dear Editor,

recently, you published an editorial article with the title "Does thermology belong to complementary medicine?"[1]. In this article, the important question was raised, how the place of thermology in the scientific spectrum should be defined. You argued that proceeding from the fact that the consideration of the definitions of both thermology and complementary medicine might help to find a correct answer to this question.

In my opinion, the clue may lie also in the history of the emergence and development of life on Earth.

The creation of a thermal imager, which allows a person to image the living and non-living nature based on their emissions radiation in the infrared range of the electromagnetic spectrum, was predetermined by the Almighty. Infrared light remains non- visible for almost all animals, and they usually do not sense heat through biological optical sensors. However, an infrared detector makes the world visible even in the total absence of light, that is, in total darkness. This is due to the fact, that thermal energy is everywhere, at any time. The intensity measure of heat is temperature, a basic quantity in physics that is often explained as the mean of the energy of the translational, vibrational and rotational motions of matter's particle constituents. Intensities are seldom equally distributed in a heat volume and the heat flow directed from high towards low temperature levels, is the mechanism to equalize differences in temperature. At the interface between air and solids or fluid, heat transfer occurs by infrared radiation. In this condition, all living organisms and all inanimate objects emit heat rays. In living systems, the emittance of heat rays is related to their body heat content that results from metabolic activities and heat gain from external sources.

In this context, it is not surprising that during evolution, some animals developed biological sensors for "seeing" heat rays enabling them, much earlier than humans, to detect distant heat sources within their environment. Infrared rays were first detected in the beginning of the 19th century [2], and apart of few attempts in the second half of the 19th century and in the early 20th century to measure infrared radiation from humans [3], the unmasking of heat rays, invisible to humans, became possible in the nineteen-sixties when infrared thermal images were recorded more regularly.

Many scientists propose that all living and nonliving is universally dependent from temperature. The Swedish scientist Svante Arrhenius was the first who established the influence of temperature on the rate of chemical reactions. However, at that time (at the end of the 19th century), he could not "see" the thermal image of interacting compounds during chemical reactions. It took another 100 years, until thermal imaging allowed us to see everything around us in all the diversity of local temperature.

In my personal understanding, temperature is of great importance for the manifestation of life: the presence of life depends on temperature in all representations of the micro- and macro world. Man is no exception: life, health and reproduction of people depend very much on the temperature of the ambient and internal environment. Moreover, the change in the metabolism and function of each cell, each part of the human body depends, on the one hand, on their local thermal environment, and on the other hand, any change in the heat content leads to heat transfer which is, dependent on the boundary conditions, achieved by infrared radiation.

In recent years, it has been shown that drugs have different effects in dependence of temperature [4]. The distribution of subcutaneously injected solutions with a different than local tissue temperature can easily be imaged by a thermal camera and otherwise invisible structures such as the subcutaneous veins become visible [5, 6, 7].

From time immemorial, the body warmth of a person was identified as a normal state of his health, a "hot" body or a "hot" part indicates inflammation and disease, and a cold body - as a sign of death. For that reason, a mother starts to measure the child's body temperature by all means available to her, when she suspects the onset of illness. But only in recent years it became possible to see on the display of a thermal imager, the temperature image of a living person in healthy condition, at the beginning and during illness, at birth and after death.

At present, we are witnessing the rapid growth of thermographic applications in medicine, as infrared diagnostics in therapeutics, surgery, orthopedics, angiology, phlebography, dermatology, oncology, dentistry, obstetrics and gynecology occur in front of our eyes. At the same time, thermal imaging is modifying our ideas about human health and disease, expands the possibilities and enhances the safety of radiation based diagnostics, improves health monitoring and assessment of the quality of medical care provided in various fields of medicine, including critical situations. All this testifies that thermal imaging will very soon firmly occupy one of the central places in medicine and very soon thermo- grams of all parts of the body recorded in disease, will appear in medical textbooks and reference books next to ordinary photographs and they will not be inferior to them in information content.

Due to the universal use in medicine infrared diagnostics is not inferior to ultrasound and X-ray examination. At the same time, thermal imaging has a significant advantage - it is safe. I believe that gradually due to the growing know- ledge about the thermal image of the human body in various areas of clinical medicine, the thermal imager will very soon become a common and routinely used tool to our eyes in assisting diagnosis, monitoring health conditions, prediction of disease and assessment of the quality of care.

The only requirement is, to have patience and wait. Very soon the amount of information derived from thermal imaging will increase and reach a critical level. This will give a new quality to thermology and the place of thermology in science will be changed from complementary and alternative medicine to mainstream medicine, since thermology has been the basis of medicine since ancient times. Simply, a person who does not use a thermal imager, remains "blind" for thermal radiation of the electromagnetic spectrum. A thermal camera provides a window that traces the effects thermal energy in animated and non-animated matter for all of us.

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Aleksandr Urakov
Izhevsk State Medical Academy,
Izhevsk, Russia

RESPONSE TO ALEKSANDR URAKOV

Dear Aleksandr Urakov !

You are the first who followed my invitation to share thoughts and ideas about the place of thermology in the spectrum of sciences, and I thank you for your contribution. I fully agree with you that temperature as basic quantity in the science of physics and all matter, irrespective of living or unanimated, must follow the laws of physics.

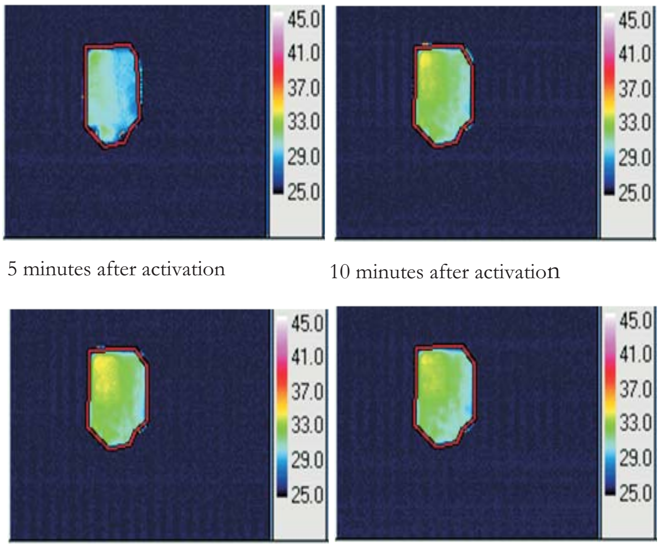
I also agree that currently a increased research activity in medical themography can be noted, and the quality of this research is constantly improving. Although most of the the fields for the use of infared thermal imaging in medicine have already been anticipated in 1964 [1], the better performance of modern equipment may now open new fields of application.

Before your enthusiastic prognosis of a bright future for medical thermography is fullfilled, a clear position must be found on the role of thermal energy in the animated nature. Body temperature, a measure of intensity of the body's heat content, is a phenomenon associated with life, but **not** the cause of life. None of the manifold forms of energy can be used to initiate or restore life in an organism, but all forms of energy can destroy life. All modelsof medicine that consider any form of energy and particularly thermal energy as a kind of "vis vitalis", must be clearly classified as complementary, because a specific biological function of heat is neither defined nor considered in biology. Consequently, thermal signatures of diseases or health exist only in complementary medical system.

This is not in contradiction to the fact, that animals developed defense mechanisms against heat load or heat loss that allowed survial in an environment of variable ambient temperatures. An infrared imager can capture temperature changes on the animal´s surface, which can be understood as responses to the thermal ambience. However, heat flows along of temperature gradients and does not follow preformed anatomical structures. Again, we must be very carefully in interpretion of temperature phenomenons on the surface if we want to avoid the trap of complementary medicine.

Caution is also recommended when we look on chemical reactions and their temperature dependence. Of course, we cannot see Arrhennius equation which describes the influence of temperature on the rates of chemical reaction [2]. However, if a exothermal chemical reaction with suffienct amount of transformed mass is observed, the heat generated results in a temperature trace on the surface of the compounds transformed. For example, in self-heated pads which are currently used as treatment option for muscle pain, the focusof the exothermal reaction can easily detected by a thermal camera.

In figure 1, the surface temperature of a self-heat ed pad is documented over time of 20 minutes at an interval of 5 minutes; The small temperature increase might be caused by non sufficient shaking. If activated in correct way, heat generation may last up to 5 hours.Figure 2 shows the mean, maximum and minimum temperature of another self heated pack observed for 511 minutes



5 minutes after activation

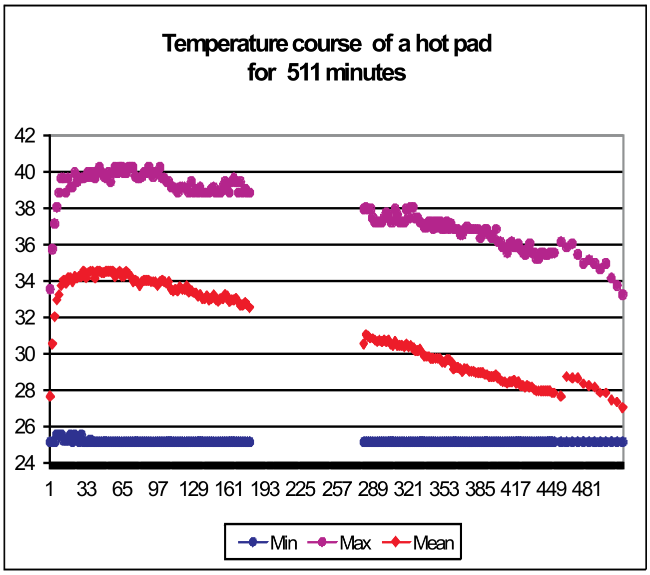
10 minutes after activation

15 minutes after activation

20 minutes after activation

Figure 1
Temperature course of a self-heating pad after slight and non sufficient shaking of the pad

However, the human metabolism is much more complicated than a mixture of iron powder and salt, and we should forget the idea that somewhere in the body some tissue starts to act as little oven and that the heat produced by such a tissue becomes visible on the skin overlying the heat source Such concepts cannot remove the label of complementary medicine for medical thermography.



Nevertheless, I see a chance for thermal image to become a recognised and valued method in mainstream, science based medicine. It is out of debate, that cutaneous temperature phenomenons are associated with symptoms of defined disorders, but a systematic registration of both clinical symptoms and temperature findings is not yet available. Even the few studies reporting skin temperature distribution of healthy subjects suffer from the lack of generally agreed standards for imaging and evaluation

[3,4]. A high standard of image recording and evaluation combined with sound medical explanations why an obviously disturbed distribution of skin temperature is commonly associated with symptoms of defined disorders might be a sucessful way to establish medical thermography as a recognised part of science based medicine.

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Kurt Ammer.

Editor in Chief, Thermology International.
Vienna, Austria

News in Thermology

EAT board meeting on 22.04.2017 in Zakopane, Poland

The EAT board meeting has started at 16:55 with the presence of all elected board members and Prof. James Mercer as invited member. The president welcomed everyone in the meeting and commented the presence of all EAT board members. The second and third points of the meeting were the interim reports of the secretary and the treasurer correspondingly. The forth point of discussion was the next EAT congress that will take place in London at National Physical Laboratory (NPL) from 4th to 9th July 2018. For the event, it is confirmed the co-sponsorship of the Institute of Physics in Engineering and Medicine (IPEM) and an attempt will be made to have it with the Royal Photographic Society (RPS). The EAT 2018 congress registration will be managed by the NPL, the extended abstracts (about 2 pages) will be managed by the EAT and electronically submitted through a website. The submitted extended abstracts will be assessed and the best submissions will be selected for publication in a special issue of Physiology Measurement. The final day of the congress, Saturday, will be spent in a visit to the Hampton Court Palace.

The fifth point of discussion was the pre-congress course that will take place on the 4th of July 2018 at NPL and will be run by the EAT, being coordinated by Adérito Seixas.

The status of the Thermology International journal was the sixth point, in which it was enforced that more contribution is needed from the EAT members and EBSCO are willing to include the journal in Medline with full text and they might provide the DOI for the articles.

The seventh point was devoted to the new EAT website, which is prepared for having authentication, that will be the same of the Thermology International access and the materials that will be made available to the authenticated members is under discussion. Any suggestions can be sent to Ricardo Vardasca.

In the last point of discussion, any other matters, it was decided that the EAT board will meet next in the 11th November 2017 in Vienna, Austria. Prof. Anna Jung will organise the XXII meeting of the Polish Society of Thermology joint with the EAT in Poland at Zakopane from the 13th to 15th April 2018 and the following EAT board meeting will be happening there.

The meeting was interrupted for dinner at 18:20 when the point 4 was being discussed and resumed at 19:10, being closed at 22:30.

Ricardo Vardasca, EAT secretary

Structure for the pre-EAT 2018 Congress Introductory Thermography Course

After reviewing all the courses that were taught in the past, trying to fulfil the expectations of those searching for a course to learn or increase the skills necessary to use thermal imaging, the EAT Board decided the final structure of the course in the last EAT Board Meeting during the XXIth Meeting of the Polish Association of Thermology in Zakopane.

Programme (4th July 2018)

9:00 Registration

9:10 Opening of the course (Kevin Howell)

9:15 Physical principles of heat transfer (Ricardo Vardasca)

9:45 Principles of thermal physiology/skin blood perfusion (James Mercer)

10:45 Coffee break

11:00 Standardization of thermal imaging, recording and analysis (Kurt Ammer)

12:00 Quality assurance for thermal imaging systems (Rob Simpson)

12:30 Producing a thermographic report (Kurt Ammer)

13:00 Lunch

Practical Session

13:45 Provocation tests (James Mercer and Manuel Sillero)

14:45 Image analysis (Kurt Ammer and Ricardo Vardasca)

15:15 Coffee break

15:30 Hands-on supervised practice (all course teachers)

16:30 Educational resources (Adérito Seixas)

16:45 Closing

A detailed review of the history of thermal images courses provided by EAT members or on behalf of the EAT is in preparation and will appear in one of the upcoming issues of Thermology international.

Aderito Seixas, EAT Board Member

New listing of Thermology international

Last year, the publisher Elsevieer confirmed that the journal "Thermology international" will continousely be listed in the database Embase/Scopus. Recently, the journal editor received an invitation from EBSCO, to include Thermology international in their scientific database in exchange for a licence that grants the non-exclusive right and license to reproduce and distribute the journal content. For that purpose the content may be adapted to allow compatibility with the database and accessibily to search engines.

The proposed database is EBSCO Medline with full text. After discussion with the EAT Board and representatives of Uhlen-Verlag agreement was achieved. A licence agreement was signed and volume 27, number 1 is already uploaded to the EBSCO server.

The editor is convinced that this new partner will increase the visibilty of the journal, may attract more submissions and support the endeavour to establish thermal imaging as recognised technique for assessment and monitoring of health conditions.

Kurt Ammer, Editor of Thermology international

2017

July 2nd-6th, 2017
2nd Asian Conference on Quantitative InfraRed Thermography in Daejeon, Korea

Venue: Interciti Hotel, 92 Oncheon Ro, Yuseong-gu Daejeon, 34189, Rep of Korea

Sessions of medical interest

Monday 3rd July

9.30 to 10.50 Medical Thermography 1

11.10 to 12.30 Medical Thermography 2

Tuesday 4th July

16.30 to 18.00 Bio Thermography 1

Thursday 6th July

10.00 to 11.30 Bio Thermography 1

Furter information
www.qirtasia2017.com

Contact : Prof Wontae Kim
Div. of Mechanical & Automotive Engineering Kongju National University, Cheonan,Chungnam, 30080, Rep of Korea, Email: kwr@kongju.ac.kr

July 17th - 19th, 2017
13th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT2017) in Portoroz, Slovenia

Conference website: http://edas.info/web/hefat2017/

Abstract submission information:
https://edas.info/web/hefat2017/cfp.html

September 15th -17th, 2017
AAT Annual Meeting in Greenville, South Carolina, USA

A Pre-Meeting Physicians Member Certification Course will occur on September 15th

2017 Program and Events

Saturday, September 16th, 2017

08:00am - Registration

08:30am - *Welcoming Remarks*
Jeffrey Lefko, Greenville, SC, Executive Director, American Academy of Thermology

8:35-9:20am *Keynote Address*: Thermal Patterns in Disease and Condition Monitoring
Marcos Brioschi, M.D., Professor of the Department of Neurology, Hospital das Clinicas da Universidade de São Paulo, Brazil.

9:20am - 10:45am *Session 1: Community Education - Promulgating Thermal Imaging Inside and Outside*

9:20am-9:40am Update on the AAT Thermography Atlas of Medical Conditions
Jan Crawford, BSN,
Member, AAT Board of Directors

9:40-10:00am Equilibration and Cold Challenge Testing Techniques
Robert Schwartz, MD, Greenville, SC,
Chairman, American Academy of Thermology

10:00am-10:30am Bridging the Thermography Gap- Public and Physician Outreach
Christine Horner, MD, San Diego, CA,
Member, AAT Board of Directors

-10:30-10:45am Panel Discussion

10:45am -11:15am Break

11:15am -12:30 pm *Session 2: Advancements in Infrared Imaging Cameras, Equipment, and Translational Applications*

11:15-11:30pm Physics-Importance of Sensivity in Camera Selection
Robert Schwartz, MD,
Chairman, AAT Board of Directors

11:30-11:50am Adsorption/Absorption Thermography-Concurrent Use with Steam for Finger Print Identification
Michael L. Myrick, PhD., Professor, Department of Chemistry and Bioc hemistry, University of South Carolina, Columbia, SC

11:50am-12:20pm Forensic and Sports Medicine Applications for Thermal Imaging
Marcos Brioschi, MD, President of Brazilian Medical Thermology Association

Q&A/ Panel Discussion

12:30pm - Lunch (provided)

1:30pm -3:00pm *Session 3: Clinicians Corner: Thermography as an Extension of the Physical Exam for Use in Diagnosis and Treatment*

1:30-2:00pm Breast Cancer Prevention
Christine Horner, MD,
Member, AAT Board of Directors

2:00- 2:20PM Integrating a Thermal Imaging Lab Within a Medical Practice: Clinical Applications and Practical Pitfalls
George Schakaraschwili, MD, Aurora, CO,
AAT Atlas Editor

2:20-2:40PM How I Learned to do Interpretations
Eric Ehle, DO, Amarillo, TX, Member, AAT

2:40-3:00pm Thermal Imaging: How It Changed My Approach to Patient Care
Matthew Terzella, MD, Greenville, SC, Member, AAT

Panel Discussion

3:00pm - Break

3:30pm -5:00pm *Session 4: Thermal Imaging Advances and Development Issues and Challenges*

3:30-4:00pm "Picture This.." The Independent Technician's Role in Properly Conducting Exams Which Contribute to Physician Diagnostic Information
Jan Crawford, BSN, Member, AAT Board of Directors

4:00- 4:20pm Thermal Images among Different Animals
Dr. Tracy Turner, DVM, Elk River, MN,
Member, AAT Board of Directors

4:20-4:40pm Use of Thermographic Imaging: An Internist's Perspective
Tashof Bernton, MD, Aurora, CO,
Member, AAT Board of Directors

4:40-5:00pm Integration of Thermography into PMR, Educational Components of Medical Residency Programs
Bryan O'Young, MD, Geisinger, PA.,
President, AAT Board of Directors
Sam Wu, MD, Geisinger, PA.,
Member, AAT Board of Directors

5:00pm - Annual Scientific Session Wrap Up and Remarks

5:30pm - Session Ends

Shuttle back to Crowne Plaza Hotel

6:30- 7:30pm - Meet and Mingle Reception with the Leadership at the Crowne Plaza Hotel

Presentation of AAT 2017Achievement Award

Sunday September 17th, 2017 Committee Meetings

07:30am - Shuttle from Crowne Plaza Hotel

08:00am - SPECIAL THERMOGRAPHERS WORKSHOP: How to Build and Grow Your Thermology Practice - Open for all Attendees

Marketing/Promotion/ Communication Tactics and Plans
Office Practice Issues and Challenges
Website Development
Q&A Session
Networking, Information Exchange

09:30am -10:30am *Open General Session (for all attendees)*

Topics to be Discussed -Membership, Education, Advocacy, Website Development

10.30 Shuttle returns to Crowne Plaza Hotel

10:45am - 12:45pm Board of Directors Meeting (Board Members Only)

Further information

American Academy of Thermology

500 Duvall Drive

Greenville, SC 29607

Info@aathermology.org

website: http://aathermology.org/annual-session-program/

September 27th - 29th, 2017
14th AITA 2017 (International Workshop on Advanced Infrared Technology and Applications) in Québec City, Canada

Conference venue: Université Laval

In the 14th AITA edition, special emphasis will be given to the following topics:

Advanced technology and materials
Smart and fiber-optic sensors
Thermo-fluid dynamics

Biomedical applications

Environmental monitoring
Aerospace and industrial applications
Nanophotonics and Nanotechnologies
Astronomy and Earth observation
Non-destructive tests and evaluation
Systems and applications for the cultural heritage
Image processing and data analysis
Near-, mid-, and far infrared systems

AITA 2017 is pleased to announce the following keynote speakers:

Dr. Paolo Bison, CNR - ITC, Italy on "IR thermography applied to assess thermophysical properties of Thermal Barrier Coatings".

Dr. Roman Maev, University of Windsor, Canada on "Cultural Heritage, an IR Perspective".

Dr. Andreas Mandelis, University of Toronto, Canada on "Photothermal Coherence Tomography (PCT): Three-Dimensional Imaging Principles and Non-Invasive Biomedical, Dental and Engineering Materials NDI Applications"

Information: http://aita2017.gel.ulaval.ca/home/

AITA Secretariat
e-mail: quebec@gel.ulaval.ca

18th-20th October 2017
VipIMAGE2017,

VI ECCOMAS Thematic Conference on Computational Vision and Medical Image Processing in Porto, Portugal

Thematic Session on
Infrared Thermal Imaging in Biomedicine

Topics of interest include (but are not restricted to):

• Botany
• Camera technology
• Dentistry
• Dermatology
• Endocrinology
• Fever screening
• Forensic and evidence medicine
• Integrative medicine
• Oncology
• Orthopaedics

- Paediatrics
- Physiotherapy
- Rheumatology
- Sports medicine
- Surgery
- Temperature measurement
- Thermal image processing
- Thermal physiology
- Vascular medicine
- Veterinary medicine

The proceedings book will be published by Springer under the book series "Lecture Notes in Computational Vision and Biomechanics" and indexed by Elsevier Scopus

A special issue of the Taylor & Francis international journal "Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization" , indexed in ISI Thomson Reuters, Elsevier Scopus and dblp, will be published. All authors of works presented in VipIMAGE 2017 will be invited to submit an extended version to the special issue

Further information
Www.fe.up.pt/vipimage
Web.fe.up.pt/~vipimage/nav/conference/sessions.htm

Organizers

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MEETING ANNOUNCEMENT

14th European Association of Thermology Congress

"Thermology in Medicine:

Clinical Thermometry and Thermal imaging"

4th – 7th July 2018

National Physical Laboratory, Teddington, London

United Kingdom

LONDON 2018

XIV E.A.T. Congress, 4-7 July

www.eurothermology.org

The EAT and the National Physical Laboratory are delighted to invite you to participate in the XIV EAT Congress in Teddington, London, United Kingdom from 4th to 7th July 2018.

The European Association of Thermology exists to promote, support and disseminate research in thermometry and thermal imaging in the fields of human and veterinary medicine and biology. We do this through our peer-reviewed journal Thermology International, regional seminars around Europe, and our flagship Congress, which takes place every three years.

Following on from the most recent meetings in Porto (2012) and Madrid (2015), the Congress heads back to northern Europe for 2018 to the National Physical Laboratory (NPL) in the United Kingdom.

The EAT Board looks forward to welcoming you to NPL's world class conference facilities in the summer of 2018.

Dr. Kevin Howell
EAT President
Chair, 2018 EAT Congress Organising Committee

VENUE.

The National Physical Laboratory (NPL) is the United Kingdom's National Measurement Institute and is located in Teddington, south west London, approximately 30 minutes by taxi from Heathrow Airport and a 30 minute train journey from London Waterloo. www.npl.co.uk/location.

LONDON 2018
XIV E.A.T. Congress, 4-7 July NPL

XIV EAT CONGRESS 4th – 7th July 2018, NPL.

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KEY DATES.

Abstract submission will open online on 31st July 2017, and authors will be notified of acceptance for oral or poster presentation by 29th January 2018.

December 2016. Publication of the First Announcement.
July 2017. Publication of the "Call for Abstracts" document.
31st July 2017. Opening of abstract submission and registration.
29th November 2017. Abstract submission deadline
29th January 2018. Acceptance notification to authors.
26th February 2018. End of Early Registration and deadline for registration of presenting authors.

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KEY MEETING THEMES.

Calibration and traceability in biomedical thermometry

Infrared thermography in biomedicine

Contact temperature measurement

Hardware and software solutions for infrared imaging

Biomedical applications: surgery, dermatology, neurology, vascular and pain syndromes

Thermometry in exercise physiology, rehabilitation and human performance research

Temperature measurement in animal welfare, veterinary applications and equine physiology

REGISTRATION FEES (*)

	Early Registration (Until 26 FEB 2018)	Late Registration (After 26 FEB 2018)
EAT MEMBER	£200	£250
Non-Member	£250	£300
Student (**)	£170	£220

(*) Further information about the registration process will be provided in the "Call for abstracts" document. Registration includes access to all congress sessions, congress lunch and coffee breaks, the Congress Dinner, and a guided visit to the historic Hampton Court Palace on 7th July.

ACCOMMODATION

There are a number of hotels within walking distance of the National Physical Laboratory and Teddington railway station, and even more choice within a 15 –minute radius by train, taxi or bus. Further information about local hotels can be found at http://www.npl.co.uk/contact-us/local-hotels. Early booking in 2018 is advisable!

ACCOMPANYING PERSONS

With central London just 30 minutes away by rail, Teddington is an excellent base for accompanying persons to enjoy the capital city of the UK without the need for an organised tour. All accompanying persons will be invited to join the Congress Dinner and social programme upon payment of the appropriate fee.