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Programme and Abstracts

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20th National Congress of The Polish Association of Thermology in Cooperation with the European Association of Thermology

Gdansk, 4th June 2016

Programme

Abstracts

Programme

Monday, July 4th, 2016

09:00 - 11.00 Session I: Chair: Prof. Francis Ring, Prof. Kurt Ammer

1. *Ring F* (United Kingdom)	The Infrared Controversy 1800 -1840
2. *Ammer K.* (Austria)	Does the type of skin temperature distribution matter?
3. *Wiecek B.*(Poland)	Spectral aspects of IR measurements in biomedical thermography,
4. *Marianovic E., Howell K.* (United Kingdom)	Thermal camera performance at six sites
5. *Gabrhel J, Popracová Z, Tauchmannová H* (Slovakia)	Differential Diagnosis of Growth Pains In Thermal And Musculoskeletal Sonography Imaging
6. Kala R Prodiagnostic - company presentation	

11:00 - 11:15 Coffee break

11:15 - 13:00 Session II Chair: Prof. Anna Jung, Dr Kevin Howell

1. *Seixas A, Silva M, Souto M, Gabriel J, Rodrigues S* (Portugal)	Reporting Body Composition In Thermal Imaging Studies, General Or Local Measures? Preliminary Results.
2. *Sillero-Quintana M., Lopez Diaz de Durana A., Moreira DG, Fereira J.J., Brito C.J.,* (Spain)	Skin temperature response on junior athletes after high intense judo training
3. *Pypkowska A. Szczesniak A, Jung A* (Poland)	The analysis of the cooling process of the breastarea in women under thermographic monitoring,
4. *Trojankowska A, Cholewka A, Rzany M, Stanek A, Sieron-Stolny , Kawecki M, Marcol W*(Poland)	Thermal imaging in the evaluation of the carpal tunnel syndrome
5. *Kluwe B.*(United Kingdom)	Technical Challenges in Infrared Foot Screening
6. BRASTER - company presentation.	

13:00 - 14:00 Lunch

14:00 - 15:00 Session III Chair: Prof Ricardo Vardasca, Dr Armand Cholewka

1. *Liszka G, Englisz B, Knefel G, Kawecki M,Nowak M Stanek A, Sieron-Stolny K. Cholewka A(* Poland), -	Evaluation of hyperbaric oxygen therapy effects in ulceration of cruras studied by thermal imaging and planimetry first annoucement.
2. *Urakov AL, Urakova TV, Kasatkin AA* (Russia),	Infrared thermography to assess the blood donors adaptation to blood loss
3. *Strakowska M, Strakowski R, Wiecek B, De Mey G.* (Poland)	Inverse thermal modeling of tissues - practical application of thermography to perfusion measurement

15:00 - 15:15 Coffee break

15:15 - 16:15 Session IV Chair: Prof. Boguslaw Wiecek ,Prof. Manuel Sillero-Quintana

1. *Vardasca R, Gabriel J* (Portugal) Is the low cost thermal camera FLIR C2 suitable for medical thermal measurements?
2. *Nowakowski A. Kaczmarek M* (Poland) Importance of ADT in medical applications,
3. *Rutkowski P* FLIR company presentation.

16:15 - 17:30 EAT board meeting

19.00 - 21.30 Welcome Dinner

Speakers and Chairmen

Prof Francis Ring Dsc	Medical Imaging Research Unit; University of South Wales, CF37 1DL Pontypridd, United Kingdom
Prof Kurt Ammer MD, PhD	European Asssociation of Thermology, Vienna, Austria Medical Imaging Research Unit; University of South Wales, CF37 1DL Pontypridd, United Kingdom
Ricardo Vardasca PhD	LABIOMEP, UISPA-LAETA-INEGI, Faculty of Engineering, University of Porto, Portugal
Aderito Seixas MSc	Escola Superior de Saúde, Universidade Fernando Pessoa, Porto, Portuga
Prof Manuel Sillero PhD	Physical Activity and Sports Sciences Faculty (INEF). C/ Martín Fierro, 7, 28040, Madrid, Spain
Prof Aleksandar Urakov MD	Izhevsk State Medical Academy, Izhevsk, Russia
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Prof Anna Jung MD,PhD	Military Institute of Medicine, Warsaw, Poland
Prof Antonin Nowakowski PhD	Electronics, Informatics & Telecommunication. Department of Biomedical Engineering, Gdansk University of Technology,Gdansk Poland
Jozef Gabrhel MD	Private Practice for Rehabiltation Medicine, Acupuncture & Thermography.Trencin Slovakia
Ben Kluwe Bsc	University of South Wales, CF37 1DL Pontypridd, United Kingdom
Prof Boguslaw Wiecek PhD	Institute of Electronics,LodzUniversity of Technology, Poland
Aleksandra Pypkowska	Braster S.A.,Warsaw, Poland

Abstracts

IS THE LOW COST THERMAL CAMERA FLIR C2 SUITABLE FOR MEDICAL THERMAL MEASUREMENTS?

Ricardo Vardasca, Joaquim Gabriel

LABIOMEP, UISPA-LAETA-INEGI, Faculty of Engineering, University of Porto, Portugal

Compact low cost infrared thermal imaging systems have been launched to the market in 2015. Their specifications are low, not meeting the minimal requirements suggested for clinical use, although given the relative low cost and portability, they have attracted enthusiasts, which attempted to use it for clinical purposes claiming applicability.

Attention is required and comparative assessment must be performed to raise advisory warning to this enthusiasts in the outcomes given by those low cost and specification systems.

It is aim of this research to acquire thermal images with the FLIR C2 compact system, which has an sensor array size of 80x60, NETD < 100mK and accuracy of ±2ºC, and a FLIR E60sc portable camera, which has an sensor array of 320x240, NETD < 50mK and an accuracy of ±2ºC, and compare the obtained temperature values of regions of interest (ROI).

A total of 12 thermal images were taken with each imaging system from 4 volunteers of 3 different views of ankles following the Glamorgan capture protocol guidelines and 4 ROIs were defined to perform the measurements, which were assessed in terms of mean, minimum and maximum temperature and standard deviation. Examples of images are shown in Figure 1

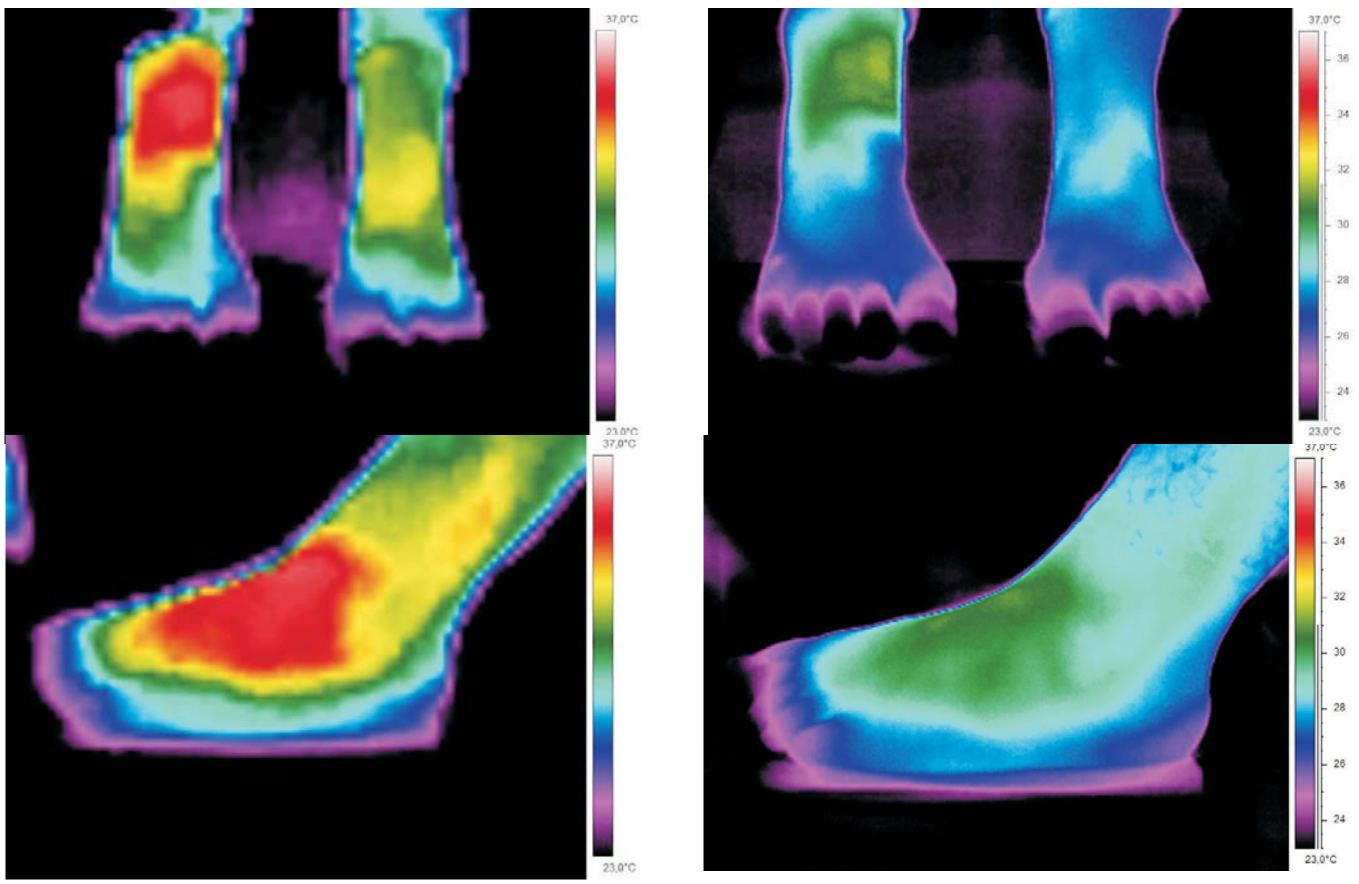
From the obtained results, despite from the good value presented by the correlations between the four quantitative parameters (mean temperature = 0.8037; minimum temperature = 0.8528; maximum temperature = 0.4076; standard deviation = 0.8222) within the two used systems, significant mean differences were found (mean temperature = 0.74±0.72; minimum temperature = 0.16±0.81; maximum temperature = 0.74±1.36; standard deviation = 0.04±0.15), which are able to strongly influence clinical outcomes.

With this, regardless the attractiveness of the price and apparent correlation of measurements obtained, the low sensitivity of the compact costless infrared imaging instruments, they do not offer the minimal guarantees to be able to be used for clinical purposes, and its use is not advised for that purpose.

ACKNOWLEDGMENT

The authors would like to thank Mr. Pedro Rebelo, from MRA Instrumentacao for borrowing the thermal camera FLIR C2 and this research was partially funded by National Funds through FCT - Foundation for Science and Technology under the project (UID/SEM/50022/2013) and the research project NORTE-01-0145-FEDER-000022 SciTech – Science and Technology for Competitive and Sustainable Industries – Research RL3 - Product & Systems Development, funded through the program Portugal 2020.

Figure 1
Thermal images recorded from the same individual with the FLIR C2 (left column) or the FLIR 60sc (right column)



DOES THE TYPE OF SKIN TEMPERATURE DISTRIBUTION MATTER?

Kurt Ammer

European Association of Thermology, Vienna, Austria
Medical Imaging Research Unit, University of South Wales, Pontypridd, United Kingdom

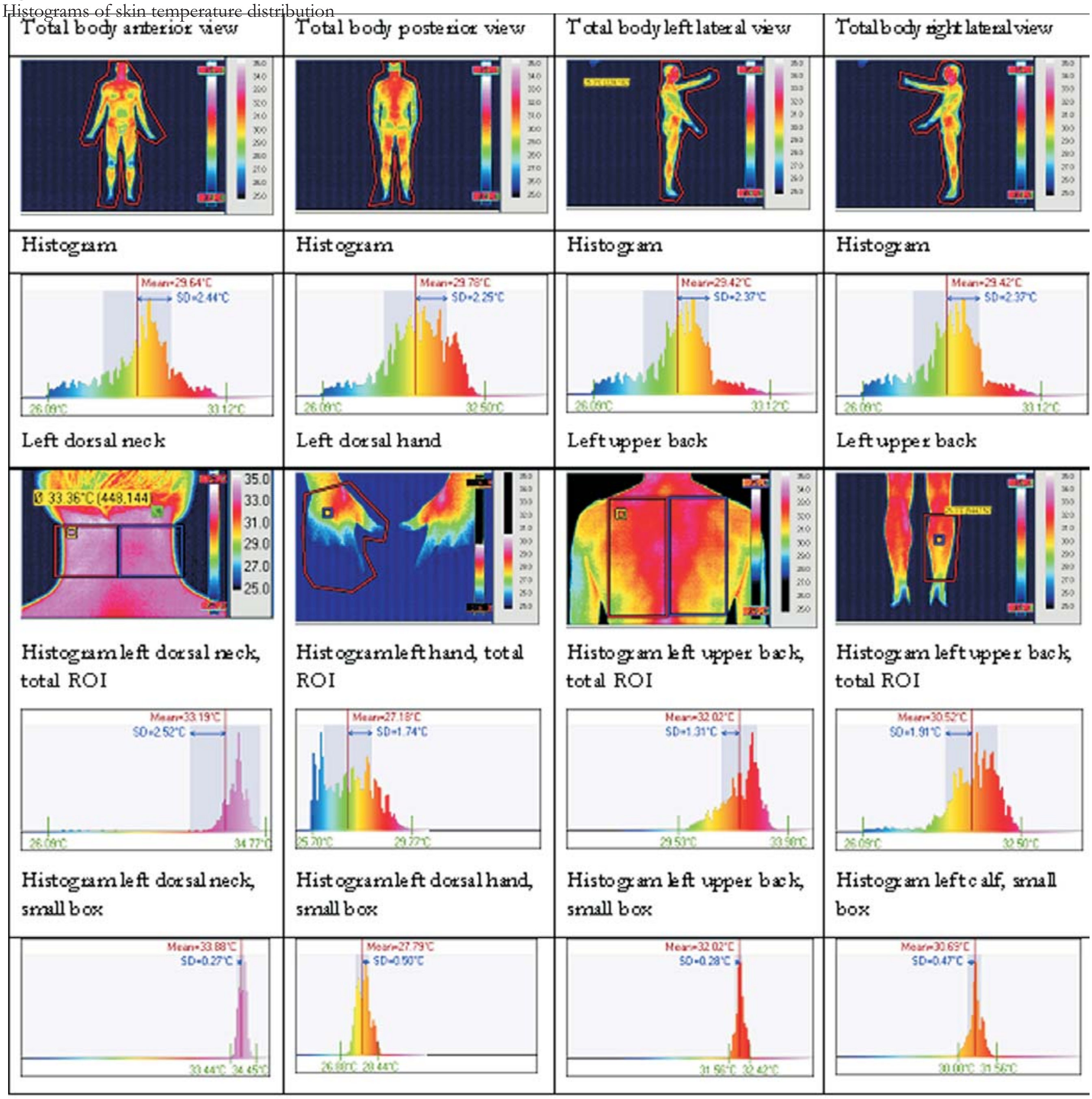
It is generally assumed that skin temperature follows a normal Gaussian distribution in which mean, mode and median are in the same place i.e. the middle of the bell-shaped outline of the distribution. Consequently. regional skin temperatures are described by mean temperature and standard deviation following classical statistics. For allowing explanatory data analysis, skin temperatures [1] should behave like

1. random drawings;
2. from a fixed distribution;
3. with the distribution having fixed location; and
4. with the distribution having fixed variation

If one tests the 4 assumptions above, it turns out that skin temperature data violate 1 or 2 of these basic requirements of a valid statistical analysis.

METHOD: Thermal images were retrieved from the database "Atlas of normal skin temperature distribution" and all total body views, the views "neck (dorsal view)", "upper back", "both hands (dorsal view)" and "lower legs (dorsal view)" from the same subject were selected. Regions of interest were defined with respect to the proposals of the Glamorgan protocol [2] using the software package CTHERM. An additional rectangular measurement area of 900-pixel size was located at the left scapular region, the left ROI of the neck, the left dorsal hand close to the 3rd metatarsal joint and in the middle of the right calf. Mean, standard deviation and histograms of each region were obtained from the statistics sub-programme in CTHERM. Mean skin temperature was estimated using the mean temperatures of the small rectangular boxes in the formula
Tskin= (Tneck 0.28)+(Tscapula0.28)+(Thand0.16)+(Tcalf 0.28)
and compared to the mean temperatures of all total body views.

Figure 2
Histograms of skin temperature distribution



RESULTS: Histograms clearly show, that skin temperature does not follow a Gaussian distribution (figure 2). In most regions of interest, the distribution is skewed to the left. However, the histograms of the small rectangular measurement were close to normal distribution.

Estimated mean skin temperature was 31.49°C, which is about 2 degrees higher than the mean temperature readings obtained from the total body view (anterior view: 29.64; posterior view:29.78; lateral view: 29.42) However, the median of skin temperature in total body views was with 29.61°C close to the estimated value of mean skin temperature.

CONCLUSION: Skin temperature is not normally distributed in large measurement areas irrespective if they enclose the total body or only defined anatomical regions. Better agreement exists between estimated mean skin temperature and the median temperature than with the mean temperature of total body views

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THE INFRARED CONTROVERSY 1800 -1840

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It has been widely reported that infrared radiation was discovered by William Herschel at the age of 61 in England in 1800. Further research into the publications of time reveal that this announcement by Herschel was received with mixed reactions. The president of the prestigious Royal Society in London was delighted to write to Herschel to say that he considered this discovery to be even more important than his earlier discovery of the new planet (Uranus) in 1781. However, the idea that invisible rays were contained within the well known properties of sunlight was to some impossible to accept. The Scottish physicist John Leslie in particular was quick to publish a scathing criticism of Herschel, claiming that this was a disgrace to science.

He had worked for 10 years and was about to publish his opus magnum on radiant heat.

This led to a commissioned retrial of Herschel's experiment with a group of well established scientists. Independent witnesses were also brought in for experiments to be held at The Royal Institution in London in 1801. This did result in a confirmation of Herschel's findings, i.e. that "dark heat" could be detected beyond the red end of the spectrum. Herschel published further papers to compare light and heat, noting that some features were common to both such as reflection and refraction. Others were, however showing differing properties. Then followed the debate on the pluralistic vs the unified theory of radiation.

Subsequently work by the Italian Macedonio Melloni (1798-1854) who with a Fresnel lens was able to detect low levels of heat from moonlight in 1846, and the emergence of differences in wavelength substantiated the presence and properties of what is now termed infrared radiation. John Herschel after his father's death made an image from sunlight by evaporography [1] in 1840 which he termed a Thermogram (figure 3), the term still in use today to describe a thermal image.

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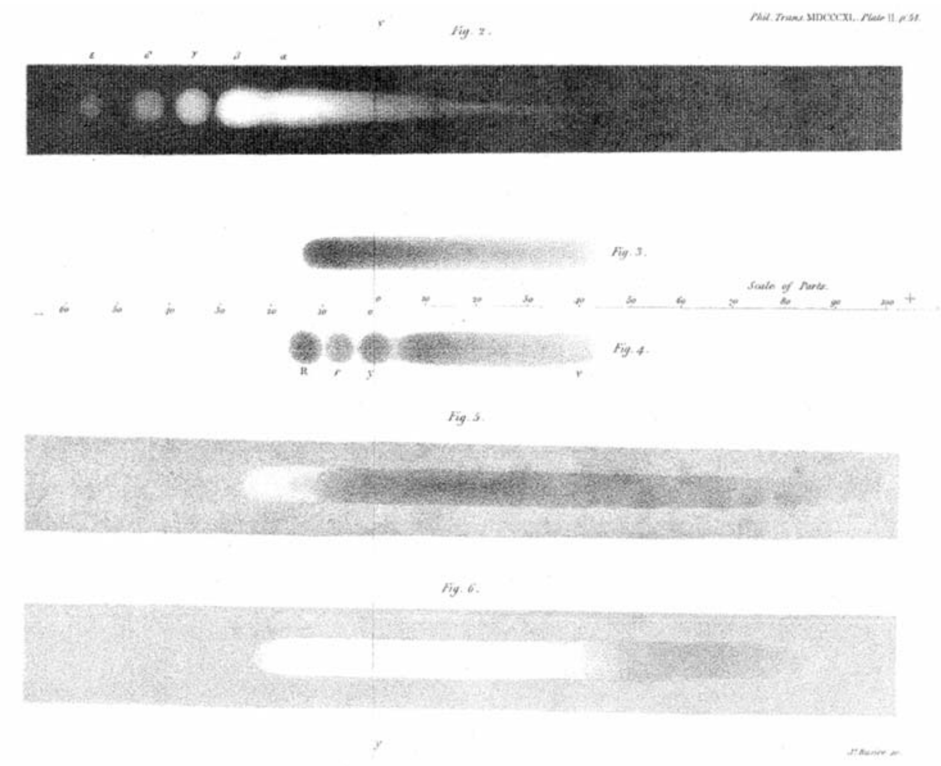
Figure 3
Herschel´s first thermograms



REPORTING BODY COMPOSITION IN THERMAL IMAGING STUDIES, GENERAL OR LOCAL MEASURES? PRELIMINARY RESULTS.

Seixas, A.[1,2], Silva, M.[1], Souto, M.[1], Gabriel, J.[2],Rodrigues, S.[1]

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A recent review [1] has emphasized the possible influence of personal factors in skin temperature measurements. Body composition related variables are particularly important as fat has been pointed as insulator and may affect thermoregulation [2]. Skinfold thickness, fat percentage, lean mass percentage and body mass index are variables that can inform on body composition, however, the question whether to report general measures (e.g. weight, body mass index) or local measures (e.g. skinfold thickness) has not received much attention from researchers. More importantly, the relationship between skin temperature and body composition measures is not well established [2, 3].

The aim of this study was to assess the relationship between skin temperature over the biceps and general and local body composition measures - body mass index, body fat percentage and skinfold thickness.

Eleven healthy subjects (six females) aged 20-32 years were recruited from the local community. Ambient temperature, humidity and air flow were controlled to avoid experimental bias. Anthropometric variables were measured according to the recommendations of the International Society for the Advancement of Kinanthropometry [4]. Before thermal data were acquired, all participants followed a 15 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 anterior view of the arm and one region of interest was defined over the right biceps (figure 4). Thermograms were analyzed with FLIR ResearchIR Max software.

Thermogram analysis revealed a high negative and significant correlation ($r=-0.832$; $p=0.001$) between skin temperature over the biceps and subcutaneous fat percentage and non-significant correlations between skin temperature over the biceps and body mass index ($r=0.134$; $p=0.694$) and biceps skinfold thickness ($r=-0.506$; $p=0.113$).

In this study subcutaneous fat percentage was the body composition measure that correlated best with skin temperature over the biceps. In this sample body mass index and skinfold thickness were not associated with local skin temperature. The results suggest that researchers should be controlling and reporting subcutaneous fat percentage in studies assessing skin temperature in the anterior surface of the arm. More studies are needed to confirm our findings and explore this relationship in other areas of the body.

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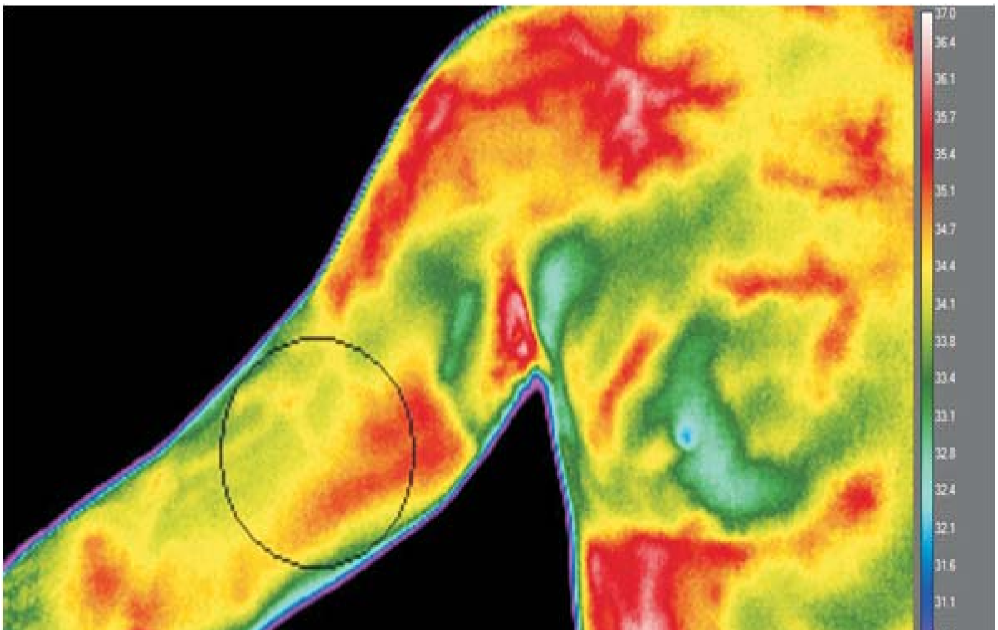

Figure 4: A thermogram with the selected region of interest for the analysis.

DIFFERENTIAL DIAGNOSIS OF GROWTH PAINS IN THERMAL AND MUSCULOSKELETAL SONOGRAPHY IMAGING

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[3] National Institute of Rheumatic Diseases, Piešťany

DEDICATION:
This work is dedicated to the jubillee of our longtime friend and colleague Doc. MUDr. Helena "Vara" Tauchmannová, CSc.

INTRODUCTION: Growth pains were first described by a French physician Marcel Duchamp in 1823. They appear at the age of 2-19; however, their most frequent clinical presentation falls between the ages of 3-5 and 8-12. Their clinical manifestation primarily includes deep muscle pain. Most often the pain appears in the area of thigh, shin, calf, and popliteal fossa. Pain attacks occur in the late afternoon and night hours, lasting from several minutes to hours. Etiology and pathogenesis of growth pains remain unknown. As a result, they belong to the category of per exclusionem diagnoses, i.e. being defined upon excluding other causes such as inflammatory rheumatic diseases, orthopedic disorders, unrecognized trauma, neuromuscular disturbance, endocrine malfunction, malignant diseases, or sympathetically mediated pain.

METHODS: Examination by thermal imaging in both research and clinical practice for assisting differential diagnosis of musculoskeletal pain has been routinely done at our clinic for 30 years. In this period of time, we have completed and analyzed tens of thousands of thermography records of different musculoskeletal system areas. Of these, one third contained thermographic records of lower extremity joints in all projections, with the knee area presenting the largest proportion. The acquired temperature records were analyzed using both the absolute values of thermal parameters and evaluations of thermal images in each of the recoded views. The result of these analyses were specified thermal patterns typical of particular age periods, thermal patterns generated by various types of defects, disorders, or excessive load in sport.

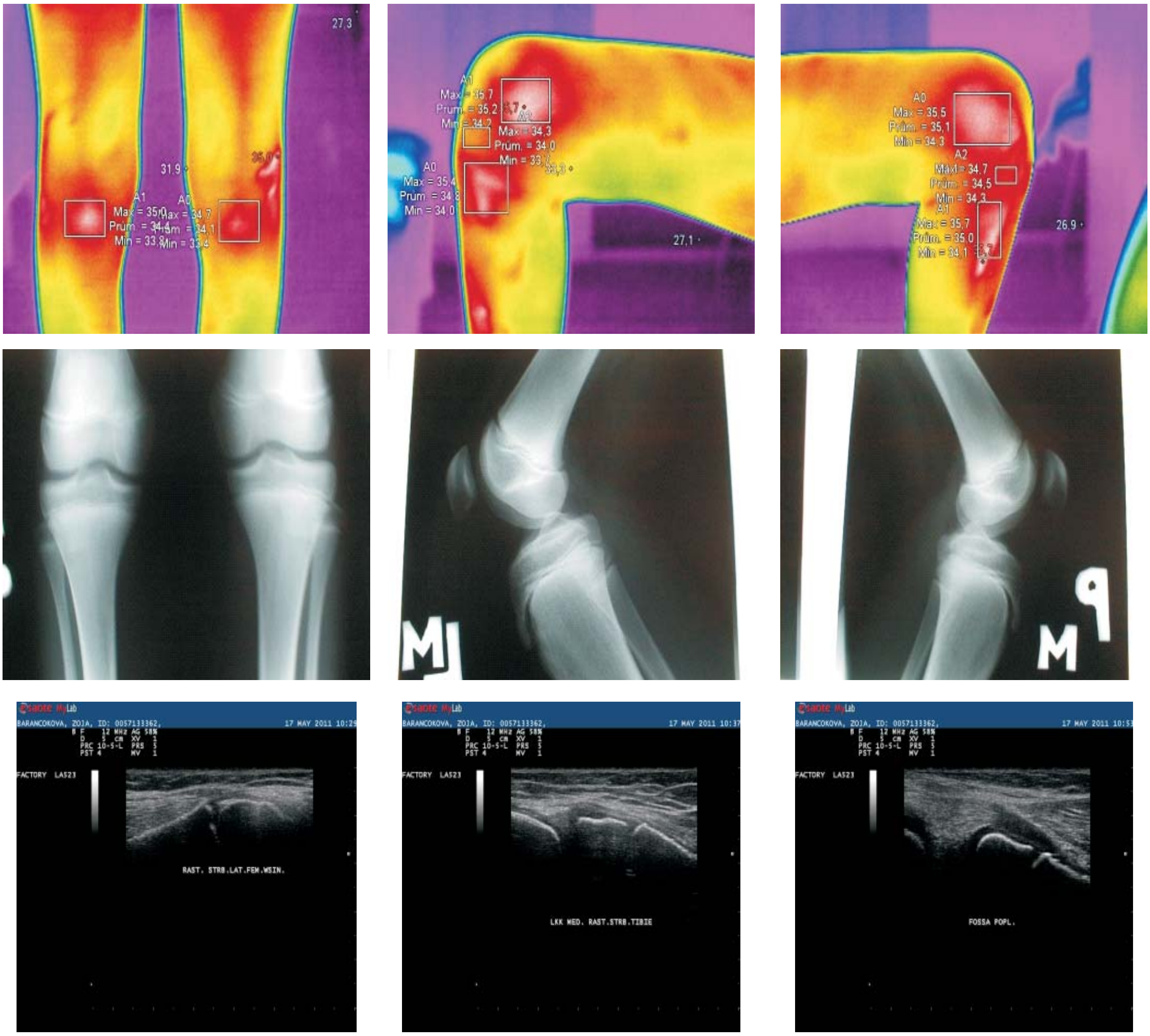

Figure 5
Thermographic (top line), radiographic (mid line) and ultrasonographic (bottom line) in a child with growth pains

By analysing thermal patterns in children with leg pain, labeled with an established diagnosis"growth pains" per exclusionem, we recorded a significantly different thermal pattern from a normal thermal pattern, and from a thermal pattern in adults, especially in the knee area. When continually monitoring knee thermal patterns in adolescent athletes of different sports disciplines, we have noticed that this pattern no longer exists upon completion of physical growth in the monitored individuals. Hence, we do not consider this pattern to be of pathological origin; however, we assume it to be caused by increased temperature in the area of epiphyseal and diaphyseal plates due to their increased metabolic activity when the physical growth is most accelerated.

Since 1992 we made efforts to gradually report our findings in domestic and international thermography conferences [1,2], and also in sports-medicine and rehabilitation symposia [3]. Our data were published in both domestic [4-7] and international journals [8-10] and were part of proceedings books [1, 3. In recent years, a thermography examination complements the classic musculoskeletal sonographic examination. This way we not only obtain the information about the patho- physiology of pain, but about the type and the extent of damage to the soft musculoskeletal structures as well. Between January 8, 2013 and June 28, 2014, we had 29 pediatric patientswith lower extremity pain who underwent differential diagnostic tests at our clinic.

RESULTS: Of the total sample of 29 pediatric patients in whom differential diagnosis was used to examine pains occurring in different lower limb areas, 24 were presented with a specific structural cause, or some sort of patho- physiology behind the cause. A diagnosis of growing pains made per exclusionem can be assigned to five patients. Our paper describes normal thermal patterns and ultrasound findings of different lower extremity sites, thermal patterns and ultrasound findings suggestive of growing pains, and thermal patterns and ultrasound findings of certain types of damage and lower limb disease, excluding growing pains as the core diagnosis.

CONCLUSION: Thermal imaging and musculoskeletal ultra sound examination of individual lower extremity areas may help us differentiate standard findings from findings suggestive of growing pains and also from other serious diseases and injuries to the lower extremity area.

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THERMAL CAMERA PERFORMANCE AT SIX SITES

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[2]Microvascular Diagnostics, Institute of Immunity and Transplantation, Royal Free Hospital, London, United Kingdom

BACKGROUND: To determine the accuracy of the thermal camera measurements in a multi-centre study, a blackbody has been imaged at each of six centres (Salford, Cambridge, Newcastle, Leeds, London and Bath).

METHODS: Measurements of the blackbody were obtained during the thermal camera warm-up period (30 minutes) and at 2°C intervals between 18oC and 40oC. These measurements have been obtained before and following patient visits.

RESULTS: Five of the thermal cameras reached the target temperature of 30°C (±2°C) within the 30 minute warm up period. One camera did not reach the target temperature. The temperature varying results showed a bias between the thermal camera and blackbody measurements that were significantly different to zero ($p<0.05$) at four centres (mean difference- Cambridge 3.2°C, Bath 1.4°C, Leeds 1.1°C and Salford 0.3°C).

CONCLUSION: The majority of thermal cameras reached the target temperature within the warm-up period and there was a strong linear relationship between the thermal camera and blackbody measurements. There was however, a significant bias at four centres where the thermal camera recorded higher/ lower temperatures than the blackbody although once this bias was accounted for, the range of differences between the blackbody and the thermal cameras were at most ±1.37°C which is well within the ±2°C thermal camera accuracy.

SKIN TEMPERATURE RESPONSE ON JUNIOR ATHLETES AFTER HIGH INTENSE JUDO TRAINING

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INTRODUCTION. The skin temperature (Tsk) registered by infrared thermography (IRT) may assist the coaches and athletes to understand organic responses resulting from the training. This study measured Tsk before and after training and during the recovery process in highly trained junior judokas in order to understand the thermal adaptations of the judoka to the training.

METHODOLOGY. The sample consisted on 33 judokas (17 male and 6 females) of the High Performance Training Center of Madrid (18.81±3.95 y.o.) training judo since 7.07 4.10 years and currently training 13.76 6.0 hours per week. They were measured before and immediately after a high intensity 90-min judo training (IAT), and 1-hour and 24-hours during the recovery process. We selected 8 ROI in the anterior and posterior views of the lower limbs and 9 ROI in the anterior and posterior views of the upper limbs and trunk from a thermograms recorded by a FLIR T335 thermal imager following the TermoINEF protocol.1.

Thermal data were analyzed considering lateral dominances of the athlete.

RESULTS AND DISCUSSION. Thermal profile of the evaluated judokas is characterized by symmetry. They have not been registered the thermal asymmetries reported in previous pilot studies. Distal ROIs of the lower limbs are quite cold probably due to the isolating (cooling) effect of the tatami in the judokas feed. Results show significant decrements of Tsk between 0,5°C (Knees) and 2.0°C (Low back) in most the considered ROIs IAT. Anterior and Posterior Forearms did not significantly modified their Tsk (0,1°C) and Triceps and Ankle increased their Tsk IAT (0,2 and 0,4 °C respectively). Judokas recovered or overpassed their basal values after 1-hour of recovery and recoved their basal temperatures 24 hours after training in all the cases. Different response thermal patterns have been registered with local (local) and spotted (dalmata) responses of skin temperatures probably related with the intensity of the performed exercise and/or the physiological characteristics of the judoka.

CONCLUSIONS. Thermography is able to register the thermal response of the judokas after training and could be an useful tool to estimate the recovery of the athlete after training.

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THE ANALYSIS OF THE COOLING PROCESS OF THE BREAST AREA IN WOMEN UNDER THERMOGRAPHIC MONITORING

Aleksandra Pypkowska[1], Anna Szczesniak[1], Anna Jung[2]

1 Braster S.A., Warsaw, Poland
2 Military Institute of Medicine, Warsaw, Poland

INTRODUCTION: Controlled decrease in the temperature of the specific body surface area can increase the possibilities of recording detection of infrared radiation from tissues located close to the skin surface. This phenomenon is used in dynamic thermography when external cooling sources are used. The specific body surface area is cooled with the use of, for example, cold air flow. There is, however, concern that this cooling method does not cover equally the whole area of interest, which may impact the thermographic examination results. Therefore, it seems interesting to follow the cooling process in which no external sources are involved.

STUDY PURPOSE: The purpose of this study was to analyze the process of cooling the women's breast area at ambient temperature without involving any external cooling sources.

MATERIAL AND METHOD: The study included a group of women, healthy volunteers, aged 20-68 years (average age: 32 years old) who consented to participate in the study. In total, 93 examination procedures were performed in these women in accordance with the adopted scheme. Prior to the commencement of the examination in the diagnostic laboratory, the body temperature was determined for each woman, by calculating the average value of each measurement taken from inner corner of the eye with the use of thermovision camera FLIR T650 SC. Next, each woman was asked to undress from the waist up and remain calm in a sitting position. The ambient temperature was in the range of 20-25 degrees Celsius. Thermographic images of the breasts were recorded immediately after the woman undressed,

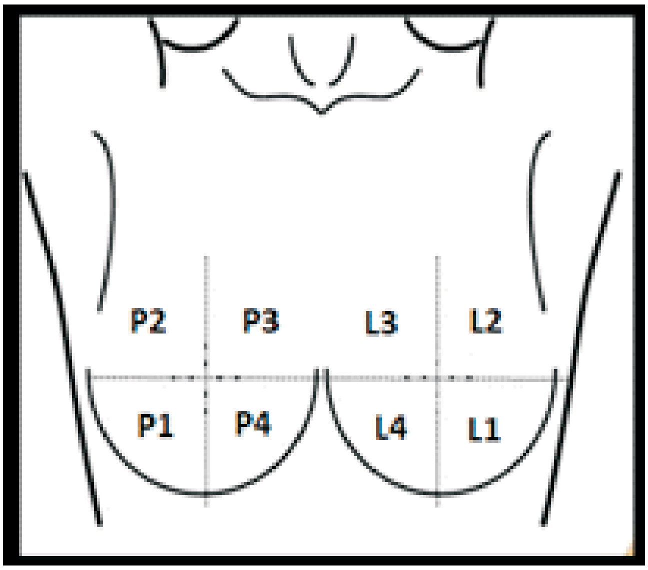

Figure 6:
Average temperature of the right (P) and left (L) breast measured at different times [0 min, 6 min, 12 min]

and then after the 6th and 12th minute of the examination in the regions of interest corresponding to the quadrants of both breasts. At the same time the average temperature - Delta-T - was determined with the use of the FLIR software.

The area of the examined surface was divided into 4 symmetric quadrants for each breast: bottom outer quadrant, upper outer quadrant, upper inner quadrant and bottom inner quadrant, marked as P1, P2, P3, P4 respectively for the right breast and L1, L2, L3, L4 respectively for the left breast. A figure 6 shows the marking of examined quadrants.

For each quadrant average temperatures were determined: the temperature at the beginning of the acclimatization / cooling process as well as the temperatures measured after the 6th and 12th minute of the acclimatization / cooling process. The results obtained are presented in the charts below, divided by right and left breast (figure 7Average temperature of the right (P) and left (L) breast measured at different times [0 min, 6 min, 12 min]).

Table 1
The characteristics of the number of procedures in examined women according to the BMI and age

BMI \ Age	<31	31-51	>51	Total
≥ 19,9	4	1	0	5
20–24,9	60	10	2	72
25–29,9	6	1	1	8
> 30	0	4	4	8

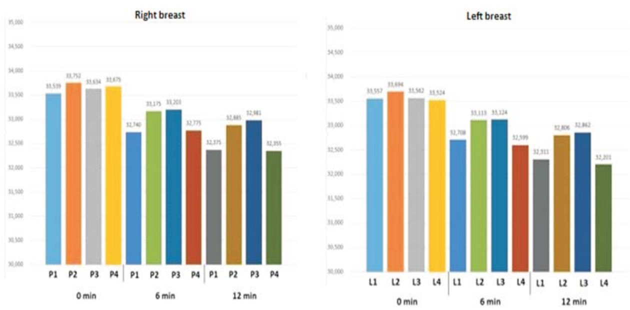

Figure 7
Average temperature of the right (P) and left (L) breast measured at different times [0 min, 6 min, 12 min]

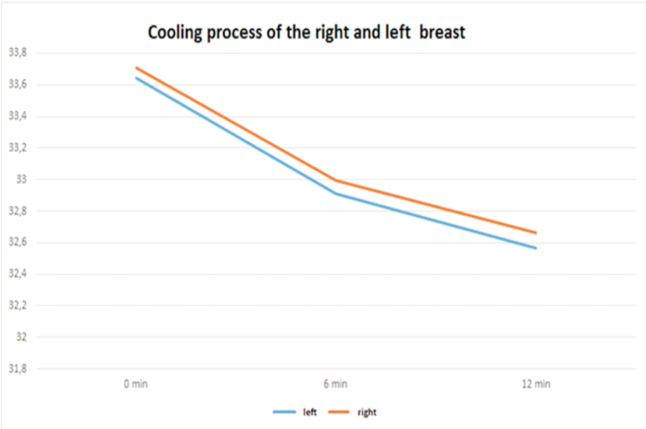

Figure 8
Cooling process of the right and left breast.

Additionally, besides calculating average temperatures of the quadrants according to the time of the measurement, also it was examined in detail what is the influence of such indicators as BMI and age on this dependence. Appropriate graphs were created indicating the average temperature of quadrants at different times (0 min / 6th min / 12th min) broken down by subgroups (table 1) with regard to the examined indicators.

CONCLUSIONS: Based on the preliminary analysis of the results obtained, some dependencies were observed:

- regardless of the age group and BMI, bottom quadrants (P1, P4, L1, L4) are characterized by a lower temperature measured after the 6th and 12th minute of the acclimatization as compared to upper quadrants (P2, P2, L2, L3) (figure 7);
- regardless of the age group and BMI, the cooling process is symmetrical for right and left breast (figure 8);
- in women with lower BMI a higher breast surface temperature was observed. Similar conclusions were drawn with regard to women from younger age groups. The younger the age group, the higher the breast temperature (figure 9).

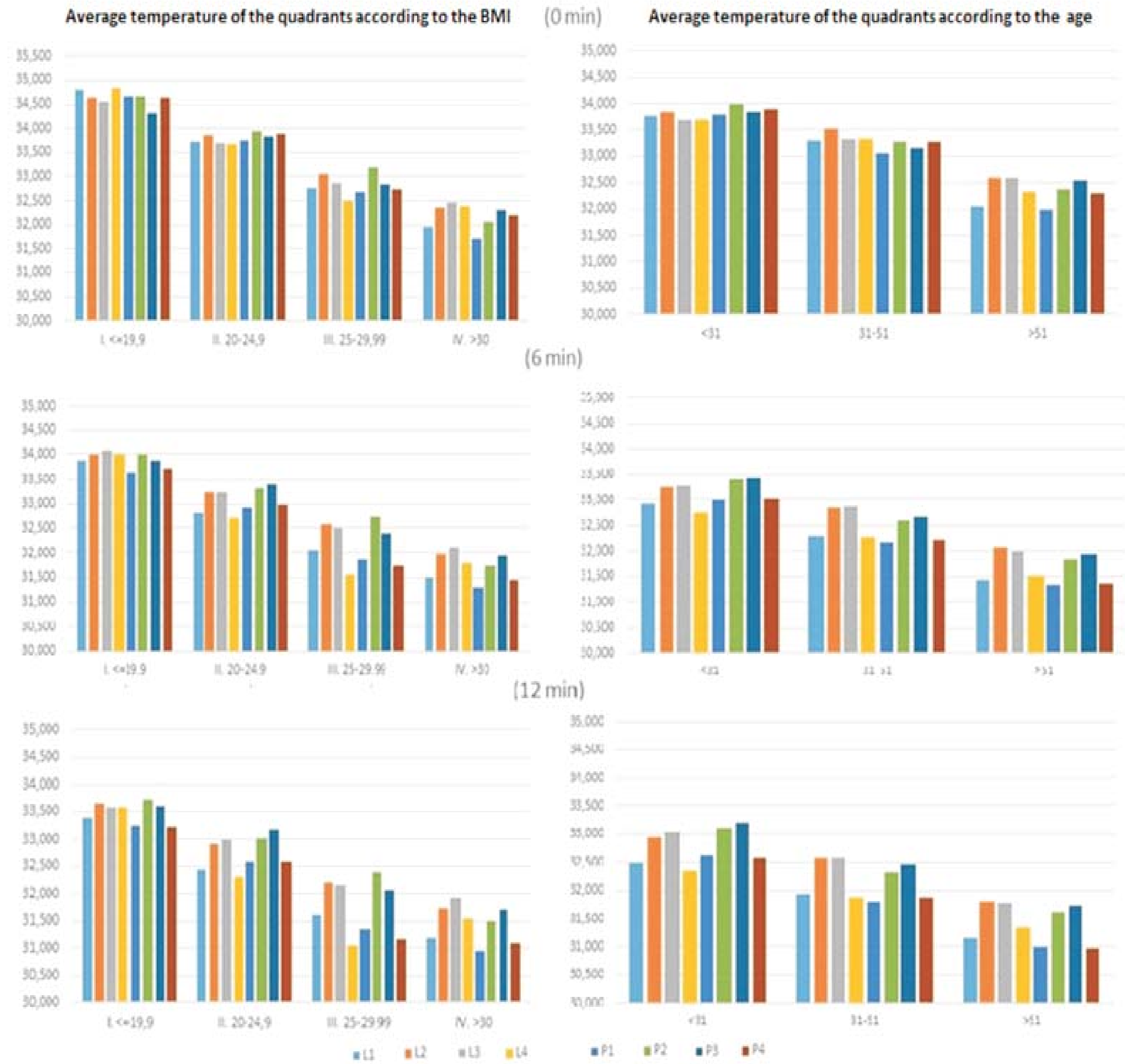

Figure 9
Average temperature of the quadrants according to the BMI and age.

INFRARED THERMOGRAPHY TO ASSESS THE BLOOD DONORS ADAPTATION TO BLOOD LOSS

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INTRODUCTION: It is known that short-term and long-term hypoxia, as well as acute massive blood loss causes adaptive changes in the human body, which manifest his spontaneous cooling (1-4). We hypothesized that the spontaneous cooling is universal protective mechanism which can be measured using infrared thermography. The aim of this study was to investigate the dynamics of the local temperature in the hands of blood donors.

METHODS: Dynamics of right hands temperature in 5 adult blood donors was study before, during and within 60 minutes after 400 ml of blood loss. During the entire period of collecting the blood donors were in the semi-recumbent position. Blood sampling for all donors was performed of the saphenous vein of the left hand. Spot temperatures of the finger tips were measured. Mean finger temperature was calculated by averaging the finger tips temperature of the 2nd to the 5th finger. Thermal images of the right hand was perfomed immediately after the regular blood loss of donor in volume of 50 ml. Infrared monitoring of hands temperature was performed by using ThermoTracer TH9100XX (NEC, USA) thermal imager. 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 36°C. The obtained data were processed using the Thermography Explorer and Image Processor software. The obtained data were processed using software Thermography Explorer and Image Processor. The study was approved by the Ethics committee at Izhevsk State Medical Academy and complied with the Declaration of Helsinki. All donors gave informed consent.

RESULTS: The average age of donors was 45 ± 11 years, female 2/5. Body Mass Index 32.2 ± 7 (n = 5). Blood collection took 10 - 15 minutes. After donating, the donors were kept in the semi-recumbent position for 15 minutes more. After that, donors stood up and walked or stayed in the sitting or standing position.

We found that the temperature in all fingers' pads of the right hand in all donors was decreased by more than 0.1 °C after taking approximately 100 ml of blood from the vein (the blood volume which is usually taken in 2 - 4 minutes after the introduction of the injection needle into the cubital vein of the left hand). Then, in all donors, the temperature in each distal phalanx of the right hand was progressively decreasing together with the increase in the volume of blood drawn from the vein of the left hand. At the same time, the area of local hypothermia was increasing in each fingertip. This increased cooling of fingertips and an increase in local hypothermia areas was observed until 400 ml of blood was drawn from veins (Fig. 1). In the final stage of blood collection, local hypothermia in the fingertips increased by 0.8 ± 0.2 °C (n = 5), and the size of the hypothermia area in the distal phalanges increased by more than 3 times. Donors finger temperature begins to rise 30 minutes after blood loss After 60 minutes of blood loss from all donors fingertip temperature was increased and the initial values above 1.1 ± 0,2°C.

Thus, an acute blood loss of more than 100 ml triggers an organism's protective. The fingers are among the first body parts to respond to this signal that triggers a reflex spasm of blood vessels. Infrared monitoring of local temperature performed by using thermal imaging camera provided this information in real time.

CONCLUSION: Thus acute blood loss might trigger this protective response in healthy and sober people. Infrared thermography reveals early adaptive response of the human body to acute blood loss. The body activates it not only during apnea and ischemia, but also in any other acute critical conditions. The findings may provide the basis for developing a method to assess the stability of the donor acute hemorrhage.

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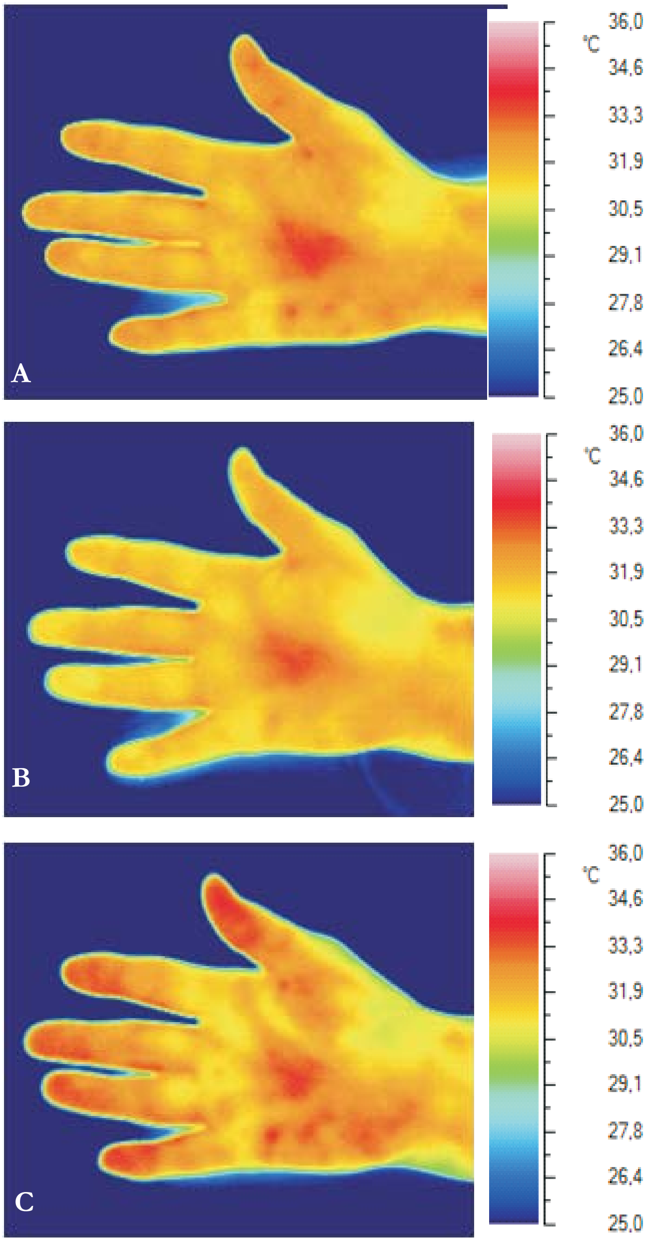

Figure 10
Infrared image of the right hand of blood donor (female U., at age 60), recorded before (A), immediately after blood loss 400 ml (B) and 60 minutes after 400 ml of blood loss (C).

THERMAL IMAGING IN THE EVALUATION OF CARPAL TUNNEL SYNDROME

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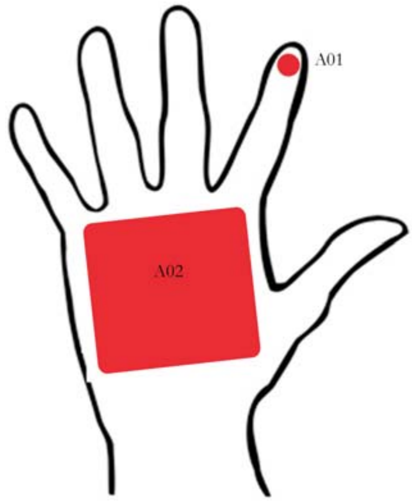
INTRODUCTION: It is known that body core temperature changes are connected with health state and the magnitude of the core temperature is in standard used as an indicator of diseases. As a standard method the contact thermometry is used where the thermometers must be stick to the skin or put inside the organism cavities i.e. mouth or ear. Mentioned methods evaluate the core temperature but it is very simple method to check and visualize the skin temperature which also can give us some important information about health state. The skin temperature changes is sensitive indicator of metabolism taking place in the superficial tissues which can be related to health state. Using the thermal imaging and very sensitive thermal cameras we can find some quantitative thermal parameters to evaluate or even diagnose some diseases. It is also possible to characterize some diseases i.e. spine diseases by using thermal maps obtained for chosen patient. Maybe it may be possible to diagnose or evaluate the level of carpal tunnel syndrome by using the thermovision.

The carpal tunnel syndrome is revealed by pressed and squeezed the median nerve. The nerve runs from the forearm into the palm of the wrist and allows control the impulses from hand muscles and feelings from fingers (palm side) without thumb and little finger [7-11].

Carpal tunnel (CT) is the narrow, rigid place of transition from bones and ligament toward the base of the palm, in which the tendons and median nerve are located. The disease can lead even to a swelling or thickening of the tendon as a result of irritation, causing additional pressure on the median nerve. In consequence there may be occur numbness, weakness, and pain radiating to the whole arm. Such disease can lead to problems with blood microcirculation and can influence on the blood supply in the soft tissues in the hand. It should be underlined that very important factor in thermal imaging is association of the local blood flow with metabolism changes that can influence on the skin temperature gradient what is a very good disease's indicator.

Figure 11.
The scheme of regions of interest marked on the subjects hands. T is defined as T02 - T01.



Therefore the main goal of this work is to find the difference in the temperature gradient for patients suffered from carpal tunnel syndrome (CTS) and healthy ones.

MATERIALS AND METHODS: The research included two groups of volunteers: healthy (mean age 38 ± 19 years) and patients who suffer from carpal tunnel syndrome (mean age 59 ± 10 years). The Body Mass Index (BMI) was similar for studied groups. The scheme of temperature gradient analysis performed on the subjects hands is presented in Figure 11.

To monitoring of the temperature distribution on the skin surface, mainly nearby wrist and whole hand in anterior position, was done by using the Thermovision Camera E60 which was calibrated by black body. All measurements were performed at a proper distance from the camera, depending from the size of the controlling field (about 50cm) in accordance to standard protocol of infrared imaging in medicine [5,6]. To analyze obtained thermal images we use a ThermaCAM TM Researcher Pro 2.8 SR-3. All statistical analysis were performed by using the Statistica 9.1. The differences with $p<0.05$ were recognized as statistically significant.

RESULTS AND DISCUSSION: Figure 12 presents thermal images of two representative patient's wrists - with carpal tunnel syndrome (Figure 12A) and healthy volunteer's hand (Figure 12B).

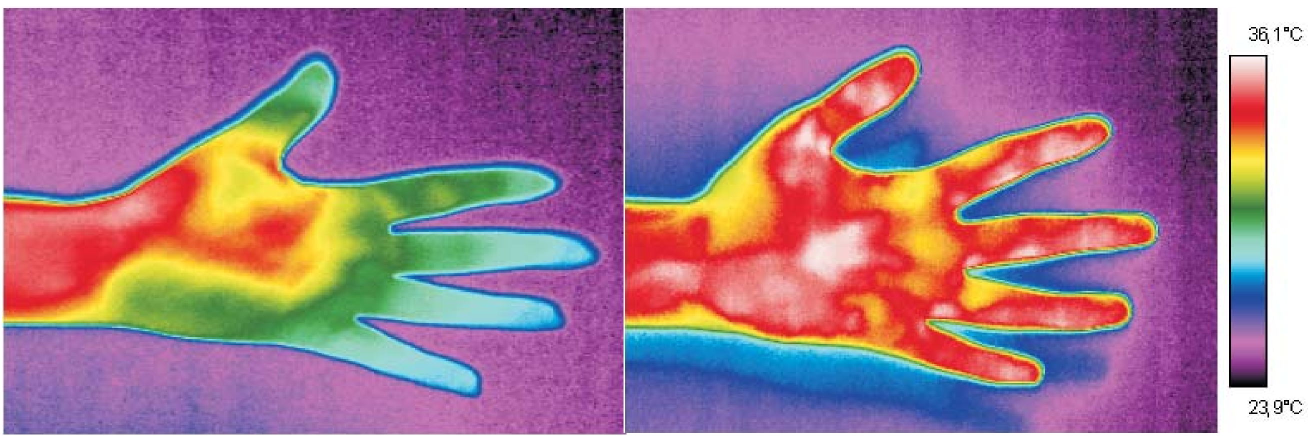


Figure 12.
The thermal images of representative patient's hand suffering from carpal tunnel syndrome (A) and in comparison the hand of representative healthy volunteer (B),

One can see from Figure 2 the differences in thermal maps. Taking into account that both thermograms were taken in the same conditions and the thermovision diagnostics in medicine protocol have been fulfilled it is easy to conclude that there can be significant differences in hand and fingers blood supply between patient and healthy. It may be connected with occurred carpal tunnel syndrome what lead to increase pressure on the nerve and changes also the microcirculation in the distal parts of the hand. However to better insight into the problem the statistical analysis were done and the temperature parameters derived from marked regions (according to Figure 1) were collected in the Table 1.

Performed test U for independent variables showed the statistical significant differences (p=0,001) between mean temperature difference T defined as T02 - T01 obtained for groups of patients suffering for carpal tunnel syndrome and healthy volunteers. It was illustrated in Figure 3.

Table 1.
The temperature parameters obtained for studied regions of interests, where for each patient T is defined as T02 - T01, and Ti is mean temperature for chosen region of interest.

PATIENTS	$\Delta T_{1\ patients}$	$\Delta T_{1\ healthy}$
1	4.0	1.4
2	4.2	0.5
3	4.1	1.1
4	5.9	0.3
5	5.6	0.3
6	2.6	0.7
7	1.5	0.8
8	2.3	

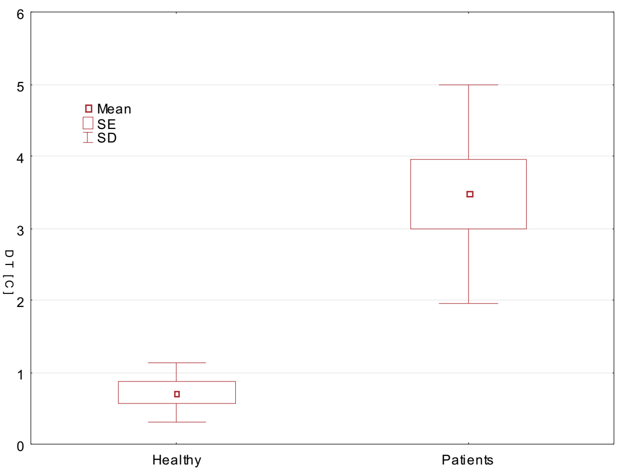


Figure 13.
The box graph presented differences between DT obtained for patients with CTS and healthy, where DT = T02 - T01

CONCLUSIONS

- Thermovision can be helpful tool for diagnosing the wrist isthmus diseases
- Further studies on the bigger studied groups are needed to confirm obtained results. However, first results are promising

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TECHNICAL CHALLENGES IN INFRARED FOOT SCREENING

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INTRODUCTION: Historically, infrared cameras were expensive and not dedicated to medical use. Consequently clinicians were forced to use devices that were in effect constructed for engineering applications rather than medicine.

With the advent of inexpensive embedded computing platforms and similarly vastly cost reduced small infrared imagers it is now possible to create devices targeted at the medical market that offer highly specialised and bespoke functionality.

Similarly, extracting information from images has been focused on algorithms for the visible spectrum. These algorithms, such as edge detection, can only be used to an extent on infrared images, making automated processing a difficult task.

METHODS: This paper outlines the concepts behind building such a device mainly from off-the-shelf hardware with only few specialised components and subsequent semi-automatic creation of comparable images for simple data extraction. This modular concept can also be extended to software aspects such as operating systems, application software and hardware drivers. An example of an instrument constructed around this concept demonstrates how medicine specific requirements can be implemented on such a platform.

RESULTS AND DISCUSSION The instrument constructed demonstrates that specific medical requirements can be implemented on such a modular platform. In particular, it can be shown how the repeatability of measurements can be improved by using live visual (non-IR) overlays of anatomical structures and landmarks. In-built user assistance for targeting and focusing and image analysis are also demonstrated.

While the advantages of designing such a modular device are obvious the approach also generates a number of drawbacks. The most significant disadvantage is the fast development cycle of industrial hardware and software modules used in such instruments. This can quickly render components out of date, unusable or no longer available.

CONCLUSION: Results obtained with the example instrument demonstrate high repeatability of measurements both in terms of positional accuracy and thermal performance. These properties make the instrument highly suitable for use in trials and in everyday clinical settings.

EVALUATION OF HYPERBARIC OXYGEN THERAPY EFFECTS IN ULCERATION OF CRURAS STUDIED BY THERMAL IMAGING AND PLANIMETRY - PRELIMINARY RESULTS

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INTRODUCTION: In hyperbaric oxygen therapy the human body is exposed to increased atmospheric pressure in a special rooms called hyperbaric chambers. There two types of hyperbaric chambers: monoplace chamber performed for therapy only one patient where gas used to pressurize the vessel is usually 100% oxygen and the chamber for several patients. Hyperbaric therapy may be also applied locally for one shin [1-5].

The main role in the therapy plays ideal gas laws. When we consider pulmonary embolism according to Boyl's law, the volume of the gas bubble in arterial decreases what lead to decrease of anoxia area. However the most important law which has its application in hyperbaric oxygen therapy is Henry's law which determinates the concentration of gas dissolved in a liquid to the partial pressure of the gas exerted on the liquid surface. This means that the increased gas pressure in the hyperbaric chamber leads to increase of oxygen dissolved into the plasma and the soft tissues due to theirs hydratation [1-5].

Nowadays the HBO can be applied to many of respiratory and circulatory diseases. However very frequent application of this treatment method in last decade can be found in different nonhealing wounds. The example of nonhealing wounds is venous leg ulceration (VLU) of cruras. It is reported in literature that almost 37% of people are endangered of venous insufficiency which can lead to VLU [1,2]. VLU is a chronic disease, characterized by periods of exacerbation and remission. Such harmful and hard to heal ulceration can last even a few years [1-5].

Hyperbaric oxygen therapy gives very good therapeutic effects probably due to increasing of tissue oxygenation and many different biochemical and physiological organism reactions speed up or even starting. The most important effect of the therapy is the increase oxygen transport capacity of the blood what gets better the tissue proliferation processes and lead to tissue healing.

There are methods like planimmetry and oximetry used in the qualification of patient to the therapy and evaluate of the therapy effects. However, the non-invasive, easy to perform and quick method of treatment effects evaluation as well as to diagnosis the health state of the patient is still needed. That is why the main aim of presented work is to determine and compare diagnostic value of thermal imaging of patients treated by hyperbaric oxygen therapy.

EXPERIMENTAL PROCEDURES: The studied group consisted of 25 patients (11 female and 14 male) in age 65 17 suffered from venous chronic ulceration. The investigations were carried out at the Burn Treatment Center in Siemianowice Slaskie. Each session of hyperbaric oxygen therapy lasted 86 minutes. The pressure of air in the chamber was 2,5 ATA.

The distribution of the skin surface temperature was monitored by using of a Thermovision Camera E60 calibrated by black body. The thermograms of chosen regions of interests were performed before and immediately after HBO in the special room outside the chamber. Thermal imagin was performed according to Glamorgan Protocol [6]. Temperature in the chamber during therapy as well as in the measurement room was 22,5±1C.

Simultaneously with thermal imaging the plannimetry parameters were measured. All parameters (such as area of wound and area counted from thermal imaging) were derived during three different periods of treatment: I: 0-10 sessions, II: 10 to 20 and III: more than 20 sessions of HBO. Statistical analysis were done in Statistica 9.1 using t-tests, Wilcoxon's and Anova tests. Differences with a $p<0.05$ were regarded as significant.

RESULTS AND DISCUSSION: The thermal imaging for representative patient suffering from VLU of crura performed before (a) and after (b) hyperbaric oxygen therapy session are shown in figure 13. A photograph of the ulcer where planimetry was performed, an a table with temperature and planimetric findings are presented in Figure 14.

The region of interest (part of the crura) was divided into three parts (inner AR2 - ulceration, AR1 - closer area above the wound, AR03 - further areas below the wound).

It can be clearly seen that body skin surface temperature is changed due to the therapy what was reported earlier [7-9]. It also follows from the studies that usually the decrease of mean temperature of skin surface could be observed due to HBO.

The increased temperature is observed around the ulceration. It can be recognized as inflammatory state and increased metabolism processes occurring in this area. It may be also connected with blood microcirculation problems in this part of wound because of capillaries malfunction. The situation seems to be changed after hyperbaric oxygen therapy when the temperature generally decreases in every region of interest.

To see the problem more clearly the deeper analysis have been performed and the mean temperature changes due to hyperbaric oxygen therapy have been presented as boxes graph in Figure 2. Such presentation confirmed that thermal map of crura is less differentiated after HBO than before one. Moreover, preliminary analysis showed the biggest changes of temperature mainly around the wound (AR01 and AR03). However, as it can be seen in Figure 2, the biggest decrease of mean temperature difference was obtained between area 1 and 2. It was nearly 3 times less, from $\Delta T=0,9$ observed before hyperbaric oxygenation to $\Delta T=0.3$ observed after one, respectively.

Such lowering the temperature especially in the closer area may be very important in the healing process due to its possible connecting with decreasing swelling and above the wound and improvement of blood microcirculation what can play role in the improvement of thermoregulation. Such phenomena may also have some therapeutic meaning in better oxygen transport to further parts of tibia and increase oxygen concentration in the tissues what was disturbed when the swelling occurred. These processes may improve the blood supply and start the neo-angiogenesis and so the neovascularization what is the symptom of wound healing.

Analyzing the effects of hyperbaric oxygen therapy by using the plannimetry in confrontation with thermal imaging it was also very interesting to check the compatibility of plannimetry parameters changes such as area of wound and area counted from thermal imaging during three different periods (I: 0-10 sessions, II: 10 to 20 and III: more than 20 sessions of HBO) of hyperbaric oxygen therapy what was preliminary presented in table 1.

Table 1.
Percentage changes of the area counted from thermal and plannimetry images in three different periods of hyperbaric oxygen therapy obtained for two studied patients. The number 1 in the Ist period means 100% - initial area.

Period of HBO / *Imaging technique*	*I*	*II*	*III*
Planimetry - Patient 1	1	0,91	0,76
Thermovision -Patient 1	**1**	**0,21**	**0,20**
Planimetry - Patient 2	1	0,82	0,38
Thermovision -Patient 2	**1**	**0,57**	**0,40**

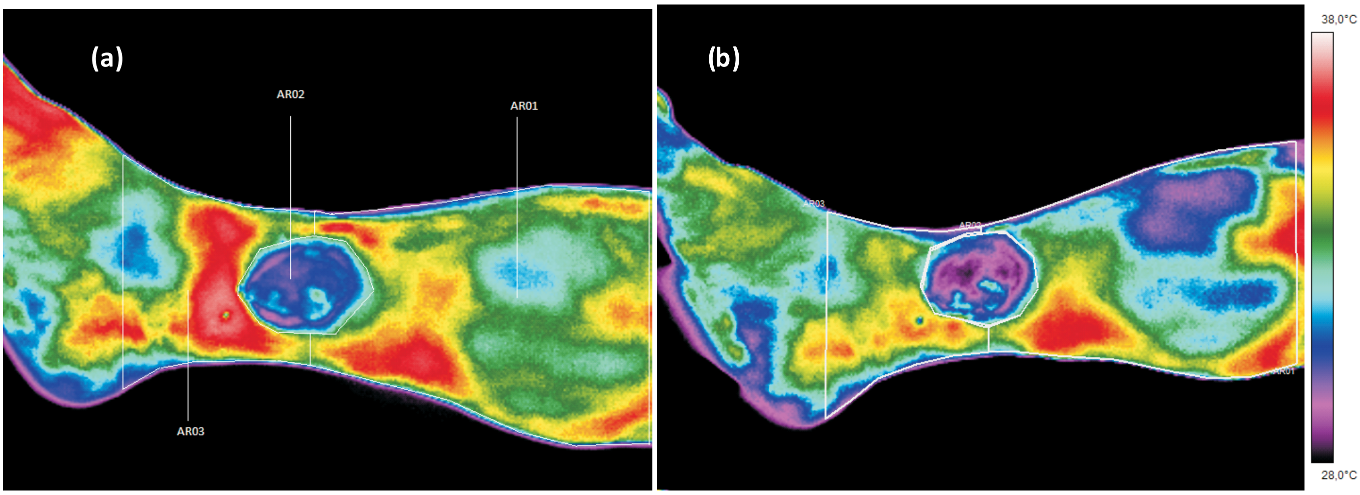
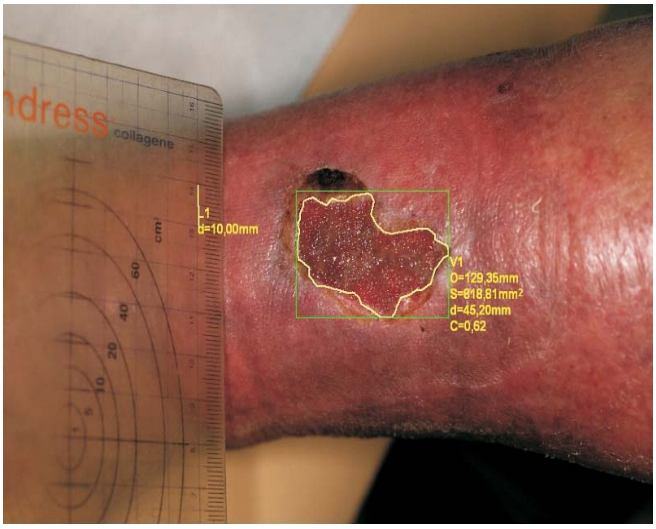


Figure 13:
The thermal image of representative patient suffering from venous chronic ulceration , performed before (a) and after (b) of the HBO session (period II)



Temperature and planimetric findings

Area	Tmean before HBO [°C]	Tmean after HBO [°C]	Area [mm²]	Number of pixels counted from thermal imaging
AR01	33,0	31,6	-	-
AR02	31,3	30,5	818,8	2330,0
AR03	33,2	31,8	-	-

Figure 14
Photograph of the ulcer with planimetry (top)
Table with temperature and planimetric findings (bottom)

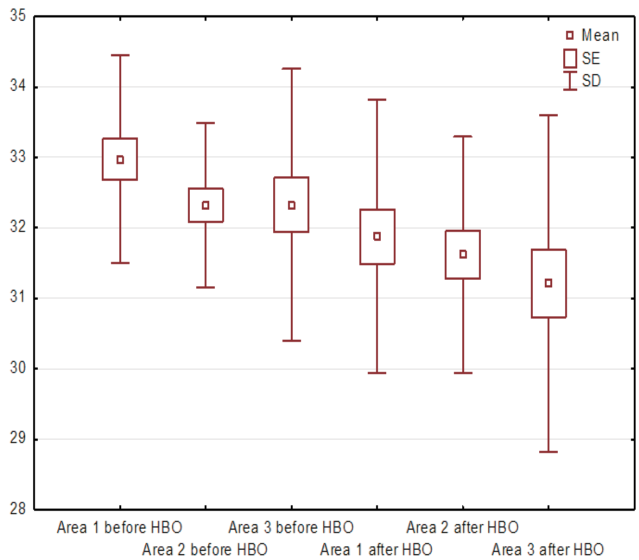


Figure 15.
Changes of Tmean obtained from chosen areas for studied group of patients performed before and after HBO

As it can be seen from the table1, there are differences in areas changes evaluated from plannimetry and the thermal images. It may be caused by two different ways of analysis - structural in the case of plannimetry and metabolical in the case of thermovision. This results must be confirmed by bigger statistics of study group of patients and now the conclusion must be draw very carefully. However it seems that connection of these two imaging techniques may give additional information for diagnosis as well as in estimation of therapy effects for the physician.

It should be underlined that the HBO effects are complicated what was reported in previous papers [7-9]. However it seems that the temperature changes and plannimetry parameters can be connected wits health state of patient as well as with progression with healing progress what requires further studies and bigger group of patients.

CONCLUSIONS: Performed studies showed that the thermal imaging can be useful in evaluation of hyperbaric oxygen therapy effects however the protocol is needed.

It seems that connection of thermal imaging and planimetry may give additional diagnosis as well as therapy effects information for the physician

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