ISSN-1560-604X
Thermology international

Volume 30 (2020)
Number 3(August)

Thermology International

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This journal is indexed in
EMBASE/Scopus

Published by the
European Association of Thermology

THERMOLOGY INTERNATIONAL

Volume 30(2020) Number 3 (August)

Published by the
European Association of Thermology

Indexed in
Embase/Scopus

Organ of the American Academy of Thermology

Organ of the Brazilian Society of Thermology

Organ of the European Association of Thermology

Organ of the Polish Society of Thermology

Contents

Awareness of measurement uncertainty is the first step to reduce the uncertainty, but one can´t get rid of it

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The term uncertainty has two different meanings: either doubt about the validity of the result of a measurement, or specific quantities that provide quantitative measures of the uncertainty concept, for example, the standard deviation. *Thus, measurement uncertainty is defined as non- negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used* [1]. Uncertainty resulted in a re-definition of accuracy and precision that are both fundamental terms of quality assurance in measurements. "The international vocabulary of metrology-basic and general concepts and associated terms (VIM)" provide definitions of all conditions and processes involved in measurements. Measuring implies comparison of quantities, or counting of entities, resulting in a process of experimentally obtaining one or more quantity values that can reasonably be attributed to a quantity.

Before I lose myself in principles of metrology, I would like to attract the reader's attention to the purpose underlying measurements, or in other words why ordinary people (not only scientists) are interested in measuring almost everything. As previously mentioned, measurement means comparison, and based on the external and internal sensory input to their complex organism, mammals have learned to estimate the dimensions of their environment by using their own body functions as a ruler for comparison. For example, an adult cat easily detects the minimum width of a gap in a wooden fence necessary for a successful escape. It is not difficult to develop a measurement task from the cat's escaping behaviour. There are many questions such as: are there gaps in the fence? And if so, how many are they and what is the dimension (width, height) of each of the gaps? What is the body dimension of the cat, and what is the minimum cross-sectional area which the body of a skilled cat can move through? Does the size of the gap area and the minimum cross-sectional area agree? What is the distance between the cat's position and a gap feasible for escape? Are there any obstacles between the cat and the target gap? And what happens when another, bigger cat wants to escape through the fence? Cats can solve all these questions subjectively in their inherited way, modified by their individual experience in moving around, but cannot solve this task for other individual cats.

People, and particularly scientists, are afraid of the results from assessing quantities in a subjective way, and insist on objective evaluation such as measurements. The VIM defines ***quantity*** as "*a property of a phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference*". To get rid of subjective estimates of quantities, measurements are assigned measurement units to quantities [1]. The VIM definition of **unit of measurement** or briefly **unit** is "*a real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number. Measurement units are designated by conventionally assigned names and symbols.*" [1]. Measurement results are ubiquitous, since simple to complex representation of quantities build the foundations of human civilisation, and are integrated parts of our daily living in economical and private context.

In science, measurements are applied either diagnostically to describe the condition under investigation, or to use the change in measurements as the outcome of an intervention. In the cat example, measuring the area of the gap in the fence, the cross-sectional area of the cat's body, the distance from the cat to the fence and counting the number of gaps, the number of cats and determining the agreement between gap and cross-sectional area are regarded as diagnostic measurements. The change of all these measurements obtained in a repeated measurement procedure becomes an outcome parameter. It is pretty obvious that repeated measurements are a source of additional measurement uncertainty, because even calibrated measuring devices of the same kind contribute individually to the variability of measured values. In other words, there is a high probability of different measurement results when a stable reference quantity such as the temperature of a black body source is measured with various thermal imagers. This was nicely evidenced by Marjanovic and colleagues who demonstrated both the differences in temperature readings between investigated infrared cameras, and their change in a period of 3 months [2].

If multiple objects with similar, but unknown stability of the target quantity are used as reference for determining the performance of two devices of the same kind, the uncertainty of results is multiplied due to the variation in each object and each device. Systematic measurement errors affect the agreement of absolute values, but do not affect the relationship of measured values located in a defined measurement area. Alfieri et al. report in their article poor agreement of absolute temperatures in thermal images recorded with a standard infrared thermal camera or a low-cost thermal imager, but found good agreement of the mean temperature in corresponding anatomical measurement areas obtained by either device [3].

Several steps of assessment must be performed for procuring a thermal infrared camera for clinical application [4]. Costs and cost-effectiveness of the equipment is among these steps, but identification of clinical needs is the primary requirement. The misuse of thermal imaging remains the biggest risk to both patient and user from thermography, because insufficient operation of the equipment may result in erroneous and misleading temperature readings, thus leading to a wrong diagnosis. Protection against this severe attack on the reputation of thermal imaging may arise from implementation of quality assurance programmes for both the technical performance and the setup of conditions for patient preparation, image capturing and image analysis. Applying the TISEM-checklist [5] for designing and monitoring a thermography study might be an initial step in the direction of "Good Clinical Thermographic Practice." Awareness of the checklist seems to improve complete reporting of thermal imaging studies [6]. The items of the TISEM-checklist might also be helpful in defining "Standard Operating Procedures [SOP]" for clinical infrared imaging, which in combination with quality assurance of the equipment may improve the diagnostic and monitoring performance of clinical thermography.

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About the Evolution of the Thermographic Profile In Breast Cancer - A Case Report

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SUMMARY

INTRODUCTION: Patients suffering from lobular breast cancer bear a high risk of a metastasising disease. Since this type of neoplasia often presents with an asymptomatic and therefore insidious growth, establishing the diagnosis through imaging may be difficult.

STUDY AIM: To report the clinical course of a patient who presented with a lobular breast carcinoma and to illustrate the contribution of infrared thermography in monitoring this lesion.

METHODS: P.L.S, a female patient 57 years old, was diagnosed with invasive lobular carcinoma in the lower right breast quadrant. A neoadjuvant chemotherapy was initiated to increase the chances of success of radical surgical therapy followed by radiation therapy. Before, during and after the completion of chemotherapy, infrared thermal images were taken of the patient's breasts in a private clinic by a physiotherapist who had been trained to record and evaluate infrared thermal images.

RESULTS: During chemotherapy, the temperatures both above the tumour and on the contralateral breast decreased by 3° C, but the side difference in breast temperature remained unchanged at 2 °C. These temperature changes were paralleled by a decrease in tumour size.

CONCLUSION: This case report suggests that infrared thermal imaging technique can be a helpful complementary diagnostic tool to follow-up tumour development or involution in patients undergoing chemotherapy. The main advantages of the technique are real-time imaging, easy handling and the possibility of performing multiple examinations that are harmless to the patient, since neither painful procedures are applied nor the patient is exposed to ionizing radiation.

KEYWORDS: Neoplasms; Breast Cancer; Infrared thermography.

ÜBER DIE ENTWICKLUNG DES THERMOGRAPHISCHEN PROFILS BEI BRUST KREBS - EIN FALLBERICHT

EINLEITUNG: Patientinnen mit lobulärem Brustkrebs haben ein hohes Risiko für eines metastasierende Erkrankung. Da diese Art von Neoplasie oft ein heimtückisches, weil symptomfreies Wachstum zeigt, kann die Bestätigung der Diagnose durch Bildgebung schwierig sein.

ZIEL DER STUDIE: Darstellung des klinischen Krankheitsverlaufs einer Patientin mit lobulärem Mammakarzinom und Veranschaulichung des Beitrags der Infrarot-Thermographie bei der Überwachung dieser Läsion.

METHODE: Bei der 57 Jahre alten Patientin P.L.S. wurde ein invasives lobuläres Karzinom im unteren rechten Brustquadranten diagnostiziert und eine neoadjuvante Chemotherapie eingeleitet, um die Erfolgschancen einer radikalen chirurgische Therapie mit anschließender Strahlentherapie zu erhöhen. Bevor, während und nach Abschluss der Chemotherapie wurden in einer Privatklinik Infrarot-Wärmebilder von den Brüsten der Patientin von einer für Aufnahme und Auswertung von Infrarot-Wärmebildern ausgebildeten Physiotherapeutin angefertigt.

ERGEBNISSE: Während der Chemotherapie verringerten sich die Temperaturen sowohl über dem Tumor als auch an der kontralateralen Brust um jeweils 3°C, der Seitenunterschied der Brusttemperatur blieb jedoch mit 2°C unverändert.

SCHLUSSFOLGERUNG: Dieser Fallbericht legt nahe, dass die Infrarot -Thermografie ein hilfreiches ergänzendes diagnostisches Werkzeug sein kann, um die Entwicklung oder Involution von Tumoren bei Patienten zu verfolgen, die sich einer Chemotherapie unterziehen. Die Hauptvorteile der Technik sind eine Echtzeit-Bildgebung, einfache Handhabung und die Möglichkeit, zahlreiche Untersuchungen durchzuführen, die für die Patienten unschädlich sind, da weder schmerzhafte Prozeduren angewendet werden noch der Patient einer ionisierenden Strahlung ausgesetzt ist.

SCHLÜSSELWÖRTER: Neoplasma. Brustkrebs, Infrarot-Thermographie

Thermology international 2020, 30(3) 83-88

Introduction

Invasive lobular carcinoma (ILC) comprises approximately 10% of breast cancers and appears to have a distinct biology [1]. It is less common than infiltrating ductal carcinoma (IDC) and few data have been reported that address the biologic features of ILC in the context of their clinical outcome. ILC responds to 28% of new cases a year and is responsible for most female's cancer deaths [2]. Although common in women, IDC is the predominant histologic type causing breast cancer in men [3].

According to Borchartt there are more than twenty types of breast cancer and among them, the ductal carcinoma, lobular and inflammatory cancer are the most common ones [4]. The most prevalent histological kind of invasive breast cancer is ductal carcinoma comprising 80% to 85% of all cases. About 15% of breast neoplasms are non-invasive "in situ" carcinomas, in situ ductal carcinoma (ISDC) appear in 80% of cases and in situ lobular carcinoma in approximately 20% [5].

By definition, an in situ ductal carcinoma represents the proliferation of neoplastic cells, limited to the ductal epithelium without invasion of the basal membrane and stroma.When the neoplastic cells break through the ductal wall and proliferate into the breast adipose tissue, this might result in metastasis and the tumour is named invasive or infiltrating ductal carcinoma.

Breast lobular neoplasm refer to a group of lesions mainly characterized by atypical lobular hyperplasia (ALH) and by in situ lobular carcinoma (ISLC) [6]. They also include the whole spectrum of atypical epithelium lesions which may evolve in the terminal ductal lobular unit. It is characterized by cells proliferation and those cells are small, uniform, round, without cellular cohesion and with or without pagetoid extension for terminal ducts. [7]. ILC has great risk of metastasizing [8]. Since this type of neoplasia often presents with an asymptomatic and therefore insidious growth, establishing the diagnosis through imaging may be difficult [7].

The National Institute of Cancer (INCA) in Brazil expected for the period 2018-2019 six hundred thousand incident cancer cases per year with breast lobular cancer being the most common among women (about sixty thousand) becoming a huge public health problem [2]. In this context, early detection and early diagnosis appear as the key actions for optimal prevention facilitating all methods for treatment and tumour control.

Infrared thermography or digital infrared thermal imaging exam has a high potential to detect circulatory changes triggered by tumour induced angiogenesis or any other breast cancer signals in the earlier stage [9]. It is possible to identify thermal signals that suggest the presence of pre-cancer cells or an initial breast lobular tumor, even if it is too small in size to be detected by physical exam, mammography or any other types of structural imaging modalities [10].

Thermography technique consists of catching infrared radiation emitted from the skin with an infrared camera, which converts the registered radiation into temperature values creating thereby a map of temperature distribution on the surface of the imaged object. On the presence of mammary tissue anomalies, like a malignant tumour or some benign alteration, the breast surface temperature can significantly change [11]. Such phenomenon may be observed in cases of malignant neoplasms where cancer cells absorbs more glycose and reproduce themselves in an unordered way. In 1994, Anbar has pointed out that cancerous breast hyperthermia is seemingly associated with non-neurological vasodilation modulated by nitric oxide (NO) [12]. 20 years later the potential roles of NO in tumour growth are much better understood as it seems well established that nitric oxide is involved in angiogenesis and promoting thereby increased blood flow in breast cancer [13]. Due to the detection of thermal signals, infrared thermography becomes a promising technique as a complementary diagnostic tool for the evaluation of lesions suspicious for cancer and to follow up thermal signs that suggest the presence of a tumour.

This study aimed to report a case of a patient who had a lobular breast cancer and to illustrate the contribution of infrared thermography in follow up of this lesion.

Case history

This case report was submitted to and approved by the Human Ethic Committee of Science Institute from Federal University of Bahia under the protocol number 3.580.028.

The patient P.L.S., a fifty-seven years old female reported a painful sensation in her right breast in July 2016. She went to a mastologist who detected at breast palpation a nodular lesion in the lower quadrant of the right breast. It was required a colour doppler ultrasonography (USG) of the breasts. Image evaluation suggested a solid neoplasm of benign pattern (Bi-RADS II). It was also observed bilateral ductal ectasia and bilateral simple cysts. A fine needle biopsy was performed with negative results for cysts or neoplastic cells. Twenty days after the first imaging exam, she returned to the mastologist complaining about pain in the right breast. On that occasion, it was required new complementary exams such as digital mammography. A normal breast´s contour and volume were identified like in the previous sonographic finding (Bi-RADS II classification).

In February 2017, seven months after her first medical consultation, the pain complaint continued, and the patient was again submitted to ultrasonography and digital mammography. Enlarged lymph nodes were observed, and the mammography findings revealed a nodule with undefinable bounds in the right breast. Its size was about 8.0 x 6.0 x 3.2 cm in the lower quadrant (Bi-RADS IV). In addition, it was suggested a new core biopsy which confirmed the diagnosis of invasive lobular carcinoma.

Consequently, the patient was undertaken to a complete investigation of the neoplasm that included a magnetic resonance imaging of breasts as well as ultrasonography, electrocardiogram (ECG), computer tomography (CT) of thorax and total abdomen and laboratory exams. The CT of the total abdomen revealed the presence of small hepatic and bilateral renal cysts and increased size of homolateral axillary ganglia on the right (lymph node enlargement in I and II levels). Laboratory findings did not show any breast change worthy to be mentioned except increased serum levels of CA15.3 (300U/l) and CEA (>10 ng/ml). Magnetic resonance images of the breasts showed a great nodule in the right breast with 8.5 x 6.9 x 3.7 cm. Its classification was described as BI-RADS VI. Regarding ECG, there were no significant alterations. Transvaginal US revealed a myoma nodule and polyps of the endometrial cavity. The oncogenetic analysis did not show any genetic mutations related to cancer.

By medical indication, the patient underwent neoadjuvant chemotherapy with paclitaxel and Doxorubicin intravenously every twenty-one days. This treatment started on March 2017 and aimed to reduce the size of the tumor mass for surgery and radiotherapy treatment. In this period, the first thermographic evaluation was already performed to follow up the development of the neoplasm.

The thermographic evaluation was done in a private clinic in preserved environment and was combined with a control exam by an oncologist. Such conditions assured comfort and security for the patient. Thermograms were recorded by a physiotherapist trained as thermography technician.

To perform thermal imaging, the environment was temperature controlled at 23ºC and 55% of relative humidity. The patient was undressed to the waist and waited fifteen minutes for thermal acclimation. It was used an infrared camera FLIR T430sc 2.0, serie number 62116523 (Sweden), with 320×240 (76,800) pixels of spatial resolution, spectral range 7,5-13 μm, uncooled microbolometer, 23o lens, 60 Hz of image frequency, dual temperature range -20°C to 120°C/0°C to 650°C, thermal sensitivity <30 mK. The patient stood in an upright position and the thermal image captured in the anterior view of the upper body allowed analysing both breasts.

Using dedicated software, circular regions of interest (ROI) were defined circumscribing each breast, in which mean, maximum and minimum temperature were determined. If necessary, spot temperature measurements were performed for describing the temperature level in the breast quadrants. The distribution of colours was used for gross estimation of temperature. Thermal assymetry was defined as a temperature difference between corresponding measurement points equal or greater than 0.5°C. Thermal asymmetry was estimated when corresponding areas varied by at least 30% size of differently coloured areas.

Results

Figure 1 shows a thermogram that exhibited asymmetry in the thorax upper region and between both breasts in the lower quadrant. In the lower quadrant of the right breast a large white coloured area can be identified where spot tem-

Figure 1.
Baseline thermal image after 1st session of chemotherapy (03/24/2017).

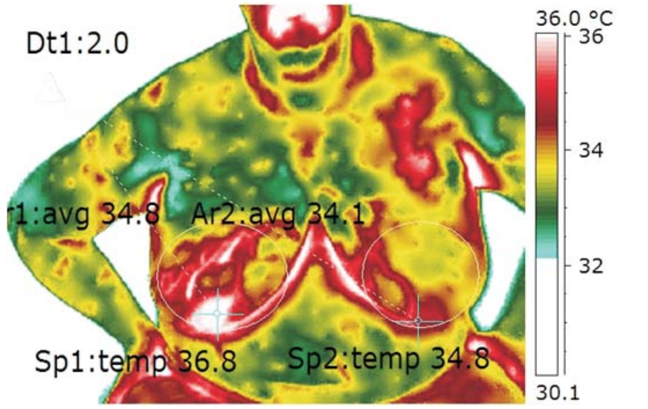

Figure 2.
Thermogram one month after the beginning of chemotherapy (04/23/2017).

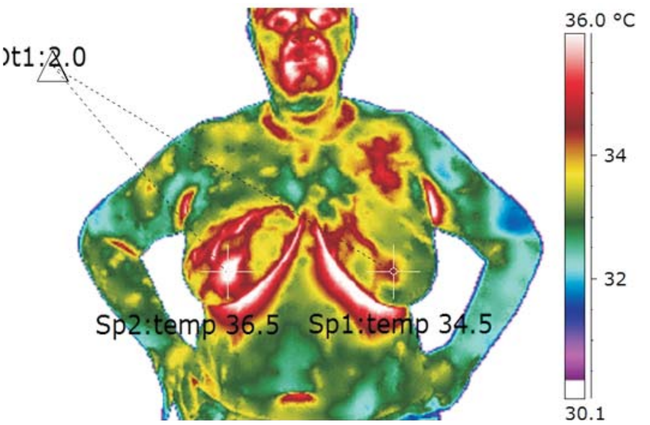

Figure 3.
Thermography after three months of neoadjuvant chemotherapy (06/06/2017).

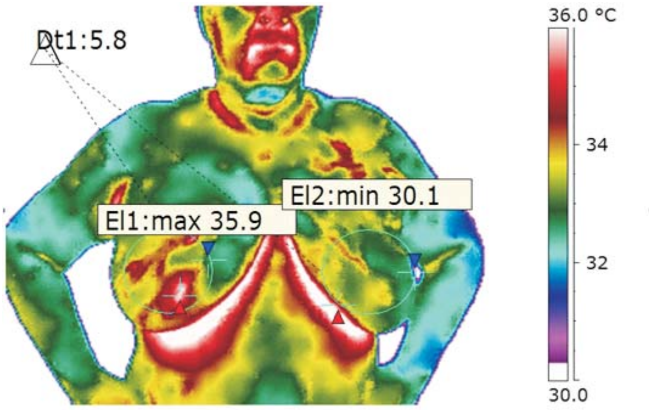

Figure 4
Thermography after last session of chemotherapy (08/12/2017).

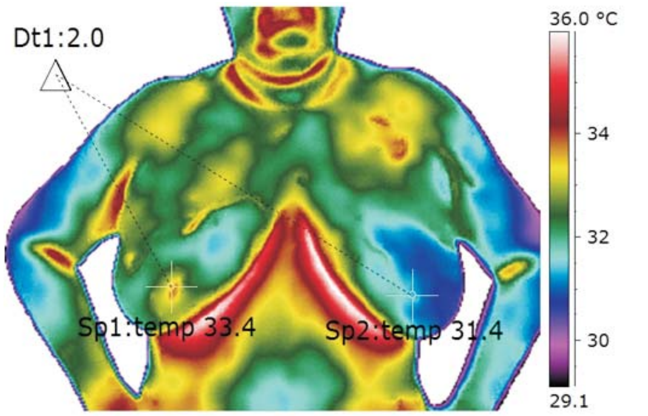

Table 1
Evolution of Spot Temperatures SP1 and SP2 throughout the period of observation.

Temperature	Figure 1 03/24/2017	Figure 2 04/23/2017	Figure 4 08/12/2017
SP1	36.8	36.5	33.4
SP2	34.8	34.5	31.4
Delta T (SP1-SP2)	2.0	2.0	2.0

perature measurement (SP1) indicated high temperature (36.8ºC). The same quadrant of the left breast showed an area of red color with a spot temperature (SP2) of 34.8ºC, resulting in a difference (ΔT) between the spot temperatures of 2.0ºC. In the region of axillary lymph nodes, a symmetric colour distribution was noted with estimated temperatures between 35 and 36ºC.

Figure 2 shows thermography at the second medical examination (04/23/2017) exactly one month after first investigation. When comparing to the first thermogram, it was noticed at the breasts that the asymmetry of temperature distribution continued. However, it was verified a quantitative and qualitative improvement of the thermal image of the lower breast quadrant showing a reduction in size of the red coloured area that had changed to yellow colour. Temperature in the spot SP1 at the right breast was 36.5ºC while in the SP2 (left breast) was 34.5ºC. The temperature difference (ΔT) between Sp1 and Sp2 was 2.0ºC. According to the colour scale, the breast temperatures presented slightly reduced compared to the baseline investigation.

Figure 3 shows the third thermographic evaluation (06/13/2017). The circular area 1 represents the right breast and the other circle 2, the left one. A thermal difference of 5.8ºC was observed between the maximal temperature of area 1 and the minimal temperature of area 2.

The last thermography evaluation (Figure 4) was done at the same date as the last neoadjuvant chemotherapy session (08/12/2017). The temperature in SP1 was 33.4ºC and 31.4ºC in Sp2, the temperature difference between the breasts remained unchanged (ΔT) = 2.0ºC). Table 1 shows the temperature evolution throughout the entire period of observation, which was equal to the time of chemotherapy.

Bilateral total mastectomy was performed due to the positive response to the neoadjuvant chemotherapy. Twenty days after the surgery, the patient underwent twenty-five sessions of radiotherapy with a total cumulated dose of 50 Grays. Currently, the woman is under medical observation, makes use of anastrozole 1mg/day and now two years after the surgical procedure, she is in good health condition.

Discussion

Global and Brazilian scenarios estimate an increase in the incidence of cases of breast neoplasm and the corresponding number of deaths in women [2]. So, this report aimed to describe the use of infrared imaging as complementary exam to follow up development of neoplasms in breast. This imaging tool shows high sensitivity and may detect tumour induced alterations even in the initial stage and the method may be helpful to follow up such condition over time [14].

The choice of a patient with lobular breast cancer was based on the fact that such neoplasm shows risk of 7 to 12 times higher of having metastasis [14]. In addition, imaging diagnostic is of hard to achieve since this type of neoplasm shows an insidious and often asymptomatic growth. Thus, it has been suggested on literacy, a combination of image techniques such as ultrasonography, magnetic resonance and digital mammography in order to track the tumor in early stage and follow up patients who have genetic risk of developing breast cancer [15].

A case of a patient with lobular breast cancer was selected because such neoplasms show a 7 to 12 times higher risk of developing metastasis [15].Since this type of neoplasia often presents with an asymptomatic and therefore insidious growth, establishing the diagnosis through imaging may be difficult. It has been suggested in the literature to use a combination of imaging techniques such as ultrasonography, magnetic resonance and digital mammography in order to track the tumour in the early stage and follow up patients who have genetic risk of developing breast cancer [16].

In this study, the patient reported painful sensation in her right breast in July 2016 and such symptom are suspicious for a possible neoplasm. However, even though the neoplasm has been tracked through imaging exams as digital mammography, doppler ultrasonography, the diagnosis of a lobular invasive carcinoma was difficult to establish. Conclusive diagnosis was obtained as late as in February 2017 by core biopsy when the tumour was already measuring 8.0 x 6.0 x 3.2 cm and classified as BIRADS- IV.

Brazilian's health services have some barriers particularly regarding cancer diagnosis [17]. Thus, it is important to explore new techniques which allow tumour identification. Some imaging methods previously mentioned are very effective but have some limitations detection in an early stage. For instance, digital mammography, which is considered highly effective, might offer risks for women's health since it uses ionizing radiation. Another limitation is the low quantity of equipment available for population screening. These conditions make it difficult to interpret exams from patients for pro- gnosis [18].

In this context, infrared thermography, which can detect thermal asymmetries, might be a feasible tool for monitoring carcinomas without raising risks for women's health. This technique checks points with higher temperature on the body surface. Such areas with high temperature may indicate an increase in local blood flow resulting from neoangiogenesis or metabolic changes related to tumour growth [19].

This case report corroborates the sensitivity of infrared thermography for monitoring tumour development, since in this case focal hyperthermia visible in the breast thermogram was closely related to the location and area of the tumour invasion. A previous study found thermography not useful in the follow-up of breast cancer patients after breast-conserving treatment by tumourectomy and therapeutic irradiation [20]. However, these negative results might be explained by the fact, that high energy irradiation is followed by an increase in surface temperature of the treated breast.

A thermal asymmetry was noticed in the thermograms of the breast during chemotherapeutic treatment. The thermal difference ΔT between corresponding regions of right and left breast (Sp1-Sp2) did not change throughout the observation period. ΔT values of 2.0°C were understood as an indicator of ongoing tumour presence. It was also observed that there was a significant reduction in temperature of both SP1 and SP2, indicating a good response to the applied treatment that caused a reduction inflammatory activity of the tumour. The temperature of area of right breast decreased by 3.4°C and this finding might be explained by a possible reduction of microcirculation in tumour area. When doing imaging exams prior to surgery, it was observed that a significant reduction in size tumour occurred with a decrease in diameter from 8.5 to 0.6 cm. Thus, this case report description is relevant because it allowed patient's follow up through infrared image pattern during the entire period of neoadjuvant therapy.

The thermal difference between the maximum right breast temperature and the minimum temperature of the left breast was 5.8°C with Tmax right = 35.9°C and Tmin Left - 30.1°C. Regarding the left breast, a hot spot was present in the medial lower quadrant since the basal thermal image, but a tumour was not detected in this breast region by any of the conducted imaging exams. Thermography demonstrated temperature reduction in the hot spot of the left breast pointing to good response to chemotherapy. When looking on the initial thermography exams, the patient had already carried a high risk for breast cancer according to the breast thermography grading scale of the Ville Marie Women's Hospital in Montreal (Range of IR 5/5) [21]. This risk was found reduced after chemotherapy, but as it sustained on a moderate level, the patient opted for bilateral mastectomy. As a matter of fact, biopsy results from the left breast taken prior to mastectomy, were similar to that of the right one.

Conclusion

This case report recommends thermography as a valuable tool for monitoring patients who are under chemotherapy due to breast cancer. The advantages of this imaging method include the possibility to achieve results quickly, easy equipment handling, high image quality, multiple exam repetitions without exposing the patient to ionizing radiation or any painful procedure during the examination.

Conflict of Interest

The authors declare that they have no conflict of interest.

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(Received 15.05.2020, revision accepted 28.07.2020)

Care required in comparing thermographic methods to other thermological techniques

Review of the paper by Maley et. al. **"Infrared cameras overestimate skin temperature during rewarming from cold exposure."** Journal of Thermal Biology 2020; 91:102614

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Summary

Background

The measurement of skin temperature from a wide variety of body sites is required for research into human thermal physiology. Conductive devices (typically thermistors) are considered to be accurate and stable, but can only produce a temperature measurement from a single point. Infrared devices (thermal cameras) offer the advantage that temperature can be measured over a wide area of skin, and data can be analysed off-line after the experiment from any defined region of interest (ROI) within the image. The uncertainty associated with non-contact infrared skin temperature measurements is, however, inherently greater than with conductive devices. A research team based in the UK and Australia therefore sought to compare thermistor and infrared skin temperature measurements from the finger pulp after hand cooling, in order to understand if there were clinically important differences arising from the two techniques after cold exposure.

Methods

After acclimatisation and a short period of hand prewarming, 52 males underwent cold challenge of the right hand for 30 minutes at 8°C in a room temperature of 30°C. After the cold stress, rewarming of the skin at the index finger pad was monitored for 10 minutes at one-minute intervals with a Type EUS-U thermistor secured with Transpore tape. Thermal images of the hand were also recorded every minute during rewarming with a FLIR A320G thermal imager from a distance of 1m, and index finger pad temperature was measured using the image analysis software spot tool at a point 1cm distal to the thermistor.

Results

Across all time points, and averaged across all subjects, the authors reported that the infrared imager recorded finger pad skin temperature 1.80°C (SD 1.16°C) warmer than the thermistor. The 95% limits of agreement on the associated Bland Altman plot ranged from -0.46°C to 4.07°C.

Conclusion

The authors concluded that there was a clinically significant difference between the thermistor and imager readings, the threshold for which they had defined to be a difference >0.5°C, with limits of agreement ranging across 1°C. They commented that this difference may have safety implications when it is necessary to ensure that cold injury is not induced in cooling experiments?

Commentary

Dear Editor,
the recent study by Maley et. al. [1] attempts to address an important question in physiological measurement: how well do infrared and conductive devices agree when used to measure skin temperature during dynamic rewarming experiments? This question has not been explored well in the existing literature, and I commend the authors for presenting work which begins this discussion.

Some of the design aspects of the study do, however, enforce important limitations on the interpretation of the findings. This is particularly the case with regard to the infrared measurements performed. Since these limitations are not discussed in the manuscript, I would like to address them within this commentary.

Firstly, there is the issue of thermal camera quality assurance, and the specifications of the device. The authors describe the calibration process for the thermistors used in detail: this was performed before experimental use at eight water temperatures between 5°C and 40°C, at 5°C intervals. This is clearly a quality assurance process appropriate to the measurement of skin temperature after cold water challenge. In contrast, however, the thermal imager is merely described as "calibrated within 12 months of use." No data are provided on the calibration equipment used, or the temperature points at which the calibration was performed. It is also not explained whether the calibration data obtained was used to correct the readings recorded in the cold challenge study. Overall, it is not possible for readers to conclude that the quality assurance was appropriate for the thermal imager in the same way that they can for the thermistor.

Performance specifications for the FLIR A320G thermal imager used are not given in the manuscript. The most important performance factor in this case is probably the imager's accuracy, which for this model is stated by the manufacturer as ±2°C. Whilst our experience at the Royal Free Hospital is that better accuracy than this can be achieved with the A320G under laboratory conditions, this is of course dependent on careful quality assurance against a blackbody at appropriate temperature points. The stated accuracy of ±2°C reinforces the requirement to perform careful QA and report it in full detail in any study discussing comparisons of skin temperature measurement. Considering that the authors were seeking an acceptable level of agreement with the thermistor of 0.5°C, it is curious that they chose an infrared device with a stated accuracy of ±2°C to explore if this was possible. Even before other experimental sources of error are considered, it is unlikely the requirements could be met due to the limitations introduced by imager uncertainty alone.

Next, we should also cast a critical eye over the collection of temperature data from the finger pulp with the infrared camera. The authors quite correctly point out the study limitation that infrared measurements were recorded from a point 1cm distal to the thermistor site. Hence it is important to consider if there could be a significant temperature difference across that distance that could contribute to the large discrepancy between the two techniques at each timepoint. The authors state that they are "confident that the difference of around 1 cm between device measurement locations is not the reason for the overestimation of temperature from the infrared camera," and cite work by Maniar et. al. [2] as evidence that skin temperature varies by only a few tenths of a degree Celsius across ROIs of width up to 5cm. Considering the Maniar et. al. study in more detail, however, reveals that the ROIs used for their research were at the neck, scapula, shin, and dorsum of the hand. Fingertip skin was not used, and this citation is not valid evidence that significant temperature gradients do not exist over a distance of 1cm at the finger pulp after cooling. In fact, there is strong evidence from thermal physiology to suggest sharp temperature gradients exist during rewarming at the finger pulp, owing to the rich subcutaneous supply of arterio-venous anastomoses under sympathetic control in the area [3]. This warrants further research, and should certainly be discussed as a limitation by the authors.

Finally, the use of "spot" measurements in infrared thermography is not recommended. The manuscript does not define how many image pixels constitute a "spot"; it may be the case that the measurement ROI was a single pixel. Grgic and Pušnik [4] have described that such readings are prone to measurement error induced by size-of-source effects. Phillips [5] recommends a minimum ROI size of 3x3 pixels for any thermography measurement; the exact requirements are a function of imaging distance and the camera's Instantaneous Field of View (IFOV). The study would have achieved more reliable infrared temperature readings if a small, multi-pixel ROI had been employed rather than a spot measurement.

When conceiving a study comparing two methods, it is important to ensure that the research team has the capacity to employ both techniques with the same level of expertise. This is vital to avoid biasing the outcome: no poorly-executed measurement is ever likely to out-perform a well-executed alternative, no matter how valid it may be. Thermography, often introduced to research facilities as a "novel" technology, seems particularly prone to this problem. Keyserlingk et. al [6] have described in detail how the poorly-controlled introduction of thermography to the Breast Cancer Detection Demonstration Project in the 1970s ultimately taught us very little about the utility of infrared imaging for breast cancer as an adjunct to mammography. This situation came about because many of the participating centres could readily provide radiological expertise, but could not match that experience when it came to thermological methods.

In an earlier review in Thermology International of a published study, my EAT colleague Adérito Seixas [7] commented on a perceived lack of expertise on thermography matters amongst the editors of even high-impact journals, and the colleagues they invite to perform peer review. In both the paper discussed by Seixas, and also the study I discuss above, opportunities were missed to help the authors improve their manuscripts. All research has limitations, but if these are not discussed in published papers, studies quickly become cited as undisputed "evidence" supporting sub-optimal experimental techniques or questionable findings. In a world where infrared technology is increasingly used, journals have a duty to become more inquisitive about thermographic methods, and the EAT will also continue with its educational objectives to promote the best possible thermological techniques.

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Comparison of iOS smartphone-attached infrared camera and conventional FLIR camera for human temperature measurement: an agreement study

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SUMMARY

BACKGROUND: Low cost infrared sensors have been recently released, and despite lacking a high resolution, they have already been employed in clinical research The objective of this study was to demonstrate the agreement of thermal images captured by a low-cost smartphone-attached Infra-Red camera compared to a professional Infra-Red camera.

MATERIALS AND METHODS: This is a cross-sectional study with 20 healthy male individuals whose skin temperature has been assessed. Anterior and posterior thermal images were simultaneously captured by FLIR T650sc camera and FLIR ONE Pro for iOS, a smartphone-compatible infrared (IR) imaging device. The subjects stood 4 meters away from both IR devices, subject's preparation and image recording were standardized according to specialized literature, and all images were processed by the software FLIR Tools. Skin temperatures were recorded in 10 different regions of interest: thigh, leg, knee in the anterior view and thigh and leg in the posterior view. Agreement of absolute temperature values obtained by either infrared device was evaluated using Lin's Concordance Correlation Coefficient test (CCC) and Bland & Altman's limits of agreement (LOA); secondary analyasis was conducted to identify sources of temperature disagreement.

RESULTS: 20 participants (38.2 ± 9.42 years) were included, and the temperatures in 180 ROIs were compared for agreement. Both devices managed to show thermal symmetry in all participants, however Lin's CCC and Bland & Altman LOA evidenced poor or absent agreement of temperatures obtained by either device (c = 0.03, p = 0.453 and bias of -1.23, CI95% -6.85 to 4.4, respectively). The analysis after stratification to ROIs showed similar results. Secondary regression analysis did not evidence relevant sources of disagreement.

CONCLUSIONS: Considering the methodology used, FLIR ONE Pro for iOS managed to show thermal symmetry on the lower extremities, however. there was no evidence of agreement with absolute temperature values obtained with the FLIR T650sc, neither in pooled nor in stratified analysis.

KEYWORDS: infrared thermography, mobile thermography, affordable IR cameras, FLIR ONE

VERGLEICH EINER SMARTPHONE-KOMPATIBLEN INFRAROTKAMERA MIT EINER KONVENTIONELLEN FLIR-KAMERA ZUR MESSUNG DER MENSCHLICHEN TEMPERATUR: EINE UNTERSUCHUNG AUF ÜBEREINSTIMMUNG

HINTERGRUND: Kostengünstige Infrarotkameras stehen seit kurzem zur Verfügung, und obwohl sie keine hohe Auflösung haben, wurden sie bereits in der klinischen Forschung eingesetzt. Das Ziel dieser Studie war es, die Übereinstimmung von Wärmebildern zu demonstrieren, die von einer kostengünstigen, mit dem Smartphone verbundenen Infrarot-Kamera im Vergleich zu einer professionellen Infrarotkamera aufgenommen wurden.

MATERIALIEN UND METHODS: In dieser Querschnittsstudie die Hauttemperatur von 20 gesunden Männern anhand von Wärmebildern erhoben, die gleichzeitig mit einer Infrarotkamera (IR) der Marke FLIR T650sc und mit der Kamera FLIR ONE Pro für iOS aufgenommen worden waren. In einem Abstand von 4 Metern zu beiden IR-Geräten wurden Wärmebilder der Probanden nach einer der Fachliteratur entsprechenden Standardisierung angefertigt und alle Bilder wurden mit der Software FLIR Tools bearbeitet. Die Hauttemperaturen wurden in 10 verschiedenen regionalen Messarealen (ROIs) erhoben: Oberschenkel, Unterschenkel und Knie in der Ansicht von vorne sowie Oberschenkel und Unterschenkel in der Ansicht von hinten. Mit dem "Lin's Concordance Correlation Coefficient Test (CCC)" und Bland & Altman's "Limits of Agreement (LOA) wurde die Übereinstimmung der absoluten Temperturwerte geprüft, die mit jeder Kamera erhoben worden waren. Sekundäre Analysen wurden durchgeführt, um den Ursprung einer mangelnder Übeinstimmung der Temperaturen zu identifizieren.

ERGEBNISSE: 20 Teilnehmer (38,2 x 9,42 Jahre) wurden einbezogen, und die Temperaturen in 180 ROIs wurden auf Übereinstimmung untersucht. Beide Geräte konnte eine symmetrische Temperaturverteilung bei allen Teilnehmern nachweisen, jedoch zeigten Lin's CCC und Bland & Altman LOA eine schlechte oder fehlende Übereinstimmung der Temperaturwerte beider Geräte (c = 0,03, p = 0,453 und Bias von -1,23, CI95% -6,85 bis 4,4). Eine Analyse nach einer auf die Messareale bezogenen Datenschichtung zeigte ähnliche Ergebnisse. Die sekundäre Regressionsanalyse entdeckte keine relevanten Faktoren für die geringe Temperaturübereinstimmung.

SCHLUSSFOLGERUNG: Unter Berücksichtigung der verwendeten Methodik gelang es mit der FLIR ONE Pro für iOS, eine symmetrische Temperaturverteilung zu zeigen, jedoch gab es weder in der gepoolten, noch in geschichteter Analyse Beweise für eine Übereinstimmung mit den absoluten Temperaturwerten, die mit der FLIR T650sc erhoben wurden.

SCHLÜSSELWÖRTER: Infrarot-Thermographie, Mobiltelefon-Thermographie, kostengünstige Infrarotkamera, FLIR ONE

Thermology international 2020, 30(3] 91-96

Introduction

Thermography is a method that allows superficial skin temperature measuring with safety and good reproducibility and is being widely employed in clinical research [1].

A review of this technique indicates that some variables may affect the clinical examination: environmental factors, individual and technical issues. Regarding the latter, it is recommended that the camera resolution is at least 240 x 320 pixels [2]. Recently, low cost cameras have been released in the market, but they lack this minimum resolution.

This type of camera tends to be attached to a smartphone and has been employed in studies investigating ophthalmologic diseases [3], stress [4], arterial mapping [5]. This last study assessed the use of a smartphone-attached camera in mapping peroneal artery perforation, together with computed tomography and angiography demonstrated that infrared thermography was able to detect 42 out of 57 perforations in 24 limbs. This resulted in a sensitivity of 73.7% and a predictive value of 65.6%. Authors concluded that sensitivity and predicted value of this technique are low, thus it must be used in combination with the other established image techniques [5]. Other clinical conditions were analyzed with these devices, such as subclinical inflammation in pressure ulcers of diabetic feet [6,7], tissue perfusion in arterial disease [8], inferior limb acute ischemia [9], and peritonsillar abscesses [10]. Some authors have positively evaluated this type of camera, demonstrating high concordance with respective gold standard methods [11,12].

Regarding smartphone attached IR devices, a previous study tested the repeatability, bias and mean difference (agreement) of IR images captured by a low-cost IR device (FLIR ONE) compared to a medical IR spot thermometer (Exergen DermaTemp 01001RS), even though this is not an IR camera and it is not accredited as a medical device. The authors collected bilateral temperature measurements of index fingers of healthy participants and tested repeatability with Intraclass Correlation Coefficient (ICC), which was higher for the smartphone attached device than for the spot thermometer (0.97 and 0.89, respectively). The authors concluded that the smartphone attached IR device had higher precision and could be applied to provide information on temperature distribution of whole hand, allowing immediate and quick comparison of hand injuries. Nonetheless, the temperatures measured by the smartphone attached IR device were higher than those shown by the conventional IR camera. According to the authors, this is evidence that these devices are not interchangeable for absolute values, being suitable to monitor temperature changes, however; also, they suggest this device has potential to be applied in telemedicine [13].

Even though the low-cost feature of these devices is attractive, a study emphasizes their operational performance does not meet required standardization to be applied in clinical settings, and that their absolute temperature values should be corrected [14]. Such devices could be applied as an objective measuring tool for quantifying cutaneous temperature in clinical research [15], however reliability and agreement are yet to be evidenced [16].

The applicability of low-cost portable smartphone attached devices in clinical settings may benefit from concordance and reliability studies comparing with professional devices, such as FLIR T650sc. This is corroborated by a recent study whose future projections of thermography suggest the use of devices such as the FLIR ONE, a device that may be suitable in biomedical applications [17].

Therefore, the objective of this study is to establish the agreement of FLIR ONE Pro for iOS, a smartphone attached Infra-Red imaging device, compared to FLIR T650sc in a standardized clinical setting for health professionals.

Method

This cross-sectional observational study was performed in line with the principles 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 837.421. Healthy adult males, staff of a rehabilitation facility, were invited to participate. Persons with musculoskeletal pain (greater than 5 in the visual analogue scale), fever or in use of anti-inflammatory drugs were excluded from the study. Subjects presented no previous injuries or surgeries, severe structural alterations, or chronic diseases.

Subjects were instructed to stand up on a mark on the floor, 4m away from the infrared sensors and 0.4m away from the wall. The procedure followed the criteria adopted and recommended by previous study [1]. Volunteers remained standing in same prescribed position during image capture. The camera was perpendicularly positioned in relation to the research subject.

The subjects were instructed not to perform movements with arms or legs, or to scratch any region of the body before and during the procedure. Before the exam (about 2 hours), participant could not take hot baths or showers, spread creams or powder, or perform exercises. They were instructed not to take in stimulants, beverages containing alcohol or caffeine, not to use nasal decongestants and not to smoke [1,18,19]. Once all requirements were met, volunteers were asked to keep their lower limb areas exposed to room temperature for a period of 15 minutes to achieve thermal equilibrium with the temperature of the examination room. The temperature of the examination room was 20.9 ± 0.44 °C with 65.80 ± 2.61% humidity. Evaluations were always carried out in the morning. Thermal images were captured by two infrared devices: FLIR model T650sc and a FLIR ONE Pro for iOS.

The thermographic images were captured by a FLIR T650sc infrared device, with 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 precision 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 to be 0.98. The images were simultaneously collected with the FLIR ONE Pro for iOS device, with spatial resolution of 160x120, at a frequency of 8.7Hz, precision of 3°C or ±5%, sensor pixel size of 12μm, spectral bandwidth of 8 to 14μm, and thermal sensitivity MRDT, (Minimum Resolvable Temperature Difference) of 150 mK. The smartphone-based IR-camera was attached to an iPhone 7 A1778 (iPhone, Apple Inc. EUA).

Both devices were previously switched on for image and temperature stabilization fifteen minutes before data collection. Then, images were simultaneously captured by two evaluators (FMA and CSD) to minimize bias of the time gap between pairs of images of the same Region of Interest (ROI). These IR images were captured in both anterior and posterior views of the volunteers included.

The images were analyzed by the software FLIR Tools. Average temperature was evaluated for each ROI (region of interest). ROIs were rectangles or circles determined by anatomical references, and were previously described [1,18,20].

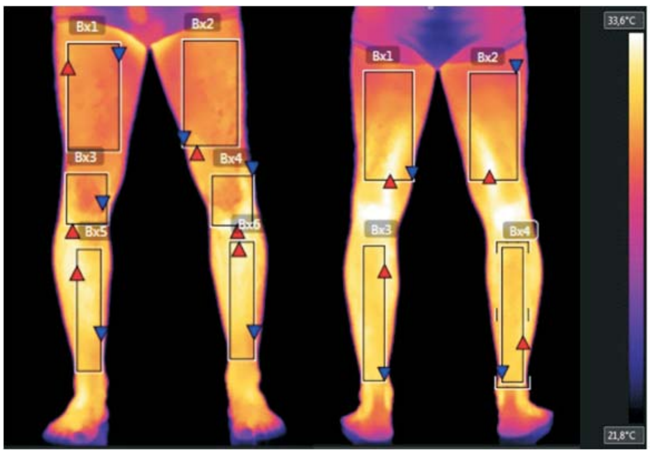


Figure 1
Regions of Interest (ROIs) of lower limbs. On the left, anterior view; on the right, posterior view.

The regions of interest (ROI) were rectangles determined by anatomical landmarks: 1- thigh: 5 cm above the superior border of the patella and the inguinal line, 2- leg: 5 cm below the inferior border of the patella and 10 cm above the malleolus and the entire anterior region of the 3-knee (about 2 centimeters above and below the upper and lower edges of the patella respectively) as can be seen in figure 1.

Data analysis

Data was analyzed with Stata14® for Windows. Descriptive analysis was conducted, and comparisons between values provided by both cameras were made using Lin's Concordance Correlation Coefficient (CCC, or ρc), followed by a Bland & Altman Limits of Agreement test (LOA) [21,22].

To identify possible sources of disagreement, secondary analysis was conducted with a linear regression test to compare demographic or environmental variables (age, BMI,

Table 1
Demographic and baseline clinical features

Variables	
N	20
Age (years)	38.2 ± 9.42
BMI (kg/m²)	28.93 ± 3.99
Room temperature (°C)	20.9 ± 0.4
Relative Humidity (%)	65.8 ± 2.6

BMI: body mass index; Kg: kilogram; m: meter; °C: degrees Celsius. Data are expressed as means ± standard deviations or absolute values

Table 2
Comparison of temperature between right and left sides.

		FLIR T650SCR	FLIR ONE Pro iOS
Anterior view			
Thigh	Right	29.9 ± 0.8	28.8 ± 2.5
	Left	29.9 ± 0.8	28.8 ± 2.4
	Difference (p-value)	0.005 (0.960)	0.06 (0.590)
Knee	Right	29.7 ± 0.9	28.7 ± 2.5
	Left	29.5 ± 1.1	28.7 ± 2.4
	Difference (p-value)	0.145 (0.137)	0.030 (0.820)
Leg	Right	30.8 ± 0.9	29.9 ± 2.4
	Left	30.8 ± 1.0	30.0 ± 2.4
	Difference (p-value)	0.055 (0.396)	-0.015 (0.866)
Posterior view			
Thigh	Right	30.4 ± 0.7	28.8 ± 2.8
	Left	30.3 ± 0.8	28.8 ± 2.8
	Difference (p-value)	0.065 (0.341)	-0.075 (0.267)
Leg	Right	30.8 ± 0.8	29.7 ± 2.8
	Left	30.7 ± 0.8	29.6 ± 2.8
	Difference (p-value)	0.120 (0.065)	0.070 (0.373)

room humidity, and room temperature) with temperatures found by FLIR T650sc, FLIR ONE Pro or the difference between both cameras. Finally, post hoc analysis of CCC were conducted, controlling for the variables which were identified as sources of disagreement in the secondary analysis. Statistical significance was set at $p < 0.05$ and results were shown as IC 95%.

Results

Twenty males aged 23 to 58 years signed the informed consent form and participated in the research. Demographic and clinical characteristics of participants are presented in table 1. The temperatures measured by both cameras show that there was no difference between the right and left side, an evidence there was temperature balance among the participants. These results are presented in table 2.

Two volunteers did not have their temperatures collected by the FLIR ONE and were not included in the analysis. Considering the remaining 18 volunteers and 10 ROIs, the analysis was conducted on 180 observations (no=180). The Lin's Concordance Correlation Coefficient test evidenced that, under the parameters described in the methodology, there was no agreement between both cameras (table 3), as $\rho c = 0.03$ ($p = 0.453$) (figure 2) and average difference of -1.23 (figure 3).

The secondary analysis evidenced that BMI and humidity were slightly associated with the temperature difference of both cameras (p=0.032 and p=0.001, respectively), whereas no association was found the temperature readings and the other variables, either clinical or environmental. Given the weak association between BMI or humidity and the difference between both cameras (r^2 = 2.5% and r^2 = 6% respectively),

Table 3
CCC analysis for main comparison, after correction for humidity, and stratified by site

	Pc	SE	ρc	95% CI	p-value	B&A	SD	B&A	95% CI
General concordance	0.03	0.04	-0.048	0.108	0.453	-1.23	2.87	-6.85	4.4
Concordance corrected for humidity	0.419	0.075	0.272	0.565	**< 0.001**	-0643	2.46	-5.473	4.186
CCC by site									
Right anterior thigh	-0.118	0.102	-0.318	0.082	0.247	-1.217	2.972	-7.042	4.609
Left anterior thigh	-0.130	0.110	0.346	0.086	0.237	-1.228	2.937	-6.984	4.529
Right knee	-0.082	0.130	-0.337	0.173	0.529	-1.1	2.970	-6.921	4.721
Left knee	-0.003	0.156	-0.303	0.302	0.985	-0.978	2.834-	6.533	4.577
Right anterior leg	-0.098	0.143	-0.378	0.183	0.495	-1.017	2.844	-6.5441	4.558
Left anterior leg	-0.013	0.15	-0.307	0.282	0.933	-0.950	2.744	-6.327	4.427
Right posterior thigh	-0.025	0.096	-0.212	0.163	0.796	-1.672	3.194	-7.932	4.588
Left posterior thigh	0.3	0.101	-0.168	0.228	0.766	-1.572	3.057	-7.564	4.419
Right posterior leg	0.1	0.101	-0.097	0.298	0.320	-1.298	2.897	-6.967	4.390
Left posterior leg	0.127	0.104	-0.078	0.331	0.224	-1.233	2.88	-6.878	4.411

CCC= concordance correlation coefficient; ρc, rho-c; SE= standard error of ρc; 95% CI = 95% Confidence Interval; B&A = Bland and Altman limits of agreement.

Figure 2
Concordance correlation coefficient and the distance from the

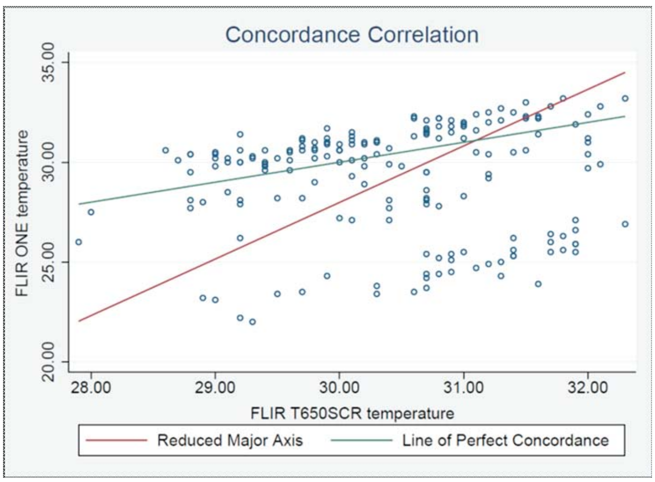
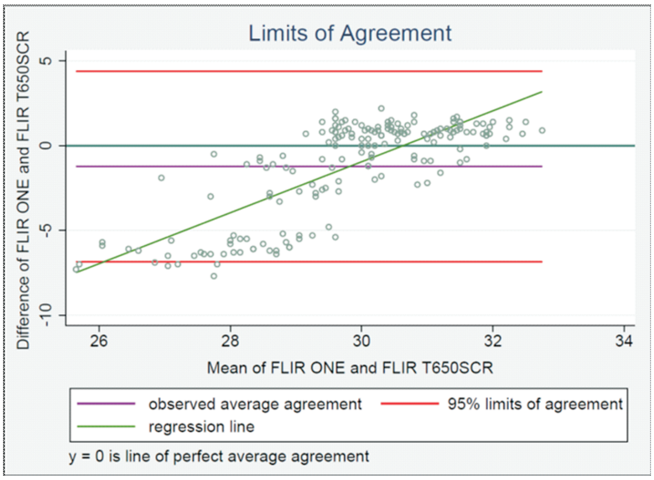


Figure 2
Concordance correlation coefficient and the distance from the line of perfect concordance.



they were not considered relevant sources of disagreement.

Finally, the CCC analysis was repeated for each ROI. The results agreed with the principal analysis as no ROI alone yielded satisfactory correlation between both cameras, and p values were all above 0.2 (table 3).

Discussion

TThe aim of this study was to establish the agreement of thermal images captured by FLIR ONE Pro for iOS, a smartphone attached IR device, compared with FLIR model T650sc. The methodology used was established by specialized literature and, under these circumstances, FLIR ONE Pro for iOS did not meet suitable agreement with FLIR T650sc.

In our study, evaluating lower limbs was meaningful, as they are often involved in degenerative and inflammatory processes. Therefore establishing agreement of an IR device for thermography is meaningful for future studies. Also, the sample was composed of male individuals and it is known that sex may influence thermal patterns [2]. The chosen devices were both made by FLIR, and have previously shown potential and capacity of temperature detection in biomedical models [17]. The images were collected simultaneously in order to avoid differences caused by environmental factors such as humidity and temperature that may influence the readouts of both devices.

Literature emphasizes that room temperature is a crucial factor for thermography in humans, and most studies suggest a temperature range of 19ºC to 25ºC for clinical applications [2]. In the present study, the average room temperature was 20.9ºC, virtually identical to the ideal temperature of 21ºC [23], nonetheless, our results showed that room temperature variations did not influence the concordance between the cameras, therefore, it was not a critical variable in our study.

Another environmental aspect that is commonly addressed is relative humidity. Fernández-Cuevas [2] reported that although humidity is trivially reported in studies with human models, these publications rarely provide a justification for controlling this variable. In this valuable review on thermography, the authors reported that relative humidity should be controlled in order to avoid shivers or sweat. Also, the authors state there is no correct value for humidity, however the most commonly suggested numbers range from 40% to 70% [2], therefore the average humidity observed in our study is within this range.

Regarding the temperature readings obtained by the cameras, both devices demonstrated similarity of temperature between both corporal sides, whose difference was close to 0.1. Primarily, this result corroborates the commonly found thermal contralateral symmetry in healthy individuals [1]. Thermal symmetry can be defined as a similar temperature distribution in corresponding anatomical regions of the body, which in statistical terms means a close agreement of means and standard deviations between both sides of the body, what was clearly observed in our results (Table 2), meaning this low-cost camera may be used for verifying thermal symmetry. Also regarding symmetry, the differences between contralateral ROIs we found were smaller than those found by Vardasca et al. [24] who reported asymmetry of 0.4ºC ± 0.3 between both sides of the body of healthy individuals. Nonetheless, opposed to another study [13], the absolute values obtained by the professional camera were higher than those shown by FLIR ONE, with mean temperature of 30.29ºC and 29.18ºC, respectively.

The accuracy for detecting body symmetry by FLIR ONE can be explained once the device was equidistant from both contralateral sides of the body of the participants, therefore the device was not subject to environmental variations. Nonetheless, the disagreement in absolute temperature readouts may be due to the distance of 4m from the sensor to the subjects, once the spatial resolution of FLIR ONE Pro for iOS is smaller when compared to FLIR 650SC, 160x120 and 640x480, respectively.

A study [25] reports that absolute cutaneous temperature values should not be used alternately between FLIR ONE and FLIR E8, once, according to the authors, both devices do not have suitable agreement, however, they also state that the method they applied to assess the medial portion temperature of the Achilles tendon with FLIR ONE reached excellent intra-rater reliability for both cameras at distances of 0.5m to 1m. They concluded temperature measures taken by FLIR ONE are acceptable in these distances and recommend these devices to be used in short distances [24]. This finding is relevant, once in our study the distance from the sensor to the volunteers was 4m, even for the smartphone-based IR device, what may explain the lack of agreement between the temperature values read by both cameras. Nevertheless, future agreement or reliability studies on this matter should take the distance into consideration.

According to Lawrence and Lin [21], the Concordance Correlation Coefficient quantifies, from -1 to 1 how much two readings of the same subject measured by 2 different devices or raters fall on the 45º line from the origin, i.e. x=0 and y=0. In his famous 1989 paper, he describes that other statistical approaches, such as Pearson correlation coefficient, t-test or even least squares from regression analysis fail to detect agreement between two sets of measurements [21]. Still on this matter, Bland & Altman Limits of Agreement propose the quantification and analysis of mean differences between pairs of variables, which, when combined with the 95% Confidence Interval, provides mean differences and the limits of agreement [26]. In our study, these analyses were used to address agreement. We understand reliability should not be tested before adequate agreement with a professional camera is shown.

The relative small sample size may seem to prevent generalization of the results herein, however the total amount of ROIs analyzed yielded an important sample of temperature measurements. The generalization may be questioned due to the absence of female participants, although it is unlikely that sex of the subjects would change the results. This methodological decision diminished temperature variations within the sample, what could have imposed another source of disagreement. A limiting factor of our research was the lack of calibration protocol of both devices with a blackbody, what may have caused an unknown offset between them, therefore future studies that evaluate agreement, should take into consideration the suitable calibration of the IR devices. At last, the methodological rigidity that did not allow shorter distances from the subject to the FLIR ONE Pro sensor may have been the cause of insufficient of absent agreement of absolute values with FLIR T650sc, nonetheless the symmetry was satisfactory captured by FLIR ONE Pro. As the low cost of this type of infrared sensor may lead to the popularization of its use, it is worth to point out the limitations of this equipment.

Conclusion

The difference in performance observed between FLIR ONE Pro for iOS and the high-resolution sensor FLIR T650sc evidence little to no agreement between both devices, if they are tested under the same methodological rigor, especially considering a distance of 4m. Nonetheless FLIR ONE Pro for iOS managed to show thermal symmetry in all analyzed ROIs.

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(Received 07.07.2020, revision accepted 20.08.2020)

News in Thermology

Global initiative to improve infra-red based body temperature measurements

Graham Machin[1], Xiaofeng Lu[2], Dolores del Campo[3], Maria-Jose Martin[3], Igor Pusnik[4], Wang Li[5]

1 National Physical Laboratory, UK, 2 National Institute of Metrology, China; 3 Centro Espanol de Metrologia, Spain
4 University of Ljubljana, Slovenia; 5 NMC, A-Star, Singapore

The Covid-19 pandemic has brought into the spotlight how unreliable body temperature measurement can be in health services and more generally around the world. The authors of this letter want to introduce to the readers a global initiative, whose objective is to improve body temperature measurement, primarily by infra-red methods, on a global basis.

The initiative is led from the Consultative Committee of Thermometry (CCT). The CCT is a Consultative Committee of the International Committee of Weights and Measures (CIPM), which is ultimately responsible for the realisation and dissemination of the International System of Units (SI) on a global basis. As such the CCT is made up of leading temperature metrologists from around the world.

The CCT has established a Task Group for Body Temperature Measurement (TG BTM) whose objective is to establish reliable clinical thermometry on a global basis and whose initial focus will be to improve infra-red methods of body temperature measurement (ear, forehead, thermal imaging). The inaugural chair of the TG will be Professor Graham Machin, NPL.

The task group will aim to achieve this objective through the following five actions:

- Lead a global comparison of calibrators for infra-red body temperature thermometers (ear/forehead/thermal imagers)
- Collect current best practice/standards of body temperature thermal imaging in a) health services b) airport and other screening situations around the world, and develop best practice recommendations
- Collect current best practice of infra-red body temperature measurement (ear, forehead), and develop best practice recommendations
- Review standards and work with appropriate standardisation bodies (e.g. ISO/IEC) concerned with producing standards for body temperature measurement devices
- Establish metrology, medical and manufacturer forums within the metrology regions to identify the problems with the current approaches to body temperature measurement and develop practical solutions and establish appropriate links to the World Health Organisation

A paper is being prepared giving more details of the work of the TG BTM which we plan to submit for publication before the end of September.

2020

12th - 13th September 2020

The 2020 Medical Thermal Imaging Scientific Session will be offered in a virtual format on September 12th and 13th. The Physicians Interpretation Course will be performed via live stream on September 11th.

CME for 2020 will not be offered.

Details regarding access to the Virtual Scientific Session and the Live Streaming Physician's Interpretation Course will be Emailed to you after registration and prior to the event.

For registration fees and deadlines please contact: https://annualmeeting.aathermology.org/product/annual-session-tickets

2020 Conference Schedule

Day 1

Pre-Meeting Physician Member Interpretation Course (separate registration required): Friday, September 11th, 2020

8:30 am - 4:00 pm

Take the next step toward AAT Membership status elevation! Take an AAT Member Certification Course. This course is held the day before AAT's Annual Scientific Session and upon request for groups of three or more. Read more about the session
here.

Where

Live Streamed

Day 2

General Sessions: Saturday, September 12th, 2020

8:00 am Registration

IR Temperature Measurement For Fever Screening

8:15 am Welcoming Remarks by Robert Schwartz, MD AAT COB, Greenville, SC

8:30 am IR Temperature Measurement For Coronavirus In Brazil by Marcos Brioschi, MD, PhD Sao Paulo, Brazil

9:15 am Infrared Screening of Upper Respiratory Infections In China by Cunlin Wang MD, PhD San Francisco, CA

9:45 am AAT Best Use Practices for Temperature Screening Using Hand Held IR Devices By Robert Schwartz, MD AAT COB, Greenville, SC

10:00 -1:30 am Break

Neuro-Musculoskeletal Thermology

10:30 am Thermology Validation: Neuro-Musculoskeletal Applications by Tashof Bernton, MD President AAT, Denver, CO

10:45am Using Medical Thermography to Build a PM&R Practice by Matthew Terzella, MD AAT Board, Greenville, SC

11:00 am What I Learned About CRPS/RSD From Medical Thermology by George Schakaraschwili, MD AAT Board, Denver, CO

11:15 am PM&R Resident Medical Thermology Presentations by Temple University Hospital | Temple Health Philadelphia, PA

11:35 am Virtual Exhibit Hall

12:00-1.00 pm Lunch

Clinicians Corner: Breast Thermography

1:00 pm Trends In Breast Thermography Interpretive Services by Christine Horner, MD AAT Board, San Diego, CA

1:20 pm Applications of Breast Thermography in Holistic Breast Health Treatment by Robert Kane, DC San Francisco, CA

1:40 pm A Novel Monitoring & Treatment Protocol for Breast Intervention by Phillip Bretz, MD La Quinta, California

3:10 - 3:40 pm Break

Medical Thermology Presentations

3:40 pm Veterinary Thermal Imaging by John Godbold, Jr., DVM Jackson, TN

4:00 pm Veterinary Thermography: Small Animal Cases by Ronald Riegel, DVM Marysville, OH

4:20 pm Future Developments In Medical Thermology by James Campbell, MD AAT Board, Clemmons, NC

4:40 pm Intraoperative Hypothermia in Laparoscopic Surgery and Effect of New Air Conditioning System by Hisashi Usuki, MD Surgical Center of Kagawa University Hospital, Japan

5:00 pm Saturday Session Ends

5:30 pm Virtual Meet and Mingle Reception

Day 3

General Sessions and Annual Business Meeting: Sunday, September 13th, 2020

Special Session: Innovations In The Delivery of Thermographic Services

8:00 am Outreach Marketing of Thermography Services by Natahlie Yahle, DC Dayton, OH

8:20 am New Collaborations, New Approaches by Robert Schwartz, MD AAT COB, Greenville, SC

8:40 am Regenerative Esthetics and Thermal Imaging by Matthew Terzella, MD AAT Board, Greenville, SC

9:00 am Artificial Intelligence (AI) In Healthcare: Opportunities and Challenges by Alex Tokman M.S., B.S. AAT Board of Directors, Seattle, WA

9:40 am How The AAT Thermology Guidelines Create Distinction Between Breast Thermography & Thermology by Jan Crawford, RN, BSN AAT Board, Scaly Mt, NC

10:00 am AAT Annual Business Meeting (Open to all Attendees)

11:00 am General Session Ends

11:00 am Board of Directors Meeting (Board Members Only)

IMPORTANT !
CHANGE OF DATE AND ORGANISATION

Due to the COVID pandemia, the International Consensus and Guidelines on Medical Thermology (2020 ICGMT) in Curitiba, Brazil, scheduled for 17th - 19th September 2020, was postponed to

16th-20th November 2020

and the combined conferences

I South Brazilian Congress of Intervention in Pain

International Consensus and Guidelines in Medical Thermology 2020

II Paranaense Meeting of Pain Leagues

will take place entirely **ONLINE**!

Further information are available at https://abraterm.com.br/2020/

19th -20th November 2020
International Congress on Application of Infrared Thermography in Sport Science in Valencia

The Reseach Group in Sport Biomechanics (GIBD), research group of the Faculty of Physical Activity and Sports Science of the University of Valencia are delighted to invite you to the **I International Congress on Application of Infrared Thermography in Sport Science** scheduled to take place in Valencia, Spain at 19-20 November 2020. In our debut congress, we intend to carry out a meeting for researchers, students and every professional interested in explore the applicability of this technique in the sport field.

Important message from the organising committe chairman

Dear colleagues,

COVID-19 is significantly affecting the health and well-being of citizens in a global way. Therefore, we hope that you are facing this situation with the least possible inconvenience.

One of the minor effects of the current health threat is on the organization of different events. In this sense, the congress has the intention of being a face-to-face congress, but it has been prepared to be carried out in the planned dates no matter what happens with an online platform. In case it cannot be done in person, it will be done completely online.

If you have already processed your registration and want to buy a flight to attend, take into account the airline fares, the possible restrictions on travel that are in force in the European Union and remember to follow the instructions of the local Health Authorities.

We hope that this situation is resolved as soon as possible and do not hesitate to contact us if you have any questions or concerns.

Warm greeting,

Jose Ignacio Priego Quesada
President of the Organizing Committee.

COVID and modalities registration FAQ

- I International Congress on Application of Infrared Thermography in Sport Science is a face-to-face congress that allows online attendance.
- "Congress in any case will take place. If for COVID reasons, it cannot be done in face-to-face modality, it will be completely online, and both invited speakers and authors of oral communications will make their presentations online
- "What if I have paid a face-to-face registration and when the time for the congress arrives there is a lockdown, I am not allowed to travel, etc.? The organization will allow changing the type of inscription from face-to-face to online, and the economic difference between both inscriptions will be returned due to COVID or health reasons. For any other change, cancellation policies will be applied.

- Participants with oral communication is recommended to do the presentation face-to-face in Valencia. However, if in the period of the congress, they had problems in their origin location to travel to Valencia due to COVID reasons, the organization will allow them to carry out their oral communication in an online modality. It is the responsibility of the participants to know if they are able to travel from their location until Valencia and participants must know if any restrictions of traveling apply.
- The online modality will allow: to attend and submit questions to the invited speakers' presentations and oral communications, visualize posters communications and to contact the corresponding author, and to vote the best oral and poster communications. Also, online attenders could visualize for one month after finishing the congress the invited speakers, oral communications, and posters.
- Online attenders could submit communications for an e-posters modality.

Registration

Face-to-face modality

	Regular (deadline: 31/08)	Advanced
Students of the University of Valencia	75 €	100 €
Students	110 €	135 €
Professionals of the University of Valencia and collaborating organizations	145 €	170 €
Professionals	190 €	215 €

The registration face-to-face includes:

- Official documentation of the Congress
- Congress attendance
- After the congress, one month of access to the online platform to visualize oral and poster communications
- Welcome cocktail and coffee break
- Submission and presentation of works
- Attendance certificate
- A certificate presentation for each presented work in which all authors will be listed

Online modality (limited registrations)

	Regular (deadline: 31/08)	Advanced
Students of the University of Valencia	60 €	80 €
Students	75 €	95 €
Professionals of the University of Valencia and collaborating organizations	90 €	110 €
Professionals	110 €	130 €

The online registration includes:

- Online congress attendance
- After the congress, one month of access to the online platform to visualize oral and poster communications
- Submission and presentation of e-poster
- Attendance digital certificate
- A digital certificate for each e-poster accepted in which all authors will be listed

Cancellation Policy

Cancellation requests must be sent in writing to the email thermography@cevents.es

Cancellation requests received before 19th September will be entitled to the refund of the amount paid, minus 20% for administrative management.

Cancellation requests received before 19th October will be entitled to the refund of the amount paid, minus 40% for administrative expenses.

Subsequent cancellation requests will not be entitled to a refund.

To contact with the organization of the congress:

cevents

Technical secretariat: thermography@cevents.es
Phone: +34 960914545, www.cevents.es

Office Hours: Monday to Thursday: from 9 a.m. to 6 p.m.
Friday: from 8 a.m. to 3 p.

Programme

19th November. 2020

16:00-18:00. Workshops perfomed by companies

18:00-18:30. Opening ceremony

18:30-19:30. Opening lecture:
Prof. George Havenith (University of Loughborough, UK): Infrared thermography for mapping skin temperature profiles for thermophysiological research and evidence based clothing design.

19:30-20:30. Welcome cocktail.

20th November 2020

8:30 - 9:00 Registration

9:00 - 10:00
Application of Infrared thermography on sports field

9:00 - 9:30 **Invited lecture:** Prof. Jose I. Priego-Quesada (University of Valencia, Spain): Assessment of skin temperature to control physiological stress

9:30 - 9:40 Ismael Fernandez-Cuevas et al. (Universidad Politecnica de Madrid, Spain): Correlation between external (GPS) and internal load (Infrared Thermography) in professional soccer players

9:40 - 9:50 Marcio Tannure et al. (Clube de Regatas do Flamengo, Brasil): Injuries identification under different load control models: a case of the Clube de Regatas do Flamengo Youth Football Team

9:50 - 10:00 Questions

10:00 - 11:00 **Infrared thermography and Sport Medicine**

10:00 - 10:30 **Invited lecture:** Prof. Manuel Sillero (Universidad Politecnica de Madrid, Spain): Present and future of thermography as an injury prevention tool.

10:30 - 10:40 Alejandro Del Estal Martínez et al. (Universidad Politecnica de Madrid, Spain): Thermal and girth assessment after total knee replacement.

10:40 - 10:50 Barlo Hilen et al. (Johannes Gutenberg University, Germany): Infrared thermography in exercise testing: Comparison between cystic fibrosis patients, trained and untrained

10:50 - 11:00 Ismael Fernandez-Cuevas et al. (Universidad Politecnica de Madrid, Spain): Thermal profile description of most common soccer injuries by Infrared Thermography: case studies

11:00 - 11:10 Questions

11:10 - 12:00 Coffee break and posters session

12:00 - 13:00 **Infrared thermography and sport garments/equipment**

12:00 - 12:30 **Invited lecture:** Prof. Inmaculada Aparicio (University of Valencia and AITEX, Spain): Use of infrared thermography for the evaluation of textiles and sports accesories

12:30 - 12:40 Saray Ricote López et al. (Inescop, Spain): Influence of waterproofing level on thermal comfort of men's trekking footwear.

12:40 - 12:50 Irene Jiménez-Pérez et al. (University of Valencia, Spain): Relationship between plantar pressure and temperature of the sole of the foot or the footwear outsole

12:50 - 13:00 Questions

13:00 - 16:00 Lunch

16:00 - 17:00 **Infrared thermography and sports thermoregulation**

16:00 - 16:30 **Invited lecture**: Prof. Maria Soroko (Wroclaw University, Poland): Application of infrared thermography in equestrian sport

16:30 - 16:40 Marina Gil-Calvo et al. (University of Valencia, Spain): Skin temperature is not related to front crawl performance in young swimmers.

16:40 - 16:50 Robert Sanchis-Sanchis et al. (University of Valencia, Spain): Skin temperature asymmetries in archery

16:50 - 17:00 Questions

17:00 - 18:00 **New methodologies**

17:00 - 17:30 Invited lecture: Prof. Damiano Formenti (Università Degli Studi Dell'Insubria, Italy): Thermal images analysis: procedures and new perspectives

17:30 - 17:40 Daniel Andrés López et al. (Johannes Gutenberg University, Germany): Deep learning based segmentation of uncovered body parts in thermal images during dynamic exercise

17:40-17:50 Lara Requena-Bueno et al. (University of Valencia, Spain): Comparison of thermoHuman automatic software and manual analysis for assessing foot temperature

17:50-18:00 Mireia Muñoz-Alcamí et al. (University of Valencia, Spain): Effect of strength fatiguing exercise on skin temperature response after a cold stress test: preliminary study

18:00 - 18:10 Questions

18:10 - 18:30 Closing ceremony

Posters session

Title: Coplanar arrangement of shortwave diathermy is the most efficient in skin temperature change
Authors: Benincá, Inaihá; De Estéfani, Daniela; De Avelar, Núbia; Haupenthal, Daniela; Silveira, Paulo; Haupenthal, Alessandro
Affiliation: Federal University of Santa Catarina ; Federal University of Santa Catarina; Federal University of Santa Catarina; The Universidade do Extremo Sul Catarinense; The Universidade do Extremo Sul Catarinense; Federal University of Santa Catarina

Title: Effects of 24-h use of compression stockings with menthol and camphor on skin temperature following running
Authors: Kunzler, Marcos Roberto; Carvalho, Jean da Silva; Priego-Quesada, Jose Ignacio; Aparicio, Inmaculada; Pérez-Soriano, Pedro; Machado, Álvaro Sosa; Carpes, Felipe Pivetta
Affiliation: Applied Neuromechanics Research Group, Laboratory of Neuromechanics, Federal University of Pampa, Uruguaiana, Brazil; Research Group in Sports Biomechanics (GIBD), Department of Physical Education and Sports University of Valencia, Valencia, Spain.; Biophysics and Medical Physics Group, Department of Physiology, University of Valencia, Valencia, Spain; AITEX (Textil Research Institute), Alcoy, Spain.

Title: Effects of a single session of high intensity continuous exercise on skin temperature at different times of day
Authors: Kunzler, Marcos Roberto; Pereira, Matheus Dotto; Azevedo, Renato Ribeiro; Machado, Álvaro Sosa; Da Silva, William; Carpes, Felipe Pivetta
Affiliation: Applied Neuromechanics Research Group, Laboratory of Neuromechanics, Federal University of Pampa, Uruguaiana, Brazil

Title: Infrared thermography applied to professional athletes of pelota valenciana.
Authors: Tejero Pastor, Robert ; Calzadillas Valles, María del Carmen; Salvador Palmer, Rosario; Cibrían Ortiz de Anda, Rosa; Priego Quesada, Jose Ignacio
Affiliation: Research Group in Sports Biomechanics (GIBD), Department of Physical Education and Sports; Research Group in Medical Physics (GIFIME), Department of Physiology, Universitat de València, Valencia, Spain

Title: Skin temperature measurement in people with spinal cord injury during exercise: systematic review.
Authors: Sánchez-Jiménez, Jose Luis ; Romero-Ávila, Jose Luis; Aparicio-Aparicio, Inmaculada; Priego-Quesada, Jose Ignacio
Affiliation: Research Group in Sports Biomechanics, Universitat de València, Valencia, Spain; Department of Physiotherapy, Universitat de València, Valencia, Spain; AITEX (Textil Research Institute), Alcoy, Spain

Title: Thermovision assessment of surface temperatures changes following the cryostimulation in football players
Authors: Lubkowska, Anna; Klejdysz, Robert
Affiliation: Chair and Department of Functional Diagnostics and Physical Medicine, Faculty of Health Sciences, Pomeranian Medical University in Szczecin, Szczecin, Poland

Title: The effect of sweat after running on skin temperature: infrared thermography vs thermal contact sensors
Authors: Machado, Álvaro ; Gil-Calvo, Marina; Jimenez-Perez, Irene; Cibrián Ortiz de Anda, Rosa Maria; Salvador Palmer, Rosario; Pérez-Soriano, Pedro; Priego-Quesada, Jose Ignacio
Affiliation: Applied Neuromechanics Group, Laboratory of Neuromechanics, Federal University of Pampa, Uruguaiana, Brazil; Research group in sports biomechanics (GIBD), Department of physical education and sports, Universitat de València, Valencia, Spain; Research Group in Medical Physics (GIFIME), Department of Physiology, Universitat de València, Valencia, Spain.

Title: The clinical evaluation of an accidental injury of skin in Athletes
Authors: Kolosovas-Machuca, Eleazar Samuel; Martínez-Jiménez, Mario Aurelio; Ramirez-GarcíaLuna, José Luis; Arriaga-Caballero , Jesús Emmanuel
Affiliation: Coordinación para la Innovación y Aplicación de la Ciencia y la Tecnología, Universidad Autónoma San Luis Potosí San Luis Potosí, SLP, México; Doctorado Institucional en Ingeniería y Ciencia de Materiales (DICIM-UASLP), Universidad Autónoma de San Luis Potosí, San Luis Potosí, SLP, Mexico; Division of Experimental Surgery, Faculty of Medicine, McGill University. Montreal, QC, Canada; Gabinete de termografía potosina

Title: Wellness perception in young high-performance rugby players correlates with thermal physiological response after training
Authors: Del Estal Martinez, Alejandro ; Correa Wirgues, Amanda; Fernández, Ana; Torralba-Estellés, Javier
Affiliation: INEF- UPM Thermography laboratory, Sports Science Faculty, Technical University of Madrid (Spain); EEFE-USP, School of Physical Education and Sport, São Paulo University (Brazil); Medicine & Health Sciences Faculty, Catholic University of Valencia (Spain); Medicine & Health Sciences Faculty, Catholic University of Valencia (Spain)

Title: Effect of a high-intensity interval training session on the skin temperature of the thigh.
Authors: Pinheiro, Ramon ; Uchoa, Paulo; Borba Neves, Eduardo; Scipião, Lino; Cavalcante, Jurandir; Vilaça-Alves, José; Pinheiro, Bruno
Affiliation: University Center UNIFAMETRO, Fortaleza, Brazil; Brazilian Army Sports Commission, Rio de Janeiro, Brazil; Research Center in Sports, Health and Human Development, Vila Real, Portugal.

Title: Low-Cost Infrared Thermography to Evaluate Rectus Abdominis Muscle Activation After Exercise
Authors: Omar, Trejo-Chavez; Irving A., Cruz-Albarran; Luis A., Morales-Hernandez
Affiliation: Mechatronics Laboratory, Autonomous University of Queretaro, Santiago de Queretaro, Queretaro, Mexico

Title: Pain as a mediator of thermal response to plyometric training on ankle strain rehabilitation: case study
Authors: Escamilla Galindo, Víctor ; Del Estal Martínez, Alejandro; Fernández Cuevas, Ismael
Affiliation: Sports Department, Faculty of Sciences for Physical Activity and Sport (INEF), Universidad Politecnica.

Title: Infrared thermography during graded exercise testing in patients with cystic fibrosis, including two retests
Authors: Hillen, Barlo; Pfirrmann, Daniel; Etzel, Jakob; Poplawska, Krystyna; Simon, Perikles
Affiliation: Institute of Sports Science, Department of Sports Medicine, Prevention and Rehabilitation, Johannes Gutenberg University, Mainz, GER; Medical Department of Pediatrics Pulmonology Allergology and Cystic Fibrosis, University Medical Centre, Mainz, GER

12th - 13th December 2020

4th Asian Congress of Thermology and 40th Korean Society of Thermology

Venue: National Health Insurance Service Ilsan Hospital

Further Information:

Ho Yeol Zhang, M.D., Ph.D.

Department of Neurosurgery, National Health Insurance Service ILSAN Hospital
Clinical Professor, Yonsei University College of Medicine
President, Korean Society of Thermology
Director, Data Center for Korean Body Temperature, Republic of Korea

Email: hyzhang@nhimc.or.kr

CALL FOR ABSTRACTS

WROCŁAW UNIVERSITY
OF ENVIRONMENTAL
AND LIFE SCIENCES

XV Congress of the European Association of Thermology

1st – 4th September 2021

Faculty of Biology and Animal Science

Wrocław University of Environmental and Life Sciences

Wrocław, Poland

XV Congress of the European
Association of Thermology

Wrocław • POLAND 2021

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Making Life Better

www.eurothermology.org/XVCongress.html

The EAT and Wrocław University of Environmental and Life Sciences are delighted to invite you to participate in the XV EAT Congress in Wrocław, Poland from 1st to 4th September 2021.

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

Following on from the most recent meetings in Porto (2012), Madrid (2015) and London (2018) the Congress heads to eastern Europe for 2021 to Wrocław in Poland.

The Organising Committee looks forward to welcoming you to Wrocław University of Environmental and Life Sciences in the summer of 2021.

Dr. Kevin Howell
EAT President

VENUE.

Wroclaw lies on the banks of the River Oder in western Poland, and is the capital of the Lower Silesian Vovoideship. It was the European Capital of Culture in 2016, and won the "European Best Destination" title in 2018.

Our venue will be the Faculty of Biology and Animal Science at the prestigious University of Environmental and Life Sciences on Chelmonskiego Street in the eastern suburbs of Wrocław. The Faculty building boasts excellent conference facilities including a large lecture theatre, ample lobby space for networking and poster presentations, and a spacious restaurant for lunch breaks. This is the perfect environment for delegates to present their thermological research at Europe's flagship biomedical temperature congress.

XV Congress of the European Association of Thermology
Wrocław · POLAND 2021

XV EAT CONGRESS, 1st – 4th September 2021, Wrocław

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Ricardo Vardasca (POR)
Ho Yeol Zhang (KOR)

KEY DATES.

Abstract submission will open online on 31st August 2020, and authors will be notified of acceptance for oral or poster presentation by 1st March 2021.

31st August 2020. Opening of abstract submission and registration.
31st December 2020. Abstract submission deadline.
1st March 2021. Acceptance notification to authors.
3rd May 2021. End of Early Registration and deadline for registration of presenting authors

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REGISTRATION FEES (*)

	Early Registration (Until 03 MAY 2021)	Late Registration (After 03 MAY 2021)
EAT MEMBER	€250	€300
Non-Member	€300	€350
One-day registration	€100	€150
Student	€100	€150
Accompanying person	€50	€50

(*) Further information about the registration process is online at www.eurothermology.org/XVCongress.html
Registration includes access to all congress sessions, congress lunch and coffee breaks, the Gala Dinner, and other congress social programme events.

ACCOMMODATION

Recommended hotels:

1. **Hotel ZOO**

Address: ul. Wroblewskiego 7, 51-627 Wroclaw
website: http://zoo-hotel.pl/

2. **Radisson Blu Hotel Wroclaw*******

Address: ul. Purkyniego 10, 50-156 Wroclaw
website: https://www.radissonblu.com/pl/hotel-wroclaw

3. **Grape Hotel & Restaurant*******

Address: Parkowa 8, 51-616 Wroclaw
website: https://www.grapehotel.pl

4. **URO Wroclaw Old Town*****

Address: Pawla Wlodkowica 6, 50-072 Wroclaw
website: https://purohotel.pl/pl/wroclaw

5. **HOTEL EUROPEUM *****

Address: ul. Kazimierza Wielkiego 27A, 50-077 Wroclaw
website: https://europeum.pl

6. **Hotel Mercure Wroclaw Centrum******

Address: pl. Dominikański 1, 50-159, Wroclaw
website: https://www.accorhotels.com/pl/hotel-3374-hotel-mercure-wroclaw-centrum/index.shtml

ACCOMPANYING PERSONS

All accompanying persons will be invited to join the Congress Gala Dinner and full social programme upon payment of the appropriate €50 fee.

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KEY MEETING THEMES

- Infrared thermography in biomedicine.
- Temperature measurement in animal welfare, veterinary applications and equine physiology.
- Contact temperature measurement.
- Hardware and software solutions for infrared imaging.
- Biomedical applications: surgery, neurology, vascular and pain syndromes.
- Thermometry in exercise physiology, rehabilitation, and human performance research.
- Calibration and traceability in biomedical thermometry.

ABOUT WROCŁAW

Wrocław is also called "The Venice of the North" due to the fact that, after Amsterdam, Venice and St. Petersburg, it has the biggest number of bridges and footbridges in Europe.

Notable landmarks include the 10th century Cathedral, the Centennial Hall from 1913 (one of the UNESCO world heritage sites), and the distinctive architecture of the Town Hall and Market Square. Wrocław is also host to the Racławice Panorama, a 114m-long cycloramic painting from 1894, commemorating the 100th anniversary of the Battle of Racławice. In recent years Wrocław has also become well-known for its "little people" or "dwarves": small figurines scattered across the city streets which were first conceived as part of the city's anti-communist movement in 2005. These now number more than 350, and can be located with the help of a dedicated tourist map. Wrocław Zoo, close to our congress venue, is the oldest zoo in Poland, and the third largest zoological gardens in the world in terms of the number of species on display. In summertime, large numbers of visitors are attracted at night to Wrocław's "Multimedia Fountain" close to the Centennial Hall. This is one of the largest operating fountains in Europe, and stages dramatic light shows set to music. We will have the opportunity to visit this spectacle as part of the congress social programme.

TRAVEL

COPERNICUS AIRPORT WROCŁAW is about 10 km from the city centre, and connects Wrocław with Warsaw, Gdansk, and destinations throughout Europe. From the airport you can reach the city centre by a shuttle bus (journey time about 30 minutes), or by bus No. 106, which leaves every 15 minutes (journey time about 40 minutes) or by taxi. Wrocław's main rail station, WROCŁAW GŁÓWNY, connects the city to other major destinations across Poland and eastern Europe. Wrocław's central bus station is located at 1/11 ul. Sucha, adjacent to the main railway station, and connects the city by road to all major Polish and European destinations.

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Preliminary Schedule.

XV Congress of the European Association of Thermology, 1st – 4th September 2021, Wrocław University of Environmental and Life Sciences.

Time	Wednesday	Thursday	Friday	Saturday
8.30	Course Registration	Registration	Registration	Tour around Wrocław's Old Town and Ostrów Tumski 
9.00 - 10.30	Short Course on Medical Thermography	Morning session 1	Morning session 1	
10.30 - 11.00		Coffee break	Coffee break	
11.00 – 12.30		Morning session 2	Morning session 2	
12.30 – 13.00		Poster viewing 1	Poster viewing 2	
13.00 – 14.00		Lunch	Lunch	
14.00 – 15.30		Afternoon session 1	Afternoon session 1	
15.30- 16.15		Tea break	Tea break	
16.15 – 17.30		Afternoon session 2	Afternoon session 2	
17.30 – 18.30	Registration		EAT General Assembly	
18.30 – 20.00	Welcome Reception, Faculty of Biology and Animal Science			
19.00- 22.00		Gala Dinner at Summer Restaurant	Fountain show	

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European Association of Thermology

Short Course on Medical Thermography

Wednesday 1st September 2021, Wrocław University of Environmental and Life Sciences Wrocław, Poland

Following on from successful courses in Porto, Madrid and London, the next EAT Short Course on Medical Thermography will take place immediately prior to the EAT 2021 Congress in Wrocław, Poland. The course aims to deliver a thorough introduction over one full teaching day to basic thermal physiology and the principles of infrared thermography for human body surface temperature measurement. It will be taught by an experienced faculty of EAT clinicians, biomedical researchers and imaging scientists. Aspects of reliable thermogram capture will be demonstrated in a laboratory session, and students will have the opportunity to practice thermal image analysis in a supervised "hands-on" session.

Syllabus

- Physical principles of heat transfer
- Principles of thermal physiology/skin blood perfusion
- Standardisation of thermal imaging, recording and analysis
- Quality assurance for thermal imaging systems
- Producing a thermographic report
- Provocation tests
- Image analysis
- Hands-on supervised practice
- Educational resources

Registration

The course fee (inclusive of lunch and coffee breaks) is €200

Register from 1st January 2021: details online at www.eurothermology.org/education.html

Questions? Contact the EAT at eurothermology@gmail.com

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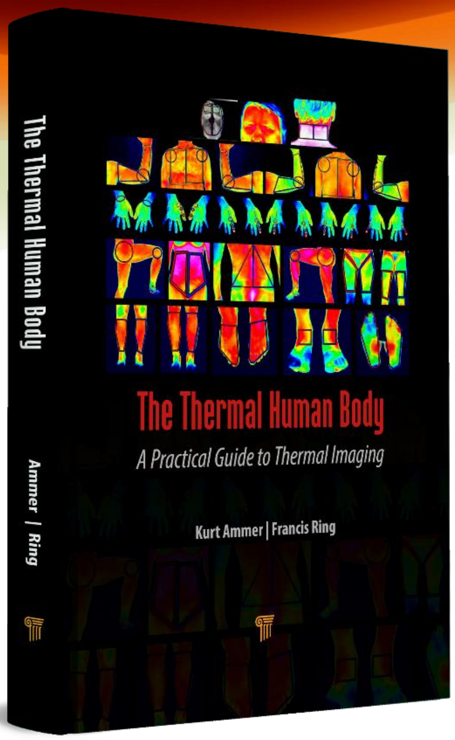
The Thermal Human Body

A Practical Guide to Thermal Imaging



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Key Features

- Combines the physics of heat transfer with thermal physiology to understand skin temperature distribution
- Provides a framework for standardized recording and analysis of medical thermal images
- Includes an atlas of body positions of proven reproducibility for infrared image capture
- Proposes regions of interests for reliable quantitative analysis

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by
Kurt Ammer & Francis Ring

Reviews

"There is no way to study thermal imaging and not learn from the writings of Francis Ring and Kurt Ammer. Pioneers of the application of infrared thermography in medicine, the authors unveil the direction for a sensible use of the method. Luck for us—students, professionals and enthusiasts—because we can be grateful to receive a differentiated material that shortens the learning path. No doubt a remarkable book."
- Prof. Danilo Gomes Moreira, Science and Technology of Minas Gerais, Brazil

"This book is set to become essential reading for anyone who wants to perform reliable thermal imaging of the human body, whether it be in medicine, clinical practice, sports science or research."
- Prof. Graham Machin, National Physical Laboratory, UK

"This book is a wonderful practical guide that takes the reader through all the main stages required and will be of special interest for those interested in entering the fascinating field of clinical thermal imaging."
- Prof. James B. Mercer, UiT—The Arctic University of Norway, Norway

Description

This book is a guide for the constantly growing community of the users of medical thermal imaging. It describes where and how an infrared equipment can be used in a strictly standardized way and how one can ultimately comprehensively report the findings. Due to their insight into the complex mechanisms behind the distribution of surface temperature, future users of medical thermal imaging should be able to provide careful, and cautious, interpretations of infrared thermograms, thus avoiding the pitfalls of the past. The authors are well-known pioneers of the technique of infrared imaging in medicine who have combined strict standard-based evaluation of medical thermal images with their expertise in clinical medicine and related fields of health management.