ISSN-1560-604X
Thermology international

Thermology International

Volume 34 (2024)
Number 2 (May)

Infrared thermography assessment of patients with stroke under neuromuscular blockade intervention -A Pilot Study

Abstracts: Thermography Application in Medicine in Wisla, Poland, 26th April 2024

This journal is indexed in
EMBASE/Scopus
EBSCO, BIOSIS

Published by the
European Association of Thermology

THERMOLOGY INTERNATIONAL

Volume 34(2024) Number 2 (May)

Published by the
European Association of Thermology

Indexed in
Embase/Scopus, Biosis, EBSCO

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Contents

Original article

Artur Cesar Aquino dos Santos, Fábio Marcon Alfieri, Linamara Rizzo Battistella
Infrared thermography assessment of patients
with stroke under neuromuscular blockade intervention - A Pilot Study 29
(Infrarrot-Thermographische Beurteilung von Patienten nach Schlaganfall nach neuromuskulärer Blockade)

Abstracts

20th Conference of the Polish Society of Medical Physics in Wisla,26th April 2024,
Thermography Application in Medicine.....36

News in Thermology

Peer review of submissions to the EAT 2024 Congress is complete.....40

Meetings

Meetings 43

Infrared thermography assessment of patients with stroke under neuromuscular blockade intervention - A Pilot Study

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SUMMARY

INTRODDUCTION: Spasticity, motor sequelae of stroke, can be treated by botulinum toxin type A (BoNT-A) neuromuscular blockade, an intervention that requires follow-up by a trained professional. Infrared thermography can be an alternative for remote assessment of spasticity, however, it is not yet established.

OBJECTIVE: The objective of this study was to demonstrate the association between spasticity and thermo-asymmetry between the plegic and contralateral limbs of patients with stroke treated with BoNT-A.

METHODS: This is a pilot study of eight patients with motor sequelae of stroke. Lower limb spasticity was measured with the Modified Ashworth Scale (MAS) and cutaneous temperature with infrared thermography. The assessments were collected immediately before the intervention and one, two, and three months after BoNT-A application. The variables were analyzed in association by linear regression where the dependent variable was the temperature asymmetry between the lower limbs, and the independent variable was the mean muscle spasticity.

RESULTS: Spasticity and asymmetry of the lower limbs are significantly associated (β=0.39; r^2=0.29; p=0.031), and the effect of BoNT-A measured by thermography is more evident in the evaluations of the first and third months. The thermo-asymmetry evolution tends to return to baseline values before spasticity measurements.

CONCLUSION: Changes in lower limb spasticity intensity is associated with cutaneous temperature asymmetry in patients with stroke possibly due to greater blood perfusion after muscle relaxation effect caused by the blockade. Also, future studies should address vascular effects of BoNT-A and confounding variables such as age, BMI, and concomitant treatments.

KEYWORDS: Stroke, spasticity, neuromuscular blockade, body symmetry, thermography.

INFRARROT-THERMOGRAPHISCHE BEURTEILUNG VON SCHLAGANFALLSPATIENTEN NACH NEUROMUSKULÄRER BLOCKADE

EINLEITUNG: Spastik, motorische Folge eines Schlaganfalls, kann durch eine neuromuskuläre Blockade von Bo- tulinumtoxin Typ A (BoNT-A) behandelt werden, eine Intervention, die eine Nachsorge durch eine geschulte Fachkraft erfordert. Die Infrarot-Thermografie kann eine Alternative zur Fernbeurteilung der Spastik sein, ist aber noch nicht etabliert.

ZIEL: Das Ziel dieser Studie war es, den Zusammenhang zwischen Spastik und Thermoasymmetrie zwischen den plegischen und kontralateralen Gliedmaßen von Patienten mit Schlaganfall, die mit BoNT-A behandelt wurden, nachzuweisen.

METHODEN: Es handelt sich um eine Pilotstudie mit acht Patienten, die motorische Folgeerkrankungen nach Schlaganfall boten. Die Spastik der unteren Extremitäten wurde mit der modifizierten Ashworth-Skala (MAS) und die Hauttemperatur mit Infrarot-Thermografie gemessen. Die Bewertungen wurden unmittelbar vor der Intervention und ein, zwei und drei Monate nach der Anwendung von BoNT-A erhoben. Die Variablen wurden in Assoziation mittels linearer Regression analysiert, wobei die abhängige Variable die Temperaturasymmetrie zwischen den unteren Gliedmaßen und die unabhängige Variable die mittlere Muskelspastik war.

ERGEBNISSE: Spastik und Asymmetrie der unteren Extremitäten sind signifikant assoziiert (β=0,39; r^2=0,29; p=0,031), und der Effekt von mittels Thermografie gemessenem BoNT-A ist in den Auswertungen des ersten und dritten Monats deutlicher. Die Entwicklung der Thermoasymmetrie tendiert dazu, zu den Ausgangswerten vor den Spastikbeur- teilungen zurückzukehren.

SCHLUSSFOLGERUNG: Veränderungen der Intensität der Spastik der unteren Extremitäten sind bei Patienten mit Schlaganfall mit einer Hauttemperaturasymmetrie assoziiert, die möglicherweise auf eine größere Durchblutung nach dem durch die Blockade verursachten Muskelentspannungseffekt zurückzuführen ist. Zukünftige Studien sollten sich auch mit den vaskulären Auswirkungen von BoNT-A und Störvariablen wie Alter, BMI und Begleitbehandlungen befassen.

SCHLÜSSELWÖRTER: Schlaganfall, Spastik, neuromuskuläre Blockade, Körpersymmetrie, Thermografie.

Thermology international 2024, 34(2) 29-35

Introduction

Stroke is a significant prevalent disease [1], recognized as an event with great potential to cause physical disability, decreased independence, emotional disturbances, and sensory deficits [1-6]. Among the sequelae of a stroke, spasticity is constantly present as one of the most common complications, reported by some authors with a prevalence of 30% to 70% of all cases [7-10].

Spasticity, as described by Lance (1980), is a velocity-dependent disorder resulting in increased muscle tone and hyperexcitability of the stretch reflex [11]. Even though there is still no consensus on the real definition of this sequelae [10], other authors expanded the definition of spasticity, such as Young (1994), who considered the neurophysiological components of spasticity and described it as a motor disorder that leads to a speed-dependent stretch reflex, resulting from an abnormal intraspinal afferent process [12].

Among the physical and pharmacological treatments for the management of spasticity described in the literature, neuromuscular blockade with botulinum toxin seems to be the most effective [10,13], with level 1a evidence for reducing stroke-related spasticity. Botulinum toxin (BoNT-A) is a protein that inhibits the release of acetylcholine in the motor plate, reducing the motor hyperactivity of spasticity [10,14]. This treatment has few side effects, therefore, it is a drug with specificity and safety for controlling spasticity [10,15].

The effect of neuromuscular blockade by BoNT-A begins at approximately 3 to 5 days after application and lasts for 3 to 6 months [16]. The tracking of the BoNT-A effect is usually based on the modified Ashworth scale (MAS), an assessment that demands the presence of qualified [10,17]. However, another method that could monitor the patient's evolution after the application of BoNT-A is the infrared thermography, a non-invasive evaluation that is easy to perform and has good reproducibility, given there is a proper standardization environment's temperature, humidity, and light incidence [18-25]. This approach has been discussed [26,27] in studies that demonstrated temperature changes of the paretic limb after a spasticity treatment. Nonetheless, to the best of our knowledge, there are no studies that demonstrate a correlation between spasticity reduction and changes in temperature asymmetry between the paretic and the contralateral limbs. Considering that the temperature difference between both sides of the body among healthy individuals is close to 0º (some studies report that physiological variations may generate up to 0.3ºC of difference), values above these can be considered temperature asymmetry [28].

Therefore, the objective of this study is to demonstrate whether there is any association between the reduction in spasticity after the application of BoNT-A and changes in thermal asymmetry of the lower limbs (LL) of patients with motor sequelae due to stroke.

Methods

This is a short-term longitudinal pilot study and a series of eight cases of patients with motor sequelae stroke. This is an ancillary publication of the study by Silva Dias and colleagues (2021)[29], approved by an ethics review board (registration 2.335.371).

The participants in this study were patients of a physical rehabilitation program at the Instituto de Medicina Física e Reabilitação of the Hospital das Clínicas da Faculdade de Medicina da Universidade de Sao Paulo (IMREA-HCFMUSP). They were 18 years old or above, with a clinical diagnosis of stroke, presence of spasticity in lower limb above 1+ as measured with the modified Ashworth scale (MAS), cognitive ability to understand the study procedures, and prescription of neuromuscular blockade.

Patients with hemiplegia due to other diseases, with the presence of double hemiplegia or double hemiparesis, presence of diabetic neuropathy, peripheral vascular disease with manifestations in the lower limbs, or clinical instability were not included.

Patients were recruited and invited to participate in the study during their rehabilitation program. They were informed about the study procedures and requested to sign the Informed Consent Form (ICF). After singing the ICF they were included in the study.

Neuromuscular blockade

The application of BoNT-A occurred especially in the distal portions of the lower limb (semitendinosus, semimembranosus, tibialis posterior, soleus, medial gastrocnemius, lateral gastrocnemius, flexor digitorum longus, flexor brevis of the fingers, and flexor hallucis longus), except for three applications on rectus femoris (patients DRMV, JCT, and EJP).

Assessments

The participants had their demographic data (sex and body mass index) and clinical data (stroke etiology, hemiplegic side, and concomitant treatments) recorded for sample description and analysis.

Patients were evaluated regarding the spasticity and skin temperature of the lower limbs immediately before and immediately after the application of neuromuscular blockade, and subsequently one and two months after application.

The Modified Ashworth Scale (MAS) [30,31] was the scale used for spasticity assessments. In this scale, spasticity is classified into 6 categories that range from normal (0) to rigid flexion and extension [4], depending on muscular resistance against passive movement. Patients were evaluated on knee flexion and extension, dorsiflexion and plantar flexion, considering the adductor muscles, rectus femoris, semitendinosus, semimembranosus, tibialis posterior, soleus, medial gastrocnemius, lateral gastrocnemius, flexor digitorum longus, flexor brevis of the fingers, and flexor hallucis longus.

Associated with spasticity assessments, infrared thermography assessments of the lower limbs were performed using the FLIR T450sc camera. The FLIR T450sc camera has a focal plain array size of 320 × 240 pixels and image collection frequency of 60Hz. Its sensor can collect images with a range of temperature from -20°C to +120°C, with measurement uncertainty of 1% or ± 1°C and a spectral band of 7.5 - 13.0 μm, NETD <30mK. The images were collected considering a skin emissivity of 0.98. The participants had thermographic images of both right and left sides of the legs, in the anterior and posterior incidences collected.

Thermographic images were collected according to standards already known in the specialized literature [22, 24, 32-34] with the FLIR T450sc camera (Wilsonville, Oregon, USA). Approximately 2 hours before image collection, the patient was instructed not to take hot baths or showers, not to use ointments, powders or perform intense exercises. Regarding food intake, they were requested not to eat for two hours before the image collection, not consume stimulants or substances with caffeine, alcohol, and not to use nasal decongestants. Finally, the evaluation was carried out after detecting the absence of signs of fever or infections [35]. On the day of image collection, the individuals had an acclimatization time of 20 minutes in the thermography lab in an average temperature of 19°C, exposing the lower limbs from the lower third of the thigh. The windows and curtains were closed and the relative humidity was not controlled.

The temperature scale used was Celsius degrees and the mean temperature of each region of interest (ROI) was the outcome for skin temperature. These ROIs were the available area of the posterior leg, considering the gastrocnemius muscles, lateral and medial portions of soleus muscles, and the proximal calcaneal tendon above the medial malleolus line. These ROIs selection is similar to previous studies [22,23], however the ROI area is different, as demonstrated in Figure 1, since it was intended to capture and demonstrate temperature changes in the region more closely related with the neuromuscular blockade applications. The images were analyzed with the ResearchIR® software.

Figure 1
Example of ROI determination. Temperature measured as Celsius degrees, °C. Temperature difference between the plegic leg (left) and contralateral leg (right): -1,68°C.
(Patient DRMV at baseline).

Sample

The sample for this study is composed of eight patients and was not statistically estimated, given the nature of a pilot study.

Data Analysis

Firstly, thermo-asymmetry was defined as the temperature difference between the plegic and contralateral sides, according to the formula

$T_{pl} - T_{cl}$

where T_{pl} is the temperature of the plegic side and T_{cl} is the temperature of the contralateral side.

Demographic, clinical, and body temperature spasticity data were described separately for each patient. The variables were tested for normality with the Shapiro-Wilk test and continuous variables were described as mean, standard deviation, median, and interquartile range.

Spasticity and thermo-asymmetry values were tested in association at baseline, 1, 2 and 3 months after neuro-mu scular blockade. The variables for assessing spasticity of the adductor, rectus femoris, semitendinosus, semimembranosus, posterior tibialis, soleus, medial gastrocnemius, lateral gastrocnemius, flexor digitorum longus, flexor digitorum brevis, and flexor hallucis longus muscles were grouped into a single average.

Associations with $p<0.05$ were considered statistically significant, and the STATA 14® (StataCorp LLC, Texas, USA) statistical package was used.

Results

Of the eight patients included in the study, five were male and three were female. They aged 60.59 (±13.50), had BMI of 24.53 (±3.66), and time since stroke of 7.39 years (±3.21). Table 1 describes the data for all individuals. One patient withdrew before baseline assessments, and between the first and third months after the application of neuromuscular blockade, three patients withdrew from participating. Therefore, the assessments conducted three months after the BoNT-A application included only four patients.

The Shapiro-Wilk tests showed that the data had parametric characteristics, therefore the inferential statistical analyzes were parametric. However, some data were demonstrated were as median and interquartile.

Individual results of specific temperature asymmetry are shown in Table 2, and the thermo-asymmetry and spasticity values combined measured throughout the study are presented in Table 3, where similar variations can be seen over the data collection times, that is, there was a beginning of reduction in both thermo-asymmetry and spasticity in the first month, followed by an increase in all values, espe-

Table 1
Individual characteristics of the participants.

Initials	Age (years)	Sex	BMI	Time since stroke onset (years)	Etiology	Hemiplegic side	Concomitant treatment
DRMV	40.86	F	24.0	4.85	Ischemic	L	None
CRAO	56.85	M	28.68	7.83	Hemorrhagic	R	None
AAS	81.29	M	20.55	5.11	Ischemic	L	Physical activities
JCT	62.47	M	25.88	6.75	Ischemic	L	Physical activities
ESM	43.61	M	25.94	13.50	Ischemic	L	None
EJP	70.89	M	24.53	5.08	Hemorrhagic	L	None
SMZS	67.84	F	27.81	5.11	Hemorrhagic	L	None
BSSF	61.17	F	18.83	10.87	Hemorrhagic	L	Physical activities

BMI, body mass index; F, female; M, male; R, right; L, left.

Table 2
Individual temperatures asymmetry between the plegic and contralateral sides at baseline and one, two and three months after neurochemical blockade of the analyzed patients.

Initials	Baseline	1 month	2 months	3 months
DRMV	1.68	1.19	2.87	3.25
CRAO	2.02	1.11	1.82	2.54
AAS	0.44	0.23		
JCT	0.92	0.41	1.10	1.25
ESM	0.92	0.85	1.14	2.39
EJP	0.77			
BSSF	0.61			

Patients AAS, EJP, and BSSF were not analyzed for the follow up assessments.

Table 3
Spasticity and asymmetry Evolution from baseline.

Assessment	Spasticity	Asymmetry	Linear regression analysis
Baseline	2.93 (0.73) / 3 (2.75 – 3.43)	1.05 (0.58) / 0.92 (0.61 – 1.68)	β=0.39; r^2=0.29; **p=0.031**
First month	1.85 (1.55) / 1.37 (0.71 – 3)	0.76 (0.42) / 0.85 (0.41 – 1.11)	
Second month	1.58 (1.55) / 1 (0.4 – 3.33)	1.73 (0.83) / 1.47 (1.11 – 2.35)	
Third month	2.44 (1.39) / 2.5 (1.37 – 3.5)	2.35 (0.83) / 2.47 (1.82 – 2.89)	

Data described as mean (standard deviation) / median (interquartile range); β linear regression beta coefficient.

cially in the data collected in the third month. Figure 1A and 1B demonstrate the evolution from baseline of spasticity and thermo-asymmetry, respectively.

As for the main outcome, the linear regression analysis showed that, considering all collection times, the data presented a statistically significant association with β=0.39, r^2=0.29 and p=0.031 (Table 3). Figure 3 demonstrates the association between the two variables through the projection of Z scores over time, starting from the baseline.

Discussion

The spasticity as a motor sequela of stroke has been assessed with different scales, however, to the best of our knowledge, this is the first study to demonstrate a correlation between the degree of spasticity and thermo-asymmetry. According to the results, the evolution of treatment for spasticity reflected the changes in the body asymmetry of the lower limbs of these patients, resulting in a statistically significant association.

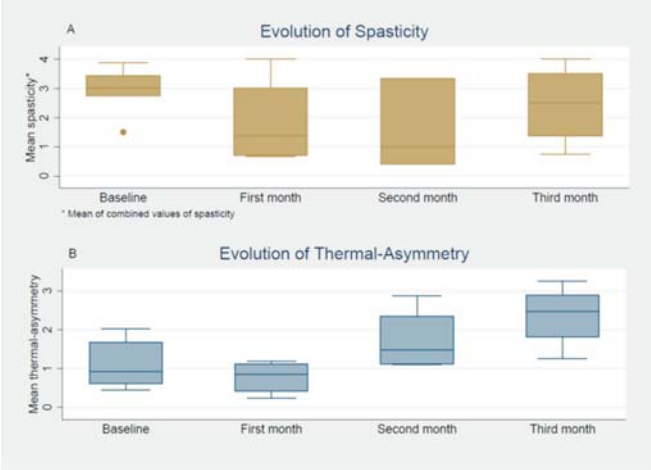

Figure 2A and 2B:
Evolution of spasticity and thermal asymmetry from baseline to follow up assessments.

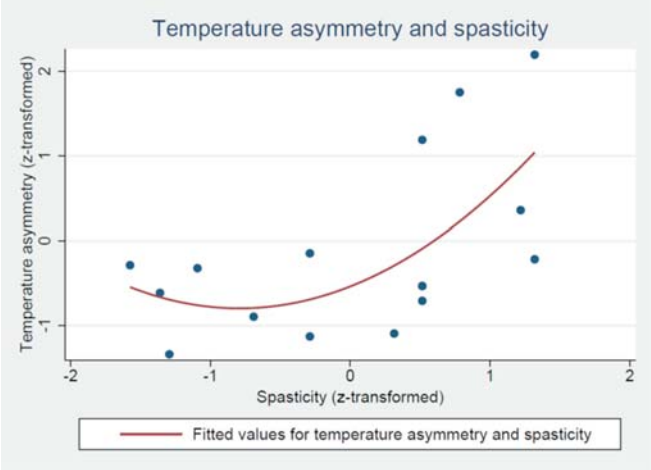

Figure 3
Plot and fitted values of z-transformed spasticity and temperature asymmetry, considering all time points.

The literature reports that there may be peripheral vaso- dilation after the application of neuromuscular blockade by BoNT-A in animal models [34-38] or humans [39]. However, the application sites of BoNT-A in the present study are different from those presented by these authors. Küçüker (2012) and Van Beek (2007) performed intramuscular applications [36,39], and Arnold and collaborators (2009 & 2009) performed perivascular applications or directly into arteries and veins [37,38]. In these studies, a rapid vascular vasodilation was observed in the first month after the application of neuromuscular blocks, similar to our study, as observed in the thermographic images. However, regardless of the similarity between the results between our results and these studies, the mechanism does not seem to the same, at least not exclusively, given the applications of our case report were delivered at the neuromuscular junction without events of blood vessels puncture. Also, there was no inclusion of an active control group for comparison between a neuromuscular blockade with BoNT-A and another chemical agent, such as Phenol, as to isolate the vasodilation effect of BoNT-A.

Previous studies have shown that BoNT-A might have different outcomes depending on the application sites and the systemic status of patients. Kellogg et al. evidenced that cutaneous active vasodilation is not necessarily mediated acetylcholine, but that a muscarinic co-transmitter might be involved [40]. The authors conducted experiments and demonstrated that whenever muscarinic receptors are blocked, acetylcholine has no effects on active cutaneous vascular dilation; oppositely when acetylcholine release is blocked by BoNT-A but the muscarinic receptors are unblocked, the active vasodilation occurs normally. Therefore, they conclude that the only active receptor on cutaneous vascular dilation is muscarinic, but a co-transmitter other than acetylcholine is involved. On animal models, Roh et al. demonstrated increased blood perfusion after BoNT-A administration [41], contrarily, Gazerani et al. 2008 and Gazerani et al. 2009 demonstrated that BoNT-A reduced skin temperature and blood flow during inflammation processes [42,43]. Be that as it may, the literature ensures that BoNT-A may have different outcomes on skin temperature, depending on the application site, the receptor, and the presence of co-transmitters, being the possible reason why the temperature deltas returned to baseline, as shown in Table 2, while the spasticity was still relatively controlled. Thus, other studies addressing the peripheral effects of BoNT-A on patients with spasticity after stroke must be implemented.

Among the sequelae of stroke, vascular changes in the affected limb have been reported. Studies show that the calibers of large arteries in the lower and upper limbs are reduced after a stroke, being subsequently affected by physical rehabilitation programs [44-46]. Therefore, it is suggested that this vascular adaptation after stroke is one of the causes of the temperature reduction on the affected side [47]. Also, even in a study with patients with spinal cord injury, Dhindsa and collaborators (2011) found associations between the intensity of spasticity and blood perfusion of the lower limbs [48]. Therefore, the association between spasticity and thermo-asymmetry found in our results may be due to lower blood perfusion in the lower limbs. Hence, by reducing spasticity, the temperature of the affected limb can also be changed. Nonetheless, we emphasize that there were no blood perfusion assessments of the participants of this study.

The associations found were statistically significant, however, Figure 1A and 1B, showed that the thermo-asymmetry has a tendency to return to baseline values before the spasticity scores. This may be due to the BoNT-A application sites were different depending on the patient, and was not necessarily at the same muscles of the ROIs studied. The ROI assessed by thermography was the posterior portion of the leg showing the lateral and medial gastrocnemius muscles, and a portion of the soleus muscle (Figure 1). The applications of neuromuscular blocks included especially these muscular portions, as described in the methods, and given the limitations of a pilot study, the intention

of assessing such ROIs was to detect temperature changes as closely as possible to the blockade application.

Other variables that may have influenced the different course between the variables in the second month of follow-up are concomitant treatment, reported by three patients, and the use of medications. It was not the objective of this study to address the effect of concomitant treatments. Regarding the use of medications, our group showed in a recent publication that tricyclic antidepressant and serotonin reuptake inhibitors seem to have some influence on the temperature distribution of the paretic limb in patients with stroke [49], however, due to the sample size, the lack of a control group, and objective of this study, the use of medication was not analyzed.

The thermo-asymmetry, despite returning to baseline values before the end of the effect of neuromuscular blockade, was constantly associated with spasticity, as shown in graph 2, as negative values of spasticity generated negative projections in thermo-asymmetry, and vice versa. This arrangement of the data, with the z transformation, shows that even values further from 0 (the average), that is, more extreme values of both variables, had significant associations [50]. This fact demonstrates that infrared thermography may be an anti-spastic treatments assessment of patients with motor sequelae of stroke.

Other variables may have influenced both thermo-asymmetry and spasticity, such as age and BMI. However, these variables were not analyzed due to the limited sample size. We also consider that the lack of a control group, either active or passive, the non-standardization of possible concomitant treatments throughout the study, and the short follow-up period (three months) were other limitations of the study. At last, future studies should evaluate other lower limb regions, such as lateral, medial, and anterior ROIs, as well as feet of patients with spasticity as sequela of stroke.

Conclusion

Changes in spasticity is positively associated with thermo-asymmetry of patients with motor sequelae due to stroke, possibly due to greater blood perfusion after muscle relaxation effect caused by the blockade. In depth studies should be conducted to provide understanding of thermography as a method for evaluating spasticity in patients with stroke, also addressing possible vascular effects of BoNT-A blockade and confounders such as age, BMI, and concomitant treatments.

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(Received 15.12.2023, revision accepted 06.04.2024)

20th Conference of the Polish Society of Medical Physics in Wisla, 26th - 28th April

26th April 2024, THERMOGRAPHY APPLICATION IN MEDICINE

Part 1

12:00-12:30 Prof. Joanna Chwiej, PhD Eng
AGH University of Krakow, Krakow, Poland
"Imaging in the mid-infrared region in the investigations of the microplastics risks"

12:30-13:00 Prof. Jakub Adamczyk, PhD
Józef Pilsudski University of Physical Education, Warsaw, Poland
"Thermal imaging - new perspectives in recovery evolution"

13:00-13:30 Maria Soroko - Dubrovina, PhD, Assoc. Prof.
Wroclaw University of Environmental and Life Sciences, Wroclaw, Poland
"Application of equine thermography in veterinary medicine and physiotherapy"

13:30-13:50 Piotr Gosciniewicz, MD, PhD
University Clinical Center, Medical University of Silesia, Katowice, Poland
"Thermography in ophthalmology - own experience"

13:50-14:10 Antoni Swiatkowski, MD
Medical University of Silesia, Katowice, Poland
"Thermal imaging of the tongue surface as a screening method for type II diabetes"

14:10-14:30 Teresa Kasprzyk-Kucewicz, PhD, Eng
University of Silesia, Katowice, Poland
"The applications of thermal imaging in pathophysiology assessment of migraine - case study"

Part 2:

15:15-15:30 Aleksandra Mrowiec, Eng
University of Silesia, Katowice, Poland
"Application of thermovision in the diagnosis of spinal curvatures in children and adolescents"

15:30-15:45 Adam Suchanski, Msc
University of Silesia, Katowice, Poland
"The use of infrared thermography as a method to support the pedalling optimization in cyclists"

15:45-16:00 Karolina Rykala, Eng
University of Silesia, Katowice, Poland
"The use of preliminary cooling in thermographic diagnostics in breast cancer screening"

16:00-16:15 Pavel Haidukovich, Eng
University of Silesia, Katowice, Poland
"The evaluation of aesthetic laser procedures thermal effects by using of the thermovision - pilot study"

News in Thermology

Peer review of submissions to the EAT 2024 Congress is complete

The peer review of submissions to the EAT Conference is tradition since 2012 [1-4]. This year 37 extended abstracts were submitted, originating from 11 European (Germany, Hungary, Italy, Poland, Portugal, Norway, Slovakia, Slovenia, Spain, Sweden, United Kingdom) and 3 Extra-European countries (India, Brazil, Uruguay).

The peer review was performed under the guide of Dr Kevin Howell. Two referees blinded to the authorship independently assessed the submission using a 5-point scale (5 = outstanding, 4 = strong, 3=somewhat or mixed, 2=limited, 1=unclear or not at all) in the following categories: relevance, novelty, objective, methodology, results, conclusion, future implications. The mean value of the score in these categories was the result of assessment of 1 referee; the final score was built from the average score of both reviewers[1].

23 submissions have been accepted for oral presentation (final score range: 2.7 to 4.85). 9 submissions have been accepted as posters (final score range: 3.2 to 4.75). 2 submissions which were originally rejected have not replied to our invitation to re-submit significantly revised abstracts (final score range: 2.2 and 3.0).

The following presentations will be included in the conference programme.

Oral Presentations

INFRARED THERMOGRAPHY AS A SCREENING TOOL FOR SECONDARY RAYNAUD'S PHENOMENON: A DIAGNOSTIC TEST STUDY (India)

LONGITUDINAL EVALUATION OF ORAL MUCOSITIS LESIONS BY INFRARED THERMOGRAPHY: A CASE SERIES (Brazil)

INTERPRETATION OF BODY TEMPERATURE AND OXYGEN SATURATION BASED ON INDIVIDUAL NORMAL RANGES IN HABITUAL CONDITION: A STEP FORWARD FOR APPLIED PRECISION MEDICINE (Sweden)

DYNAMIC INFRARED THERMOGRAPHY (IRT) AND INDOCYANINE GREEN FLUORESCENCE ANGIOGRAPHY (ICG-FA) COMPARED TO THE GOLD STANDARD COMPUTED TOMOGRAPHY ANGIOGRAPHY (CTA) IN PREOPERATIVE PERFORATOR MAPPING IN AUTOLOGOUS BREAST RECONSTRUCTION (Noway)

TECHNOSTRESS DETECTION THROUGH FACIAL DYNAMIC THERMOGRAPHY (Italy)

UTILITY OF THERMOGRAPHY FOR ASSESSMENT OF NECROTIZING ENTEROCOLITIS IN PRETERM INFANTS (Brazil)

INVESTIGATION OF THE IMPACT OF THE ROBOTIC TOUCH TEMPERATURE ON HUMAN ENGAGEMENT DURING INTERACTIONS WITH THE NAO ROBOT (Italy)

UTILIZING THERMOGRAPHY AS AN EFFECTIVE TOOL FOR OPTIMIZING HEMODYNAMIC MANAGEMENT IN PRETERM INFANTS (Brazil)

THE POTENTIAL OF GYNECOLOGICAL AND ENDOCRINOLOGICAL THERMOGRAPHY. ENDOMETRIOSIS: A NEW PERSPECTIVE (Hungary)

SEX, DRUGS & ROCK N' ROLL WITH INFRARED THERMAL IMAGING (Portugal)

PREVENTING DIABETIC FOOT ULCERS BY IR IMAGING - AN UPDATE (United Kingdom)

ASSOCIATION BETWEEN SKIN TEMPERATURE AND PLANTAR PRESSURE IN THE FOREFOOT OF PATIENTS WITH DIABETES (Portugal)

SKIN TEMPERATURE, BLOOD AMMONIA, AND LACTATE RESPONSE DURING INCREMENTAL EXERCISE UNTIL EXHAUSTION IN ELITE ATHLETES (Poland)

Meetings

May 31st, 2024, New Orleans

Live scientific session at the Roosevelt Hotel in conjunction with the 2024 new Cardiovascular Horizons (NCVH) Annual Meeting.

Webpage:
https://annualmeeting.aathermology.org/

About The Event

The 2024 Annual Scientific Session will be a live, in person meeting with opportunity for virtual presentations. It will be held in conjunction with The 2024 New Cardiovascular Horizons Proceedings, held in New Orleans, at the Roosevelt hotel. The AAT Session will be a single day event from 8am-2pm on May 31st, 2024.

The Pre-Meeting Physician's Thermography Interpretation and the Getting Started Courses will be offered subject to demand and meeting space availability. The Interpretation course is on line, and at your own pace. Typically, the Physician live question and answer session is conducted between 9:00am and 12:00pm (Eastern Time). The Getting Started course runs from 2:00pm to 5:00pm. Use the "Registration" link on the top tool bar to sign up.

Registration will be required for BOTH the NCVH meeting and the AAT Scientific Session. The registration link for the NCVH meeting is NCVH Registration (https://ncvh.org/ncvh-2024/) Use the Promo code AAT24 for the AAT discounted rate. Use the Registration link on the top tool bar of this page to register for the AAT Sessions.

If you would like to stay at the Roosevelt Hotel or have NCVH assist you with travel arrangements use this link: Hotel & Travel. (https://web.cvent.com/event/bdc39ff6-d452-413a-bcdc-50d97ffcad4f/summary?locale=en) Make sure to list AAT in the reservation

2024 Conference Schedule

Day 1

The Pre-Meeting Physician's Thermography Interpretation and the Getting Started Courses will be offered subject to demand and meeting space availability.

9:00 am - 12:00 pm
Physician Interpretation Q & A Session
By Robert Schwartz, MD AAT COB, AIIR Imaging Alliance, Greenville, SC

2:00 pm - 5:00 pm
"Getting Started In Medical Thermology" Round Table
By Jan Crawford, RN, BSN AAT Board, Scaly Mt, NC, Robert Kane, DC AAT Member, San Francisco, CA

Day 2

PROGRAM

8:00am - 8:10am
Welcoming Comments

8:10am - 8:40am
The Emergence of Point of Care Infrared Thermography (POCIT) in Circulatory Disorders
By Ariel Soffer, MD AAT Member

8:40am - 9:10am
The Cutting-Edge Fusion: POC AI-Enhanced Dual Infrared-Visual Thermography in Vascular Imaging
By Marcos Brioschi, MD, PhD AAT Honorary Member, AIIR Imaging Alliance, ABRATERM, Sao Paulo University, Brazil.

9:10am - 9:30am
AAT POC Guidelines
By Jan Crawford, RN, BSN AAT Board, Scaly Mt, NC

9:30am - 10:00am
Panel Discussion: Soffer, Brioschi, and Crawford

10:00am - 10:15am Break

10:15am - 10:45am
Musculoskeletal Causes of Chest, Neck and Arm Pain
By Robert Schwartz, MD AAT COB, AIIR Imaging Alliance, Greenville, SC

10:45am - 11:15am
Thermal Imaging RSDS/CRPS: Case Reports
By George Schakaraschwili, MD, AAT Board, Denver, CO

11:15am - 11:45am
CCI, CCJ Procedures, and SSR Assessments
By Jaime Browning, DC, DCCJP, AAT Member, Spartanburg, SC

11:45am - 12:15pm
A Novel Approach to Dysautonomia
By Robert Schwartz, MD AAT COB, AIIR Imaging Alliance, Greenville, SC

12:15am - 1:00pm Lunch

1:00pm - 1:30pm
The AAT Collective Intelligence Initiative
By Marcos Brioschi, MD, PhD AAT Honorary Member, AIIR Imaging Alliance, ABRATERM, Sao Paulo University, Brazil.

1:30pm - 2:00pm
The Blue Highways Book Tour. Clinical Thermography in the United States 2022
By James Stewart Campbell, MD AAT Senior Member, Pfafftown, NC
2:00pm Adjourn

6th - 8th September 2024, Wroclaw, Poland

XVI Congress of the European Association of Thermology

Venue
Wroclaw University of Environmental and Life Sciences

The EAT and Wroclaw University of Environmental and Life Sciences are delighted to invite you to participate in the XVI EAT Congress from 6th to 8th September 2024. Following on from the most recent meetings in Porto (2012), Madrid (2015), London (2018) and online in 2021, the Congress heads to eastern Europe for 2024 to Wroclaw in Poland. The Organising Committee looks forward to welcoming you to Wroclaw University of Environmental and Life Sciences in the summer of 2024

Dr. Kevin Howell, President, European Association of Thermology

Dr. Maria Soroko-Dubrovina, Chair, XVI Congress Organising Committee

The Congress is held under the honorary patronage of His Magnificence, Rector of the Wroclaw University of Environmental and Life Sciences.

Organising Committee

This committee is responsible for all operational aspects of the Congress, including delivery of the meeting at the local venue

- **Maria Soroko-Dubrovina (POL), Chair**
- Kurt Ammer (AUT)
- Kevin Howell (GBR)
- Anna Jung (POL)
- Adam Roman (POL)
- Adérito Seixas (POR)
- Manuel Sillero-Quintana (ESP)
- Karolina Sniegucka (POL)
- Ricardo Vardasca (POR)
- Anna Zielak-Steciwko (POL)
- Paulina Zielinska (POL)

International Scientific Committee

This committee is responsible for reviewing all submitted abstracts to the Congress, and approving the final Congress programme

- **Kevin Howell (GBR), Chair**
- Kurt Ammer (AUT)
- John Allen (GBR)
- Danilo Gomes Moreira (BRA)
- George Havenith (GBR)
- Anna Jung (POL)
- James Mercer (NOR)
- Adérito Seixas (POR)
- Manuel Sillero-Quintana (ESP)
- Maria Soroko-Dubrovina (POL)
- Hisashi Usuki (JPN)
- Ricardo Vardasca (POR)

Registration fees

Registration for the XVI EAT Congress is now open. Please register by completing the form here. (https://docs.google.com/forms/d/e/1FAIpQLSeAj9BsmoTFQcFXMwuh0IYl1m0c4GKWtQClBbPDQ_lWSvUZMA/viewform)

Registration includes access to all congress sessions, congress lunch and coffee breaks, the Gala Dinner and walking tour.

	Early registration (until 6 May 2024)	**Late registration (after 6 May 2024)**
EAT member	€360	€410
Non-member	€440	€490
One-day registration	€200	€250
Student	€200	€250
Accompanying person	€120	€120

Attendance at the pre-congress Short Course on Medical Thermography requires a separate registration and payment. More information, when available, will be posted here (http://www.eurothermology.org/education.html) .

Short Course in Medical Thermography

Date: 6th September 2024

*Venue:*Wroclaw University of Environmental and Life Sciences

The European Association of Thermology has education as one of its key aims. To that end, we offer the EAT "Short Course in Medical Thermography," taught by an experienced faculty of thermology researchers.

The Course normally takes place every three years, along with the Congress of the EAT, at a European venue.

Main themes of the 2024 course in Wroclaw will include:

- Physical principles of heat transfer
- Principles of thermal physiology and skin blood perfusion
- Standardization of thermal imaging, recording and analysis
- Quality assurance for thermal imaging systems
- Producing a thermographic report

- Provocation tests
- Image analysis
- Educational resources

Local hotels

Below is a list of hotels near to the Congress venue in Wroclaw...

- Hotel ZOO (recommended) (https://zoo-hotel.pl/)

10% discount for congress participants: please quote "XVI Congress of the European Association of Thermology" when booking

Address: ul. Wroblewskiego 7, 51-627 Wroclaw

Phone: +48 510 091 913; 510 663 963

Reservations: biuro@zoo-hotel.pl

- Green Hostel Wroclaw

Address: ul. Mickiewicza 4, 51-619 Wroclaw

Phone: +48 71 348 06 06

Reservations: info@greenhostel.wroclaw.pl

- Radisson Blu Hotel Wroclaw

(https://www.radissonhotels.com/en-us/hotels/radisson-blu-wroclaw)

Address: ul. Purkyniego 10, 50-156 Wroclaw

Phone: +48 71 375 00 26; 71 375 00 370

Reservations: reservations.wroclaw@radissonblu.com

- Grape Hotel and Restaurant (https://www.grapehotel.pl/en/)

Address: Parkowa 8, 51-616 Wroclaw

Phone: +48 71 73 60 400

*Reservation*s: biuro@grapehotel.pl

- Hotel Puro (https://purohotel.pl/en/wroclaw/)

Address: Pawla Wlodkowica 6, 50-072 Wroclaw

Phone: +48 71 772 51 00

Reservations: wroclaw@purohotel.pl

- Hotel Europeum (https://europeum.pl/en/)

Address: ul. Kazimierza Wielkiego 27A, 50-077 Wroclaw

Phone: +48 71 371 44 00; 71 371 44 02

Reservations: europeum@europeum.pl

- Hotel B and B Wroclaw Centrum (https://www.hotel-bb.com/en)

Address: Piotra Skargi 24-28, 50-082 Wroclaw

Phone: +48 71 324 09 80

Reservations: wroclaw@hotelbb.com

- Hotel Mercure Wroclaw Centrum (https://all.accor.com/hotel/3374/index.en.shtml)

Address: pl. Dominikanski 1, 50-159, Wroclaw

Phone: +48 71 323 27 00

Reservations: H3374-SL2@accor.com

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XVI Congress of the European Association of Thermology

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THERMOGRAPHIC AND ULTRASOUND FINDINGS OF PATIENTS WITH PAIN OF KNEE JOINTS: RETROSPECTIVE STUDY FROM JANUARY 2010 TO JULY 2023 (Slovakia)

THE DIFFERENCE ON SKIN TEMPERATURE RESPONSES BETWEEN AN EXERCISE WITH AND WITHOUT MUSCLE DAMAGE (Spain)

INFLUENCE OF CENTRAL NERVOUS SYSTEM ACTIVATION ON LOWER LIMBS SKIN TEMPERATURE AFTER A RESISTANCE TRAINING (Spain)

THE IMPORTANCE OF QUALITY ASSURANCE IN CLINICAL THERMOGRAPHY: A CASE STUDY (United Kingdom)

A PRELIMINARY EVALUATION OF THE LOW-COST HIKMICRO POCKET 2 IR CAMERA FOR ITS SUITABILITY IN MEDICAL THERMOGRAPHY - A CROSS-COMPARATIVE STUDY (Norway)

THE PRACTICAL PROBLEMS OF INTRODUCING IR TECHNOLOGY INTO HEALTH SERVICES (United Kingdom)

KEYNOTE McCafferty THERMAL IMAGING IN CAPTIVE AND WILD ANIMALS: APPLICATIONS AND FUTURE DIRECTIONS (United Kingdom)

THE EFFECT OF LOW AND HIGH HEEL SYNDROME ON INFRARED THERMOGRAPHIC IMAGES OF THE FORELIMB OF THOROUGHBREED RACEHORSES (Poland)

APPLICATION OF INFRARED THERMOGRAPHY IN THE ASSESSMENT OF BEMER PHYSICAL VASCULAR THERAPY ON BODY SURFACE TEMPERATURE CHANGES IN RACING THOROUGHBREDS (Poland)

USEFULNESS OF INFRARED THERMOGRAPHY IN CLINICAL FOLLOW-UP IN BITES WITH POISONOUS ANIMALS IN URUGUAY (Uruguay)

THERMOGRAPHY AS A METHOD FOR THE EARLY DETECTION OF ORTHOPEDIC INJURY IN THE FORE LIMBS DURING THE TRAINING OF 2-YEAR-OLD THOROUGHBRED RACEHORSES (Poland)

Posters

THE ROLE OF INFRARED THERMOGRAPHY IN ASSESSMENT OF THE PHOTOTHERMAL EFFECT OF CLASS IV LASER THERAPY IN HORSES (Poland)

DO CHARACTERISTICS OF RIDERS INFLUENCE HEART RATE AND BODY SURFACE TEMPERATURE OF LIPIZZAN HORSES AFTER GRADED EXERCISE LOAD? (Slovenia)

ARE THERE THERMAL AND PERFORMANCE-RELATED ASYMMETRIES BETWEEN THE PREFERRED AND NON-PREFERRED LEG IN HEALTHY AMATEUR SOCCER PLAYERS? (Germany)

UTILITY OF THERMOGRAPHY IN THE EARLY DIAGNOSIS OF CATHETER SEPSIS IN A PEDIATRIC INTENSIVE CARE UNIT IN URUGUAY (Uruguay)

FEET TEMPERATURE IN MAXIMUM ERGOMETRIC TEST: A PRELIMINARY STUDY (Brazil)

DEVELOPMENT OF A VASCULAR OPTICS AND MICROVASCULAR SENSING RESEARCH FACILITY - THE COVENTRY UNIVERSITY EXPERIENCE (United Kingdom)

RELATIONSHIP BETWEEN SKIN TEMPERATURE AND MUSCLE OXYGEN SATURATION DURING VOLUNTARY EXERCISE FOR KNEE EXTENSORS (Spain)

CORTISOL LEVEL AND EYE TEMPERATURE IN DOGS WORKING IN ANIMAL-ASSISTED EDUCATION (Poland)

DYNAMIC THERMOGRAPHY USED TO SUPPORT THE DIAGNOSIS OF DIABETIC FOOT WITH THE ASSESMENT OF BALANCE AND FOOT POSITIONING (Poland)

Many authors have commented to Dr Howell that the review process is very important to research groups, and the feedback received from reviewers is considered extremely valuable. This review process was only possible by the assistance of members of the Scientific Committee and their expertise and willingness to evaluate the submitted papers.

We like to thank the following colleagues for their help:

John Allen, UK

Kurt Ammer, Austria

Danilo Gomes Moreira, Brazil

George Havenith, UK

Kevin Howell, UK

Anna Jung, Poland

James Mercer, Norway

Aderito Seixas, Portugal

Manuel Sillero-Quintana, Spain

Maria Soroko-Dubrovina, Poland

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Abstracts

IMAGING IN THE MID-INFRARED REGION IN THE INVESTIGATIONS OF THE MICROPLASTICS RISKS

J. Chwiej[1], M. Wytrwal[2], E. Oclon[3], Z. Setkowicz[4], M. Kukula[1], K. Papacz[1], J. Gol[1], M. Rugiel[1], D. Oczkiewicz[1], K. Lechowicz[1]

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3Centre for Experimental and Innovative Medicine, University of Agriculture in Krakow, Krakow, Poland

4Institute of Zoology and Biomedical Research, Jagiellonian University, Krakow, Poland

Plastic pollution of the natural environment is currently one of the main environmental protection problems in the world. Plastic production has increased 25 times over the last 40 years. Due to their improper disposal and non-recycling, they constitute the long-term pollution and seriously threaten ecosystems, especially aquatic ones. A particular problem here are primary and secondary microplastics, which, mistaken for food, enter in large quantities into living organisms inhabiting the seas and oceans. Humans are also exposed to microplastics, which may come from drinking water, consumed food, clothes or cosmetics. Knowledge about the harmful effects of microplastics on living organisms, including humans, is still very poor. Therefore, it is necessary to intensify research in this area.

Among the numerous instrumental methods used to analyze microplastics, vibrational spectroscopy techniques such as infrared and Raman microscopy are of particular importance. These techniques enable not only the observation and confirmation of the presence of plastic particles in the tested samples, but above all, the identification of microplastics based on the analysis of their molecular spectra. Both methods, although characterized by different spatial resolution, also allow for the assessment of biomolecular changes occurring in cells and tissues as a result of the influence of various physiological and pathological factors. In frame of the presentation the examples of our own research in which the mentioned vibrational microspectroscopy techniques were used to assess the internalization, biodistribution, fate and toxicity of microplastics in in vitro and in vivo conditions will be shown. The influence of polystyrene microparticles with different size on the cells of the immune (macrophages) and the respiratory system (lung fibroblasts) as well as on the entire body will be analyzed.

ACKNOWLEDGEMENTS:The work was financed by the funds granted to the AGH University of Krakow in the frame of the "Excellence Initiative - Research University" project (Action 12: Integration of the educational process with scientific research, PL-Joanna Chwiej).

THERMAL IMAGING - NEW PERSPECTIVES IN RECOVERY EVOLUTION

Jakub Grzegorz Adamczyk, Dariusz Boguszewski, Bartlomiej Michalak

Department of Theory of Sport, Józef Pilsudski University of Physical Education, Warsaw, Poland

Post-exercise recovery is crucial for achieving optimal physical condition and performance in sports. During intense physical activity, muscles undergo microtrauma, and the body depletes its energy resources. The regeneration process allows for the repair of muscle tissues, replenishment of muscle glycogen, and elimination of toxins accumulated during exercise. Adequate regeneration also helps prevent overtraining, reduces the risk of injuries, and improves sleep quality, which is crucial for overall health and physical fitness. The key issue remains the monitoring of post-exercise regeneration effectiveness.

Engaging in physical activity involves initially restricting skin flow (vasoconstriction), followed by the phenomenon of reverse action (vasodilation) to expel excess heat. The elevation of body temperature and its eventual return to resting values also occur during rest. The return time depends on the type, volume, and intensity of exercise, as well as the individual adaptive capabilities of the athlete. Thermography, currently considered the most attractive method for remote temperature measurement, provides new possibilities for evaluating the effectiveness of regeneration.

The study analyzed thermographic imaging results of the lower limb surfaces (Tsk) in relation to biochemical indicators (blood lactate concentration) and subjective pain assessment scale (VAS). In all studies, participants performed maximal anaerobic exercise, followed by one of the regeneration support methods: classical massage, isometric massage, hot stone massage, rolling, stretching, ice massage, or immersion in cold water. Measurements were taken immediately after exercise and 30 minutes after its completion.

Observation results indicate that the ability to observe increased regenerative activity of the body depends on the form of the applied action. Test results showed a significant decrease in lower limb surface temperature of approximately 1.2-1.5°C immediately after exercise. Activation of regenerative processes was confirmed by a temperature increase of at least 1°C 30 minutes after exercise cessation in each muscle group for most applied methods. Gradual restoration of peripheral circulation was associated with an increase in temperature as well as a decrease in capillary blood lactate concentration.

Almost all types of regenerative activity led to an increase in lower limb surface temperature above resting values, with the most informative location likely being the anterior surface of the thigh due to the high load on the knee extensor muscles. Increased heating was also observed with cryotherapy methods; however, in this case, the 30-minute period was insufficient to achieve thermal equilibrium. A high correlation ($R=0.8$; $p<0.05$) was noted between Tsk increase and pain intensity (VAS).

In case of the a inapplicability of objective biochemical methods, thermal imaging may be an interesting alternative for assessing the intensity of post-recovery processes. The expected increase in Tsk above resting values may indicate intensification of metabolic processes associated with post-exercise regeneration. In the context of the undertaken effort, observation of the anterior thigh surface appears particularly important.

APPLICATION OF EQUINE THERMOGRAPHY IN VETERINARY MEDICINE AND PHYSIOTHERAPY

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Thermography has found wide application in equine veterinary medicine and physiotherapy as a complementary diagnostic tool

for diagnosing musculoskeletal disorders, monitoring tissue regeneration processes, and assessing the effectiveness of anti-inflammatory drugs. It is particularly useful in diagnosing inflammatory processes, especially in the distal parts of forelimbs including: arthritis, tendonitis, bucked shins, bone fractures, and laminitis. In the case of the back, this method is effective in diagnosing lumbar-sacral muscle tension, inflammation of the thoracic vertebrae and muscles. Thermography is also effective in diagnosing subclinical inflammatory processes, even up to two weeks before clinical symptoms appear. Utilizing this method in diagnosis and prevention can reduce the risk of more serious injuries and expedite the healing process.

Recently thermography has been used to assess and monitor the effectiveness of physical devices such as magnetotherapy, laser therapy, shockwave therapy, cryotherapy, and kinesiotherapy, for example electric treadmill.

Modern thermographic camera systems, supported by advanced image analysis programs, ensure high-quality images, and the obtained data can be further processed to obtain reliable information. Establishing clear procedures for conducting thermographic examinations and early diagnosis methods for equine musculoskeletal disorders can contribute to the dissemination of this effective diagnostic method in equestrian centers.

THERMAL IMAGING OF THE TONGUE SURFACE AS A SCREENING METHOD FOR TYPE II DIABETES.

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Diabetes mellitus is a disease of civilisation whose prevalence has increased significantly over the last 20 years, making it a global public health problem.

The aim of this study was to develop a method for early detection of the disease using thermal imaging to assess the dynamics of changes in tongue surface temperature due to the mouthwash procedure used.

Sixty-three adults - 30 patients with type II diabetes and 33 healthy volunteers - were studied. The temperature distribution on the dorsal and apical surface of the tongue after the cooling procedure was performed using a FLIR T540 thermal imaging camera. A significant correlation was found between thermal parameters such as temperature difference, defined as the difference between the median temperature of each surface of the tongue 10 and 2 minutes after mouth rinsing (ΔT), and glycated haemoglobin (HbA1c) levels. In addition, the median mean dorsal temperature measured 10 minutes after rinsing was almost 0.8[°C] lower in people with diabetes than in healthy people. The study showed a correlation between tongue temperature and the standard biochemical parameter characteristic of type II diabetes, glycated haemoglobin.

The method presented here may provide a specific screening method for this disease entity.

THE APPLICATIONS OF THERMAL IMAGING IN PATHOPHYSIOLOGY ASSESSMENT OF MIGRAINE - CASE STUDY

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Migraine is described as the most common spontaneous headache. It is characterised by a throbbing, usually unilateral headache. It is accompanied by gastrointestinal complaints, hypersensitivity to stimuli and vegetative disturbances. Despite numerous studies and a number of models of pathophysiology, no clear etiopathogenesis of this disease entity has been established to date. This provides an opportunity to search for novel diagnostic methods to analyse and assess the course of the disease in patients, such as infrared thermography. Thermal imaging makes it possible to visualise the thermal map of the surface under examination and identify areas with a different thermal pattern, and is therefore helpful in localising pathologically altered tissues.

The present study focuses on the analysis of 4 migraine pain attacks in one patient over a 9-month period. Follow-up measurements were taken in the same patient on 5 different days when no complaints were observed in the subject. The facial surface in the frontal plane was imaged, taking into account the patient's temperature acclimatisation process. In addition, heart rate and blood pressure were measured and the severity of pain during the attack was assessed on the NRS scale.

Already on the basis of visual assessment, a change in the temperature distribution on the body surface can be seen. A careful analysis of the parameters of temperature variation between the side of the forehead where the migraine occurred and the pain-naive side showed statistically significant differences between the group of measurements during a pain attack and the control group.

Based on the correlations obtained, it appears that the analysis of temperature changes on the facial surface may be helpful in understanding the neurophysiology and refining the model of migraine pathophysiology. However, it is necessary to increase the study group of patients and carefully verify the aetiology of pain occurrence in a given case.

APPLICATION OF THERMOVISION IN THE DIAGNOSIS OF SPINAL CURVATURES IN CHILDREN AND ADOLESCENTS

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INTRODUCTION: In the last two decades, the time children and adolescents spend in front of phones and computers has increased significantly, which contributes to the problem of poor

posture that can lead to spinal curvatures. Currently, the main methods used to diagnose spinal curvatures in children and adolescents are posturography and X-ray examination (X-ray), which is not inert to the body. There is a lack of easy-to-use, low-cost, fast and precise non-invasive techniques that could not only be equally effective in the assessment of the curvature itself but could be used in screening examinations. Thermal imaging appears to be a promising non-invasive method that could be useful for the early detection of lateral curvatures of the spine in children and adolescents.

METHODOLOGY: The study was carried out in the Sports Medicine Laboratory, at the Institute of Biomedical Engineering at the University of Silesia in Katowice, Poland, with 10 patients aged between 11 and 23 years. The patients were subjected to a thermal imaging study, which consisted of two phases: before entering (cooling the body) and after leaving the cooling cabin. Before the test, each person was acclimatised to room temperature for 10 minutes. The body was then cooled in the cooling cabin using a supply of air at 0°C for 3 minutes. The thermograms were analysed using ThermaCAM Researcher Pro 2.10, which allowed the body areas to be delineated and the measurement data to be read out.

RESULTS: The results obtained showed a correlation between the difference in mean temperature of the respective spinal segments compared against the spinal line and the degree of curvature calculated using the scoliometer. It was found that as the curvature of the spine increased, the thermal asymmetry relative to the spine increased. A pilot study of thermal imaging assessment of spinal curvatures after initial cooling of the body showed an increase in the diagnostic sensitivity of thermal images. The results suggest that thermal imaging may be an effective screening technique for the diagnosis of lateral spinal curvatures in children and adolescents. Additionally, the use of pre-cooling of the body prior to thermal imaging may improve the diagnostic sensitivity of this method. Such results may have important implications for future research into new non-invasive methods of diagnosing spinal curvatures.

THE USE OF INFRARED THERMOGRAPHY AS A METHOD TO SUPPORT THE PEDALLING OPTIMIZATION IN CYCLISTS

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Thermal imaging has found application in the field of sports medicine and training in recent years. It is known that the human body emits the infrared radiation and the skin has good emission properties. In addition, the performance of work by the muscles contributes to changes in the temperature distribution observed on the body surface due to changes in blood distribution and an increase in the metabolism of muscle tissue.

The aim of this study was to develop a research protocol for monitoring the pedalling process of cyclists using infrared thermography and measurements of muscle electrical activity (sEMG).

Three volunteers, cyclists with more than 12 years of training experience with a mean age of 37 ± 9 years, a body weight of 72.7 ± 5.5 kg and a mean resting heart rate of 47 ± 3 bpm, participated in the study. The measurement protocol consisted of training on a cycle trainer with 4 load thresholds from 150 to 300 W with an interval of 50 W, preceded by an 8-min warm-up with a workload of 100 W. Thermal imaging was performed for the quadriceps and biceps femoris muscles before the workout and after each load threshold, while sEMG was measured continuously throughout the workout.

A preliminary visual assessment of the thermal images taken shows changes in the temperature distribution of the lower limb surfaces, indicating changes in the metabolism of the muscle tissue involved in training. The average temperature of the analysed muscles shows a slight oscillation during training. The preliminary correlations performed between the electrical activity of the muscles and the thermal parameters indicate the existence of a relationship between the variables, which allows a conclusion to be drawn about a correctly selected research protocol.

Preliminary results suggest the possibility of combining a thermal imaging method with sEMG to monitor and optimise the pedalling process. However, a larger study group will be necessary to confirm these results.

THE USE OF PRELIMINARY COOLING IN THERMOGRAPHIC DIAGNOSTICS IN BREAST CANCER SCREENING.

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INTRODUCTION: Thermographic diagnostics in breast cancer has been developed since the 1950s. Traditionally, thermographic diagnostics are conducted under normal conditions, after establishing thermodynamic equilibrium between the body and the environment, which is referred to as classical thermography. This study presents preliminary research results where preliminary body cooling was applied by blowing air at 0°C for 3 minutes in a cooling chamber. This approach aims to increase the sensitivity of thermograms by highlighting areas with increased metabolism manifested by elevated temperature, which may be associated with cancerous conditions.

OBJECTIVE: The attempt is to demonstrate that preliminary body cooling as a physical factor leads to increased sensitivity of thermal images in the thermographic diagnosis of breast oncological conditions. Such a study can be used to enhance the sensitivity of screening thermography in the early diagnosis of breast gland cancer.

MATERIAL AND METHODS: The research group consisted of 6 volunteers, including 4 women with no diagnosed breast conditions and 2 women who had undergone successful breast cancer treatment. Measurements were conducted at the Sports Medicine Laboratory at the Institute of Biomedical Engineering at the University of Silesia using the CryoSpace cryogenic chamber from JBG2, which also has an air-cooling unit providing airflow at 0°C. Thermographic studies were performed using the FLIR SYSTEMS T1020 thermal camera. Each individual underwent two thermal images: the first after a 15-minute acclimatization before entering the cooling chamber, and the second immediately after exiting the cooling chamber, where the volunteers spent 3 minutes. Time analyses were also conducted during which patients stayed in the cooling chamber for 1, 2, and 3 minutes. This research protocol aimed to determine whether the duration and thus the depth of cooling significantly influence the sensitivity of thermal images. Thermal image analysis was performed using ThermaCAM Researcher Pro 2.10 software. The analysed area of the breast gland was divided into 4 quadrants labeled: P/L1 - lower outer quadrant, P/L2 - upper outer quad-

rant, P/L3 - upper inner quadrant, P/L4 - lower inner quadrant, where P indicates the right breast and L indicates the left breast, and the nipple area was separately marked as BS L/P. The results of the analysis included the average temperature value, maximum temperature, and the difference between symmetrical areas of both breasts.

CONCLUSIONS: Preliminary body cooling is a significant factor in increasing the sensitivity of thermal images. A statistically significant increase in temperature contrast was obtained from the respective quadrants after body cooling, compared to thermal images taken before cooling. It appears that a 3-minute stay in the cooling chamber is necessary to increase the diagnostic value of thermograms, which has practical implications for the design of diagnostic cabins and research protocols.

THE EVALUATION OF AESTHETIC LASER PROCEDURES THERMAL EFFECTS BY USING OF THE THERMOVISION - PILOT STUDY

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Nowadays, aesthetic medicine and dermatology are dynamically developing fields of medicine. Lasers have been playing a leading role in aesthetic treatments for several decades. The interaction of laser light with tissues causes an increase in thermal energy, which makes it possible to observe thermal effects on the body surface using a thermal imaging camera and, on this basis, draw conclusions about the dynamics of processes occurring inside the body.

The aim of this study was to assess the dynamics of thermal effects of laser therapy for skin lesions in aesthetic medicine, which may help indicate potential areas for optimization of procedures while minimizing the risk of undesirable side effects. The research was conducted at the Magnuccy Clinic in Katowice for a group of 4 patients aged 23 to 45 with stretch marks located in various areas of the body. The laser energy used for the procedure was 0.6J. Thermal imaging tests were carried out using a FLIR SYSTEMS T1020 thermal imaging camera. Thermal photos were taken of each person at time intervals of 3 minutes, with the first one taken before the start of therapy and the last 60 minutes after the end of the treatment.

The analysis of the obtained thermograms assessed temperature changes in the treatment site and adjacent body tissues, where thermal effects were visible because of the interaction of laser light with tissues. An increase in the average temperature of the treated tissue was observed, followed by its stabilization approximately twenty minutes after the end of the treatment. Changes in the isotherm area, defined as the area of the skin surface characterized by a temperature higher than the average temperature of the treated area before the treatment, were also analyzed. The obtained results showed that the area defined by the isotherm increases up to three times after the treatment, which is caused by heat transport and changes in the blood supply to both the treated and surrounding tissues. This observation provides important information on planning treatments using a high-energy laser, especially in the area of tissues and organs sensitive to temperature increases.