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Concordance study of the portable camera FLIR C5 for detecting asymmetry of skin temperature in patients with stroke sequelael

Thermographic and ultrasound findings of patients with pain of hip joints: retrospective study from April 2010 to July 2022

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In general, manuscripts hould be organized as follows: Introduction, methods, results, discussion, acknowledgements, references. A short abstract in English and, if possible, German (translation will be offered) should head the manuscript. Following the abstract, up to 5 key-words should characterize the paper.

Tables, Figures and Legends for illustrations should appear each on an extra sheet of paper.

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Gautherie M, HaehnelP, Walter JM, Keith L. Long-Term assessment of Breast Cancer Risk by Liquid Crystal Thermal Imaging. In: Gautherie M, Albert E, editors. Biomedical Thermology. New York Alan R.Liss Publ; 1982. p. 279-301.

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[1] International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. Medical Education 1999; 33; 066-078

[2] www.consort-statement.org

[3]www.strobe-statement.org

[4]www.prisma-statement.org

[5] www.stard-statement.org

[6] www.care-statement.org

[7] www.spirit-statement.org

[8]www.equator-network.org/wp-content/uploads/2013/03/SAMPL-Guidelines-3-1

[9]Moreira DG et al. Thermographic imaging in sports and exercise medicine: a Delphi study and consensus statement on the measurement of human skin temperatur. J Thermol Biol 2017, 69: 155-162

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The concordance study of the portable camera FLIR C5 for detecting asymmetry of skin temperature in patients with stroke sequelae

Fábio Marcon Alfieri[1], Artur Cesar Aquino dos Santos[1],Caren da Silva Dias[1], Linamara Rizzo Battistella [1,2]

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SUMMARY

BACKGROUND: Low-cost portable infrared cameras are increasingly used for health assessments, especially for investigating the skin temperature of the whole body. However, some of these devices have not yet been tested for agreement with high-resolution cameras. Therefore, the objective of this study was to test the agreement of FLIR C5, a portable infrared thermographic camera, compared to the FLIR T650sc, a high-quality and high-resolution thermographic device, for detecting thermal asymmetry between both sides of the body of patients with motor sequelae after stroke.

MATERIALS AND METHODS: This is an observational and cross-sectional study conducted in a physical rehabilitation facility with 14 patients with stroke sequelae. Participants had their temperature simultaneously measured by FLIR T650sc and FLIR C5 infrared thermography cameras and analyzed with the software FLIR Tools®. The temperature difference of each ROI measured by both cameras was compared with Lin's Concordance Correlation Coefficient (rho or ρc) and Bland Altman the limits of agreement (LOA).

RESULTS: the temperatures measured by FLIR C5 were lower than those measured by FLIR T650sc, regardless of the region of interest or side (-0.65, SD 1.44). We observed that the general concordance was classified as adequate to excellent (ρc=0.859; 95%CI 0.817-0.901; p<0.001) and that the forearm and leg in the posterior view presented the sites with the best associations between the temperature readings of FLIR C5 and FLIR T650sc.

CONCLUSIONS: The temperature asymmetry usually found among patients with stroke sequelae may be assessed by the portable infrared thermographic camera FLIR C5, given its suitable concordance with FLIR T650sc.

KEYWORDS: Thermography; mobile thermography, affordable infrared cameras, stroke; cutaneous temperature

KONKORDANZSTUDIE DER TRAGBAREN KAMERA FLIR C5 ZUR ERKENNUNG DER ASYMMETRIE DER HAUTTEMPERATUR BEI PATIENTEN MIT SCHLAGANFALLFOLGEN

HINTERGRUND: Kostengünstige tragbare Infrarotkameras werden zunehmend für Gesundheitsbewertungen ein- gesetzt, insbesondere zur Untersuchung der Hauttemperatur des gesamten Körpers. Einige dieser Geräte wurden jedoch noch nicht auf Übereinstimmung mit hochauflösenden Kameras getestet. Daher bestand das Ziel dieser Studie darin, die Übereinstimmung von FLIR C5, einer tragbaren Infrarot-Thermografiekamera, im Vergleich zur FLIR T650sc, einem hochwertigen und hochauflösenden Thermografiegerät, zur Erkennung thermischer Asymmetrie zwischen beiden Körperseiten von Patienten mit motorischen Folgeerscheinungen nach einem Schlaganfall zu testen.

MATERIALIEN UND METHODEN: Hierbei handelt es sich um eine Beobachtungs- und Querschnittsstudie, die in einer physikalischen Rehabilitationseinrichtung bei 14 Patienten mit Schlaganfallfolgen durchgeführt wurde. Die Temperatur der Teilnehmer wurde gleichzeitig mit den Infrarot-Thermografiekameras FLIR T650sc und FLIR C5 gemessen und mit der Software FLIR Tools® analysiert. Die Temperaturdifferenz jedes ROI, der von beiden Kameras gemessen wurde, wurde mit dem Lins Konkordanskoeffizienten (rho oder ρc) und Bland Altmans Übereinstimmungsgrenzen (LOA) verglichen.

ERGEBNISSE: Die von FLIR C5 gemessenen Temperaturen waren niedriger als die der FLIR T650sc, unabhängig vom Messareal oder der Seite (-0,65, SD 1,44). Wir beobachteten, dass die allgemeine Konkordanz als ausreichend bis ausgezeichnet eingestuft wurde (ρc=0,859; 95%KI 0,817-0,901; p<0,001) und dass der Unterarm und das Bein in der hinteren Ansicht die Stellen mit den besten Assoziationen zwischen den Temperaturmesswerten von FLIR C5 und FLIR T650sc aufwiesen.

SCHLUSSFOLGERUNG: Die Temperaturasymmetrie, die normalerweise bei Patienten mit Schlaganfallfolgen auftritt, kann mittels der tragbaren Infrarot-Thermografiekamera FLIR C5 erfasst werden, zumal sie mit den Messungen der FLIR T650sc übereinstimmt.

SCHLÜSSELWÖRTER: Thermografie; mobile Thermografie, leistbare Infrarotkameras, Schlaganfall; Hauttemperatur

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Introduction

Modern thermography techniques began in the 1950s with military issues [1], and now it is currently used in several fields such as engineering and architecture [2], veterinary medicine [3,4], police monitoring, ecology, medicine, and biology [5], among others.

In the evaluation of human subjects, the basis of thermography is the detection of the thermal radiation emitted by the skin [1]. This technique is an assessment that provides an image of the thermal distribution of body surfaces, using a special camera that captures the long infrared radiation in the range of 6μm to 15μm emitted by the human body. Non-invasive, completely painless, fast, and free of contraindications or side effects, thermography imaging can indicate and monitor physiological dysfunctions of temperature-related diseases [1,5,6].

However, some considerations must be emphasized before using thermographic devices [7]. The specialized literature reports that environmental, individual, and technical factors confound these assessments. Regarding the technical factor, issues such as validity, reliability, and using standardized protocols must be considered [7].

A relevant matter of thermography assessments is the recent use of low-cost technologies to investigate body temperature. In scientific terms, these infrared sensors were recently released, and, despite the lack of high resolution, they have been used in clinical research. Two studies conducted by our group compared the FLIR ONE Pro for iOS connected to a smartphone and a high-resolution camera (FLIR T650sc). We found that the portable device does not have a satisfactory agreement for absolute temperature values, neither in grouped nor stratified analysis, compared to the high-resolution camera. Nonetheless, the FLIR ONE Pro for iOS reached adequate reliability for detecting asymmetry between the sides of the body of healthy individuals [8,9]. An article on this type of camera by Professor Ammer [10] notes that infrared cameras attached to smart- -phones can have their place for quick temperature documentation, assuring that FLIR ONE should not be ignored.

Recently, portable pocket cameras have been considered a possibility for health use. An example was demonstrated in a study that used the FLIR C3 model to assess the body temperature of healthy pregnant women [11] or another that used this same camera model to assess points of infection in individuals using external fixation [12].

As the use of low-cost thermal cameras is still relatively recent, concordance or reliability studies are common requests [9], and to the best of our knowledge, no study has seen the agreement of the FLIR C5 model compared to a high-resolution camera. Therefore, the objective of this study was to establish the extent of agreement of the FLIR C5 camera compared to the high-resolution FLIR T650sc to detect thermo-asymmetry of individuals with stroke sequelae.

Methods

This cross-sectional observational study was performed according to the guidelines of the Declaration of Helsinki. Participants consented to participate in the study that was approved by the Ethics Committee of the University of Sao Paulo under protocol number 3.102.199. Adult males and females with stroke motor sequelae admitted to the physical rehabilitation program were included in the study after verbal invitation and signing the informed consent form.

Patients with chronic motor sequelae after stroke up to 36 months, clinical and psychological stability verified at medical screening, self-report of temperature asymmetry between the plegic and contralateral sides, and cognitive ability to understand the study procedures were included in the study. Participants with fever, signs of infection, use of anti-inflammatory medication, or Diabetes Mellitus were not included in the study.

Infrared image capture

The preparation for the data collection requested that the participants could not take hot baths or showers, spread creams or powder, or perform physical exercises two hours before the thermographic images were captured. Also, they were asked not to drink stimulants, alcohol, or caffeine, not to use nasal decongestants, and not to smoke [8,13-15].

Immediately before the data collection, the participants were asked to keep their lower and upper limb areas exposed to room temperature for 15 minutes to achieve thermal balance with the thermography laboratory temperature.

During the collection of the thermographic images, the participants remained in the orthostatic position. The participants stood 4m and 1.5m from the infrared sensors of FLIR T650sc and FLIR C5, respectively, and 0.4m away from the wall behind. Both cameras were placed perpendicularly to their bodies.

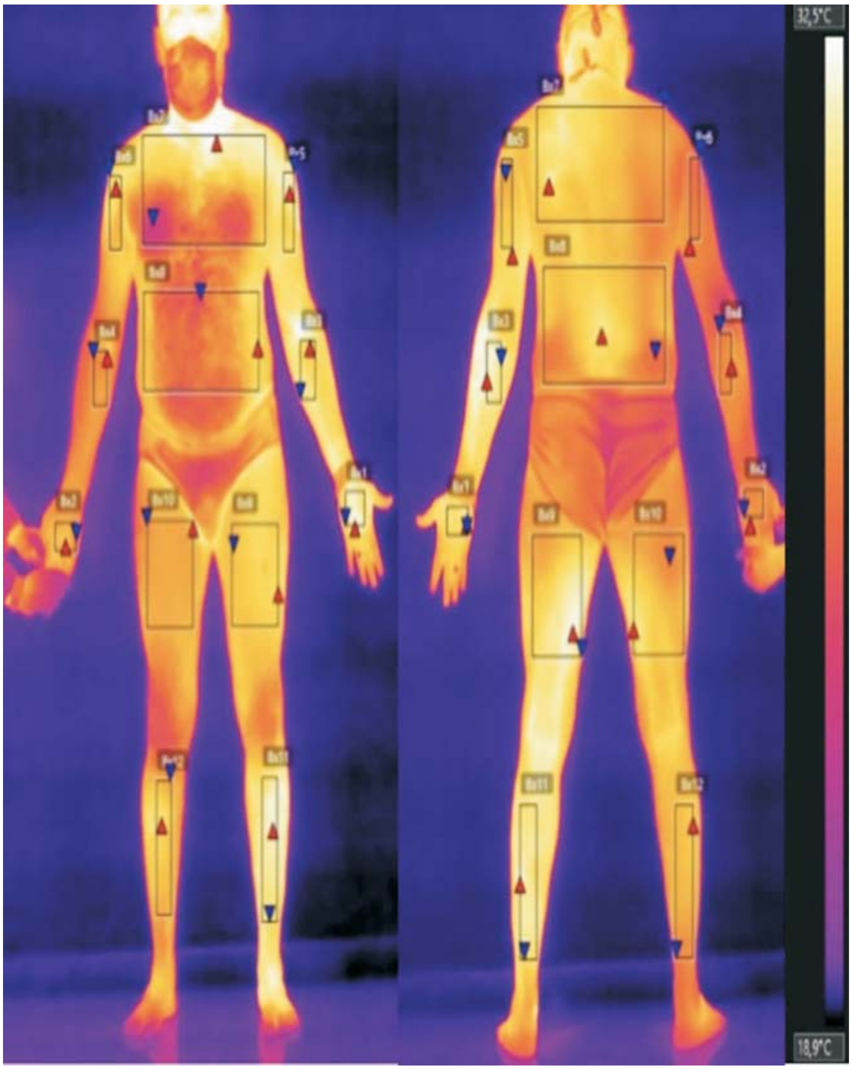
The participants were requested not to move their arms or legs or to scratch body regions before and during the data collection procedure, and all assessments were carried out in the morning.

The thermographic images captured by a FLIR T650sc infrared device had a spatial resolution of 640x480 pixels at a frequency of 30Hz. Its sensor can collect images with a range of temperature from -40ºC to 70ºC, with an accuracy of 1%, and a spectral band of 7.4 - 14 μm, NETD (Noise Equivalent Temperature Difference) <20mK. The images were collected considering the skin emissivity of 0.98 and adjusted for room temperature. The images collected with the FLIR C5 infrared device had a spatial resolution of 160 x 120 pixels at a frequency of 8.7Hz, accuracy of 3°C, and thermal sensitivity of <70mK. Such difference in spatial resolution is the justification for different distances from the participant to the infrared sensors.

Both devices were previously switched on for image and temperature stabilization fifteen minutes before data collection. These IR images were captured in both anterior and posterior views of the participants, all data collection was performed at the Thermography Laboratory of the Institute of Physical Medicine and Rehabilitation (IMREA).

After collecting the images, the data were analyzed by the software FLIR Tools. Average temperatures were evaluated for each ROI (region of interest). The temperature scale used was Celsius, and the analyzed data were the mean temperature of each ROI. These ROIs were rectangles within the anatomical features, as follows: 1 - hand (junction of the third metacarpal with third proximal phalanx and the cubital styloid process); 2 - forearm, distal forearm, and cubital fossa; 3 - arm, cubital fossa and axillar line; 4 - abdomen (and lumbar region), xiphoid process and 5cm below the umbilicus; 5 - thorax (and upper region of the back): nipple line and upper bond of the sternum; 6 - thigh, 5cm above the upper bound of the patella and the inguinal line; 7 - leg, 5cm below the lower bond of the patella and 10cm above the malleolus. This evaluation has been described by previous studies [14,15]. (Figure 1) The image collection and image analysis were conducted by a single researcher, therefore there up to 5 seconds of difference between both images.

Figure 1
Images of upper and left sides of upper and lower limbs



Statistical analysis

The data collected were described as means and standard deviations for continuous variables and frequencies for categorical variables concerning the demographical and clinical characteristics of the participants, environmental measures of room temperature and humidity during data collection, and the temperature readings by FLIR C5 and FLIR T650sc.

The test of FLIR C5 reliability compared to FLIR T650sc considered the capacity to detect the temperature asymmetry, or thermal asymmetry, between the plegic and contralateral sides of patients with stroke sequelae. Thermal asymmetry was established as the difference in temperature between both sides of the body using the formula

Tpl - Tcl

where Tpl is the temperature of the plegic side and Tcl is the temperature of the contralateral side. Nonetheless, chest, abdomen, upper, and lower back temperatures were compared based on their raw values.

The temperature differences of each ROI captured by both cameras were compared with Lin's Concordance Correlation Coefficient (rho or ρc) and Bland Altman the limits of agreement (LOA) [16,17].

Concordance coefficient classification

Lin's ρc ranges from -1 to 1, similar to Pearson's correlation coefficient, however as the nature of this analysis is to test the 45° positive correlation between two variables of the same measurement [17], negative values are not typical nor expected therefore, the classification of Lin's ρc considers positive values. The classification is not entirely established as different authors suggest different ways to rate Lin's ρc. McBride [18] suggests a strict classification with ρc<0.90 being considered a poor correlation, whereas Lin did not establish a classification when they developed the test [17,18]. Oppositely to McBride, Altman suggests Lin's ρc should be interpreted like Pearson's correlation coefficient (r), i.e., $r < 0.2$ as poor correlation and $r > 0.8$ as excellent correlation(15). In our analysis, we decided to rate Lin's $\rho c > 0.8$ as adequate or good and Lin's $\rho c > 0.9$ as excellent.

Results

From 2021 to 2022, 14 patients were included in this study. Table 1 shows the demographical and clinical characteristics of the participants, as well as the environmental measures of room temperature and humidity.

Regarding the temperature readings by FLIR C5 and FLIR T650sc, the raw temperature values for both plegic and contralateral sides are presented in Table 2 as means and standard deviations, evidencing that the temperatures mea-

Table 1
Demographic and clinical characteristics of participants and environmental measures during data collection.

Variables	**Distribution**
N	14
Age (years)	53.6 (13.6)
Males / Females	10 /4 (71.4% / 28.6%)
BMI (kg/m²)	23.5 (3.0)
Time since stroke onset	17.8 (9.4)
Ischaemic stroke	9 (64.3%)
Ischaemic with haemorrhagic stroke	2 (14.3%)
Haemorrhagic stroke	3 (21.4%)
Room temperature (°C); range	21.4 ± 1.1; 19.9 – 23.2
Relative Humidity (%)	76.5 ± 7.1

BMI: body mass index; kg: kilogram; m: meter; °C: degrees Celsius.

Table 2
Comparison of temperature between plegic and contralateral sides.

ROI	Side	FLIR T650sc	FLIR C5	FLIR T650sc	FLIR C5
		Anterior View		Posterior View	
Hand	Plegic	31.1 (2.2)	29.8 (2.9)	30.1 (1.9)	29.4 (2.4)
	Contralateral	31.6 (1.2)	30.5 (2.2)	30.9 (1.4)	30.0 (2.0)
	Difference	-1.1 (1.76)		-0.8 (1.3)	
Forearm	Plegic	31.1 (1.7)	30.2 (2.7)	29.8 (1.8)	29.3 (2.4)
	Contralateral	32.0 (0.9)	31.2 (2.2)	31.8 (0.8)	31.3 (1.6)
	Difference	-0.8 (1.5)		-0.5 (1.2)	
Arm	Plegic	31.4 (1.2)	30.7 (2.5)	29.7 (1.6)	29.3 (2.2)
	Contralateral	32.1 (0.7)	30.6 (1.9)	30.8 (1.3)	30.3 (1.9)
	Difference	-1.0 (1.7)		-0.5 (1.0)	
Chest / Upper back	-	32.1 (1.5)	31.6 (3.2)	31.9 (1.4)	31.9 (2.0)
Abdomen / Low back	-	31.8 (1.6)	31.2 (3.0)	31.7 (1.5)	31.7 (2.1)
Thigh	Plegic	30.2 (0.9)	29.8 (2.3)	30.4 (1.1)	30.4 (1.8)
	Contralateral	31.0 (0.8)	30.5 (2.3)	31.2 (0.9)	31.2 (1.6)
	Difference	-0.5 (1.8)		-0.0 (1.0)	
Leg	Plegic	29.6 (0.8)	28.5 (2.0)	28.9 (1.1)	28.3 (1.8)
	Contralateral	31.0 (1.1)	29.4 (2.4)	30.4 (1.3)	29.7 (1.8)
	Difference	-1.2 (1.5)		-0.7 (1.2)	
Overall Difference		-0.65 (1.44)			

Data are described as means and standard deviations; The temperature unit is °C sured by FLIR C5 are lower than those measured by FLIR T650sc, regardless of the ROI or side.

The results of temperature differences and the tests of Lin's ρc and LOA are presented in table 3 for the whole sample and each ROI separately. We observed that the general concordance was classified as adequate to excellent (ρc=0.859; 95%CI 0.817-0.901; p<0.001) and that the forearm and leg in the posterior view presented the sites with the best associations between the temperature readings of FLIR C5 and FLIR T650sc (ρc=0.958; 95%CI 0.913-1.00; p<0.001 and ρc=0.944; 95%CI 0.883-1.00; p<0.001, respectively).

Figure 2a and 2b present the concordance and LOA plots comparing FLIR C5 and FLIR T650sc temperature readings. Figures 3a and 3b present the concordance and LOA plots comparing temperature readings of the forearm in the posterior view. Figures 4a and 4b present the concordance and LOA plots of the leg in the posterior view.

Discussion

The objective of this study was to test the concordance between the infrared imaging device FLIR C5 compared to the high-resolution device FLIR T650sc camera for detecting the thermal asymmetry of patients with stroke sequelae. This disease was chosen due to its known cause of death and disability [19,20], the changes in thermal sensation [21,22], as well as the confirmed changes in body temperature, as the patients, have a colder plegic side when compared to the contralateral side [23,24]. In other words, it causes asymmetry in the distribution of body temperature, as demonstrated in a recent study by our group that showed relevant body temperature differences between the sides of the body of 43 patients with stroke sequelae, as measured with the FLIR T650sc infrared camera [25].

In the present study, this thermal asymmetry was also detected by the FLIR C5 camera, a portable, easy-to-use, and low-cost device. These findings confirmed its potential to be applied in clinical practice to compare skin temperature between the body hemispheres of individuals with motor stroke sequelae.

The raw temperature data of the evaluated ROIs show that for the 2 cameras tested the measurements are constantly lower when obtained by the FLIR C5 compared to the FLIR T650sc, as shown in Table 2. However, the Limits of Agreement (LOA) of all the ROIs combined, or those with good or excellent concordances, were always below 0.3ºC. According to the specialized literature, this limit of

Table 3
Results of Lin's concordance correlation coefficient and Bland Altman limits of agreement.

	ρc	SE	ρc 95% CI		p.	LOA	SD	LOA 95% CI	
General concordance	**0.859**	**0.021**	**0.817**	**0.901**	**< 0.001**	**-0.11**	**0.626**	**-1.34**	**1.17**
Anterior View									
Hand	**0.914**	0.047	0.821	1.00	<0.001	-0.08	0.555	-1.17	1.00
0Forearm	**0.941**	0.031	0.879	1.00	<0.001	-0.09	0.418	-0.91	0.73
Arm	0.364	0.162	0.046	0.683	0.025	0.81	1.276	-1.70	3.31
Chest†	0.655	0.111	0.437	0.873	<0.001	0.53	2.021	-3.43	4.49
Abdomen†	0.709	0.093	0.526	0.892	<0.001	0.67	1.771	-2.80	4.14
Thigh	**0.863**	0.070	0.727	0.999	<0.001	0.13	0.429	-0.71	0.97
Leg	0.760	0.118	0.528	0.993	<0.001	0.13	0.377	-0.61	0.87
Posterior View									
Hand	**0.879**	0.059	0.763	0.995	<0.001	0.13	0.550	-0.94	1.21
Forearm	**0.958**	0.023	0.913	1.00	<0.001	0.04	0.499	-0.93	1.02
Arm	**0.879**	0.058	0.766	0.992	<0.001	-0.05	0.667	-1.36	1.26
Upper back†	0.773	0.115	0.548	0.997	<0.001	0.07	1.15	-2.18	2.32
8Low back†	**0.832**	0.081	0.674	0.990	<0.001	-0.09	1.071	-2.19	2.01
Thigh	**0.881**	0.059	0.765	0.997	<0.001	0.01	0.244	-0.46	0.49
Leg	**0.944**	0.031	0.883	1.00	<0.001	0.06	0.202	-0.33	0.46

ρc, Lin's rho of concordance correlation coefficient; SE, standard error of ρc; 95% CI, 95% Confidence Interval of ρc; LOA, Bland Altman limits of agreement; SD, standard deviation of the limits of agreement; LOA 95% CI, Bland Altman limits of agreement 95% confidence interval; p: p-value

Figure 2:
A, Concordance correlation plot for all ROIs combined; B, Limits of agreement plot for all ROIs combined

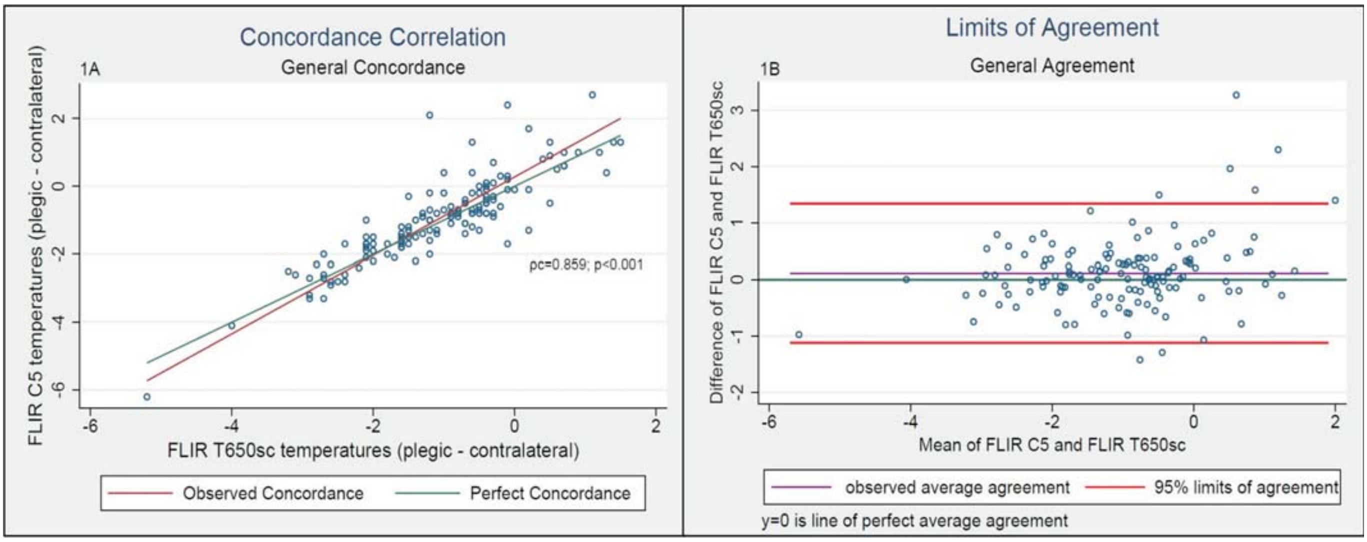


Figure 3:
A, Concordance correlation plot of the forearm in the posterior view;
B, Limits of agreement plot of the forearm in the posterior view.

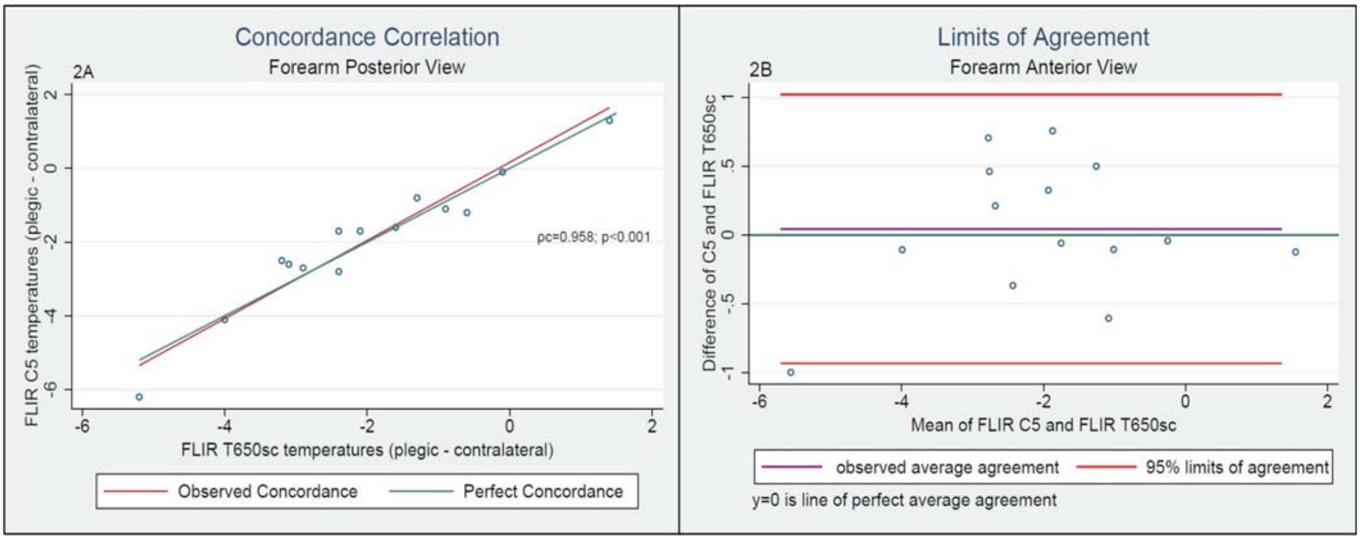
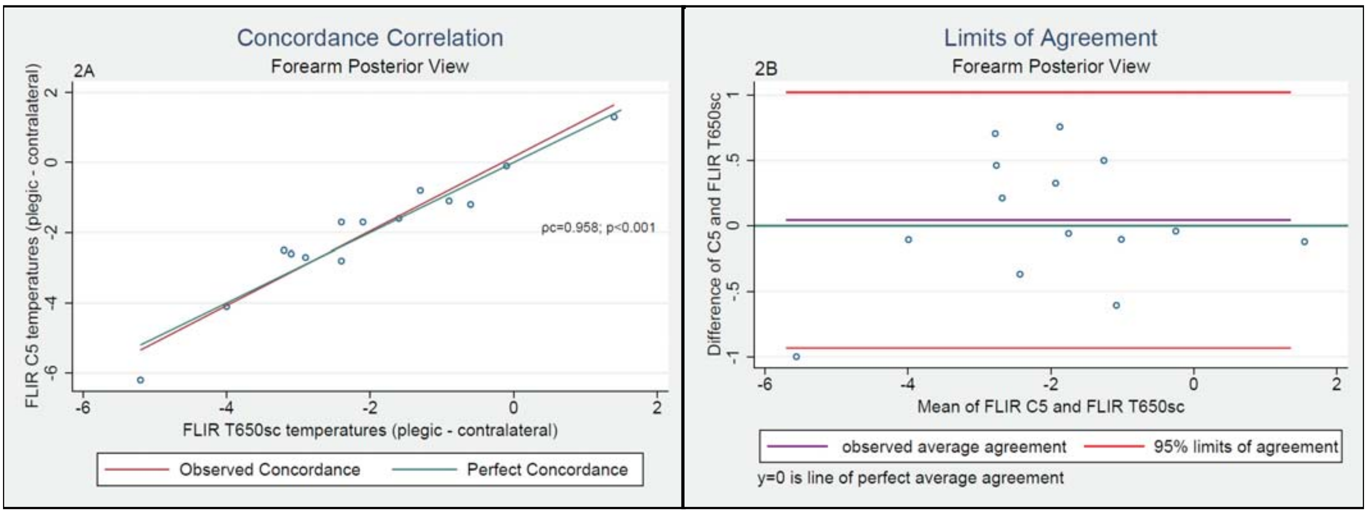


Figure 4:
A, Concordance correlation plot of the leg in the posterior view; B, Limits of agreement plot of the leg in the posterior view.



agreement is relevant because a temperature difference greater than 0.5ºC between the plegic and contralateral sides can be considered pathological thermal asymmetry [6,26-28].

The agreement of absolute values of this type of camera, as published in studies that compared the FLIR ONE Pro for iOS with the FLIR T650sc [8,9], does not seem to be the best way to test the reliability of these devices, as the purpose of this type of analysis aims to compare the temperature differences between both sides of the body, not the absolute values themselves. We did not analyze the absolute values but the temperature differences or thermal asymmetry between the sides of the body. This approach demonstrated that the FLIR C5 showed adequate to excellent agreement in comparison with the FLIR T650sc device.

Regarding the analyzed ROIs, the forearm and leg in the posterior view showed the best agreement among the temperatures evaluated by the cameras. Therefore, these regions seem to be the ones for analyzing the temperature distribution of patients with stroke sequelae. This finding may be associated with greater thermo-asymmetry between the plegic and contralateral sides in the most distal portions of the limbs, given the distance from the heat-generating core [29]. Nonetheless, this fact does not prevent other proximal portions, such as the thigh and arm, from being evaluated with the FLIR C5 camera since these proximal ROIs reached an adequate agreement (?c>0.8).

The findings of greater agreement at the distal ROIs may be relevant for future analyses of physical rehabilitation programs once they usually address the functional recovery of the lower limbs. As demonstrated in previous studies, reduction in thermal asymmetry may be associated with physical activity and motor recovery of patients with motor sequelae of stroke [24,30]. These thermal cameras are not classed as medical devices however and should not be used for diagnostic purposes but can be used for supporting research type assessments and studies.

In the present study, the small sample size is a limiting factor. However, this issue may have been compensated by the large number of ROIs evaluated, which may have generated a sensitive amount of temperature measurements. Another limitation is the lack of an accuracy test with a black body device to enhance our results. Also, the general agreement of FLIR C5 was considered adequate, but this does not reduce the importance of its agreement among the most relevant ROIs for assessing functionality in stroke patients.

Conclusion

The present study established that the thermo-asymmetry between right and left sides of the body in patients with stroke sequelae, defined as the temperature difference between the plegic and contralateral sides, captured by the FLIR C5 portable thermographic camera, can be considered concordant with the FLIR T650sc, especially in the posterior view of the limbs. We suggest that thermal asymmetry analyses conducted with the FLIR C5 should be performed on the arms, the anterior region of the hands, or the posterior region of the legs.

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Thermographic and ultrasound findings of patients with pain of hip joints: retrospective study from April 2010 to July 2022.

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SUMMARY

A retrospective review of medical records was performed to identify patients who attended a private clinic for rehabilitation medicine in Trencin between April 2010 and July 2022, where their hip joint pain was evaluated by physical examination in combination with thermographic and sonographic imaging. Pain was classified with respect to the skin temperature over the symptomatic hip joint, and alterations in anatomical structures were suspected by physical examination and confirmed by sonography. Data were included from 232 patients, 133 males and 99 females. While sonography obtained conspicuous findings in all patients, 42% of patients presented with increased temperature over the affected hip joint, and 17% showed reduced temperature over the affected hip joint. The remaining 41% of patients showed a symmetrical skin temperature distribution between hip joints. Examples of normothermic, hypothermic and hyperthermic temperature patterns and their corresponding sonographic findings are provided.

KEY WORDS: Thermography, Sonography, painful hip joint

THERMOGRAFISCHE UND SONOGRAFISCHE BEFUNDE BEI PATIENTEN MIT HÜFTSCHMERZEN: RETROSPEKTIVE STUDIE VOM APRIL 2010 BIS JULI 2022

Es wurde eine retrospektive Durchsicht der medizinischen Aufzeichnungen durchgeführt, um Patienten zu identifizieren, welche die private Ordination für Rehabilitationsmedizin in Trencin im Zeitraum zwischen April 2010 und Juli 2022 aufgesucht hatten, wobei deren Hüftschmerz durch körperliche Untersuchung in Kombination mit Wärme- und Ultraschallbildern evaluiert wurde. Schmerz wurde über der symptomatischen Hüfte mit der Hauttemperatur in Beziehung gesetzt, und Veränderungen der anatomischen Strukturen wurden durch die körperliche Untersuchung vermutet und sonografisch bestätigt. Befunde von 232 Patienten, 133 Männer and 99 Frauen wurden eingeschlossen. Während in der Sonografie bei allen Patienten verdächtige Befunde erhoben wurden, zeigten 42% der Patienten eine erhöhte Temperatur und 17% boten eine verminderte Temperatu an der betroffenen Hüfte. Die restlichen 41% der Patienten zeigten eine symmetrische Verteilung der Hauttemperatur über den Hüftgelenken. Bespiele normothermer, hypothermer und hyperthermer Temperaturmuster und ihrer entsprechenden sonografischer Befunde werden gezeigt.

KEY WORDS: Thermografie, Sonografie, schmerzhafte Hüfte

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Introduction

The hip joint is a spherical joint, composed of head and fossa, which is completed by fibrous cartilage. Fibrous cartilage increases the margins of the fossa. The joint capsule is strengthened by 4 ligaments: lig. iliofemorale, lig. pubofemorale, lig.ischiofemorale and zona orbicularis. The next 2 ligaments are lig. transversum acetabuli and lig. capitis femoris. 23 muscles begin or are anchored around the hip joint. There are 10 primary muscles of the hip joint. The anterior group is formed by the m.iliopsoas. The posterior group is composed of: a) superficial muscles - m.gluteus maximus, m.gluteus medius, m.gluteus minimus, m.tensor fasciae latae, b) deep muscles, so-called pelvitrochanteric - m.piriformis, m. gemelus superior, m.gemelus inferior, m.obturatorius internus, m. quadratus femoris.

There are 10 muscles of the thigh. The ventral group of thigh muscles are m.sartorius and m. quadriceps femoris. M.quadriceps femoris is composed of m.rectus femoris, m.vastus medialis and m. vastus lateralis. M.rectus femoris has 2 origins - caput rectum and caput reflexum. The medial group of thigh muscles are m.pectineus, m. adductor longus, m. gracilis, m.adductor brevis, m.adductor magnus and m. obturatorius externus. The dorsal group of thigh muscles is composed of m.biceps femoris - caput longum, m. semitendinosus and m. semimebranosus [1].

The hip joint is innervated by a number of nerves. The medial and front part is innervated by rr. articulares n. obturatorii. The anterior and lateral part is innervated by rami articulares n. femoralis. The caudal part is innervated by ramus articularis n. ischiadici, rami articulares n. gluteus superior and n. gluteus inferior. The vascular supply is provided by a.femoralis, a.glutea superior, a. glutea inferior, a.

circumflexa femoris medialis and a.circumflexa femoris lateralis [2].

Around the hip joint 21 bursae occur, which mediate gliding movement of the muscles. Bursae are structures closely associated with tendon sheaths. The lining of the bursa is a smooth vascular synovial membrane, which has lower coefficient of friction. It facilitates sliding of the tissue near the bursa. Even though 21 bursae are described aroud the hip joint, the official anatomical terminology presents only 3 of them: on the front part of the hip bursa iliopsoatica, a complex of epitrochanteric bursae (which are in relation with the abductor mechanism) and 3 caudal ischiogluteal bursae [3]. The nomenclature of bursae is combined with their anatomical location.

The growth of the joint is mediated partially genetically. Biomechanical factors are the main influence on the development and formation of the hip joint. Coxarthrosis is a degenerative process of the hip joint cartilage. Consecutive changes of the joint capsula and the muscles develop gradually. When the static and biomechanic force on a joint is changed, the lower limb may become shorter. Different biomechanical and biological factors can lead to cartilage damage. The causation of primary coxarthrosis is unknown. Mechanical and biological factors are important for the maturing of mesenchymal tissue. Secondary coxarthrosis is developed after joint disease - infection, rheumatic inflammation, Mb.Perthes, fracture, dysplasia of the hip joint and others. In patients younger than 40 years it is necessary to use all of the conservative healing possibilities. After 55-60 years of age, a total end prosthesis (TEP) is implanted in painful patients with ROM limitation and coxarthrosis III.-IV.degree [4].

A pain generator may occur following an injury or disease in any of the anatomical structures of the hip joint. At the painful site, several physical and chemical stimuli can activate nociceptors and subsequently activate nociception pathways. Local inflammatory processes lead to nociceptive pain, and depending on the severity of the inflammation skin temperature is increased over the painful area. Pain may also result in a disturbed balance within the autonomic nervous system, which may be maintained and became dissociated from the original nociception. Affected regions often present with low skin temperature that may respond paradoxically to heat supply or heat removal [5]. However, pain may not be associated with an altered skin temperature in several cases, as reported in patients with non-specific back pain [6]. Thermal imaging provides clues to the pathophysiological processes involved in various pain syndromes. However, thermography fails to accurately identify the anatomical structures where activated nociceptors are located. For that purpose, imaging methods such as radiography, magnetic resonance imaging (MRI), computed tomography (CT), or sonography must be used because they are able to resolve anatomical and tissue details [7]. Over the last decade, the quality of ultrasonographic imaging has enormously improved the diagnosis of disorders of the musculoskeletal system. It is now possible to display deep-lying structures, and the sonographic image has an improved contrast that enables easy differentiation of the examined structures [8]. Thermographic and sonographic examinations are regularly performed in the first author´s private clinic of rehabilitation medicine and findings related to back pain [9], knee [10], elbow pain [11] and shoulder pain [12] have already been reported. Since the hip joint is amongst the most frequently experienced pain locations of the musculoskeletal system, we decided to add another report to this series of thermographic and sonographic findings, focusing this time on findings in patients with painful hip joints. The aim of this study was to classify hip joint pain by thermographic findings, and to evaluate the sensitivity of thermography in relation to the morphological findings recorded by sonography. Such knowledge might be useful in developing a targeted treatment and an individually-tailored treatment plan.

Method

We searched in the archive of medical records of our private clinic for patients who were medically evaluated due to hip joint pain in the period from April 2010 to July 2022. Inclusion criteria were hip joint pain, abnormal findings in hip joint sonography and recorded infrared thermal images. The standardised procedure of the medical examination in our clinic was described in detail elsewhere in patients with elbow pain [11]. In brief, a medical history was recorded in all patients and they underwent a detailed musculoskeletal examination. The physical examination was completed by a sonographic assessment and thermal imaging of the painful region.

Physical examination

The clinical examination included a record of each patient´s medical history, especially focusing on pain characteristics: when and at what site pain started at first, the direction in which the pain spread, what conditions aggravate or reduce the pain such as rest, movement, work, stress, relaxation and so on. At the end of this interview, externally realised investigations such as blood tests, radiographs or MRIs were collected. The physical examination included inspection with a particular focus on abnormal vascular findings and superficial skin lesions. Palpation of the hip joint included testing for tenderness of insertions of ligaments and tendons, assessment of swelling, thickened synovial folds and effusions. Functional tests were performed including range of motion, assessment of joint play, joint stability and joint stiffness. Muscle tone and muscle strength were also tested.

Thermal imaging

For thermal imaging, we used the Fluke infrared camera Ti32, equipped with a 320 x 240 focal plane array, uncooled microbolometer with thermal sensitivity (NETD) 0.05 °C at 30 °C target temperature. The patient, disrobed other than a small thin covering of intimate areas, was equilibrated in a darkened room at 25° ± 1.0°C for 20 minutes. The analysis of thermal images was based on the extraction of the temperature values Tmax, Tmean and Tmin from regions of interest as proposed in the Glamorgan Protocol [13]. Normal temperature distribution is based on the so-called thermal symmetry, which is defined as the similarity of mean temperatures in corresponding body regions mirrored across the median body axis. Differences in temperature between corresponding body regions less than 0.5 °C indicate a normal temperature distribution. Compared to the reference site, a temperature decrease by 0.5 °C or more is named the hypothermic pattern, while an increase in temperature of the same magnitude defines the hyperthermic pattern. In the case of thermal symmetry, deviations in temperature of 0.5°C to the surrounding temperature are labelled as local hyperthermia or hypothermia respectively. Thermographically, we evaluated findings in the anterior, lateral and posterior areas of the hip joint and findings in the thigh area.

Sonography

We used an Esaote MyLabSeven ultrasound device with a 5-12 MHz linear probe to perform the sonographic examination. We did not focus exclusively on the painful area; but rather examined the entire hip joint in each patient. Dynamic tests were included in the sonographic evaluation when necessary.

Results

The total number of patients selected was 232. Of these, 99 were women aged between 18 and 83 years (with the average of 55 years) and 133 were men aged between 11 and 79 years (with the average age of 45 years). In most of the cases the examinations were completed with other imaging methods such as radiography, MRI or CT scans. Biochemical examinations were performed as well, if required for a definite diagnostic decision.

Table1.
Thermal patterns and sonographic findings

Thermal pattern	Number of patients (232)	Number of sonographic findings (397)
Hyperthermia (temperature at the symptomatic hip joint higher by at least 0.5 °C than the temperature of the contralateral side)	97	Total: 167 Coxarthrosis I.,II.st.: 8% Coxarthrosis III., IV.st.: 3% Lymphadenopathy, lipomas, fibromas, fibrotization: 4% Bursae, cystae: 17% Calcifications, osteophytes: 45% TEP: 4% Traumas: 8% Thigh: 11%
Hypothermia (temperature at the symptomatic hip joint at least 0.5 °C lower than the temperature of the contralateral side)	40	Total: 67 Coxarthrosis I.,II.st.: 5% Coxarthrosis III., IV.st.: 58% Lymphadenopathy, lipomas, fibromas, fibrotization: 10% Bursae, cystae: 10% Calcifications, osteophytes: 21% TEP: 2% Traumas: 2% Thigh: 2%
Normothermia (temperature difference between hip joints less than 0.5 °C)	95	Total: 163 Coxarthrosis I.,II.st.: 2% Coxarthrosis III., IV.st.: 8% Lymphadenopathy, lipomas, fibromas, fibrotization: 10% Bursae, cystae: 17% Calcifications, osteophytes: 53% TEP: 2% Traumas: 6% Thigh: 2%

Table2.
Sonographic findings and their temperature patterns

Sonographic findings total 397	↑T%	↓T%	normT %
Coxarthrosis I.,II. 49	54%	33%	13%
Coxarthrosis III., IV 28	4%	84%	12%
Lymphadenopathy, lipomas, fibromas, Fibrotization 29	28,5%	0%	71,5%
Bursae, cystae 47	36%	21%	43%
Calcifications, Osteophytes 194	38%	17,5%	44,5%
Traumas 19	50%	12,5%	37,5%
TEP 7	50%	25%	25%
Thigh 24	69%	12,5%	18,5%

Sonographic findings

According to the character of sonographic findings we divided them into:

- Lymphadenopathies, lipoms, fibroms, fibrotization in total number 29, of these anteriorly 20, posteriorly 9.
- Bursas and cysts in total number 47, of these anteriorly 15, laterally 22, posteriorly 10.
- Calcifications and osteophytes in total number 194, of this anteriorly 82, laterally 74, posteriorly 38.
- Bone and muscle traumas in different areas in total number 19.

In 7 patients, complications after TEP were evaluated. In 77 cases, patients with coxarthrosis were examined, by degree of these: 1st stage 25 patients, 2nd stage 24, 3rd stage 22, 4th stage 6. The number of pathological structural findings in the thigh area was 24. The total number of pathological findings of the examined patients was 397. This means that several patients had two or more types of pathological findings.

Temperature distribution over the skin

Only 59% of the 232 patients with sonographic abnormalities showed a disturbed temperature distribution. 42% of patients presented with hyperthermia in the painful hip joint region, while 17% of patients showed low temperatures over the symptomatic hip joint. There were 41% of patients whose thermal pattern in the painful hip joint region was similar to that of the unaffected side.

Normal temperature patterns

Typical normal temperature distributions at the anterior, lateral and dorsal sites of the hip joint recorded in subjects free of symptoms are presented in figure 2a-2d. We observed symmetric hypothermy in the gluteal area, which was combined with a higher temperature in the proximal part of the intergluteal groove and a butterfly pattern of slightly increased temperature over the sacroiliac area, plus a continuous narrow strip with higher temperature over the processi spinosi of the lumbar spine. Slightly increased temperature activity was observed in the lateral projection in the area of muscle insertion into the front part of crista iliaca and spina iliaca anterior superior.

Pictures 3, 4, 5, 6 show thermograms of the temperature distribution of patients with hyperthermia and hypothermia in the hip joint area. In pictures 7, 8, 9, 10 are sonographic findings.

Figure 2a.
Hip joint anterior

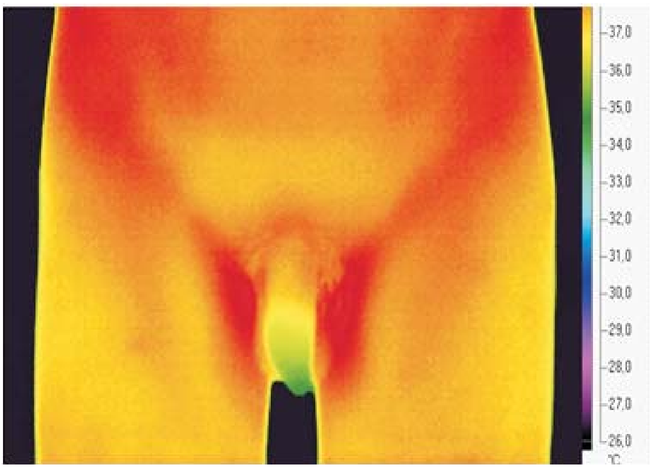
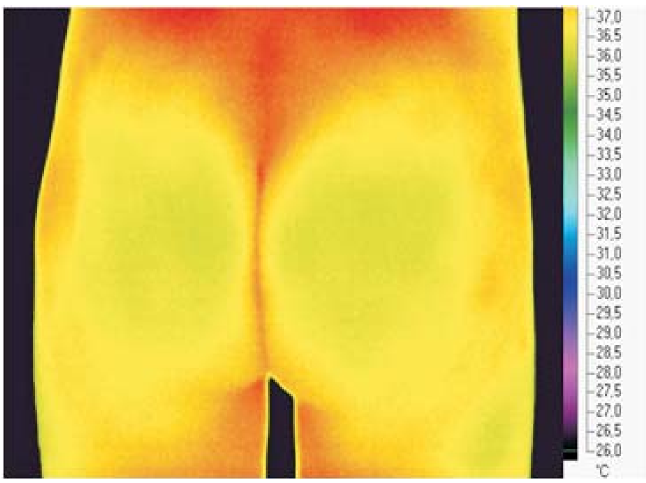


Figure 2b.
Hip joint posterior



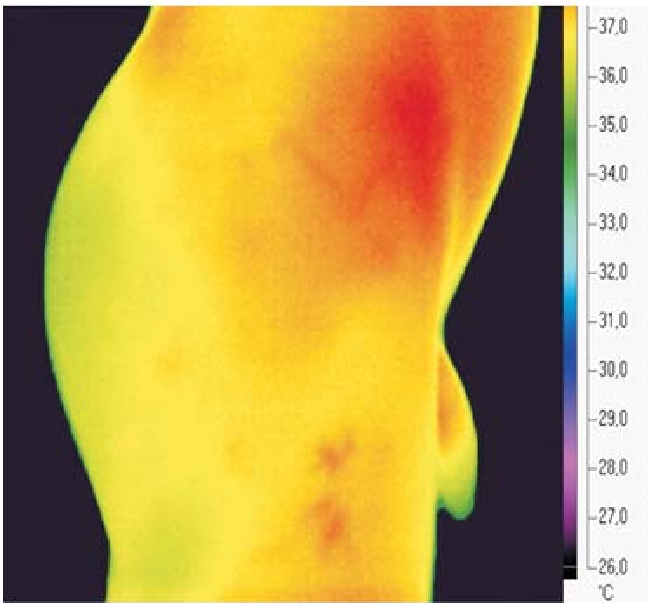


Figure 2c.
Hip joint lateral right side

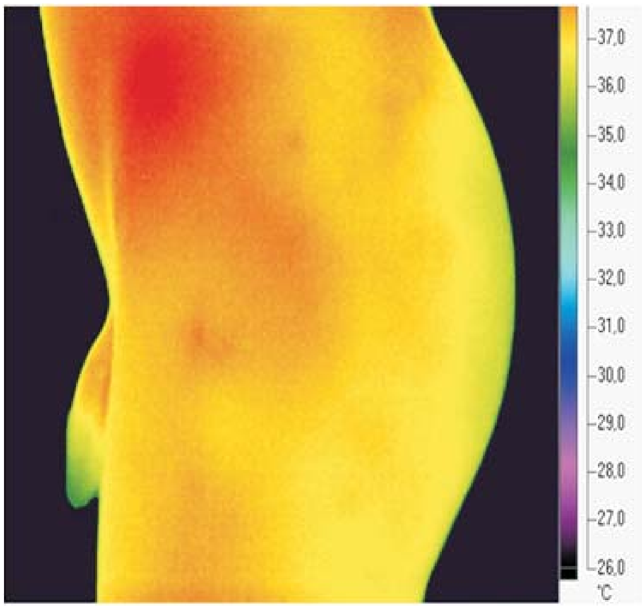


Figure 2d.
Hip joint lateral left side

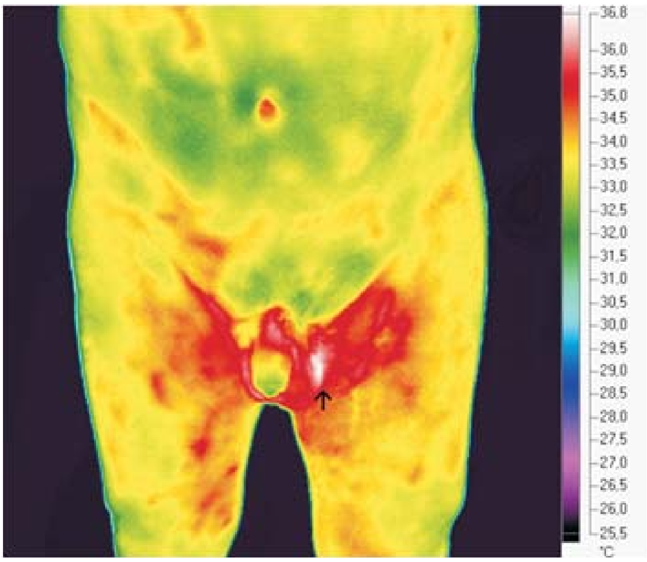


Figure 3.
Thermography ↑ increased temperature activity on the left

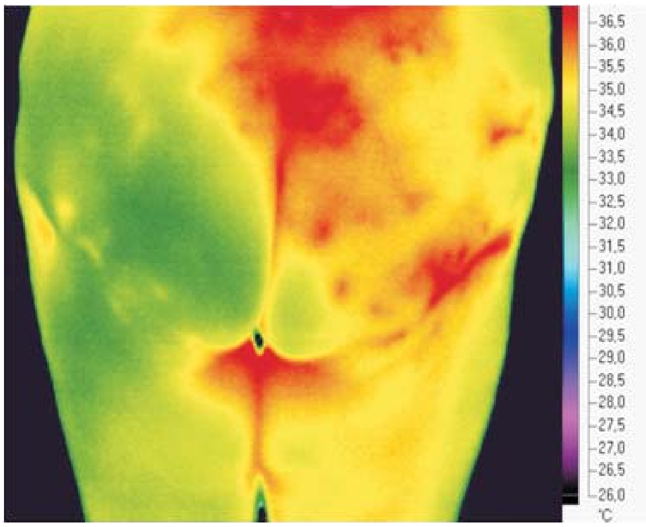


Figure 4.
Thermography ↓ hypothermia on the left side in coxarthrosis IV.st

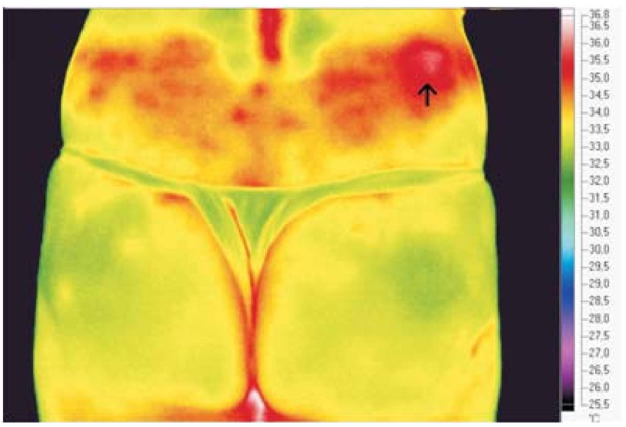


Figure 5.
↑ focal increased temperature activity posteriorly in the area of the crista iliaca on the right side

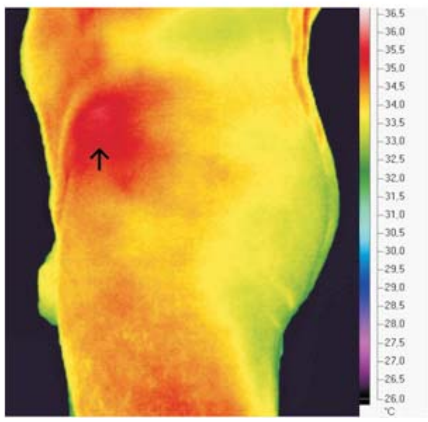


Figure 6.
↑focal increased temperature activity laterally in the region of the spina iliaca anterior superior

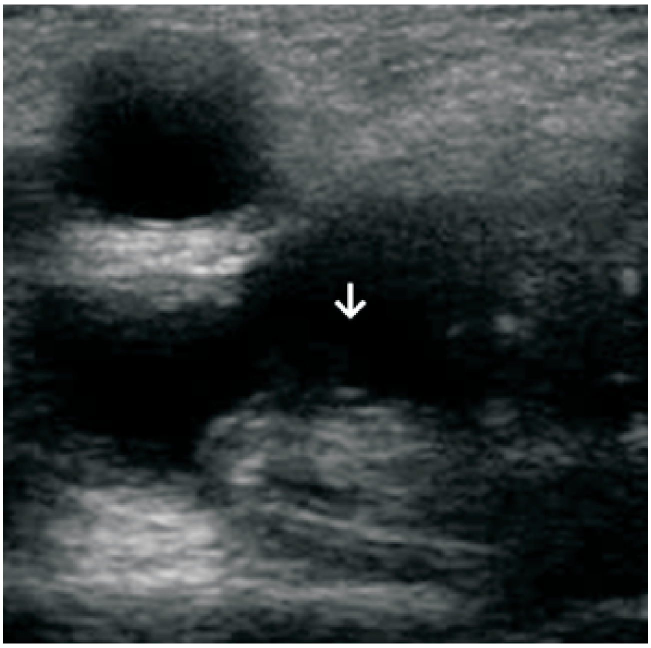


Figure 7.
Sono: hypoechoic filling bursa iliopectinea ↓

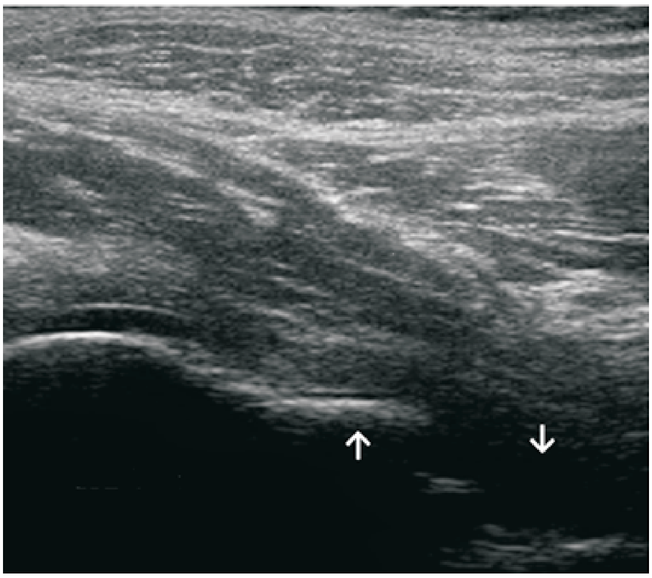


Figure 8.
hypoechoic filling ↓hydrops articularis and ↑osteophyte at the point of transition caput femoris to collum femoris

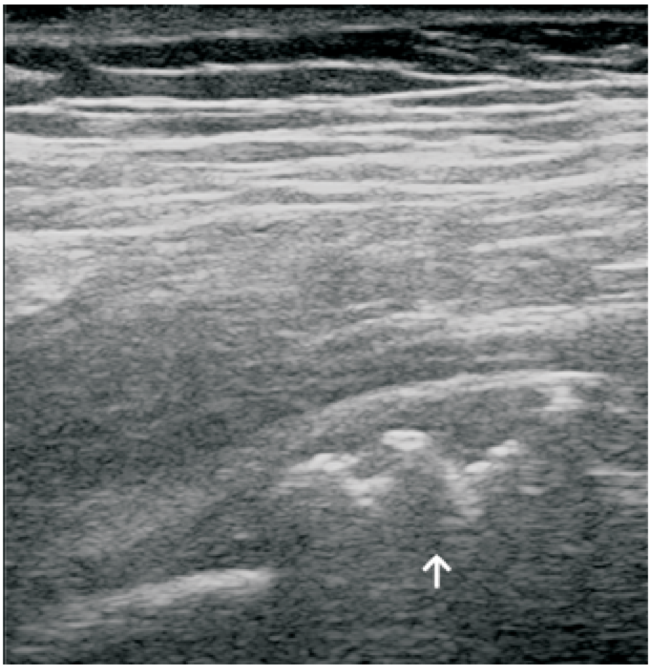


Figure 9
Sono: image of the head of the femur ↑at coxarthrosis IV.st

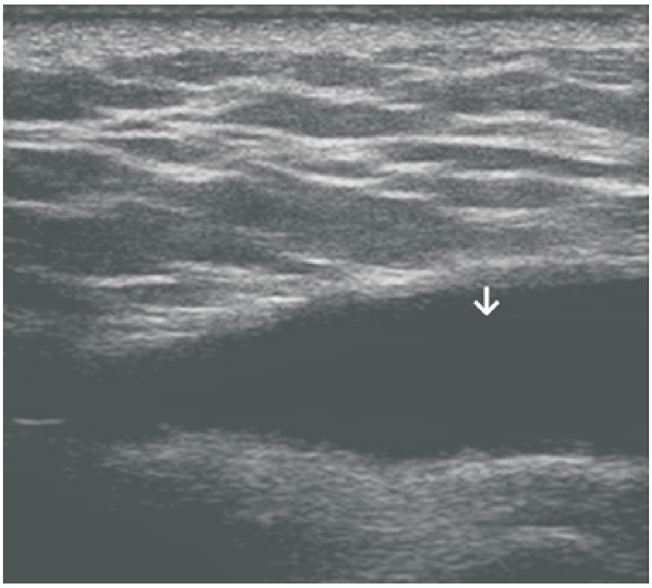


Figure 10.
Sono: hypoechoic filling bursae trochantericae

Discusion

The authors Krause and Novák assembled a group of 300 hip joints of subjects above 65 years of age. They found 43% of aging hip joints. One third of these patients reported subjective complaints. It is sometimes difficult to differentiate between the maximum changes typical of the aging hip joint and incipient arthrosis. Correct evaluation can be made only after prolonged follow-up of the patient [14]. Suresh states that osteoarthrosis was traditionally detected by X-ray examination. X-rays however have limited sensitivity for demonstration of the small changes of cartilage in the early stages of osteoarthrosis. MRI has a high ability to differentiate soft tissues, however its high cost and low availability limits its common usage. Daily routine use of arthroscopy is limited by its invasivity. Due to tremendous progress in ultrasound during the last 10 years we can better understand this disease and better evaluate the effect of treatment [15]. Ultrasound imaging can also detect minimal changes in soft tissues and joint effusion, which are not detectible by physical examination because of the deep location of the hip joint. Ultrasound guidance now also plays a significant role in reliable and safe execution of therapeutic interventions. [16]. Marcelis, Daenen, and Ferrara performed ultrasound examination of hip joints mainly for newborn hip joint dysplasia evaluation [17]. Due to the progress of device sensitivity, today we perform more hip joint examinations in adults [16]. Chhem and Cardinal published findings suggesting that pain from the hip joint could result from articular and periarticular structures. Ultrasound is suitable for examination of pathology of the surrounding soft structures and for examination of TEP complications. It is possible to distinguish solid mass from pseudomass and cystic lesions. However, it is supplementary to X-ray examination, because bone and intraarticular lessions could be underestimated by ultrasound. They recommend the use of ultrasound also for navigation during aspiration of joint filling and joint applications [18].

According to Ring and Ammer, infrared thermal imaging records the temperature distribution on the surface of the human, which may detect abnormalities in spatial and intensity distribution that are associated with defined diseases [19]. There are only a small number of articles dedicated to thermographic investigations of hip joint pain. Ryoichi Kanie used pre and post-operative thermographic measurement of osteoarthritis of the hip. The results show that the skin temperature of the gluteal region is lower on the diseased than on the healthy side, and, if both sides are diseased, the more seriously affected side has a lower temperature. In patients with unilateral disease, the temperature difference correlates with the grade of symptoms [20]. We can confirm these findings based on the results of our studies. In a previous study from 2013, we noted hypothermia in the gluteal region in a high percentage of cases (74.5%) in patients with significantly limited range of motion (ROM) in the hip joint [21]. Even in the currently presented study, there was a significantly greater number of hypothermic findings in the gluteal region in the case of coxarthrosis of a higher degree (III.-IV.grade), namely in 84% of such findings. Only 33% of patients with coxarthrosis of the I.-II.grade had a hypothermic finding. Ryoichi Kanie describes that in 20 surgical cases, the lowered temperature found before operation improved along with the relief of symptoms after operation. The temperature difference between both sides became smaller over time (20). This is consistent with the results of our study, where the number of hypothermic findings was reduced to 25% after TEP. Local circulatory insufficiency caused by gluteal muscular atrophy and shortening, and hip joint pain, which are the result of osteoarthritis of the hip, are thought to play a major role in the lowered temperature in the affected areas. The clinical application of thermographic examination to cases of osteoarthritis of the hip is considered to be of value in evaluating the progress of disease, deciding on appropriate treatment, and in follow-up evaluation (20).

Alves and co-workers evaluated the use of digital thermography in assessing treatment response in dogs with hip osteoarthritis (OA). They compared their results with an objective measure and two clinical metrology instruments. 100 hip joints of 50 police working dogs with bilateral osteoarthritis were examined in a randomized, double-blinded study. Digital thermography, mainly lateral T view evaluation, correlated with weight-bearing distribution, clinical metrology instrument scores, and the presence of caudolateral curvilinear osteophytes on the ventrodorsal view at the initial assessment. These findings are associated with the development of clinical symptoms of hip OA. Hypothermia was noted in the case of severe OA. But the differences were not statistically significant [22].

The application of laser spot thermography was used for damage detection in ceramic samples of hip joint implants with surface breaking cracks by 4 authors - Roemer, Pieczonka, Juszczy and Uhl. The technique is based on an external heat delivery to a test sample, by means of a laser pulse, and signal acquisition by an infrared camera. Obtained results are compared with reference measurements obtained with vibrothermography. Both techniques can be effectively used for damage detection and quality control applications of ceramic materials [23].

Fukahori´s team evaluated clinically 31 dogs with and without inflammation in the coxofemoral joint. The temperature registered by the thermograph in the lateral projection by patients with joint inflammation was significantly different from that of control animals without inflammation. The method showed a sensitivity of 80%, specificity of 87.5%, and accuracy of 83.87% [24].

Scheidt and co-workers performed a systematic online database search, based on the Cochrane, PICOT and PRISMA guidelines, and they retrieved 254 studies. All publications referring to thermographic examination in arthroplasty of the hip and knee were included. 249 of the studies were later excluded due to the defined inclusion and exclusion criteria, and so five studies with 251 patients were included finally in the evaluation process. The conclusion was that infrared thermography is a useful tool in the perioperative care of patients after arthroplasty of the knee and hip joint [25].

Kjær and co-workers investigated 56 total hip replacement patients for deep vein thrombosis using contact thermography and bilateral ascending phlebography. Examinations were performed on the 7th day after surgery. Phlebography discovered unilateral deep vein thrombosis in six patients. Two of them had corresponding findings at thermography. This means that thermographic examination gave four false negative results, and 14 false positive thermograms were also found. Contact thermography is of no value as a screening test for deep vein thrombosis following major hip surgery [26].

Bouffard and Goltz recommend the use of ultrasound in sport medicine for detection of musculoskeletal lesions which are occuring acutely or the result of likely overloads. Ultrasound visualizes extra- and intraarticular structures. The immediate receipt of data increases the possibility of early restoration of the patient into training. The advantage of ultrasound is the possibility of dynamic examination and the use of stress maneuvers. The causes of hip joint pain in power sports are often cortical tendon attachment avulsions, intratendineal ruptures, ruptures of labrum acetabuli, hip joint effusion, direct and indirect thigh traumas. These can be sonographically visualised as hypoechoic defects. Heterotopic ossifications could be displayed even earlier than radiologically. MRI is nonspecific in these cases: it shows just deviation in the hyperintensity of the signal. These recommendations correlate with the results of our study, where we noticed most of the extra-articular findingswere in athletes. Mobile ultrasound units allow the monitoring of athletes, and their training and match data can be stored on electronic storage media [27]. The use of ultrasound for the purpose of hip joint pain examination in sportsmen is recommended also by Jacobson. We can distinguish pain caused by joint disease from pathology of the tendons and muscles [28].

Conclusion

Coxarthrosis is considered to be the most common cause of hip joint pain. However, in a cohort collected in a private clinic over 12 years, coxarthrosis and complications after TEP explained only 36% cases of all hip joint pains. The rest are findings in extra-articular structures. Infrared imaging is highly sensitive in cases of high grade coxarthrosis, when the image of hypothermia can alert the physician to the morphological changes associated with aging in a timely manner. Its importance is also in monitoring changes in the temperature pattern after medical interventions. Evaluation of hip joint pain cause and their exact specification without the use of imaging methods is difficult.

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News in Thermology

EAT Website - usage report for 2022

Kevin Howell

EAT President

Usage data for the EAT website shows that activity remained quite high in 2022, with just a slight reduction in overall visitors compared to the previous year. This is encouraging when one considers that 2021 was a congress year for the EAT, when we would expect the highest traffic to the EAT website.

Figure 1 shows a graph of website users by country of origin for 2022. The dark blue bars represent activity in 2022, and the previous year's activity is shown in the light blue bars for comparison. New users are also listed in this figure by country. Overall users fell by less than 1% in 2022, and over 95% of our users were newly-acquired. The most popular countries visiting our site were the United States, China, Brazil, the United Kingdom and India. Amongst countries that had lesser activity, there was nonetheless strong growth in interest from nations such as Japan, France, Germany, Bangladesh, the Czech Republic, Italy and Slovakia.

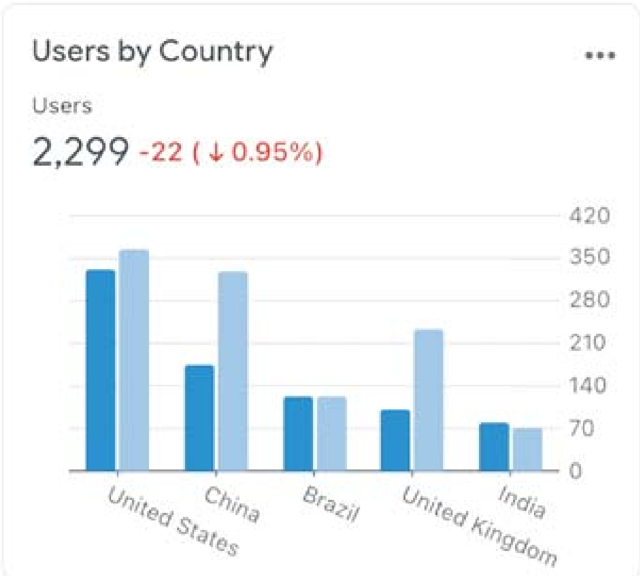


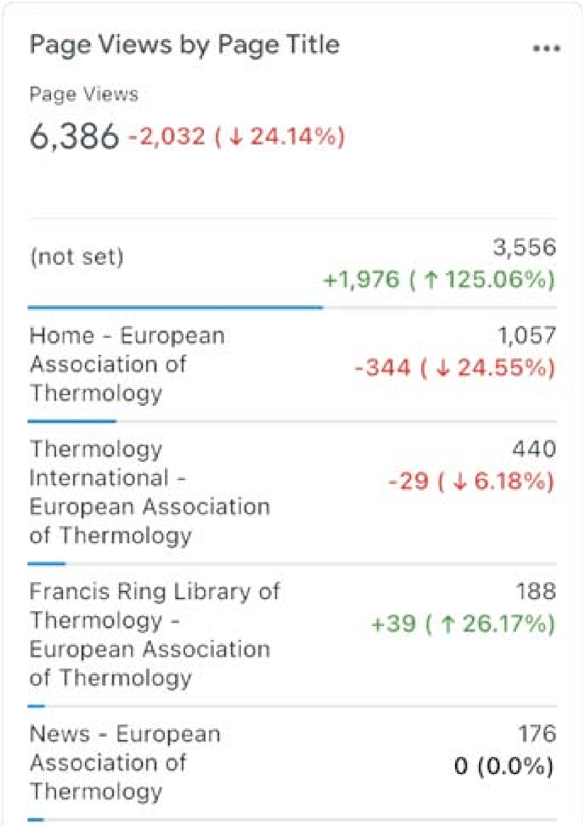
Figure 1: Website users by country in 2022

Table 1
New Users by Country 1 Jan 2022 - 31.Dec 2022 vs 1 Jan 2021 - 31 Dec 2021

Country	Total 2022	Difference to 2021 (%)
United States	323	-40 (⇓ 11.02)
China	172	-156 (⇓ 47.56%)
Brazil	120	-1 (⇓ 0.83%)
United Kingdom	97	-131(⇓57.46%)
India	78	+8 (⇑ 11.43%)
Japan	73	+37 (⇑ 102.78%)
Spain	71	-13 (⇓ 15.48%)
Poland	59	-81 (⇓ 57.86%)
France	55	+16 (⇑ 41.03%)
Germany	55	+12 (⇑ 27.91%)
Russia	54	+12 (⇑ 28.57)
Bangladesh	43	+24 (⇑ 126.32%)
Czechia	46	+19 (⇑ 79.17%)
Mexico	41	+11 (⇑ 36.67%)
Italy	39	+20 (⇑ 105.26%)
Canada	37	+17 (⇑ 85.0%)
Türkiye	35	+9 (⇑ 34.62%)
Portugal	33	-6 (⇓ 15.38%)
South Korea	33	+5 (⇑ 17.86%)
Indonesia	32	-8 (⇓ 20.0%)
Nigeria	32	+10 (⇑ 45.45%)
Netherlands	31	-1 (⇓ 3.13%)
Slovakia	29	+21 (⇑ 262.5%)
Philippines	24	+9 (⇑ 60.0%)
Vietnam	24	+16 (⇑ 200.0%)

Figure 2 lists the most visited pages of our website in 2022, and compares activity to the previous year. Other than our "home" pages, the most visited pages related to Thermomlogy International and information about the Francis Ring library of publications on thermology. In comparison to 2021, our pages about the EAT Congress and Short Course saw the largest reductions in visitors, because 2022 was not a Course or Congress year. Overall, page views fell by 24% in 2022.

Figure 2: Most viewed website pages in 2022



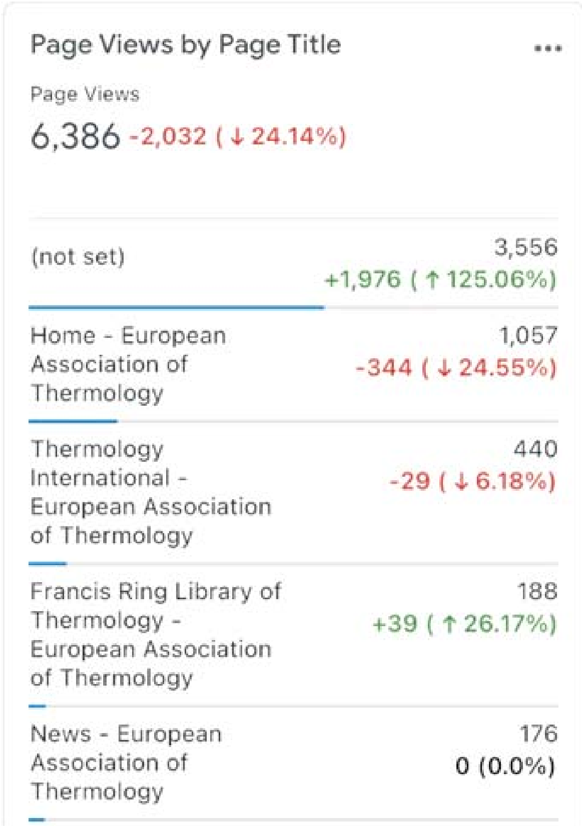


Figure 3 gives some further detail about how users interact with the website. As in the previous year, around two-thirds of our visitors used a desktop browser, and one-third viewed our pages on a mobile phone. Fortunately, we designed the EAT website to be "responsive" i.e. the layout adapts automatically to be appropriate for viewing on a desktop or mobile device. The majority of our visitors continue to access the website by typing the address into their browsers directly, but a significant minority of users continue to reach us by clicking on links at other web sites, or via search engines, of which Google remains the most used.

The EAT website continues to be an important resource for our association, and we look forward to seeing increasing activity once again, as we build towards another Congress year in 2024.

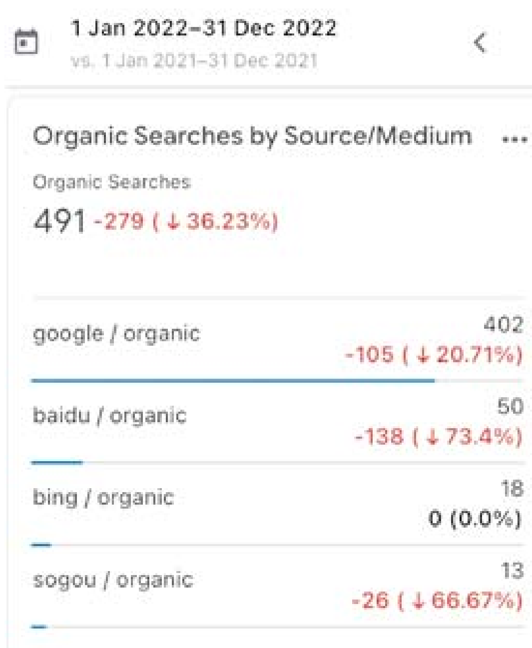


Figure 3: How website users interacted with the website in 2022.

2023

30th April - 4th May 2023
Orlando, Florida, United States

Thermosense: Thermal Infrared Applications XLV

Contains a session on Medical applications and Covid-19

- fever detection for pandemic containment
- health screening and diagnostics
- veterinary applications.

19th - 21st May 2023 Wisla, Poland

XXV Meeting of the Polish Society of Thermovision Diagnostics in Medicine combined with Polish Association of Medical Physics

Supported by the Institute of Biomedical Engineering, University of Silesia, Katowice, Poland, and the European Association of Thermology

Conference venue: Vislow Resort Hotel, 3A Czarne, 43-400 Wisla, Poland

Abstract deadline: April 15th, 2023

Abstracts should be submitted to armand.cholewka@us.edu.pl or a.jung@spencer.com.pl

Abstracts will be published in Thermology International

Accommodation (2 nights) with meals and welcome dinner:

150 EUR per person

Early reservation for accommodation before April 15th to ensure hotel reservation **by e-mail:** armand.cholewka@us.edu.pl

Organizing Committee:

Armand Cholewka, PhD, Assoc. Prof.

Prof. Anna Jung, MD, PhD

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Doc. mgr. Vladan Bernard, PhD (Czech Rep.)
Prof. Jakub Adamczyk (POL)
MUDr Jozef Gabrhel,CSc (Slovakia)

PROGRAMME AT A GLANCE.

19th May, Friday: 7 p.m. Welcome Dinner (Vislow Resort Hotel)

20th May, Saturday:

9.00 - 11.00 Session I

11.00 - 11.20 Coffee break

11.20 - 13.00 Session II

13.00 - 14.15 Lunch

14.30 - 16.00 Session III

16.00 - 16.15 Coffee break

16.15- 18.00 EAT Board Meeting

14th- 18th August 2023
Cape Town, South Africa

International Heat Transfer Conference IHTC17

Venue: Cape Town International Convention Centre, Cape Town, South Africa

Submissiion for papers closed on 30th October 2022

Website: https://ihtc17.org/

30th October-November 3rd Abu Dhabi, UAE
QIRT Asia Conference

The conference, 4th QIRT Asia 2023 will be held in Abu Dhabi, United Arab Emirates

Website: https//qirt-asia-2033.org