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Does the type of skin temperature distribution matter?

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Contents (INHALTSVERZEICHNIS)

Does the type of skin temperature distribution matter?

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Skin temperature is the result of heat transfer from deep tissues to the surface where the amount of heat exchange depends on the temperature of the environment. Heat flow occurs always along a temperature gradient as the heat energy expands from high to low temperature levels. The direction of heat transfer is only dependent on the location of different temperatures in the three dimensional space. Similar as in the body's temperature shell, the core temperature representing heat in inner organs is not the same in different deep tissues. Thus, small temperature gradients exist also within the temperature core and the shell, not only between core and shell temperature and between skin and environment. The existence of different temperature levels in the temperature shell was described by Aschoff in 1958 [1] and can nicely demonstrated by an infrared image showing isotherms (Figure 1).

However, it must be mentioned that the core zone in Aschoff´s diagram represents the temperature of deep body tissues and is not located on the surface.. Core temperature is a regulated quantity, varying in 24 hours by ±0.5° and deep body temperature is in living humans always higher than mean skin temperature. In the case that severe heat load cannot be equalised, the set-point shifts to a higher temperature level, thus maintaining in this way the temperature gradient between core and skin temperature.

The velocity of heat exchange is determined by the magnitude of the thermal gradient, the conductance of various tissues and the rate of convective heat transfer. At skin, neither in contact with other solid surface nor exposed to convection streams in the adjacent environment, heat is exchanged with the environment by radiation, which is mainly emitted from the area of superficial vascular beds located in the skin. Therefore, any variation in the area of vessels affects temperature readings based on infrared radiation.

In other words, skin temperature is not a random variable. It depends on both core and environmental temperature on one side, and on skin perfusion on the other side.

However, what is the type of distribution of skin temperature? The answer to this question is strongly related to the method of measuring skin temperature. Systematic studies of mapping skin temperature evolved in the beginning of the 20th century using mercury thermometers, thermistors or differential-thermometers. These previous investigations permitted only measurements in single points located in 5 to 20 anatomical regions. Even in the very ambitious trials aiming to investigate diurnal variations of skin temperature conducted by Foged 1932 in Danmark [2], the measurements were restricted to 2 x 11 contact thermometers which recorded simultaneously the temperature profiles in legs and arms. The study by Foged was one of the first showing that the temperature difference of corresponding anatomical regions is small. A difference equal or greater than 1°C were reported only in 3% of 5712 measurements.

Mean skin temperature was computed from measurements in various body sites. The number of proposed measure-

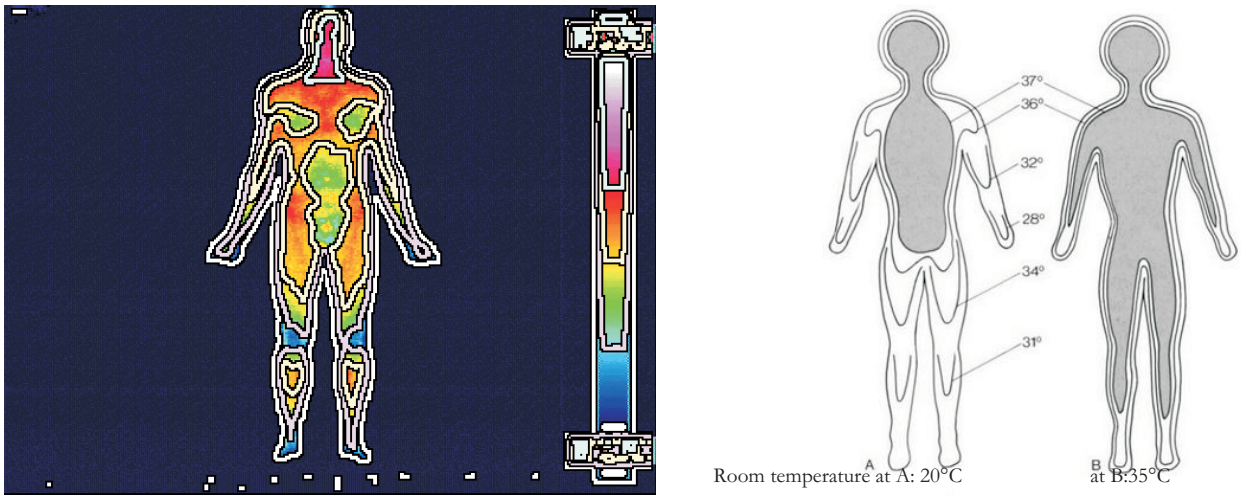
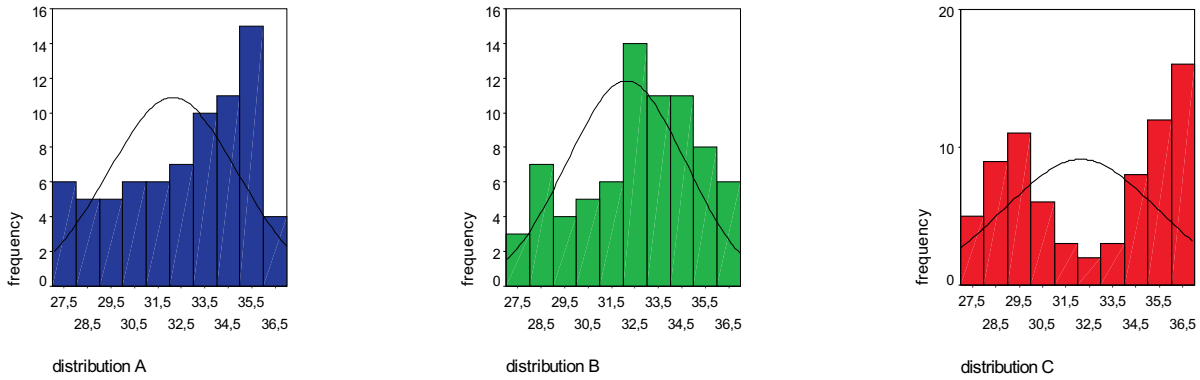


Figure 1
Comparison of isotherms in an infrared image of the total body in the anterior view with model of core and shell temperature proposed by Aschoff [1]

Figure 2
Simulated sets of temperature distribution
A: left skewed distribution
mean: 32.133 ± 2.743 median: 33
mode: 35 skewness: -0.486 ± 0.277
kurtosis:-0.979 ± 0.548

B: (approximately) normal distribution
mean:32.133 ± 2.522 median: 32
mode: 33 skewness: -0.404 ± 0.277
kurtosis:-0.718 ± 0.548

C: bimodal distribution
mean: 32.133 ± 3,273 median: 33
mode: 36 skewness: -0.179 ±0.277
kurtosis: -1.622 ± 0.548



ment sites varied between 3 and 15 [3].One of these formulas for estimation of mean skin temperature was included in the ISO Standard for mean skin temperature calculation based on thermistors [4]. A recent study investigated the distribution of skin temperature at the proposed measurement sites by thermal imaging, and found in all investigated location high homogeneity and normal distribution of skin temperature [5].

A modern infrared thermal image is generated by many pixels each representing a temperature value. The number of pixels within an image varies between 80 x 140 in cheap modern cameras, over 640 x 512 in older equipment, to 5 Mega in top modern infrared imagers. The number of pixels within an image varies between 80 x 140 in cheap modern cameras over 640 x 512 in older equip- ment to 5 Mega in top modern infrared imagers.

A rule in statistics says that, large numbers of random variables - especially in biology - approach a normal Gaussian distribution, which is characterised by the fact that all measures of central tendency (i.e. mean, median and mode) are equal in magnitude and location on the bell shaped curve.

The central limit theorem states that the means of random samples drawn from any population distribution with mean m and variance s^2 will have an approximately normal distribution with a mean equal to m and a variance equal to s^2/n Consequently, if skin temperatures taken from an area of 900 pixels follow a Gaussian distribution, mean skin temperature from a large region of interest of 12800 pixels or of the total body, sized 41320 pixels, should also be normally distributed.

But does this assumption reflect the truth? Applying the ISO formula for mean skin temperature by using small rectangular regions of interest in size of 900 pixels at the recommended sites in a set of thermal images from a healthy subject, it was found that estimated mean skin temperature overestimated the mean skin temperature measured in total body views [6], but total body median temperature was close to the estimated mean skin temperature.

The diagrams in figure 2, based on simulated temperature distributions, point to the problem of mean temperatures not derived from a normallly distributed set of data. All of these data sets show the same mean value, but only one is close to a Gaussian distribution (Kolomogorov-Smirnov Z for B: 1.261 2-tailed p=0.083). All data sets are left skewed with the mean lower than the median, and a longer or heavier tail on the left side of distribution curves. Example C shows a bimodal, very little left skewed distribution and a large deviation be-tween the mode (i.e., the most frequent observation) and the arithmetic mean.

Left skewed temperature distribution are common in thermal images recorded from humans.The histogram describing the temperature distribution of the anterior total body shown in Figure 1 proofs an asymmetric, left skewed distribution in a measurement areas of 30836 pixel (Figure 3). Another example is taken from the baseline image of the anterior thigh recorded in an exercising athlete. The histo-

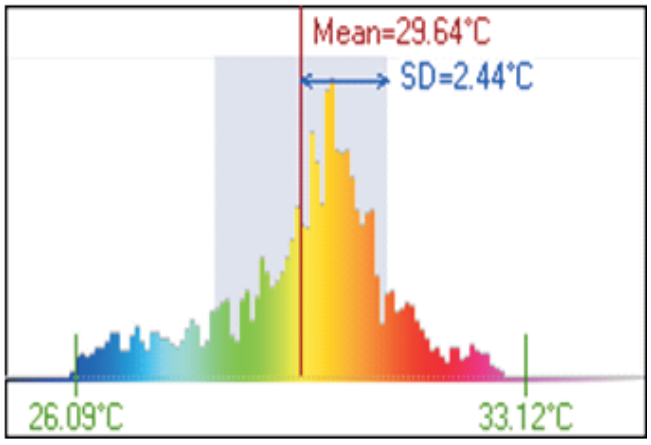


Figure 3
Histogram of the total anterior body view shown in figure 1

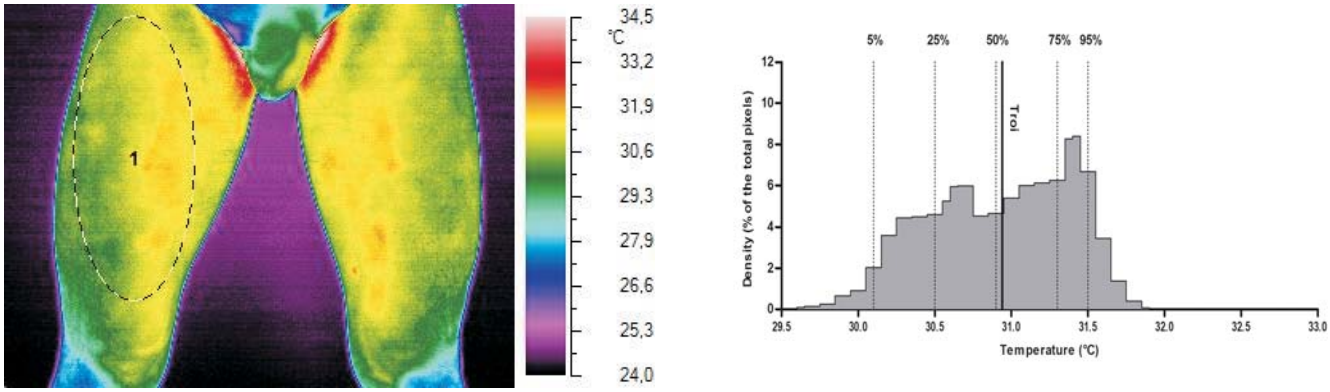


Figure 4
Thermal image and its corresponding skin temperature distribution within the region of interest on the right thigh of an athlete.

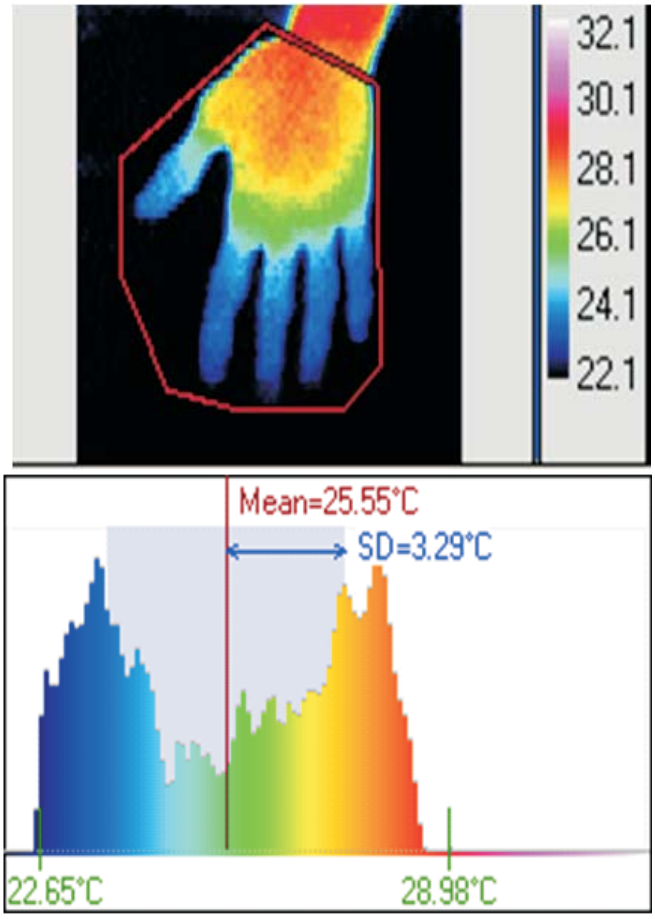


Figure 5
Bimodal distribution in a patient with Raynaud´s phenomenon

gram shows an asymmetric, left skewed distribution of temperature in a 6000 pixel sized area. (Figure 4)

But also bimodal distributions are not uncommon in thermal images. This type of distribution can be expected if large temperature gradients exist between similar sized areas of homogeneous temperture such as in the case of sponteneously developed cold fingers in Raynaud patients or immedeataly after pulling the hands out of a cold water bath (figure 5).

It is obvious that the type of temperature distribution has an impact on the statistical analysis and the selection of appropriate measures of central tendency and dispersion in the recorded dataset. The fact, that modern thermal imagers provide large number of temperature values, is not a guarantee that these temperature values are normaly distributed.

The use of histograms is strongly recommended to describe the temperature distribution in thermograms. Following changes of temperature over time with histograms is seldom applied in medicine and biology, although the problems of similar arithmetic means in different types of distribution can easily be solved. Köteles and Benkö have demonstrated the value of histograms in the assessment of radiation injuries [7]. The change in distribution occuring in a healthy subject between baseline and immedeatly after removing the hands from immersion in cold water is shown in figure 6.

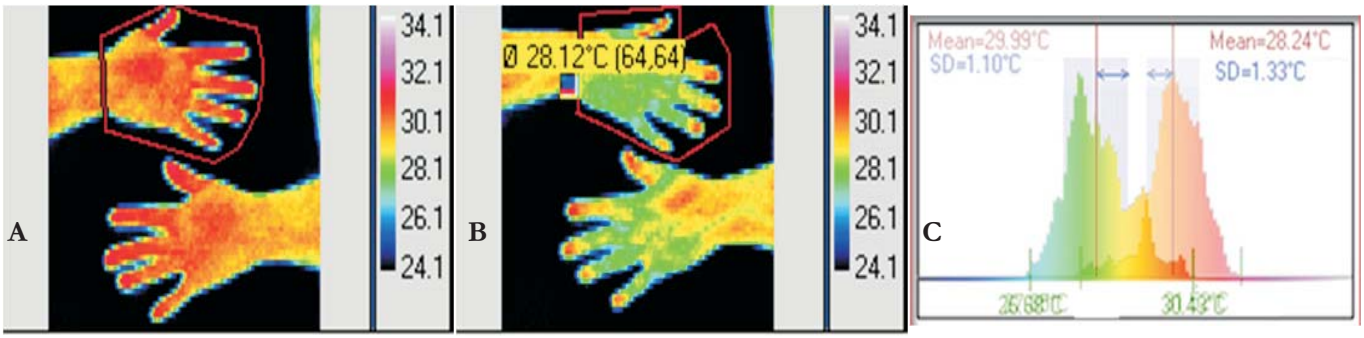


Figure 6
A: Hands prior to cold water immersion B:Immedeatly after pulling the hands out of cold water bath C: histograms of the right hand before and after immersion (mean temperature at baseline 29.99 ±1.0°C, post immersion: 28.24 ± 1.33)

Since the advantage of thermography lays in the fact that it provides a skin temperature map, skin temperature distribution within a region of interest should be considered before calculating any type of descriptive statistics. All available measures of location, statistical dispersion and distribution shape should be reported, especially when the data are intended to be used as reference values.Any analytical statistics should be calculated with non-parametric tests and all tests requiring a normal distribution should be avoided.

Disregard of selecting an appropriate model of data distribution will lead to false conclusions. Such procedures contribute to the poor reputation of thermal imaging in biomedicine and related health science. Thermographers should improve their knowledge and skills in statistical analysis to overcome the shortcomings in evaluation of thermographic data.

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Excellent agreement between standard method and thermographic evaluation of the tuberculin skin test

Review of the paper by Fiz JA, Lozano M, Monte-Moreno E, Gonzalez-Martinez A, Faundez-Zanuy M, Becker C, Pons-Rodriguez L, Manzano JR. "**Tuberculine reaction measured by infrared thermography**". Computer Methods and Programs in Biomedicine 2015, 122(2) 199-206.

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Summary

The article presents a methodology for assessing the tuberculin immune response through the tuberculin skin test (TST) monitored with IR thermal imaging. The authors claim to demonstrate that through a computer program, using advanced image-processing techniques, hot areas in thermal images indicating the tuberculin reaction, facilitating a faster assessment of the TST.

For the images capture a standard protocol was used for subjects and room preparation, but no mention is given to the equipment preparation. The thermal camera used was a Fluke TiR32, array size of 320x240, NETD < 50mK at 30°C and accuracy of ±2% of the overall temperature reading. The distance used and field of view is in line with the guidelines, images were taken from the forearm, having a coin in the scene for size reference. All images were acquired using the Fluke smartview software, storing the image in a .jpg image and the temperature values were transferred to a text file. All the subsequent image processing is made using the software package Matlab 2014b. In order to uniform the image temperatures, the authors have normalized them using a formula, which consisted of the recorded value minus the minimal temperature recorded within the image divided by the difference between the maximum and minimum temperature recorded.

All images of the forearm were normalised using image-processing techniques such as canny edge detector and Hough transform into an elliptical region of interest in an iterative manner. During the normalization process the pixels with the mean temperature normalized value were also classified through the intensity transformation (white expansion) of a centred 5x5 window in region1, Purified Protein Derivative (PPD) reaction area; region2, erythema; and background (region 3).

Results showed that in a sample of 34 subjects (12 males and 22 females), the thermal images had identified all 20 positive TST (papule > 5mm) and the remaining 14 were negative in both the standard and the thermographic evaluation. From the 20 positive TST, only 6 had tuberculosis disease demonstrated by other methods (sputum culture and thorax radiographs). The particularities found in IR images of TST positives were a most central geometric area, with elliptical irregular contours when compared with TST negatives. Significant differences in mean temperature between both groups for region 1 and region3, region 2 and region 3, and region 1 and region 2 plus 3 were found. The diameter of the tuberculin reaction area assessed with standard method or with thermal immaging did not differ significantly (14.35 ± 7.39 mm versus 16.52 ± 6.52) In TST positive patients, no differences in IR temperatures of region 1 were detected between subjects with and without tuberculosis disease.

Comment

This paper is the first known approach to objectify with IR imaging the current subjective measurement of skin induration by palpation caused by the tuberculin reaction. Although an excellent agreement between the standard method and the thermographic evaluation was observed, the TST had a high rate of false positive results. The low specificity of TST does not recommend its use for diagnosing of tuberculosis.

In my view this could be a good application, but I have doubts with the proposed methodology. The images have been processed with canny edge detection and Hough transformation. This process is relatively slow and generates pixel errors which can affect the temperature readings [1].

The normalisation procedure based on the grey value representing pixel temperature minus minimum temperature in relationship to the total temperature range within the image, could have been avoided if the recording temperature range intervals were set and kept statically, using the same temperature window.

A larger sample with images taken using a static temperature interval and having a second confirmatory method is recommended. In order to standardize the size, the simplest approach is to have a capture mask as the CTHERM software package had, and use automatic isotherms to delineate the thermally affected area. The external masks

would help to facilitate to position and distance of the arms in the image, warping techniques can standardise the view using anatomical control points, it would emphasize the validity of using the concept of hot areas in the identification of patterns in the lesion caused by the reaction to the TST test..

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A Systematic(?) Review of Infrared Thermography in Plastic Surgery

Review of the paper by John HJ, Niumsawatt V, Rozen WM, Whitaker IS "**Clinical applications of dynamic infrared thermography in plastic surgery: a systematic review".** Gland Surg 2016;5(2):122-132

Aderito Seixas

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Summary

Background

The qualities of infrared thermography (IRT) and the advances in infrared camera technology have been increasingly recognized in recent years and so has the number of studies reporting its application in many fields of surgery. Dynamic infrared thermography (DIRT), allowing to monitor the thermal recovery process is of particular interest. Therefore, authors form UK and Australia have conducted a systematic review of the clinical applications of IRT in plastic surgery.

Methods

The authors have conducted a review of all articles published until June 2012 in the electronic databases Medline, Ovid Old Medline, EMBASE and Cochrane Collaboration with the search terms "thermography" and/or "infrared" and/or "DIRT" occurring in the text and abstract of the articles. The authors included English written prospective and retrospective studies, including case reports, cohort studies, randomized control trials and clinical and laboratorial studies with human participants, cadavers and animals that underwent DIRT and computer software analysis. Studies not using IRT and studies assessing the usefulness of IRT in breast cancer diagnosis were excluded. The references of retrieved articles were also screened for additional relevant citations. Subgroup analysis were performed focusing on the use of DIRT to: 1) assess perforators in planning for flap reconstruction and wound closure; 2) monitor flaps post-operatively; 3) assess burn wound depth; 4) diagnose carpal tunnel syndrome (CTS) and 5) other uses in plastic surgery. Potential papers were examined by two reviewers to assess the adherence to selection criteria and the full text of included studies was critically assessed. Data regarding author, publication year, type of study, type of participants, study location, sample size, study aim, type of camera, type of analytical software and results was extracted. Studies were grouped by clinical application type and analysed and the quality of each paper was assessed based on the Oxford Centre for Evidence Based Medicine Levels of Evidence (OCEBM).

Results

The authors identified 147 studies in the databases and after eliminating duplicates and title and abstract reading 34 articles were chosen for full text analysis in relation to eligibility criteria and 5 more studies were excluded. A total of 29 articles were included in the review, 9 on the assessment of perforators in planning for flap reconstruction and wound closure, 5 on the monitoring of flaps post-operatively, 6 on the assessment of burn wound depth, 5 on the diagnosis of CTS.

Conclusions

The authors support the use of DIRT to identify perforators when planning flap reconstruction, intraoperatively to assess perfusion and post operatively for flap monitoring, however, consider that the use of DIRT for burn depth analysis and for the diagnose of CTS is not supported by current literature.

Comment

We read with great interest the work of John et al. [1] as systematic reviews are the opposite of narrative reviews and are, for most evidence hierarchies, the best possible evidence. There are key features of a systematic review: clearly defined objectives, eligibility criteria for studies, clear and reproducible methodology, a systematic literature search attempting to identify all literature meeting the eligibility criteria, an assessment of the validity of selected studies (e.g. through risk of bias assessment) and a systematic presentation and synthesis of the included studies. When reporting research, authors should follow existing guidelines and/or checklists for their research design, such as Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) [2], to improve the reliability and rigor of the reports. The PRISMA checklist has 27 items that can guide both authors and readers on the process of reporting/reading each step of the review.

Although the authors have included relevant data sources, they have clearly missed the PRISMA recommendations since several items are missing in the report. For instance, the abstract has not provided enough information, lacking the data sources, eligibility criteria, study appraisal and synthesis methods; the review question is not concise; no reference is made to a review protocol; the search strategy that was reported does not allow replication as it is not possible to understand how the search terms were combined and the eligibility criteria are not clearly stated and are some-

times contradictory as the authors state that clinical and laboratorial studies are included but in the flow diagram we can see that some studies were excluded because they were non-clinical. Another important issue is that the authors were committed to systematically review clinical applications of DIRT but several studies were included that were not using DIRT as assessment.

The time gap between the literature search and publication is also an issue, as the systematic review of the literature was published in 2016 (submitted in September, 2015) but only included articles published up till June 2012. The authors missed several papers that could be included in the analysis [e.g. 3-6] and if we consider not just DIRT as the assessment, even more studies could have been cited.

The assessment of the risk of bias in individual studies and across studies was not performed and summary measures (e.g. risk ratios, differences in means) were not provided in the review. The assessment of the quality of each study was based on the 2011 OCEBM Levels of Evidence for diagnostic or monitoring tests, however, the Levels do not provide a definite judgement about the quality of the evidence [7]. It would be advisable to use QUADAS-2 [8] to assess the quality of that type of research. Even the classification of some studies with the OCEBM Levels is inaccurate [e.g. 9, 10]. The classification of Tenorio et al. is debatable, as the position of animal studies in the hierarchy of evidence is near the bottom but is classified with a 2 in the review, and the other [9] is classified as level 2 but the study does not use a reference standard, meaning that the classification is inaccurate.

It could also be questioned whether diagnosis of carpal tunnel syndrome is a task of plastic surgery because none of the included studies reported DIRT as outcome measure after surgical release of the entrapped median nerve. The same applies to a minor amount to the assessment of wound depth, although it is admitted, that thermograpy has a potential value for planning skin grafts of burn defects. However, such a purpose of DIRT was not addressed in the included wound papers.

Given the issues with the eligibility criteria, search strategy, study selection, data extraction, the lack of quality assessment of the evidence and summary measures and all the bias introduced along the review we do not believe that conclusions are valid. We are not questioning the applicability of thermal imaging in plastic surgery but a systematic review that meets the requirements of PRISMA, with adequate quality assessment of individual studies is demanded to answer the questions defined initially.

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Medical Thermography Introductory Course in Portugal

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On 21st of November 2015, a Medical Thermography Introductory Course was organized in Quinta da Boeira, Gaia (near Porto), in Portugal, by the Portuguese Society of Physical and Rehabilitation Medicine (SPMFR) and the Faculty of Engineering of University of Porto (FEUP). The organizing committee was composed by Catarina Aguiar-Branco (Physician at CHEDV, assistant professor at Faculty of Dentistry of University of Porto and President of SPMFR), Joaquim Gabriel (Professor at FEUP), Ricardo Vardasca (Post-Doctoral Researcher at FEUP) and Miguel Pais Clemente (Researcher at FEUP and Dentist). The event had the scientific sponsorship of Portuguese Society of Physical and Rehabilitation Medicine (SPMFR) and University of Porto. Was finantially sponsored by Bial (Portuguese main pharmaceutical company) and MRA Instrumentação (FLIR representatives in Portugal), which provided the IR cameras for the practical session.

The event had a total of seven speakers, from who Professor Francis Ring (University of South Wales, UK) was the International Invited guest, the other speakers were Professor José Alberto Duarte (Physiologist, Faculty of Sports of University of Porto), Dr. Ricardo Vardasca (FEUP), Dra. Catarina Aguiar Branco (CHEDV, FMDUP and SPMFR), Dr. João Torres (Orthopaedic Physician at HSJ and assistant at Faculty of Medicine of University of Porto), Dra. Clara Ramalhão (Neurological Physician at HPH and SMIC/Luz Saúde) and Dr. Miguel Pais Clemente (FEUP).

A total of 70 participants had attended to the course, being mostly physicians but also physiotherapists and dentists. The course was divided in three parts: Morning, Afternoon and Practical sessions. In the morning section, chaired by Professor Joaquim Gabriel had the keynote lecture from Professor Francis Ring entitled "Evolution of Medical

Some of the instructors, from left to right: Dr. Miguel Pais Clemente, Dra. Clara Ramalhão, Prof. Francis Ring, Dr. Ricardo Vardasca, Prof. Joaquim Gabriel, Dr. Jorge Lains, Dr. João Torres, Dra. Catarina Aguiar-Branco and Hector Cordal (MRA).

Thermal Imaging Applications", were a brief view of the technique evolution and application evolved along the time. After the coffee break Professor José Alberto Duarte presented "Physiological phenomenon's associated with changes in the peripheral temperature" were the physiological principles behind skin temperature were described, this was followed by "Thermal images in biomedical applications" from Dr. Ricardo Vardasca that introduced the technical concepts of thermography and provided some examples of applications. The morning session was closed with the lecture from Dra. Catarina Aguiar-Branco "The role of thermography in the study of painful syndromes: myofascial syndromes", which has given an overview of the importance of thermography in documenting the diagnosis and treatments appraisals of painful syndromes.

The afternoon session started after the get-together lunch and was chaired by Dr. Jorge Lains (Physician at HRP and President of the European Society of Physical and Rehabilitation Medicine). It was composed of the lecture from Dr. João Torres denominated "What does thermography give us in the lower limb osteoarticular pathologies", were examples of knee prosthesis surgery and ankle sprains diagnosis and treatment follow ups were documented. Dra. Clara Ramalhão gave the next lecture about "The value of medical imaging in the orofacial pain evaluation", which presented examples with different modalities of medical imaging such as MRI and CT combined with thermal imaging. To close this session Dr. Miguel Pais Clemente presented "Thermography and temporomandibular disorders: the relevance of an differential diagnosis", were demonstrated the combination of different biomedical techniques with thermography for the correct assessment of TMD associated conditions.

To finalize the course, a practical session was delivered, having Professor José Manuel Amarante (Head of Surgery of HSJ and Faculty of Medicine of University of Porto) as chair, it consisted firstly in a demonstration in how to use the cameras and set the settings, take the images and draw regions of interest (ROI) to extract the temperature data. After in a total o eight groups, where the participants were divided and had the opportunity to set and verify IR camera settings, take images from different areas of the body and draw ROIs in the images and collect thermal data from it.

The event had great success and satisfaction from the participants, helping to promote it among clinical professionals and attract their interest for its use in their daily practice.

Participants in the course.

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Article [1]

Book [2]

Book Chapter [3]

Internet resource [4]

Thesis [5]

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2nd Seminar of Medical Infrared Thermography, London, 29th April 2016 - Abstracts

K. Howell

Guest Editor, EAT President
Microvascular Diagnostics, Institute of Immunity and Transplantation, Royal Free Hospital, London, United Kingdom

THE APPLICATION OF THERMAL IMAGING TO PREVENT DIABETIC FOOT ULCERATION

Graham Machin[1], Suhail Ainarkar[2], John Allen[3], John Bevans[2], Michael Edmonds[4], Ben Kluwe [5], Audrey Macdonald [3], Nina Petrova [4], Peter Plassmann [5], Francis Ring [5], Rob Simpson [1], Aaron Whittam [1], Leon Rogers [1]

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Type 2 diabetes is a rapidly growing problem throughout the world. It is estimated in the UK there are nearly 3.5 M people affected with the condition in the UK alone. In 2011 it is estimated that the NHS in England spent £10 billion on diabetes and related complications. Diabetes carries with it contingent risks such as blindness, stroke, organ failure and persistent foot ulceration.

Diabetic foot ulceration (DFU) is frequently linked to neuropathy (a side effect of progressed diabetes) in the feet. This means that the pain sensors in the feet which would normally alert the person to a problem are not active and skin damage and loss can occur. If not detected this could well lead to infection and then amputation of toes and feet. In fact DFU is the biggest single cause of amputation in the NHS accounting for 125 per week.

It is thought that up to 80% of such amputations could be prevented by early intervention (ie to prevent the ulcer). In addition studies have suggested that before ulceration a temperature increase of up to 2.2 °C occurs in the at risk skin. Therefore if it is possible to detect this temperature rise before skin breakdown occurs then ulceration could be prevented.

This detailed study investigates the clinical efficacy of thermal imaging in preventing diabetic foot ulceration. Three clinical centres, are using thermal imagers, built for this purpose and validated by the National Physical Laboratory. This presentation describes the first results of this research; the performance of spot (non-contact) thermometers (sometimes used in podiatry settings) and the initial analysis of baseline thermal images of 99 normals. The prospects for the project are discussed including outlining the next steps for the work.

TECHNICAL CHALLENGES IN INFRARED FOOT SCREENING

Ben Kluwe

Department of Computing, University of South Wales, Pontypridd, United Kingdom

Extracting information from an image is among some of the most complicated problems within computer science. The first step in extracting information from any image is detecting the object being imaged. Although the topic has been explored greatly for images taken in the visible spectrum and algorithms are readily available, they generally cannot be applied to infrared images. One of the most common and simple methods is edge detection, which relies on a good contrast between the background and the object being images to outline it. However, this method cannot work with infrared images because a strong contrast between object and background is not always given.

The method presented will utilise the concepts of cubic splines and barycentric coordinates to provide an approximation of the outline of an object and transforming an outlined object into a different shape. Using this method to transform over 100 plantar images into a standardised shape allows automated processing to compute statistical moments. Future work towards the automated detection of feet will be outlined.?

EXPLORATORY THERMAL IMAGING ASSESSMENTS OF THE FEET IN PATIENTS WITH LOWER LIMB PERIPHERAL ARTERIAL DISEASE

John Allen[1], Klaus Overbeck[2], Daniel Kyle[2], Gerard Stansby[2]

Microvascular Diagnostics[1] and the Northern Vascular Centre [2], Freeman Hospital, The Newcastle upon Tyne NHS Hospitals Foundation Trust, Newcastle upon Tyne, United Kingdom

Peripheral arterial disease (PAD) is an atherosclerotic condition which can result in reduced lower limb tissue perfusion. The aim of this pilot study was to explore the potential use of thermal imaging in identifying PAD.

In 44 patients (24 male; mean (SD) age 67 (12) years) thermal images of 3 regions of interest (ROI's) on the feet were collected within a normothermic measurement room. The ROI's for each foot included the 1st toe, proximal foot and whole foot. The ankle brachial pressure index (ABPI) reference test was collected for PAD diagnosis (ABPI<0.9). Parametric statistics were employed and a p value <0.05 considered statistically significant.

Twenty-three had significant PAD in at least one leg (ABPI: 0.64 (0.15)). There were no significant ROI differences between PAD and non-PAD legs for their mean or SD values. The temperature gradient (toe-proximal foot) was close to -1oC but this was not significantly different between groups. Right-left whole foot temperature differences were not significant.

We have quantified absolute, gradient, spatial, and bilateral skin temperature differences in PAD and non-PAD legs and have found no significant differences. This pilot study indicates that thermal imaging is unlikely to be of diagnostic value in detecting significant PAD.

COMPARISON OF LASER DOPPLER AND THERMAL IMAGING DATA ACQUIRED AS PART OF A COLD STRESS TEST

Jason Britton

Old Medical School, Medical Physics Department,
Leeds General Infirmary, United Kingdom

BACKGROUND: Infrared thermal imaging can provide a measurement of the temperature of the hands where as a Laser Doppler images (LDI's) measure the blood flow 1mm below the surface of the skin in the micro-vascular network. It is postulated that there should be a direct relationship between the measured temperatures at the fingertips and the blood flow measurements from LDI.

METHODs: Baseline images of the hands were acquired, simultaneously, using a SC320 Thermal Imaging camera, placed 0.8m directly above the hands and a Moor-LDI2, at an angle of 15° from the perpendicular and 0.6m from the imaging plane. The LDI's were acquired of using a sample rate of 4ms/pixel, resolution of 196x85, and gain factors set to zero. The lighting conditions and temperature in the room were kept constant. The LDI images were collected in 150 seconds whereas the multiple thermal images were acquired during this time period and average values calculated. Regions of interest were placed over the fingertips of images and the mean values used when comparing the results from both modalities.

RESULTS: The results from 37 subjects including; those with secondary and primary Raynaud's together and healthy volunteers, were reviewed. The temperature values were plotted against flux values using excel. The data suggests that there is good measurement correlation for high resolution LDI and IRT images when acquired at baseline before CST but this not observed in the recovery statistics following the cold stress test.

CONCLUSIONS: The reasons for the poor correlation/agreement with the %recovery and rewarming/flow(Flux) rates assessed by the two modalities could include:

1.Slight movement of the patient's hands in the test that affect the LDI measurements more than those acquired by the thermal camera.

2.Temporal resolution differences between the modalities i.e. one image every minute for IRT, one every 2.5 minutes with LDI

3.Noise contribution to flux values in patients with low measured flux values

4.Impact of different drugs and response to cold stimulus

REPERFUSION OF DIGITAL VASCULATURE AND PULSATILITY INDEX IN RAYNAUD'S PHENOMENON

Matt Adams[1], Kevin Howell[2]

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

This study looked to establish a relationship between pulsatility index (PI) and digital reperfusion aimed at identifying those with primary Raynaud's phenomenon (pRP) at increased risk of developing connective tissue disorders (CTDs). This is based on the fact that more severe symptoms are experienced in CTDs than in pRP and the hypothesis that PI would be capable of exposing the increased peripheral resistance that precipitates this, which can be detected in the forearm arteries.

Systemic sclerosis (SSc) was used as a model of CTD due to the prevalence of RP within the condition and tested against those with pRP and healthy controls. PI of the radial and ulnar arteries was obtained using Doppler techniques. Rewarming of the fingers was measured via means of thermography after the hands underwent cold challenge.

Baseline digital temperature demonstrated a strong negative correlation with PI in the control and pRP group that wasn't seen in those with SSc. Despite visual differences in reperfusion curves being noted Kruskall-Wallis testing showed no significant difference in reperfusion ability between groups. A non-linear relationship was seen between PI and reperfusion rate when the entire study sample was viewed together possibly implicating difference in disease pathophysiology in basal digital temperature variation.

This study was necessarily limited by time, sample size and sample quality. These factors may be attributable to the lack of significant differences noted in PI and rewarming data between groups.

THE VALIDS STUDY - DESIGN OF A MULTICENTRE THERMOGRAPHY VALIDATION STUDY FOR RAYNAUD'S PHENOMENON

Andrea Murray on behalf of the VALIDS study group

In systemic sclerosis (SSc), Raynaud's phenomenon (RP) can affect the digital vasculature so severely that irreversible tissue injury occurs; often leading to ulceration (50% of patients) and more rarely gangrene, requiring amputation (15%). Objective and reliable outcome measures for clinical trials of novel drugs to treat RP are currently lacking. Laser speckle contrast imaging (LSCI) and thermography are two non-invasive measures of blood flow that show excellent potential but require further validation in order to prove their suitability as outcome measures. Our main aim is to determine and compare the reproducibility and validity of LSCI and thermography, testing the hypothesis that both methodologies are sufficiently reproducible and valid to allow their use as outcome measures in multi-centre clinical trials.

158 patients with RP secondary to SSc have been recruited from six specialist UK centres, taking part in a cold challenge to invoke decreased blood flow prior to reperfusion/rewarming at room temperature on two consecutive days. The change in blood flow was measured by LSCI and thermography. We will present the background and set-up of the study.

THERMAL CAMERA PERFORMANCE AT SIX SITES-THE VALIDS STUDY EXPERIENCE

Elizabeth Marjanovic[1] and Kevin Howell[2]

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

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

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

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

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

THE USE OF A DORSAL APPROACH FOR THE INJECTION OF BOTULINUM TOXIN A IN THE TREATMENT OF RAYNAUD'S PHENOMENON SECONDARY TO SCLERODERMA

Kiran Dhaliwal[1], Michelle Griffin[2], Sebastian Salinas[1], Kevin Howell[3] , Chris Denton [3], Peter Butler [1]

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BACKGROUND: Botulinum toxin A (Btx-A), injected via a palmar approach, has been shown to be effective in the treatment of severe RP. However, hand weakness is a common complication, lasting up to 6 months.

AIM: To determine the effect of Btx-A injected via a dorsal approach, on hand function and symptoms, in patients with RP secondary to scleroderma.

METHODS: Twenty patients with RP secondary to scleroderma were included. 10 units of Btx-A were injected into the hand via a dorsal approach. Each patient had a hand assessment (pinch and power grip, range of movement, Kapandji score, pain score and Disabilities of the Arm, Shoulder and Hand (DASH) score) and thermographic imaging (FLIR E60bx) pre injection and post injection at 15 minutes and 6 weeks. Patients were the followed up for 6 weeks.

RESULTS: 86% of patients reported reduced pain and swelling and improved colour change. There was a significant change in pain score ($p=0.003$), DASH score ($P=0.001$) and Kapandji scores ($p=0.001$, $p=0.029$ in dominant and non-dominant hands). There was a significant mean increase in the temperature of all fingers and hand strength. No patients reported hand weakness as a complication.

CONCLUSIONS: Btx-A injected via a dorsal approach improves symptoms, reduces number of attacks in patients with RP secondary to scleroderma with lower rates of complications compared to the palmar approach.

ASSESSING BOWEL PERFUSION DURING COLORECTAL SURGERY USING MICROVASCULAR IMAGING TECHNOLOGY

Costanzo Di Maria [1,3], Paul Hainsworth [2,3], John Allen [1,3]

[1]Microvascular Diagnostics Service, Northern Medical Physics and Clinical Engineering, and
[2]Colorectal Surgical Service, The Newcastle upon Tyne Hospitals NHS Foundation Trust, Newcastle upon Tyne, United Kingdom
[3]Institute of Cellular Medicine, Medical School, Newcastle University, Newcastle upon Tyne, United Kingdom

INTRODUCTION: In colorectal resection surgery, the healing of the anastomosis depends on good blood perfusion at the bowel ends. Perfusion is currently evaluated intra-operatively only by visual investigation of clinical signs such as pulsatility, bleeding, and tissue coloration. Microvascular imaging techniques could play an important role in this clinical setting by offering a more objective assessment tool.

METHODS: We present the case of a 72-year-old man undergoing colorectal resection, where we utilised thermal imaging (TI) and laser speckle contrast imaging (LSCI) to assess blood perfusion in the exposed bowel intra-operatively. Perfusion of healthy bowel was compared to the de-vascularised section to be resected using the mean temperature (for TI) and mean flux (for LSCI) in representative regions of interest (RoI).

RESULTS: Normal bowel temperature was 28.3 °C (26.6 °C in the de-vascularised bowel). With LSCI, blood flux was 340 AFU (arbitrary flux units) in the normal bowel (67 AFU in the de-vascularised bowel).

CONCLUSION: TI and LSCI allow for rapid and non-contact evaluation of bowel blood perfusion intra-operatively. In this case study, both techniques showed higher values in the healthy section of the bowel compared to the de-vascularised bowel, consistently with the expected absence of blood perfusion in the latter.

MEASURING HUMAN BODY TEMPERATURE USING INFRARED IN THE FOREHEAD AND INNER CANTHI OF THE EYE VERSUS TYMPANIC, FOREHEAD AND AXILLA THERMOMETERS

Ricardo Vardasca

University of Porto, Portugal

There are a few sites and minimal or non-invasive methods to assess human body temperature looking for fever in normal situations. However, in a threat of pandemic situations, in which would be required a fast and massive temperature screening, efforts and attention are required for its implementation. Standards have been developed to give an answer on how to act in a situation like that. A comparison between the available methods is aim of this experiment.

A total of 75 healthy volunteers (38 males and 37 females) underwent in blood pressure and temperature screening through axillar, tympanic and forehead thermometer and frontal facial thermal imaging using internationally accepted guidelines. Mean temperature values were obtained from the different methods, assessed and compared. The most reliable, repeatable and fastest method was the inner canthus of the eye in frontal facial thermal images. It presented good correlation with current 'clinical gold standard' tympanic thermometer and debatable forehead methods. A larger sample is needed for better understanding of influence of age, gender, menstrual cycle phase, BMI and blood pressure effect in the measurements and in sensitivity and specificity to identify febrile states.

MAXIMUM EYE TEMPERATURE IN THE ASSESSMENT OF STRESS IN RACEHORSES, COMPARING THE RESULTS WITH SALIVARY CORTISOL CONCENTRATION, RECTAL TEMPERATURE AND HEART RATE

Maria Soroko[1], Kevin Howell[2] Anna Zwyrzykowska[3], Krzysztof Dudek[4,] Paulina Zielinska[5],Robert Kupczynski[3]

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[3]Department of Environment Hygiene and Animal Welfare, Wroclaw University of Environmental and Life Sciences, Poland
[4]Faculty of Mechanical Engineering, Wroclaw University of Technology, Poland
[5]Department of Surgery, Wroclaw University of Environmental and Life Sciences, Poland

We investigated agreement between eye maximum pixel temperature (using thermography), and rectal temperature in racehorses, comparing the results with salivary cortisol concentration and heart rate, both at rest and after exercise.

Nineteen horses, undergoing training for racing in their first racing season, were studied. Eye maximum pixel temperature, rectal temperature, salivary cortisol concentration and heart rate were measured before training (BT), within five minutes of the end of the training session (T+5), and two hours after training (T+120).

Eye maximum pixel temperature, rectal temperature, salivary cortisol concentration and heart rate were all significantly elevated at T+5 compared to BT (all $p<0.001$). At T+120, only eye maximum pixel temperature remained significantly elevated compared to BT ($p<0.05$). Bland Altman analysis indicated a poor agreement between eye maximum pixel temperature and rectal temperature. We noted no significant correlations amongst any of the measurements at any time point, with the exception of eye maximum pixel temperature and rectal temperature at BT ($r=0.55$, $p=0.01$).

In racehorses, eye maximum pixel temperature is a poor estimate of core temperature due to limited agreement with rectal temperature. Furthermore, eye maximum pixel temperature is not correlated with accepted measures of stress such as salivary cortisol concentration and heart rate.

THE INFRARED CONTROVERSY 1800 -1840

Francis Ring

Medical Imaging Research Unit, University of South Wales, Pontypridd, United Kingdom

It has been widely reported that infrared radiation was discovered by William Herschel at the age of 61 in England in 1800. Further research into the publications of time reveal that this announcement by Herschel was received with mixed reactions. The president of the prestigious Royal Society in London was delighted to write to Herschel to say that he considered this discovery to be even more important than his earlier discovery of the new planet (Uranus) in 1781. However, the idea that invisible rays were contained within the well-known properties of sunlight was to some impossible to accept. The Scottish physicist John Leslie in particular was quick to publish a scathing criticism of Herschel, claiming that this was a disgrace to science. He had worked for 10 years and was about to publish his opus magnum on radiant heat.

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

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

Abstract from the 20th National Congress of The Polish Association of Thermology

All the abstracts of the 20th Congress of the Polish Association of Thermology will be published in a supplementary issue to Number 2 of Thermology international in June 2016. As the editorial of this issue refers to the abstract below, it appears in advance of the announced proceedings.

Does the type of skin temperaturedistribution matter?

K. Ammer

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

Introduction

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

1. random drawings;

2. from a fixed distribution;

3. with the distribution having fixed location; and

4. with the distribution having fixed variation

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

Method

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

Tskin= (Tneck 0.28)+(Tscapula0.28)+(Thand0.16)+(Tcalf 0.28)

and compared to the mean temperatures of all total body views.

Results

Histograms clearly show, that skin temperature does not follow a Gaussian distribution (figure 1). In most regions of interest, the distribution is skewed to the left. However, the histograms of the small rectangular measurement were close to normal distribution.

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

Conclusion

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

References

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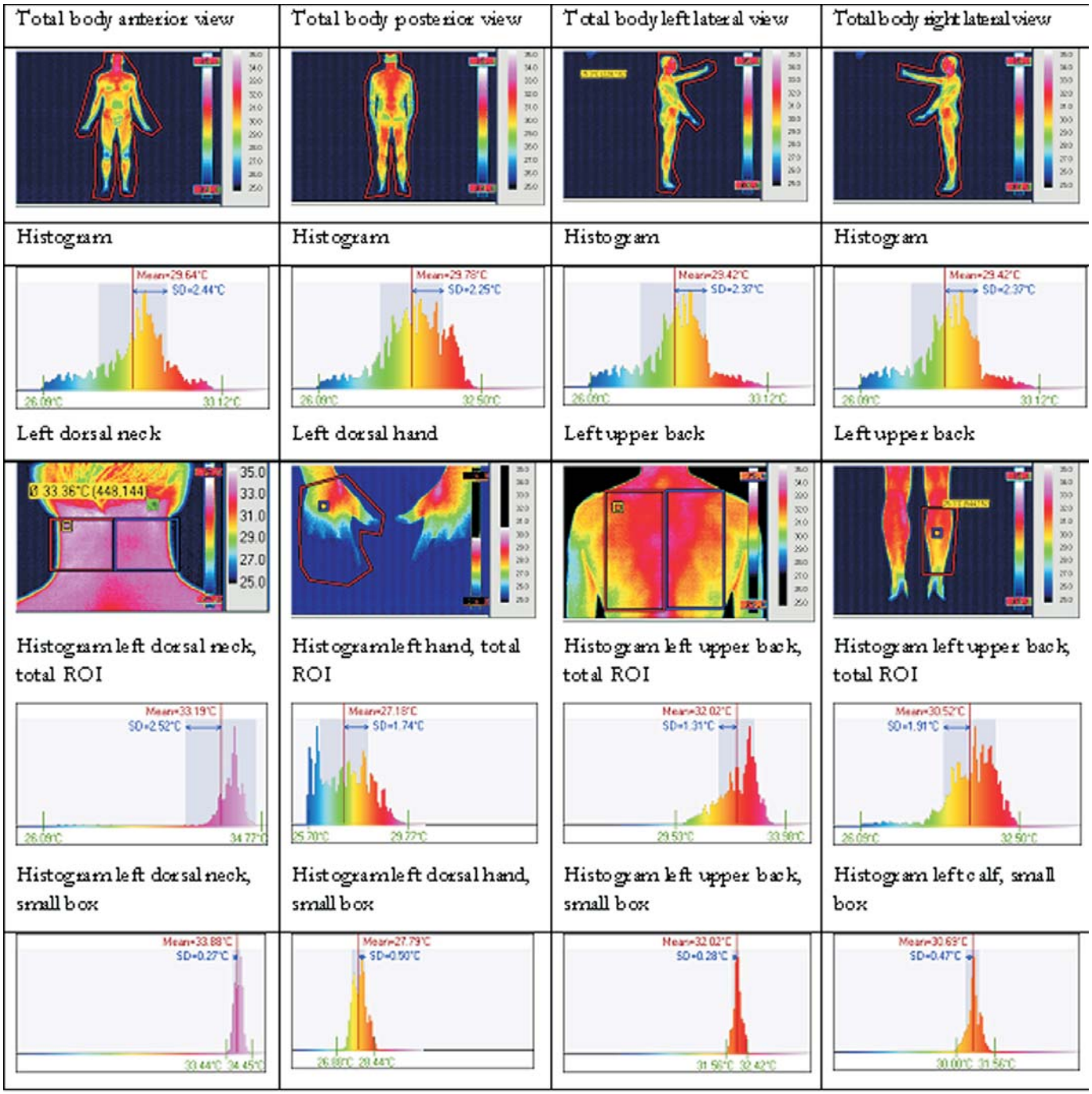
Figure 1
Histograms of skin temperature distribution



2016

3rd -4th July 2016
20th Meeting of the Polish Society of Medical Thermography Combined with The European Association of Thermology

At Gdansk University of Technology, Poland

All are warmly invited to a meeting at Gdansk University of Technology. This is a special pre QIRT conference meeting.

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Abstract deadline for Polish/EAT meeting May 1st 2016

Send to prof. Anna Jung a.jung@spencer.com.pl

MEETING VENUE: Gdansk University of Technology, Narutowicza str.11/12, 80 -233 Gdansk Poland

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PROGRAMME AT A GLANCE.

3th JULY, SUNDAY

7 p.m. Welcome Dinner

4th JULY, MONDAY

9.00 - 11.00 Session I

11.00 - 11.20 Coffee break

11.20 -13.00 Session II

13.00 - 14.15 Lunch

14.30 - 16.00 Session III

16.00 - 16.15 Coffee break

16.15 - 17.30 EAT board meeting

18.00 - Get together and QIRT Welcome

11th - 13th July 20164th-8th July, 2016
QIRT Conference 2016

Gdansk University of Technology Gdansk – Poland

*Scope of the Quantitative InfraRed Thermography Conferenc*e: State-of-the-art and evolution in the field of infrared scanners and imaging systems allowing quantitative measurements, and related data acquisition and storing systems.

Calibration and characterization of infrared cameras and related problems like certification, standardization, emissivity determination, absorption in media, spurious radiations, three dimensionality of observed objects.

Data reduction and image processing related to infrared thermography.

Application of infrared thermography to radiometry, thermometry, and physical parameters identification, in all fields: fluid mechanics, solid mechanics, structures and material sciences, non-destructive evaluations, electromagnetism, medicine and biomedical sciences, remote sensing, environment, industrial processes, etc.

• Conference Fees

Regular participants

- Early rate (deadline: May 20, 2016): **2600 PLN**
- Late rate (deadline: June 17, 2016): **3000 PLN**
- Very late registration before July 4: **3500 PLN**

Students

- Early rate (deadline: May 20, 2016): **1600 PLN**
- Late rate (deadline: June 17, 2016): **1800 PLN**
- Very late registration before July 4: **2000 PLN**

*Accompanying person*s

• Rate (deadline: June 27, 2016): **1000 PLN**

Further information:
Prof. Nowakowski antowak@biomed.eti.pg.gda.pl

Biomedical Engineering Dpt. Electronics, Informatics and Telecommunication Faculty Narutowicza Str. 11/12
80-233 Gdansk Poland

Website : www.qirt2016.gda.pl

11th - 13th July 2016
12th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT2016)

The conference is co-sponsored by the International Centre for Heat and Mass Transfer (ICHMT) and the American Society of Thermal and Fluids Engineers (ASTFE)

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Purpose
The conference is broad in scope and provides a forum for specialists in heat transfer, fluid mechanics and thermo- dynamics from all corners of the globe to present the latest progress and developments in the field. The broad scope brings together a wide range of research areas from narrow fundamental work in nanofluids to import applications such as in the broad fields of energy, manufacturing, biomedical processes, production, education, instrumentation and control, and MEMS. This will not only allow the dissemination of the state of the art, but it will serve as a catalyst for discussions on future directions and priorities in these areas. The additional purpose of this conference is to initiate collaboration in research.

Further information:
Scholarly issues
(Only for abstracts, manuscripts and programme)
Prof Josua P Meyer
University of Pretoria. South Africa
E-mail: josua.meyer@up.ac.za

Administrative issues (Payment of registration fees, travel, accommodation, welcome, banquet, etc.)
The Inside Edge, Sheryl van den Bergh
E-mail: sherylvdb@ie.co.za

Conference website: http://edas.info/web/hefat2016/

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Expert Course in Human Thermography (INEF Madrid)

Venue: Faculty of Physical Activity and Sport Sciences (INEF de Madrid).

Course Instructors

:Prof. Ricardo Vardasca PhD. Secretary of the EAT.

Prof. Kurt Ammer MD, PhD. Treasurer of the EAT.

Aderito Seixas MSc Physical Therapist and board member of the of the EAT.

Prof. Manuel Sillero-Quintana PhD. Board member of the EAT . Professor at the Technical University of Madrid. Course Director.

Ciro Brito, Danilo Gomes, Javier Arnáiz. Members of the TermoINEF research team. Technical University of Madrid, Spain.

Prof.Ismael Fernández-Cuevas PhD. Universidad Isabel la Católica.

Course fees:

	Until 1st of June	After 1st of June
EAT MEMBERS	1200.- €	1500.- €
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17th -22nd July accommodation (Optional) *	+ 350 €	Not possible

A certificate of attendance to 30 lecture hours will be provided by the Technical University of Madrid (UPM). When 10 full thermographic reports are submitted and approved, a 50 hours accreditation will be provided by the experts' panel of the course.

The preregistration will be on-line in the web based platform:http://www.coursesininef.com/thermographycourses/

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- A preinscription confirmation will be sent by email after seending the preregistration form.
- The an invoice with the payment directions will be send to the candidates once the number of minimum preregistrations (10) is reached.
- The maximum number of students is 20.

CONTENTS OF THE COURSE.

MONDAY, 18-7-16

9:00 - 10:50: THEORY CLASS 1. "Thermal Physics and technical aspects" (Ricardo Vardasca)

Basic concepts in thermology. Temperature scales. Historical evolution. Thermal Physics concepts. Rates of heat transfer. Characterization of equipments. Quality Assurance principles. Influence of distances and angles. Open issues in image processing and standards in medical infrared imaging [standard data format and DICOM]. Limitations of thermal imaging [3D and other issues].

10:50 - 11:10: COFFEE BREAK.
Free snacks and coffee in the hall of the lecture room.

11:10 - 12:00: THEORY CLASS 2.
PART-A: "Medical Thermography" (Kurt Ammer)

Basics of human thermoregulation. Thermal core and thermal shell. Heat balance equation. Anatomical and physiolo gical basis of human infrared radiation. Heat defence mechanisms Cold defence mechanisms. Distribution of skin temperature. Standard conditions for recording static thermograms. Static thermography as a complementary diagnostic aid in medicine. Static thermo- graphy as outcome measure in medicine.

PART-B: "Physiotherapy and Thermography" (Aderito Seixas)

Recent applications of IRT in Physiotherapy. Thermal imaging and occupational health. Thermographic evaluation in tendinopathies. Assessing the effects of whole-body vibration Assessing the effects of kinesio-taping application. Skin temperature

and surface electromyography. Plantar foot pressure and thermal imaging in diabetic foot patients

13:00 - 14:00: LUNCH TIME

Lunch in the cafeteria of the INEF.
(2 courses, dessert and drink, included in the course fee of the course)

14:00 - 16:00: PRACTICE CLASS 1 "Controlling the camera and the adequate protocol" (Manuel Sillero, other teachers, and TermoINEF Team)

Learning to handle the cameras of the course. Applying the adequate protocol: the Glamorgan protocol and TermoINEF protocol for sports.

TUESDAY, 19-7-16

9:00 - 10:50: THEORY CLASS 3 "Dynamic Thermography" (Kurt Ammer)

Static versus dynamic thermography. Methods for non-destructive material testing applied in medicine. Provocation of vascular heat defence mechanism. Provocation of vascular cold defence mechanisms. Cold challenge thermography in clinical medicine. Provocation of a vascular response (chemical, immunological, mechanical). Value of provoked vascular response in clinical medicine. Provoked competition for perfusion. Provoking temporary hyperthermia. Core temperature registration

10:50 - 11:10: COFFEE BREAK.
Free snacks and coffee in the hall of the lecture room.

11:10 - 13:00: THEORY CLASS 4 "Sports Thermography" (Manuel Sillero)

Evolution of Sports Thermography. Current uses of Sport Thermography: Initial evaluation of the athlete, injury prevention method, monitoring of the recovering process, quantification of the training load. Study of sport thermography cases.

13:00 - 14:00: LUNCH TIME

Lunch in the cafeteria of the INEF.
(2 courses, dessert and drink, included in the course fee of the course)

14:00 - 16:00: PRACTICE CLASS 2 "The appropriated thermogram" (Manuel Sillero and TermoINEF Team)

Practices to record the appropriated thermogram in "static" protocols according to the Glamorgan and TermoINEF protocols. NOTE: The thermograms will be used in other practices.

WEDNESDAY, 20-7-16

9:00 - 10:50: THEORY CLASS 5 "Influence factors affecting thermograpy" (Ismael Fernández)

Review of factors affecting thermography. Environmental Factors. Technical Factors (cited only). Individual factors: Intrinsic factors and Extrinsic Factors. Influence of Physical Activity: Strength exercise, Aerobic Exercise, Anaerobic Exercise.

10:50 - 11:10: COFFEE BREAK.
Free snacks and coffee in the hall of the lecture room.

11:10 - 13:00: PRACTICE CLASS 3 "Selection of ROI" (Manuel Sillero and TermoINEF Team)

Manual selection of regions of interest (ROI) from the thermograms recorded in practice 3. Practicing with Flir Tools and ThermaCam reporter to obtain thermal data of the thermograms.

13:00 - 14:00: LUNCH TIME

Lunch in the cafeteria of the INEF.
(2 courses, dessert and drink, included in the course fee of the course)

14:00 - 16:00: PRACTICE CLASS 4 "Practices with dynamic protocols: Cold stress" (Manuel Sillero and TermoINEF Team)

Practices to record thermograms with different "dynamic" protocols involving cold stress. Note: Thermograms will be used in the practice 7.

THURSDAY, 21-7-16

9:00 - 10:50: PRACTICE CLASS 5 "Practices with dynamic protocols: Exercise stress" (Manuel Sillero and TermoINEF Team)

Practices to record thermograms with different "dynamic" protocols involving exercise practice. Note: Thermograms will be used in the practice 7.

10:50 - 11:10: COFFEE BREAK. Free snacks and coffee in the hall of the lecture room.

11:10 - 13:00: PRACTICE CLASS 6 "Data processing" (Manuel Sillero and TermoINEF Team)

Data processing of data for generating reports of static thermograms with Excel and Flir Tools or ThermaCam Reporter.

13:00 - 14:00: LUNCH TIME

Lunch in the cafeteria of the INEF.
(2 courses, dessert and drink, included in the course fee)

14:00 - 16:00: PRACTICE CLASS 7

"Data processing (Dynamic protocols)" (Manuel Sillero and TermoINEF Team)

Data processing of data for generating reports of several consecutive thermograms with Excel and Flir Tools or ThermaCam Reporter.

20:00-23:00: OFFICIAL DINNER OF THE COURSE.

Informal dinner at a restaurant in the center center of Madrid (included in the course fee of the course)

FRIDAY, 22-7-16

9:00 - 10:50: PRACTICE-THEORY CLASS 1 "Interpretation of thermograms" (Manuel Sillero)

Students and teacher will interpreter different examples of thermograms from the database of the TermoINEF group and / or the most interesting thermograms recorded in the course.

10:50 - 11:10: COFFEE BREAK

Free snacks and coffee in the hall of the lecture room.

11:10 - 13:00: PRACTICE-THEORY CLASS 2

" Automatic data processing" (Manuel Sillero and representative of Thermohuman)

The student will be instructed and will practice the analysis of their thermograms with the software ThermoHuman, which generates automatic reports from 4 basic thermographic views.

13:00 - 14:00: LUNCH TIME

Lunch in the cafeteria of the INEF.
(2 courses, dessert and drink, included in the course fee)

14:00 - 16:00: PRACTICE-THEORY CLASS 2 "How should I edit the 10 reports?".

The student will be instructed to generate and submit the 10 reports required to obtain the final accreditation of the course. At the end of the session the student will receive the attendance certificate of the course.

10th- 11th September 2016

Annual Scientific Session of the American Academy of Thermology (AAT) in Greenville, South Carolina.

A Pre-Meeting Physicians Member Certification Course will occur on September 9th.

A Pre-Meeting Technicians Member Certification Course will occur on September 8th.

Further Information:

http://aathermology.org/