ISSN-1560-604X
Thermology international

Volume 19 (2009)
Number 2 (April)

Thermology International

Reproducibility of Hot Spot Count

Comparison of Infrared-Thermography and Full-Field Laser Perfusion Imaging

Comparison of Measuring Sites for the Assessment of Body Temperature

13th Congress of the Polish Association of Thermology ABSTRACTS

Published by the

European Association of Thermology
and the
Austrian Society of Thermology

This journal is indexed in
EMBASE/Excerpta Medica

THERMOLOGY INTERNATIONAL

Volume 19 (2009) **Number 2 (April)**

Published by the
Austrian Society of Thermology and European Association of Thermology

Indexed in
Embase/Excerpta Medica

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

Organ der Österreichischen Gesellschaft für Thermologie

Organ of the UK Thermography Association (Thermology Group)

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Comparison of Measuring Sites for the Assessment of Body Temperature

David D Pascoe, Gordon Fisher

Department of Kinesiology; Auburn University Thermal Lab; Auburn, Alabama 36849 U.S.A.

SUMMARY

INTRODUCTION: The use of measuring surface skin temperature as a quick assessment or screening tool to predict elevated core temperature has progressed from parents feeling their child's forehead to elaborate infrared screening procedures to identify potentially febrile individuals for pandemic screening

PURPOSE: The purpose of this investigation was to compare core temperature (oral, rectal esophageal, and tympanic) with skin temperature (axillary, inner canthi, forehead, and temporal) as influenced by differing environmental conditions.

METHODS: Twenty-two college aged, healthy participants (11 males, 11 females) performed six trials at three ambient temperatures (15.5, 21.1, or 26.6 °C /60, 70, 80 °F) and either 35% or 70% humidity. Participants wore similar clothing in all trials. The trials were performed at the same time each day with participants being equilibrated for at least 15 minutes before temperature measurements were obtained. There was a separation of at least 24 hours between each trial

RESULTS: There were significant differences between core temperatures (rectal, esophageal, tympanic, and oral) observed for all environmental conditions. Tympanic temperature was the least consistent measurement of core temperature due to variations in both ambient temperature and humidity. Variations in ambient temperature and humidity had a significant affect on all skin surface sites. The axillary site showed the most consistent skin surface measurements, while the forehead and temporal sites were the least. The inner canthi measurements increased in a linear fashion (R^2= 1) as the temperature of the environment increased.

CONCLUSIONS: As environmental temperature increased, the variance associated with the measurement of each site decreased irrespective of the humidity. Rectal temperature was the highest and most consistent measurement of all core measures regardless of changes in environmental temperature and humidity. Axillary temperature provided the most consistent measurement of the skin surface sites. The inner canthus provided the best predictive non-contact measurement of skin surface sites across all trial conditions. Thus, the inner canthi may be useful in detecting individuals with high temperatures as a potential screening method for fever related pandemic diseases

KEY WORDS: Core temperature, Skin surface temperature sites, infrared imaging

BESTIMMUNG DER KÖRPERTEMPERATUR AN UNTERSCHIEDLICHEN MESSSTELLEN

EINLEITUNG: Die Messung der Hauttemperatur als rasche Möglichkeit der Temperaturbeurteilung oder als Suchmethode für eine erhöhte Kerntemperatur hat sich vom Griff eines Elternteils auf die Stirn des Kindes zu ausgeklügelten Infrarot basierten Prozessen weiter entwickelt, um potentielle fiebrige Personen im Rahmen eines pandemischen Screenings zu erfassen.

ZIEL DER STUDIE: Ziel der Untersuchung war es die Kerntemperatur (oral, rektal, im Ösophagus und am Trommelfell) mit der Hauttemperatur (axillär, am inneren Augenwinkel, an der Stirn und an der Schläfe) zu vergleichen und deren Beeinflussung durch unterschiedliche Umweltbedingen zu ergründen.

METHODE: Zweiundzwanzig gesunde Collegestudenten (11 Männer, 11 Frauen) nahmen an sechs Untersuchungen bei drei unterschiedlichen Umgebungstemperaturen (15.5, 21.1, or 26.6 °C /60, 70, 80 °F) und einer Luftfeuchtigkeit von 35% oder 70%.teil. Die Teilnehmer waren bei allen Untersuchungen ähnlich gekleidet. Die Messungen wurden jeweils zur selben Tageszeit nach 15 minütiger Anpassung an die Raumtemperatur durchgeführt. Zwischen den einzelnen Untersuchungen war eine Pause von mindestens 24 Stunden.

ERGEBNISSE: Es fanden sich in Abhängigkeit von den Umgebungsbedingungen signifikante Unterschiede zwischen den Messstellen für die Kerntemperatur (oral, rektal, im Ösophagus und am Trommelfell). Die Messungen am Trommelfell zeigten bedingt durch die Änderung der Umgebungstemperatur und Feuchtigkeit die geringste Konstanz. Unterschiedliche Umgebungsbedingungen beeinflussten in signifikanter Weise alle Messungen der Hauttemperatur. An der Axilla zeigte sich die größte Messkonstanz, die Messungen an der Stirn und an der Schläfe varierten am meisten. Die Temperatur am inneren Augenwinkel nahm linear (R^2= 1) mit dem Anstieg der Ungebungstemperatur zu.

SCHLUSSFOLGERUNG: Mit Zunahme der Umgebungstemperatur, verminderte sich die Messvarianz an allen Messstellen unabhängig von der Raumfeuchtigkeit. Unabhängig von Raumtemperatur- und Feuchtigkeit war die Rektaltemperatur war am höchsten und varierte am geringsten von allen Messtelllen zur Bestimmung der Kerntemperatur. Die Axillartemperatur zeigte die größte Konstanz von allen Bestimmungen der Hauttemperatur. In allen Untersuchungen bot die Temperatur des inneren Augenwinkels von allen Oberflächenmessungen den besten Voraussagewert. Deshalb kann die Temperaturmessung am inneren Augenwinkel als Screening- Methode zur Entdeckung fiebriger Personen im Rahmen pandemischer Erkrankungen nützlich sein.

SCHLÜSSELWÖRTER: Kerntemperatur, Hautmessstellen, Infrarot-Thermographie

Thermology international 2009, 19(1) : 35-42

Introduction

Thermal physiologists and medical practitioners have long recognized the body's ability to maintain our core temperature within a narrowly defined thermal region of survival. This is accomplished through a multitude of tightly regulated mechanisms that provide the precise thermal environment for proper functioning of the human organism despite external perturbations. The association between increased body temperatures and disease has a long history dating back to the ancient cultures of the Aztecs, Sumerians, Babylonians, and Egyptians. Hippocrates believed that the increase in temperature associated with fever, determined by touch in those days, was the most remarkable symptom [1]. This observation was scientifically confirmed using thermometry and over 10,000 observations by Wunderlich in 1872 [2]. In this treatise, he demonstrated the importance and vital role of measuring and monitoring body temperature as an investigative tool to understanding fever and the human disease state. Since these early beginnings, the precision measurement and of the body core temperature has been vital in our understanding, detection, diagnosis, and progression of pathological conditions and to various diseases that are linked to a fever.

To obtain measurements of body temperature, various methods and devices have been utilized. The critical issues for reliable temperature measurements are the accuracy of the measuring device, the sampling time needed to obtain a stable and accurate measurement, the measurement site, and method by which a temperature measurement is obtained. At this point, it is important to distinguish between surface skin temperature, core temperature, and skin temperature adjusted to core temperature. Surface skin sites are a measurement of temperature from the epidermal surface and can vary between the extremities (arms, legs, appendages) and the head/torso, according to prevailing environmental conditions (temperature, humidity, wind), and according to clothing. Core temperature or internal temperature of the body is often obtained from the oral cavity, ear canal, esophagus, or rectum. Some temperature measurement devises obtain skin temperatures from which core temperature is predicted using a regression formula, an off-set value, or an algorithm to estimate a core temperature from an external skin surface site. Core temperature or internal temperature of the body is often obtained from the oral cavity, ear canal, esophagus, or rectum.

There is some debate as to which area provides the best representation of the body's internal temperature, as it can vary between locations. Oral temperature is often used for convenience, but this site can be altered by drinking hot or cold beverages and hyperventilation. Ear canal temperature or more specifically tympanic temperature is regarded as a reliable measurement of core temperature since it represents a measurement site close to the hypothalamus (temperature regulatory site within the brain). However, in practice taking measurement at this site can be problematic due to ear wax, climatic conditions, and the difficulty in obtaining a valid tympanic membrane measurement from misalignment of the infrared beam due to the angle and anatomical shape of the ear canal. Rectal temperature provides a stable measurement site, but it can provide higher temperatures when a person is performing exercise utilizing leg locomotion which produces heat in the gluteus and leg muscle groups. Measurements of esophageal temperature are obtained by inserting a thermal probe into a nostril and guiding it down into the esophagus with the tip positioned in the region where the esophagus is between the aorta and the left atrium. Individuals may experience a slight annoyance with the probe positioned in the throat, but this measurement responds very quickly to changes in internal body temperature within the torso region.

In recent years, infrared thermography (skin surface temperature) has been used at some airports (Canada, China, and Hong Kong) to screen individuals as potential carriers of Severe Acute Respiratory Syndrome (SARS) and Influenza A virus subtype H5N1 or avian (bird) flu. These screening sessions focused on the detection of individuals with symptoms of fever and illness and based on World Health Organization (WHO) recommendations regarding SARS epidemiology [3]. The challenge was to provide an effective scanning procedure that could handle the flow of passengers without serious time delays

Nevertheless, the fear of the spread of disease and a possible pandemic is magnified by our global transportation network which provides a convenient path for the spread of disease and provides challenges for the containment of transmittable diseases. Pandemics, such as the Bubonic or black plague, smallpox, and influenza, have been responsible for thousands of deaths and have decimated entire populations and cultures. It is often stated that the question is not "if" but "when" the next outbreak will occur. In recent years, the outbreak of SARS and the very deadly H5N1 avian flu (60% death rate) has mandated pandemic preparedness [4]. Robert Webster, a world renowned virologist in 2003 published "The world is teetering on the edge of a pandemic that could kill a large fraction of the human population" [5]. Expert projections for the potential death rate from an H5N1 outbreak in which the flu has mutated into a viable human host form are approximated at 5 -150 million [6]. Many of these diseases are not infectious prior to the onset of the illness and fever, with the exception of influenza where they are infectious prior to any apparent symptoms [7, 8].

Given these scenarios, the screening of infectious disease carrying individuals at key locations may be an undeniable safeguard in the fight against pandemic outbreaks that are characterized by fever. The appeal of being able using skin surface temperature measurements on the face for fever detection is their l relationship to the core temperature. The non-invasiveness, ease of measurement, accessibility of various surface sites, and the screening process can be developed to handle large numbers of individuals with minimal delays. The screening technique works from the pre -mise that elevated skin surface measurements of, for example the forehead, can be indicative of elevated core temperatures. Those with increased skin temperatures above a determined "threshold level" would be further screened to separate individuals with fever from those presenting elevated temperatures from non-infectious related causes, such as exercise.

During the SARs outbreak, it is estimated that some 35 million individuals were scanned at airports (China Canada, Singapore, and Hong Kong) that utilized infrared thermal imagers for skin surface screening [9]. During this implementation, the method for screening was not clearly defined which led to some problems with the original procedures. In retrospect, the most notable concerns were mass screening procedures for obtaining the temperatures, the reliability of using skin surface temperature measurements for fever detection, the scan target site, and the questionable relationships between surface temperature and core temperature as influenced by the environmental conditions.

Therefore, this study sought to compare temperatures measured at various core and surface sites under differing environmental temperatures and humidity.

Methods

Participants

The male (11) and female (11) participants were recruited from the university student population (ages 19-23 years, mean age 20.8 ±0.4 years). Prior to participation, the perspective individuals read and signed a University approved human subject's informed consent document and completed a Physical Activity Readiness Questionnaire (Par-Q) medical screening device adapted from the British Columbia Department of Health and Michigan Heart Association (10). The screening device based on 15 questions eliminated participants not 19-35 years of age, those indicating history of cardiovascular disease, diabetes, respiratory or renal problems, any ear/ nose/or throat medical issues (e.g. esophageal diverticulitis, deviated septum, etc) that would interfere with the temperature probe insertion, contraindicated medicines that may alter thermal responses, any recent hospitalization, smokers, and any reason that might disqualify the individual from participation

Test Conditions

The six trials were conducted within a environmental chamber in which temperature was maintained at 15.5, 21.1, or 26.6 °C (60,70,80 °F) and either 35% or 70% relative humidity. Participants stood passively for at least 15 minutes within the environmental chamber to allow thermal regulatory responses to equilibrate to the trial conditions before any temperature measures were made. For all six trial conditions, participants maintained the same type of clothing that was consistent with their normal daily clothing attire in environmental conditions of approximately 23-25 °C. Participants were also instructed to avoid any caffeine, meals or hot/cold drinks or exercise at least one hour prior, no use of lotions/make up on skin surface areas. At least 24 hours separated each trial and participants performed the trials at the same time of day to avoid thermal differences due to circadian rhythm. All female trials were performed during days that were not during their menstrual cycle.

Procedures

The rectal temperatures were measured using a flexible thermal probe (YSI-Yellow Springs Instrument) that was inserted 10 centimeters into the rectum by the participant. The esophageal temperatures were obtained with a flexible thermal probe (Grant Instruments). Prior to insertion, the approximate length of insertion is determined according to anatomical measurements (length from nose to sternum) of each participant. The probe was inserted by a trained technician. In some cases, participants required the use of a topical anesthetic spray to counteract the gag response in the back of the throat. This anesthetic spray application to the back of the throat did not affect the measurements. The rectal probes remained in for the duration of the trials (approximately 30 minutes) and the esophageal probe was inserted after the thermal image (allowing another 5 minutes) to insure a stable and consistent measurement. Stability of the rectal and esophageal measurement was determined by a constant measurement reading over the last minute of the data collection.

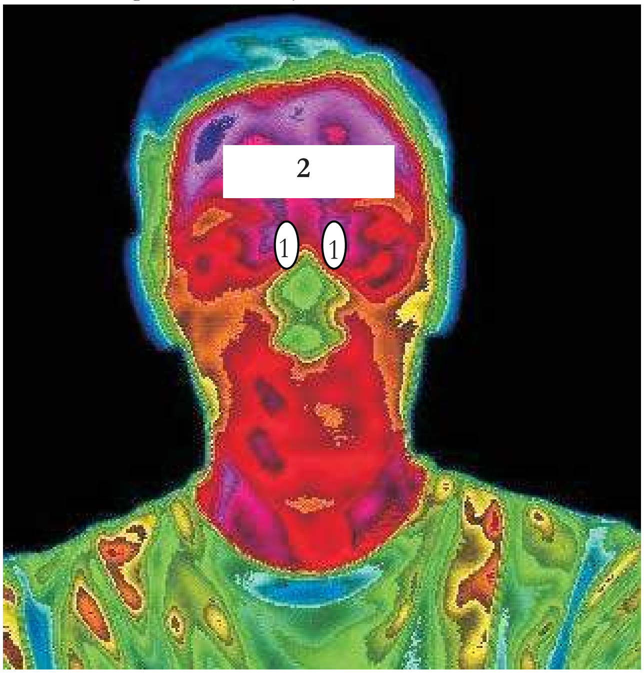
Prior to the initiation of this investigation, all rectal and esophageal probes were calibrated using a three temperature correlation between the probe and a glass calibrated thermometer. All esophageal and rectal probes were labeled by participant number, assigned to them throughout the experimental testing, and cleaned according to Centers for Disease Control (CDC) guidelines. The rectal, esophageal, oral, tympanic, and axillary temperature measurements were taken by trained research personnel.

Measurements of oral, tympanic, and axillary temperatures were taken in triplicate and the mean value was recorded. Oral and axillary temperatures were obtained using an Electronic thermometer (Filac F1500, ± 0.1°C resolution), using disposable probe covers. The values were obtained after 35 seconds when an auditory signal indicated a stable measurement had been obtained. The oral temperature was obtained by placing the probe under the tongue, one side of the center, and with lips closed. Axillary temperature was obtained by placing the probe within the armpit with the arm pressed against the body. The tympanic membrane temperature was obtained by an infrared light Thermoscan (Pro-LT, ± 0.1°C resolution). An audible beep indicated completion of a measurement. Both the Filac and Thermoscan devises are commonly used in clinical offices, hospitals, and Sports Medicine centers in the United States.

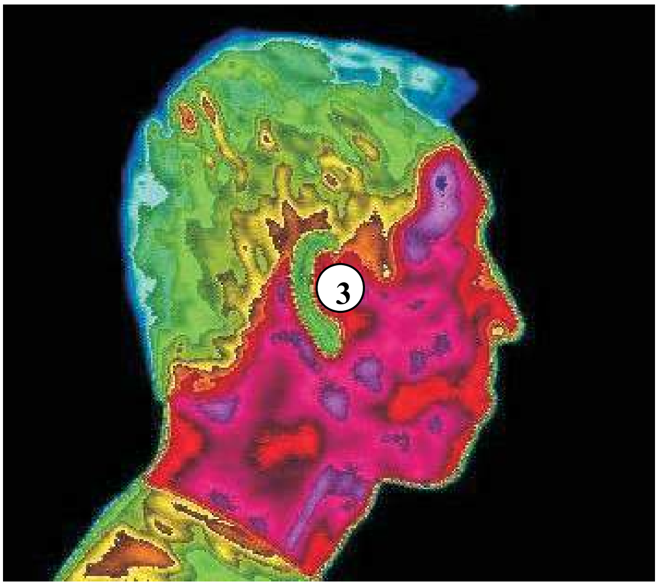
Thermography scans (frontal and side views) were taken using a Computerized Thermal Imager (CTI inc., Utah, U.S.A.). This is a pre-cooled, long wave ((8-14 μm) system with the emissivity set at 0.99. Prior to initiating this project, the thermal imaging system was checked for calibration against know temperature references (ice water/glass thermometer and an external black body temperature source). The system stability, time to provide consistent temperature measurements is 15 minutes. During the trials, the camera had been operating for at least 20 minutes prior to any imaging.

Images were obtained for the left and right inner canthi, forehead and temporal surfaces. The two facial images (frontal and right side) occupied approximately 60% of the

Figure 1:
Infrared image sites for analysis



Front view: Infrared Image
Inner canthi-1); Forehead region- 2,



Side View: Infrared Image
(Temporal region -3)

screen to insure the adequate skin surface areas for skin surface temperature analysis (see Figure 1). The inner canthi measure presented in this paper is a mean of the highest measured temperature of both right and left inner canthus. Forehead temperature recorded was the highest temperature found within the rectangular region between the midpoint of the right and left eyebrow and extending up to the hair line. During the trials, hair that would drape over the forehead image surface was secured prior to equilibration period with hair ties or rubber bands. The temporal region was defined and identified as the hottest region on the right side of the head above and in front of the ear along the lateral hairline. This region of the temporal surface is fed by the Temporal artery. The temperature values obtained from infrared thermal imaging are strongly correlated to the perfusion of skin surface area [11].

Statistical analyses

The descriptive data is presented as means ± SD. All temperature measurements were analyzed using repeated measures ANOVAs: 2 relative humidity's (35%, 70%) by 3 temperatures (15.5/60, 21.1/70, or 26.6/80 °C/°F) by 4 sites (core: tympanic, rectal, oral, esophageal) or (surface: axillary, forehead, temporal, canthi). Differences between multiple means were determined using paired T-tests with a Bonferoni correction for multiple comparisons. Pearson Regressions were run between core and surface temperature measures. The p value was set at 0.05 level of confidence and partial eta squared ($\eta p2$) calculated using a Wilk's Lambda formula was used to determine the effect size or variance described in the dependent variable : where $\eta p2$ = small effect size, 0.06 is medium effect size, and 0.14 large effect size [12].

Results

It is important to remember that these results were obtained from males and females that were passively standing in a thermal chamber, wearing normal daily attire for temperatures from 21-23°C/ 70-73°F, and with adequate time (greater than 15 minutes) to equilibrate. Statistical analyses revealed significant ($p = 0.05$) differences between core and skin surface measurement sites as influenced by ambient temperature (?p2= 0.129 moderate effect) and humidity (?p2= 0.084 moderate effect). The lower effect size for the humidity intervention is influenced by measurement sites that are partially or not exposed to ambient relative humidity conditions (rectal, esophageal, oral, and axillary). In figure 2, the comparison of core and surface measurement sites are presented by humidity (35% versus 70%) and temperature (15.5/70, 21.1/60, and 26.6/80 °C/°F). Significant differences between ambient temperature conditions are observed for tympanic core temperatures at 35% relative humidity, while forehead, temporal, and inner canthi measurement sites are significant different at both 35% and 70% relative humidity. (Figure 2)

In contrast, the four core temperature measurements sites (oral, rectal, tympanic and esophageal) were significantly different from each other at the different ambient temperatures (15.5/70, 21.1/60, and 26.6/80 °C/°F). For the different measurements of core temperature, the rectal site was the most stable across the different environmental conditions, while the tympanic temperature was the least stable being significantly influenced by both temperature and humidity.

The between site comparisons for the core and skin surface temperature measurements (temperature by humidity) are presented in Figures 3 A and 3B. For the measurements of skin surface temperature the axillary temperature was the most consistent measurement site across the different environmental conditions, while the forehead was slightly less consistent than the temporal region. In this investigation, as the environmental temperature increased, the variance between the site measures (surface and core) decreased, regardless of the humidity within the chamber.

Figure 2:
Within site measurement comparisons by temperature and humidity.
 * Significant differences (p = 05) within site measurements at the varying ambient temperatures.

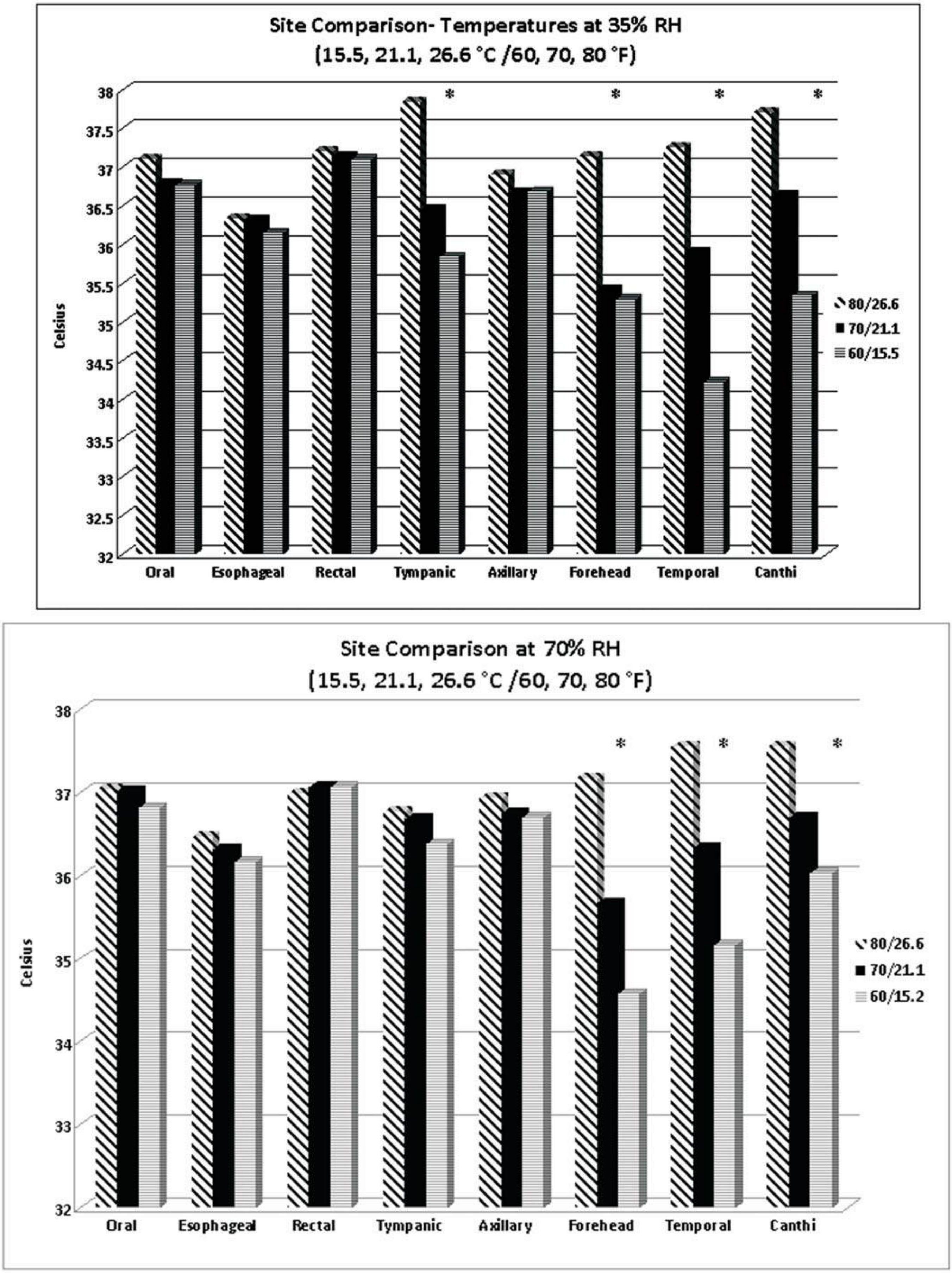
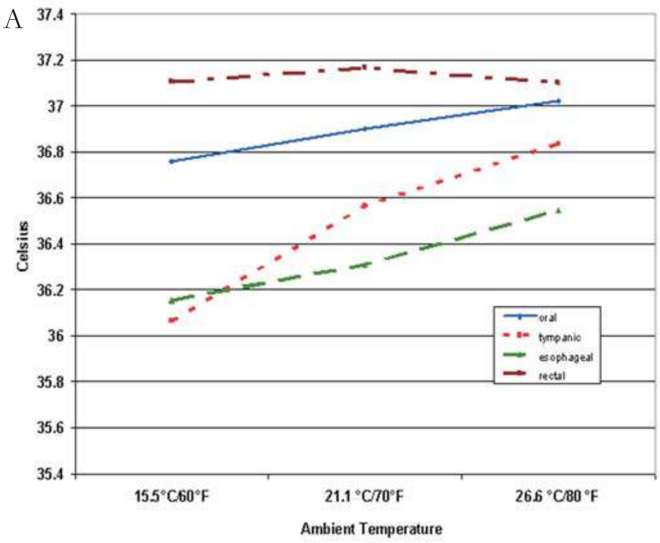
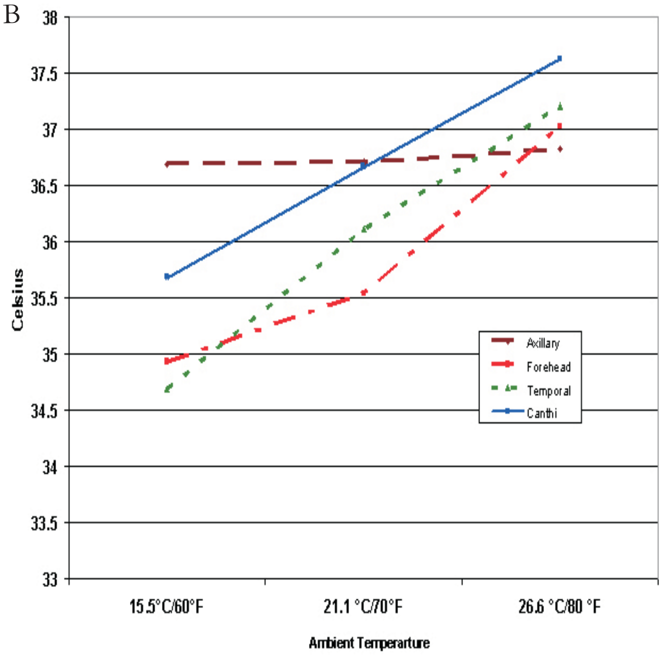


Figure 3:
Comparison between core (top) and between skin (bottom) temperature measurements as influenced by ambient temperature

A


Ambient Temp (°F/°C)	Oral	Tympanic	Esophageal	Rectal
60/15.5	36.8 ± 0.5	36.1 ± 0.6	36.2 ± 0.5	37.1 ± 0.5
70/21.1	36.9 ± 0.4	36.6 ± 0.5	36.3 ± 0.5	37.2 ± 0.5
80/26.6	37.1 ± 0.4	36.8 ± 0.4	36.4 ± 0.5	37.1 ± 0.5

B


Ambient Temp (°F/°C)	Oral	Tympanic	Esophageal	Rectal
60/15.5	36.8 ± 0.5	36.1 ± 0.6	36.2 ± 0.5	37.1 ± 0.5
70/21.1	36.9 ± 0.4	36.6 ± 0.5	36.3 ± 0.5	37.2 ± 0.5
80/26.6	37.1 ± 0.4	36.8 ± 0.4	36.4 ± 0.5	37.1 ± 0.5

Discussion

The purpose of this investigation was to compare core temperature measured at four different sites (oral, rectal, tympanic, and esophageal) with four different skin surface temperature sites (axillary, forehead, temporal, and inner canthi) and to see how the values were influenced by differing environmental conditions (temperature, humidity). The core temperature, temperature found around the vital organs, is usually maintained between 36.5 - 37.5°C. There is not one single value ascribed to core temperature. This can be attributed to the various measurement sites exposure to the environment (e.g. ear canal versus rectal orifice), blood perfusion to the measurement site, and proximity to organ or muscle metabolic activity. In this study, the rectal core temperature under all conditions provided the highest temperature measure and the most reliable across all environmental conditions. The esophageal temperature was consistently lower than all core measures with the exception of the low humidity (35%), low temperature 15.5°C/60°F condition. It should be noted that air from the environment is both heated and moisturized in the conducting zone of the respiratory tract during breathing, and this temperature measure may have been influenced by these processes. The tympanic measurement values were inconsistent and fluctuated in response to both temperature and humidity. For the measurements of tympanic core temperature the proximity of the ear canal to the environment provides a source of potential error. The oral temperature is the most convenient site for measurement but it can be influenced by hyperventilation, and cool or hot fluid ingestions. Wunderlich came to the conclusion that thermometry of the mouth and closed fist were unreliable and the rectum was indecent for measurement [13].

All core temperature measurements, with the exception of the rectal temperature, increased as the ambient temperature increased. Additionally, as the ambient temperatures became warmer, the variance between the core temperature measurements sites decreased. One may note that the core data variations (standard deviations) were smaller than those observed for the skin surface temperature measures. This is not unexpected as the skin surface serves as a thermal interface between the environmental conditions and the core temperature. Changes in blood flow to the skin provide a conduit for heat exchanges that allows the body to maintain a very stable core temperature [11].

The axillary surface temperature is sometimes used as a "surrogate" for core temperature. In this study, the axillary was the most consistent surface site measure across all temperatures and humidity conditions. With proper technique, this is not surprising when one considers the axillary site is secure within the armpit that shields this site from the environmental temperature and can alter the humidity within this region. The axillary site measurements, regardless of the environmental conditions, produced temperatures that were midway between the values obtained for rectal and esophageal core temperatures. The utility and consistency of the axillary site from this experiment give credence to the use of the axilla as an approximation of core temperature that lacks some of the problems associated with other core temperature sites. However, as a primary surface screening procedure the axillary temperature may be difficult to access, slow to obtain, and impractical.

In contrast, the other surface temperature measurements (forehead, temporal, and inner canthi) all have direct contact with environmental conditions. All of these site measurements demonstrated an increase in surface tempera-ture with increases in environmental temperature. Additionally, the degree of variance decreased as the environmental temperature increased. This finding has been ob- served by Olsen [14], who demonstrated that warmer temperatures are associated with a more homogeneous skin thermal pattern when compared to the heterogeneous patterns observed under colder conditions. Our participants were passively standing in the thermal chamber. Under these conditions, the participants did not sweat. This is an important distinction, as van der Loo and colleagues [15] measured rectal, esophageal, tympanic, and forehead sites in 21 lightly clothed participants while they rested in a climatic chamber at 30°C/20% relative humidity for 20 minutes prior to performing stepwise increases in cycling exercise. The researchers reported that forehead temperature measurements over-estimated core temperatures due to increases in blood flow due to exercise induced heat and due to the onset of sweating. Current infrared scanning procedures for potential pandemic screening have provided guidelines that attempt to control environmental to reduce the potential for sweating due to climate.

We did not obtain consistent temperature measurements taken form the temporal site across the varying environmental conditions. The use of the infrared camera allowed us to visualize the hottest temperature area, thought to represent the flow of the temporal artery. Temporal-derived temperatures are based on an assumed high and constant flow by the temporal artery. This assumption has been challenged as blood flow variances have been reported during migraine headaches, use of vasoactive agents, vasocon- striction during non fever to fever transition, vasodilatation transition from fever to non fever states, and ambient temperature changes [16].

Regression analysis did not provide any significant correlations for core temperature measures and skin surface sites. This is not surprising when one observes the influence that environmental temperature and humidity have on skin surface temperature sites. It does not, however, negate the potential use of skin site temperature measures for screening potential fever individuals.

Recent research from Ring and colleagues [17] has suggested that the inner canthi may be a good surface location to obtain a reliable febrile temperature measure. The inner canthi regions have a profuse blood supply that comes from the Lacrimal branch of the Ophthalmic Artery. Their research support a threshold temperature for febrile detection set at 37.5 °C to account for the ± 0.5 °C tolerance associated with the thermal measuring systems and to retain screening sensitivity necessary to identify those with elevated temperatures. This recommendation comes from research from 191 Children (173 normal, 18 febrile) in which core was measured by axilla thermometry and ear tympanic radiometry and surface temperature (inner canthi) by infrared thermography. This recommendation is lower than the 38°C previously used for the SARS outbreak in China [18, 19].

In our investigation, the inner canthi temperature increased linearly with increasing environmental temperatures. The regression formula (R^2 = 1) for the relationship between the inner canthus and environmental temperature for this study was:

$$\text{inner canthi temperature Celsius} = 0.1752\,(\text{environmental temperature Celsius}) + 32.97$$

Under these climatic experimental conditions (15.5 °C - 26.6 °C), the temperature measurements from the inner canthi surface increased from 35.7 °C to 37.6 °C. This is important to note because the inner canthus temperature of 37.6 °C at the extreme temperature condition (26.6 °C) exceeds the threshold of 37.5 °C proposed by Ring and colleagues during research on non-febrile and febrile individuals in a clinical setting [17]. Our study findings are not in conflict with this threshold recommendation, but reinforce the concept that the room environment for imaging must be controlled. In the clinical setting, the room temperature standard for imaging procedures is specified as 18-25 °C [20], under these climatic conditions the inner canthi would not be expected to exceed the threshold. Infrared thermal scanning procedures suggested for potential pandemic screening also adhere to room controls that limit temperature to less that 24 °C, assuring that the threshold temperature would not be exceeded due to environment. If the environment for the scanning procedure cannot be maintained within clinical standards 18-25 °C, the above regression formula allows the practitioner to make a correction for the influence of ambient temperature and humi- dity on the inner canthi measurement under conditions of 15.5- 26.6 °C (60-80 °F) and 35% to 70% relative humidity.

In conclusion, as environmental temperature increased, the variance associated with the measurement of each temperature measurement site investigated decreased irrespective of the humidity. The rectal temperature was the highest but most consistent measurement of all core measures regardless of changes in environmental temperature and humidity. The axillary site provided the most consistent values of the surface sites. The inner canthus provided the best predictive (R^2=1) non-contact measurement of skin surface temperature across all trial conditions. Thus, the inner canthi may be useful in detecting individuals with high temperatures as a potential screening method for fever related pandemic diseases. Outside of the clinical setting, the inner canthi may need to be corrected for the influence of ambient temperature and humidity

Acknowledgement

The authors wish to recognize Dr Tony Guarino, Auburn University statistician, for his assistance in running the statistical analyses. Additionally, the authors wish to thank the reviewers for their analytical comments and suggestions.

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Address for Correspondence

Prof. David D. Pascoe. PhD

Auburn University

Thermal lab Director

2050 Memorial Coliseum

Phone: (334) 844-1479, Fax: (334) 844-1467
Email: pascodd@auburn.edu

(Manuscript received on 03.11.2008, revision accepted 10.04.2009)

A comparison of infrared thermography (IRT) and full-field laser perfusion imaging (FLPI) for assessment of hand cold challenge and dermal inflammation

Buick TA[1], Howell KJ[2], Gush R[3], Denton CP[2], Smith RE[1]

Departments of [1]Medical Physics and [2]Rheumatology, Royal Free Hospital, London. NW3 2QG. UK
[3]Moor Instruments, Axminster, Devon. EX13 5HU. UK

SUMMARY

The ideal instrument for assessing microvascular blood flux in the skin should a) be non-invasive, b) have an output that is proportional to blood flow, c) have a well characterised measurement depth, and d) measure across a large area. In the current study we provide a preliminary evaluation of these requirements in a novel blood flux imaging technique: Full-Field Laser Perfusion Imaging (FLPI). We compare it with infra-red thermography (IRT) in the healthy re-warming hand, and during experimentally induced dermal inflammation. We demonstrate that FLPI provides an instantaneous yet superficial blood flux imaging technique. We also highlight the potential of FLPI in the assessment of dermal inflammation and in discriminating active disease sites in localised scleroderma.

KEY WORDS: Infra-red thermography (IRT), Full-Field Laser Perfusion Imaging (FLPI), superficial blood flow, experimental dermatitis, localized scleroderma

VERGLEICH VON INFRAROTTHERMOGRAPHIE UND GANZFELD-LASER- PERFUSIONS-IMAGING IN DER BEURTEILUNG VON HÄNDEN NACH KALTWASSERTEST BZW. VON HAUTENTZÜNDUNGEN

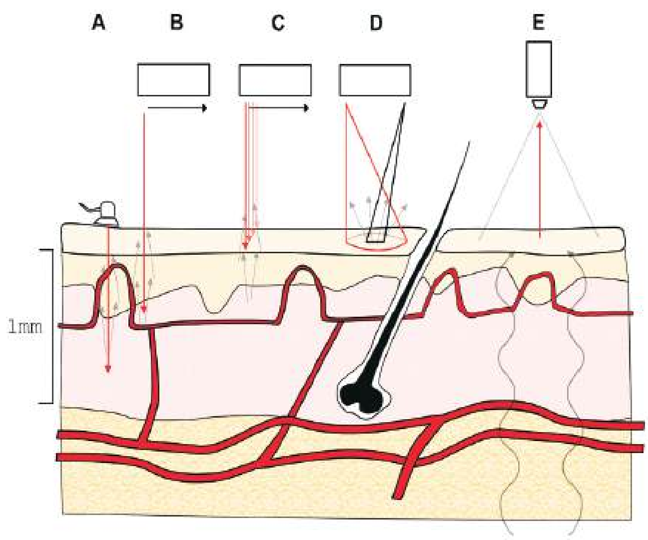
Ein ideales Instrument zur Beurteilung des Blutflusses in den kleinen Gefäßen der Haut sollte a) nicht invasive sein, b) ein Aussage liefern, die zur Blutfülle proportional ist, c) eine gut characterisierte Messtiefe besitzt und d) grße Flächen vermessen kann. Inder vorliegenden Untersuchungen werden diese Voraussetzungen für ein neues Verfahren überprüft, das den Blutfluus bildhaft darstellt: Ganzfeld- Laser-Perfusion Imaging (GLPI). Die Methode wurde mit der Infrarot-Thermographie bei der Wiedererwärmung einer gesunden Hand und bei experimentell erzeugten Entündungen der Haut verglichenn. Man kann zeigen, dass GLPI eine rasches bildgebendes Verfahren zur Darstellung der oberfächlichen Hautdurchblutung darstellt. Das Potential der GLPI bei der Beurteilung von Entzündungen der Haut und der Aktivitätseinschätzung bei lokalisierter Skleroderemie wurde beleuchtet.

SCHLÜSSELWÖRTER: Infrarotthermographie (IRT), Ganzfeld- Laser-Perfusion Imaging (GLPI), oberflächliche Durchblutung, experimentelle Dermatitis, localisierte Sclerodermie

Thermology international 2009, 19: 43-46

Introduction

The assessment and monitoring of inflammatory skin diseases relies heavily on visual examination by expert clinicians [1]. In some cases, such as in localised scleroderma, successful treatment pre-supposes the reliable detection of inflammation during the early stages of disease [2].



Laser Doppler flowmetry (LDF) and infra-red thermography (IRT) provide objective methods of assessment, although neither technique is perfectly suited to the task since LDF is limited to measurements of around 1mm^3 in tissue (Fig. 1a), and IRT provides no certainty of the depth from which heat is conducted to the skin surface (Fig. 1e) [2]. In an attempt to increase the measurement area of LDF, techniques such as Laser Doppler Perfusion Imaging (LDPI) and line scanning LDF have been developed (Fig. 1b and 1c). Such techniques can scan areas of up to 50x50cm, although instantaneous measurements are then limited by scan time. The benefits and limitations of these techniques are summarised in Table 1.

The limitations of point LDF, scanning LDF and IRT might be addressed by Full-Field Laser Perfusion Imaging (FLPI). By illuminating the skin with a diverging laser beam and assessing contrast in the resultant speckle pattern, FLPI is an instantaneous imaging technique with an output

Table 1
The benefits and limitations of various microvascular imaging techniques

	Point LDF	Scanning LDF	IRT	FLPI
Output proportional to blood flow	√	√	?	?
Non-Invasive	√	√	√	√
Instantaneous measurements	√	×	√	√√
Dynamic processes	√			√√
Measures across large skin areas	×	50 x 50 cm	√√√	8 x 12 cm
Imaging	×	√	√	√
Inexpensive	√	×	√×	×
Easy to use	√	√	√	√
Eye safe ?	moderately		√	√

that is related to blood flux. Using a CCD camera, an exposure of the randomly fluctuating speckle pattern is captured over a defined time period. From this exposure, speckle contrast (K) can be defined as the standard deviation (s) over the mean intensity *() in an area (typically 5x5 pixels) [3]:*

Exposure (or integration time) and speckle contrast follow a sigmoid relationship where an optimal contrast range is achieved around 4ms for a wide range of tissue blood flows encountered. Areas of high contrast correspond to a randomly fluctuating speckle pattern typical of a stationary object, whereas areas of low contrast represent movement which has altered the speckle pattern. Thus, when applied to the microvasculature, *K* is inversely related to red blood cell flux within an illuminated area.

During a short equipment loan we evaluated the benefits and limitations of FLPI, making comparisons with IRT in re-warming of the healthy hand and during experimentally induced dermal inflammation.

FLPI in Cold Challenge

The rate at which the hand re-warms after a one-minute cold challenge is indicative of, and reliant upon, micro-vascular function within the hand [4]. Thus, our first comparison involved the simultaneous imaging of re-warming with IRT and FLPI.

By aligning the field of view of both IRT and FLPI, we simultaneously recorded the hand re-warming of three healthy volunteers after a one-minute, 15°C cold challenge. Results showing a typical re-warming response in one volunteer are shown in Figure 2 where FLPI flux values pass the baseline with a similar trend, but different timescale to IRT. As expected, this illustrates that increased peripheral blood flow drives tissue re-warming. The results for all three volunteers are summarised in Table 2. It should be noted that the

Figure 2
Typical re-warming data from one volunteer captured simultaneously with FLPI and IRT showing flow returning around one minute before temperature. Percentage change from baseline is defined as the difference between a recorded value and baseline over the difference between baseline and the minimum value recorded. Errors inherent to the techniques are ±4% for IRT and ±10% for FLPI (error bars removed for clarity).

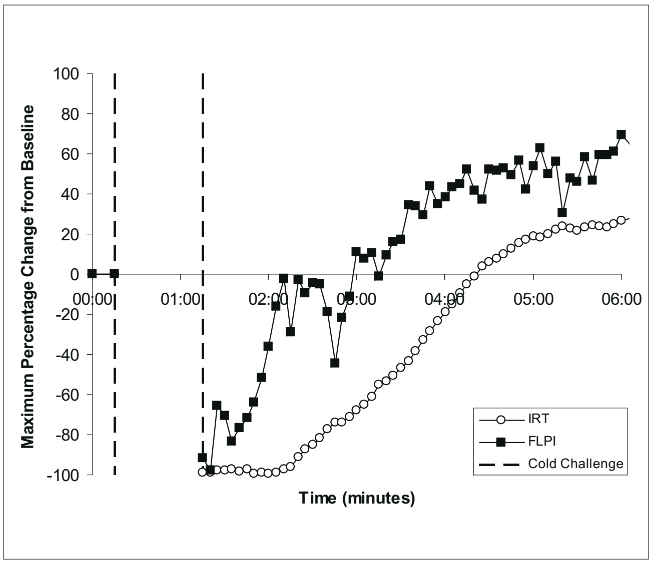


Table 2
Data from a 23yr male (A), 38yr male (B) and 28yr female (C) showing the baseline, minimum, maximum and return-to-baseline time post-challenge. †Data from volunteer C did not return to baseline temperature although a hyperaemic flux response was observed with FLPI. The time to reach the maximum temperature of 35.1°C for volunteer C was 5min 15s.

	FLPI (Flux)			IRT (°C)		
Volunteer	A	B	C	A	B	C
Baseline	465.8	443.4	458.4	32.4	34.7	35.5
Minimum	153.9	120.6	248.1	24.9	27.9	27.0
Maximum	684.2	721.2	487.8	34.6	35.2	35.1
Return to baseline	2min 5s	2min 5s	4min 25s	3min 30s	4min 15s	†

Figure 3
Snap shots from our FLPI re-warming overlay video showing (a) post-cold challenge, (b) at 1 minute 30 seconds, and (c) and at 3 minutes 30 seconds. A black line represents the FLPI field of view.

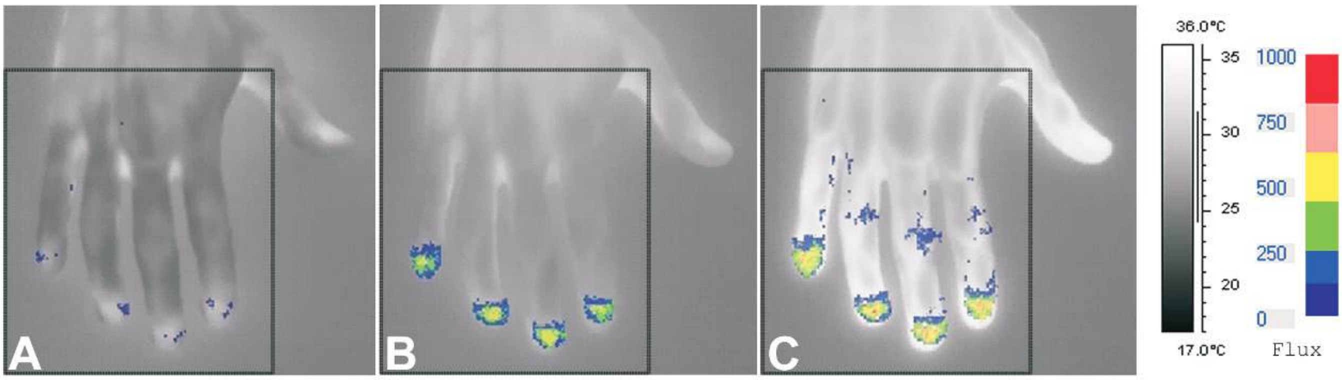
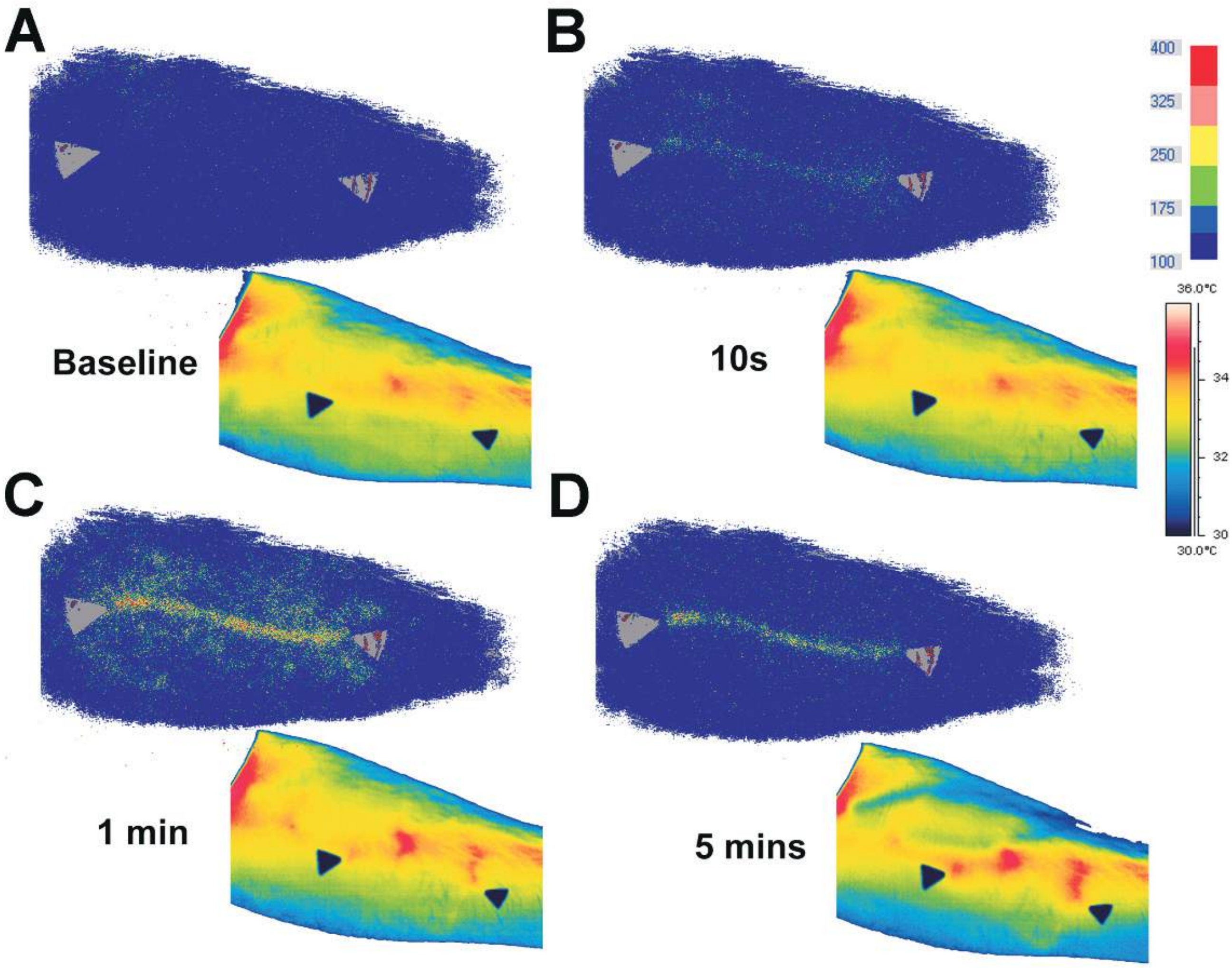


Figure 4
Selected images showing simultaneous imaging with FLPI and IRT of a mechanically induced inflammatory response where images represent a) baseline, b) immediately post-scratch, c) one minute post-scratch and d) five minutes post-scratch. Images have been scaled for presentation purposes.



female volunteer did not return to baseline temperature, although a delayed hyperaemic response was observed with FLPI. Data from the two male volunteers followed the trend illustrated in Figure 2.

In order to demonstrate the depth at which FLPI flux values are taken, we performed a high pass filter on the FLPI data set (essentially eliminating 'background' flux) and overlaid the resultant images on corresponding greyscale IRT images. This was a subjective alignment and no attempt was made to transform or co-register the images. By combining these two imaging techniques, Figure 3 illustrates the superficial nature of FLPI measurements. The dilation of deep vessels as observed on the greyscale thermogram has no corresponding increase in flux on the FLPI images. Therefore we conclude that FLPI provides a measurement of flux in the very superficial layer of the dermis.

FLPI in Inflammation

In order to induce inflammation experimentally, we ran a small blunt stick lightly between two markers placed on the forearm of one healthy volunteer. In performing this "scratch-test" our aim was to mechanically degranulate dermal mast cells in order to release histamine, eliciting a basic inflammatory reaction [5]. The skin was not broken, and no visible scratch was produced.

Baseline images were captured simultaneously with FLPI and IRT (Fig 4a), followed by images at five second intervals post-scratch. Figure 4 illustrates a selection of our results across a time period of five minutes. Increased flow between the markers was observed almost instantly with the FLPI technique (Fig 4b), while two localised regions of temperature change are observed at one minute post-scratch (Fig 4c). These localised temperature changes did not correspond with an increase in FLPI flow; therefore we conclude that the physiological processes driving them occur below the very superficial penetration depth of FLPI. The subdermal plexus is supplied by perforator vessels running perpendicular to the skin surface. During flap perfusion studies, these vessels are known to produce hotspots on IRT images [6]. We therefore suggest that the localised temperature changes shown in Fig 4c are a result of perforator vessels dilating so that superficial blood flow may increase.

Conclusions

Our preliminary results show that, while different aspects of the cold challenge are imaged, FLPI follows a similar trend but different timescale to IRT. However, during experimentally induced inflammation FLPI selectively images our scratch test site while IRT only shows the dilation of perforator vessels. Thus, FLPI is a superficial technique which provides high resolution instantaneous imaging of microvascular blood flow. FLPI shows great potential in the assessment of inflammatory skin diseases such as localised scleroderma, where point LDF measurements are better predictors of disease activity than IRT [7]. However, while FLPI may dramatically reduce the scan time compared to laser Doppler techniques, it has a limited field size and is susceptible to movement artefact. The speckle contrast technique that FLPI employs has been used successfully in the quantification of cerebral blood flow [8], and has potential for intraoperative assessment of tissue perfusion [9]. However, further study is required to explore whether this technique will ultimately supplant LDF point measurements or thermography in the assessment of inflammatory skin diseases such as localised scleroderma.

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Address for Correspondence

Tim A. Buick

Trainee Clinical Scientist
Department of 1Medical Physics, Royal Free Hospital, London. NW3 2QG. UK

Email: tim.buick@yahoo.com

(Manuscript received 06.03.2009, accepted 02.04.2009)

Reproducibility of the Hot Spot Count In Patients With Fibromyalgia: An Intra- and Inter-Observer Comparison

K. Ammer [1, 2]. B. Engelbert [1]

[1] Institute for Physical Medicine and Rehabilitation, Hanuschkrankenhaus, Vienna, Austria
[2] Medical Imaging Research Group, Faculty of Advanced Technology, University of Glamorgan, Pontypridd, UK

SUMMARY

AIM OF THE STUDY To investigate the inter- and intra-observer reproducibility of visually identified hot spots on thermal images recorded from fibromyalgia patients

METHODS: Series of thermal images (9 images in each) of 20 patients diagnosed as fibromyalgia according to the ACR criteria were evaluated by two independent readers and the number of hot spots was determined. One investigator repeated the hot spot count a week after the first test. A hot spot was defined as a small area at least 0.5 degrees warmer than the surroundings. Only hot spots located nearby the sites typically checked for tenderness were accepted. The number and the location of hot spots in all three assessments were analysed statistically.

RESULTS: The intra-rater reproducibility was moderate to fair (first count; number of hot spots: median 8.5, 5th percentile: 4.0, 95th percentile: 12.0; second count: median number: 7.5, 5th percentile:3.1; 95th percentile: 12.0, Wilcoxon-test: 2-tailed p=0.53, correlation coefficient= 0.67), the inter-rater reproducibility was poor (number of hot spots: median: 10.0, 5th percentile: 7.0, 95th percentile: 13.0; Wilcoxon-test with first count: 2-tailed p=0.001, Wilcoxon-test with second count : 2-tailed p=0.0041; correlation coefficient with first count=0.29, with second count=0.21). The sites with the highest rate of disagreement were the medial kneet (intra-rater) and the lower cervical spine (inter-rater), the highest agreement was found at the lateral epicondyle (intra-rater) and the occiput (inter-rater).

CONCLUSION: The intra-rater repeatability ofthe hot spot count is acceptable, the intra-observer repetabilty is poor. Improvement of the reliability of hot spot identification is needed and might be achieved by software assisted identification of hot spots.

KEY WORDS: hot spot, fibromyalgia, reproducibility, thermal imaging

REPRODUZIERBARKEIT DER ZÄHLUNG VON HOT SPOTS BEI PATIENTEN MIT FIBROMYALGIE: EIN INTRA- UND INTER-INDIVIDUELLER VERGLEICH

ZIEL DER STUDIE war es , die Wiederholbarkeit der Zählung von "Hot spots" in Wärmebildern von Fibromyalgie-Patienten bei demselben und bei zwei unterschiedlichen Untersuchern zu bestimmen.

METHODE: Zwei unabhängige Untersucher beurteilten 20 Serien von Wärmebildern (9 Bilder pro Serie) von Patienten, die nach den ACR Kriterien als Fibromyalgie diagnostiziert worden waren, und bestimmten die Zahl der Hot spots. Ein Untersucher wiederholte die Auswertung eine Woche später. Hot Spot wurde jedes kleine Areal bezeichnet, das zumindest 0,5 ° wärmer ist als seine Umgebung. Es wurden nur jene Hot Spots berücksichtigt, die in den Körperregionen zu finden waren, die typischerweise bei Fibromyalgieverdacht auf Berühungsempfindlichkeit untersucht werden. Die Anzahl und Lokalisation der Hot Spots in allen drei Ausswertungen wurden statistisch analysiert.

ERGEBNISSE Die intra-individuelle Reproduzierbarkeit war mittelmäßig (erste Auswertung; Anzahl der Hot Spots: Median 8.5, 5. Perzentile: 4.0, 95. Perzentile: 12.0; zweite Auswertung: mediane Anzahl: 7.5, 5.Perzentile:3.1; 95.Perzentile: 12.0, Wilcoxon-Test: 2-seitiges p=0.53, Korrelationskoeffizient= 0.67). Die inter-individuelle Reproduzierbarkeit war gering (Auswertung durch den zweiten Untersucher: mediane Anzahl der Hot spots 10.0, 5. Perzentile: 7.0, 95. Perzentile: 13.0; Wilcoxon-Test mit der ersten Auswertung: 2-seitiges p=0.001, Wilcoxon-Test mit der zweiten Auswertung : 2-seitiges p=0.0041; Korrelationskoeffizient für die erste Auswertung=0.29, für die zweite Auswertung=0.21). Die Regionen mit der geringsten Übereinstimmung waren die Knieinnenseite (intra-individuell) und die untere Halswirbelsäule (inter-individuelle), die beste Übereinstimmung fand sich für den lateralen Epikondylus (intra-individuell) und okzipital (inter-individuell).

SCHLUSSFOLGERUNG: Die intra-individuelle Wiederholbarkeit der Zählung von Hot Spots ist ausreichend, die intra-individelle Wiederholbarkeit ist schlecht. Eine verbesserte Zuverlässigkeit des Nachweises von Hot Spots ist wünschenwert und dies kann möglicherweise durch den Einsatz von Computerprogrammen erreicht werden.

SCHLÜSSELWÖRTER: hot spot, Fibromyalgie, Reproduzierbarkeit, Thermographie

Thermology international 2009, 19: 47- 51

Introduction

Fibromyalgia is a chronic disease of unknown etiology. According to the classification criteria of the American College of Rheumatology [1] the disease is characterized by chronic (i.e. symptoms longer than 3 months) widespread pain (i.e. pain in both sides of the body, pain above and below the waist ; in addition, axial skeletal pain must be present.) plus tenderness/pain in 11 of 18 predefined sites on digital palpation. The diagnostic value of infrared thermal imaging for fibromyalgia has been discussed recently [2]. The majority of studies reported that tenderness and hot spots concide in typical body sites. However, identification of hot spots in thermal images may be difficult, and neither intra-observer nor inter-observer repeatability of hot spot identification was comprehensively investigated.

Head er al, reported different counts of hot spots in thermal images of female breast recorded with different equipment [3]. They differentiated small and large focal hots spots and found different percentages of these features when using a focal plane array camera ore a single element scanning system. However, a description of focal hot spots is not provided in this paper, although abnormality was based on the temperature difference to the corresponding area of the contralateral side. Overall agreement between three independent investigators in evaluation of breast infrared thermal images was 76% [4]. Based on subjective and semi-objective criteria all three investigators' readings agreed on 107 of 141 breasts. Comparison of paired results of the three investigators resulted in 79 to 94% agreement for the six comparisons (three investigators and two breasts) with an overall agreement of 88% (371 of 424 paired comparisons).

In patients with epicondylitis, hot spots were defined by a temperature gradient of 1- 3 °C to the surrounding tissue [5]. Ammer related temperature differences of 1 and 0,5 degrees between the lateral epicondyle and the skin 5cm distal from the epikondyle with the pressure threshold at these points of the elbow region [6]. A temperature difference of at least 0,5degrees was also used a definition for hot spots in thermographic investigations of fibromyalgia patients [2, 7].

Methods

Series of thermal images (9 images in each) of 20 patients diagnosed as fibromyalgia according to the ACR criteria were evaluated by two independent readers and the number of hot spots was determined. One investigator repeated the hot spot count a week after the first test. A hot spot was defined as a small area at least 0.5 degrees warmer than the surroundings. Only hot spots located nearby the sites typically checked for tenderness (Figure 1) were accepted.

Thermal images were taken with an Agema870 Infrared Scanner at a room temperature of 24°C after the patients

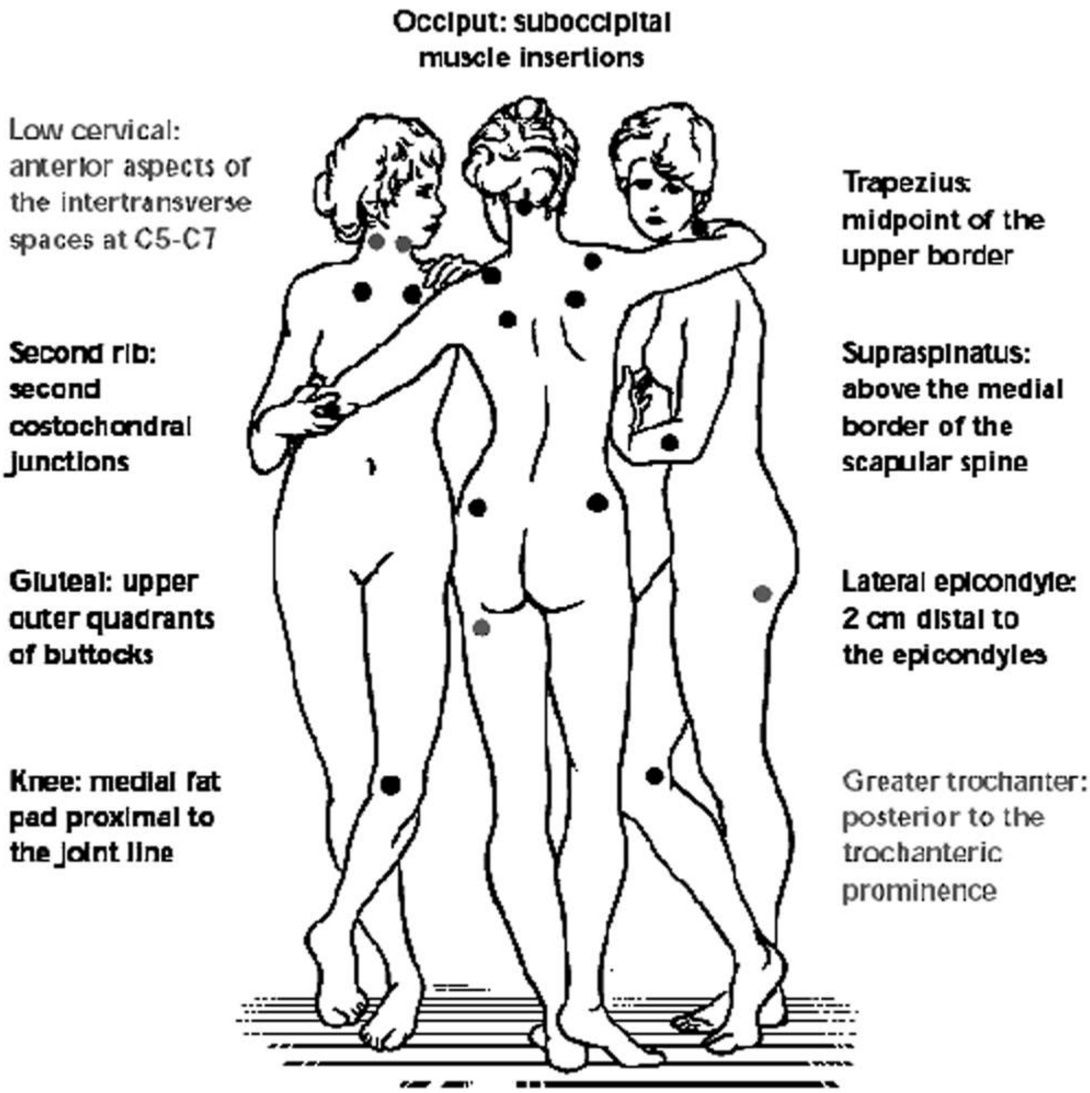


Figure 1
Typical tender sites in fibromyalgia

had acclimatized for 15 minutes. The thermal images were processed by the CATS software using the automatic mode for false colour setting that devides the range between the minimum and maximum temperature by 16. Low pass filtering removed low temperatures from the image which results in larger areas of high temperature.

The number and the location of hot spots in all three assessments were analysed statistically. The number of hot spots revealed in the 3 sets of reading were compared by non-parametric tests The 95% confidence intervals of the differences in ratings of all possible comparison were plotted. Finally, the reliabilty factor alpha was calculated for the total hot spot count. Cohens kappa was determined for all individual sites. SPSS 100 vor Windows was used for calculations. .

Results

The images from 20 patients with fibromyalgia, 18 females (age: 56 ± 9 years) and 2 males (age: 50 ± 6 years) were evaluated.

The intra-rater reproducibility was fair to good (reliability coefficient 0.80.) The first evaluation revealed a median of 8.5hot spots (5th percentile: 4.0, 95th percentile: 12.0); The second reading obtained a median of 7.5 hot spots (5th percentile:3.1; 95th percentile: 12.0), The 2-tailed p=0.53 from the Wilcoxon-test:was not significant, both hot spot counts had a correlation coefficient of 0.67. Figure 2 A is the scatterplot of the first and second hot spot count of th first investigator.

The inter-rater reproducibility was poor (reliability coefficient0. 047 and 0.36 .) The second investigator obtained median of 10.0 hot spots (5th percentile: 7.0, 95th percentile: 13.0) Both comparisons with the hot spot counts of the first investigator obtained signifikant differences (Wilcoxon-test for the first evaluation: 2-tailed p=0.001, Wilcoxon-test for second evaluation: 2-tailed p=0.0041) The correlation coefficient were small (for the first evaluation= 0.29, for the second evaluation=0.21). .Figures 2B and 2C plot the counts of the first investigator against the results of the second investigator.Figure 3 shows the mean and 95% confidence intervals of the differences in the hot spot count of all possible comparisons

The reliability coefficient alpha indicated good intra-rater agreement, but por to moderate inter-rater agreement. Ta-

Table 1
Agreement in hot spot counts (reliability coefficient alpha)

	alpha	Single Measure Intraclass Correlation (ICC)	
		ICC	95% confidence intervall
First observer, 1st versus 2nd count	0.80	0.68	0.35 to 0.86
First observer, 1st count versus second observer	0,47	0.20	-0.12 to 0-53
First observer, 2nd count versus second observer	0.36	0.15	-0.15 to 0.48

Figure 2 A
First and second count of the first observer

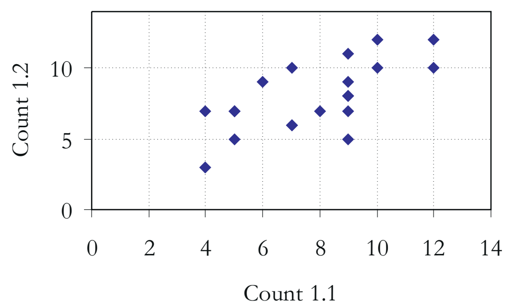


Figure 2B
First count, both investigators

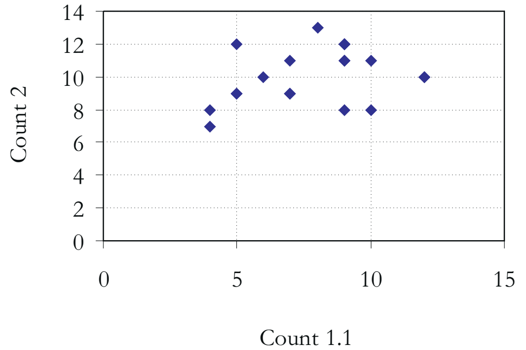


Figure 2C.
Second investigator versus 1st count of first investigator

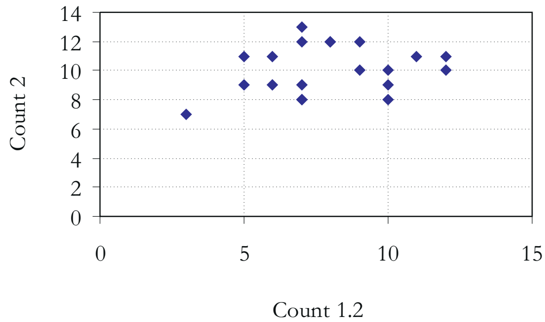
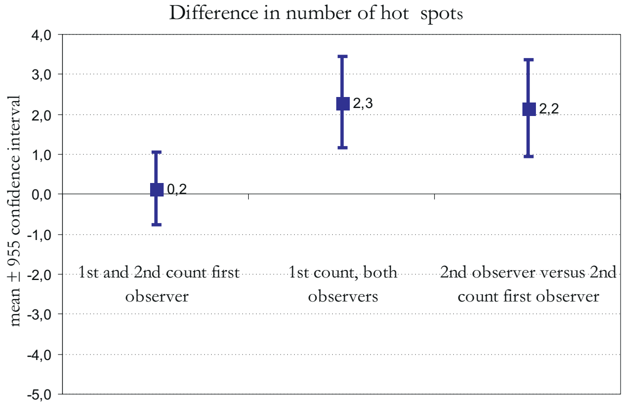


Figure 3
Difference in number of hot spots



ble 2 shows the kappa values for all possible comparisons of the assessment of individula sites. In the same observer, the highest kappa value were calculated for the right lateral epicondyle (κ= 0.69); and the lowest values for the right medial knee (κ= -0.08). In the comparison with the second observer, the best kappa values were obtained at the left occiput (2nd assesment of first observer versus 2nd observer) and at the right lateral epicondyle (1st assessment of first observer versus 2nd observer). The poorest degree of inter-rater agreement was revealed at the site left lower cervical. Overall, kappa value for comparisons between observers were lower than within investigators.

Discussion

Identification of hot spots is a semi-quantitative approach toanalyse infrared images. Combined with vascular patterns, hot spots have been used in the traditional way of evaluation of thermal images of the breast [8].This approach based on experience and subjective criteria was criticised [9]. However, the reproducibility of qualitative signs for diagnosing breast disease was seldom investigated. The study by Head et al [4] does not provide details in which thermographic signs of breast disease the three independent investigators agreed or disagreed.

The diagnostic value of hot spots over tender tendon insertions and muscles was also questioned. In a series of experiments Swerdlow and Dieter [10] were unable to find a clear relationship between tenderness or decreased pressure threshold for pain, as described by Fisher [11]. However, the number of hot spots was not different whether alcohol was sprayed onto the skin or not [10]. Alcohol was also used in the early days of breast thermography to increase the contrast of infrared thermal images, but became obsolete due to generated artifacts and the transient effect of increased contrast [9].

From the view of pattern recognition, hot spots can be regarded as elements of an image which are characterised by a boundary, shape and texture. Several attempts were made to

Table 2
Kappa values of all possible comparison in inidividual sites

Site of tender /hot spot	First observer, 1st versus 2nd count	First observer, 1st asessment versus second observer	First observer, 2nd assessment versus second observer
Occiput: suboccipital muscle insertions			
Right hand side	0.04	0.20	0.30
Left hand side	0.04	0.34	0.62
Low cervical: anterior aspects of the intertransverse spaces C5-C7			
Right hand side	0.42	-0-05	0.04
Left hand side	0.59	-0.27	-0.29
Trapezius: midpoint of the upper border			
Right hand side	-0.05	-0.01	0.12
Left hand side	0.35	0.47	0.22
Second rib: scond costochondral junctions			
Right hand side	0.32	-0.11	-0.14
Left hand side	0.34	0.02	0.38
Supraspinatus: above the medial border of the scapular spine			
Right hand side	0.32	0.03	0.41
Left hand side	-0.17	0.24	0.16
Lateral epicondyle: 2 cm dtistal to the epicondyles			
Right hand side	0.69	0.61	0.39
Left hand side	0.57	0.08	0.14
Gluteal: upper puter quadrants of buttocks			
Right hand side	0.50	0.0	0.20
Left hand side	0.51	0.38	0.12
Greater Trochanter: Posterior to the trochanteric prominence			
Right hand side	0.31	0.14	0.21
Left hand side	0.38	0.38	0.58
Knee: medial fat pad proximal to the joint line			
Right hand side	-0.08	-0-09	-0.21
Left hand side	0.64	-0.08	0.32

analyse to analyse infrared breast thermal images based on the principles of pattern recognition. Jakubowska et al [12] used image histograms and co-occurrence matrix for the analysis of thermal images, a group in Singapore based analysis of thermal breast images on image histograms [13], edge detection [14], image segmentation [15], artificial neural networks [16] and learning fuzzy neural memory structures [17]. A multi-national group used a similar approach including fuzzy classifications of breast thermograms [18]. Qi combine edge detection with texture recognition in thermal images for the assessment of assymmetry [19-21]. However, to the author´s knowledge a similar technique of automatic pattern recognition was seldom used for thermal images from patients with musculo-skeetal problems. A Dutch group assessed thermal homogenity in infrared thermograms from patients witrh complex regional pain syndrome and reported a higher diagnostic accuracy for this parameter than for the mean temperature over the affected limb [22]. Recently, artificial neural networks were used for diagnosing carpal tunnel syndrom from infrared images of hands [23].

A software based, automatic identification of hot spots may improve the repeatability of hot spot count in thermal images from patients suffering from fibromyalgia. This may increase the diagnostic value of hot spot count in fibromyalgia patients and may improve the sensitivity to change of counting hot spots. At the moment hot spot count does not seem to be a feasable outcome measure for fibromyalgia trials.

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Address for correspondence

Prof Kurt Ammer MD, PhD

Institute for Physical Medicine and Rehabilitation, Hanuschkrankenhaus, Heinrich Collinstr 30, A -1140Vienna, Austria

Email: KAmmer1950@aol.com

(Manuscript received 10.02.2009, accepted on 02.04.2009)

13th Congress of the Polish Association of Thermology

and

Certifying course: "Practical application of thermography in medical diagnostics"

Zakopane, March 27 – 29, 2009

Scientific Committee:

Prof. Jung Anna MD,PhD
Zuber Janusz MD,PhD
Prof. Ring Francis Dsc
Prof. Wiêcek Boguslaw
Murawski Piotr MSc,Bsc.
Prof. Klosowicz Stanislaw
Prof. Ammer Kurt MD,PhD

Organizing Committee:

Prof. Jung Anna MD,PhD
Zuber Janusz MD,PhD
Kalicki Boleslaw MD,PhD

Conference venue: Hotel "HYRNY"
Zakopane, Pilsudskiego str 20

Organizers: Paediatric,Nephrology and Alergology Clinic
Military Institute of Health Service
phone: +48 22 6817236; fax: +48 22 6816763

Chairman of the Organizing and Scientific Committee Prof. Anna Jung MD,PhD

Scientific and Social Programme

Friday, 27th March 2009,

19:45 Welcome

Saturday, 28th 2009

9:00-10:30 **Session I**
Chairmen: Prof. K. Ammer, Dr med. J. Zuber.

. **Opening lecture:** *Prof. Ring E.F.J., Vardasca R.*
The first International Symposium of Medical Thermography New York December 1963: Lessons from the past.

Prof. Ammer K.
Same Magnitude of Temperature Gradients When Raynaud´s Phenomenon Is Present In Individual Or In All Fingers.

Dr med. Mikulska D., Prof. Maleszka R.
Usefullness of thermal imaging in evaluation and monitoring the treatment of morphea lesions.

10:30-11:00 **Coffee break**

11:00 – 13:30 Session II
Chairman: Prof. EFJ. Ring, Dr med. J. Zuber

Vardasca R, Prof. Ring EFJ.
Symmetry of temperature distribution in the upper and the lower extremities.

Prof. Wiêcek B.
Attenuation of infrared radiation by humid atmosphere.

Prof. Nica A, Mologhianu G, Murgu A, Ojoga F, Sirghii B, Miron L
Thermography Study of Patients with Stroke in the Post-acute and Chronic Stage Treated in a Rehabilitation Department.

Prof. Hisashi Usuki
A history thermological study about carcinoma and the problems of Medical Association of Thermology in Japan.

Murawski P, Prof. Jung A, Dr med. Zuber J, Dr med. Kalicki B.
Method of the anatomical point selection on the face in the thermographic data.

13:30-15:00 Lunch

15:00- 17:00 Training course
Chairman: Prof. B. Wiêcek, Prof. S. Klosowicz

Prof. Wiêcek B.
Heat transfer basis useful for infrared thermography

Rutkowski P,
New developements in thermographic equipment

Prof. Klosowicz S.
Problems of Physics In Thermographic Studies.

19.00-22.00 Dinner

Abstracts

THE FIRST INTERNATIONAL SYMPOSIUM OF MEDICAL THERMOGRAPHY NEW YORK DECEMBER 1963: LESSONS FROM THE PAST.

E.F.J.Ring, R Vardasca.
Medical Imaging Research Unit, University of Glamorgan, CF37 1DL UK.

Infrared imaging before the late 1950's was a military classified technology.

The New York Academy of Sciences announced a conference in 1963, to bring together the pioneers in the first medical studies. This meeting's published proceedings provide a detailed record of that historical symposium, with its surprising range of clinical applications, considering the early camera technology of the time.

The introduction was written by J.Gershon Cohen and R.Bowling Barnes, the latter being the engineer who had built an infrared scanner for medical applications.

This was followed by a short history of Medical Thermometry (Gershon Cohen), a paper on elevation of body temperature in disease, and a paper by the well known pioneer Ray Lawson on early applications of thermography. The next section is on technology covering the early American and English cameras, a paper on densitometric analysis, the first attempts at quantifying thermograms and more from Ray Lawson on temperature measurements of localized pathological processes.

The third section is the largest of over 200 pages on clinical applications. There are 13 papers on medical applications and a further section of 4 papers on breast diseases. The British surgeon K.Lloyd Williams wrote on the value of infrared thermometry as a tool in medical research. Two American authors Rosenberg and Stephanides described the use of thermography in the management of varicosed veins and venous insufficiency. Another group described thermography in peripheral vascular disease. Other subjects included are Orthopaedics, Trauma, Neurology, thoracic and abdominal conditions, obstetrics and rheumatology. Veterinary medicine was presented by Wendall Smith.

In the breast diseases section were papers on the need for early diagnosis to improve the results of breast surgery, Temperature in breast disease (Lloyd Williams) Mass screening for breast cancer (P. Strax) and advances in mammography and thermography by Gershon Cohen.

Considering the passage of time and the remarkable changes in imaging technology, enhanced by computer processing, this historic meeting must have beeen ahead of its time.

Few of our modern applications for thermography had not been tried or envisaged, even with the primitive technology of the time. Some of the papers showed how carefully the authors had considered their data, and studied the relevant pathology to explain the changes in skin temperature. However, the extraction of temperature data from the early thermograms was difficult and certainly unreliable. In most cases thermal printing from slow scans (5 minutes or more) could only be analysed by densitometry, and the thermal print-outs were unstable after just a few days of storage. Today's high speed and higher resolution images, stored and analysed directly by computer has revolutionized the technique. Now some 45 – 50 years later, we know much more about the reliability of thermography and how that can be optimized. Do we understand any more than the pioneers of thermal physiology and the effects of pathology on neighbouring skin temperature? I believe that this symposium which was followed a few years later by others in Europe, particularly in Strasbourg France and Leiden The Netherlands have provided a good foundation for medical thermography despite the technical limitations. While not all the expectations described have been borne out, the majority have been repeated over time with improving camera technology.

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SAME MAGNITUDE OF TEMPERATURE GRADIENTS WHEN RAYNAUD´S PHENOMENON IS PRESENT IN INDIVIDUAL OR IN ALL FINGERS.

Kurt Ammer
Institute for Physical Medicine and Rehabilitation, Hanuschkrankenhaus, Vienna, Austria
Medical Imaging Research Group, Faculty of Advanced Technology, University of Glamorgan, Pontypridd, UK

Background: Secondary Raynaud´s phenomenon may affect individual fingers only and it was proposed that the temperature difference between finger tips and dorsum of the hand is larger than in patients suffering from primary Raynaud´s phenomenon which affects by definition all fingers.

Aim of the study: Comparison of temperature gradients from the dorsum of the hand to the fingertip in patients presenting with thermographic signs of Raynaud´s phenomenon in all or in individual fingers.

Study design: Retrospective analysis of thermal images of consecutive 135 patients with suspected Raynaud´s phenomenon

Method: After acclimatization for 15 minutes to a room temperature of 24 degrees, the hands were positioned on a table, and images in the dorsal view for both hands were recorded. Then the hands, covered with plastic gloves, were fully immersed for 1 minute in water of 20°C. Immediately after taking off the gloves, and at in interval of 10 minutes 3 other thermal images were captured. Spot temperatures were measured on the tip and over the mid of metacarpal bone of each finger. Gradients were calculated by subtracting the metacarpal temperature from the temperature of the finger. Raynaud´s phenomenon was diagnosed when negative temperature gradients > 1° were detected 20 minutes after the cold challenge. Patients were allocated with respect to the distribution of Raynaud`s phenomenon. The magnitude of temperature gradients in patients with Raynaud´s phenomenon present in all or in individual fingers was compared statistically.

102 females (age range: 14 to 81 years) and 33 males (age range: 17 to 83 years) were investigated. In total, 69 patients (8 males,61 females) showed Raynaud´s phenomenon in all fingers, and 28 subjects (10 males, 18 females) had involvement of individual fingers. The remaining 37 subjects (14 male, 23 females) presented with normal temperature recovery after the cold challenge.

No significant difference in the magnitude of temperature gradient was obtained in patients with Raynaud´s phenomenon present in all or in individual fingers. A higher proportion of females (78%) than males (66%) presented with thermographic signs of Raynaud´s phenomenon. Involvement of all fingers, was a common finding in our sample,which was not restricted to young age, as slow recovery of temperature after cold challenge was detected in all fingers in 20 of 29 patients aged 65 years or older.

Conclusion: There is no relationship between the magnitude of temperature gradients and the distribution of thermographically identified Raynaud`s phenomenon in all or in individual fingers

USEFULNESS OF THERMAL IMAGING IN EVALUATION AND MONITORING TREATMENT OF MORPHEA LESIONS

Danuta Mikulska, Romuald Maleszka
Department of Dermatology and Venereology, Pomerania Medical Academy, Szczecin

Objective: The aim o the study was to define the usefulness of thermal imaging in detection and monitoring the response to treatment of morphea skin lesions.

Materials and methods: The studies included 14 patients suffering from morphea (9 female, 5 male), aged from 16 to 65 years. The diagnosis of morphea was based on typical clinical picture, there were no evidence of systemic involvement and no history of Raynaud's phenomenon. Laboratory tests: scleroderma antibodies (ACA, SCL70) in all patients were negative. ThermaCAM SC500 thermographic camera was used in the study. All cases were confirmed by histopathology. The patients were separated in to different disease subsets: localized scleroderma, generalized morphea and linear scleroderma. Thermal images of 104 morphea plaques were evaluated and compared with 104 thermograms of symmetrical skin regions. The average and maximal temperatures were estimated. All patient's skin morphea lesions were monitored during 1.0 to 1.5 year of the treatment.

Results: 1/ All skin morphea lesions were hyperthermic. 2/ The higher mean of median temperature was recorded in the central regions of morphea plaques, with the increased fibrosis revealed in the histopathological examination. 3/ Thermal images of 104 morphea lesions had higher mean of median temperature value than 104 healthy summetrical skin regions of the same group of patients (>1.7°C, $p<0.001$). 4/ Thermal images of 104 morphea plaques had higher mean of maximal temperature value than 104 healthy symmetrical skin regions of the same group of patients (> 1.9°C, $p<0.001$). 5/ The clinical improvement of morphea lesions correlated with decrease of local hyperthermia of morphea plaques.

Conclusions: Thermal imaging is helpful in evaluate and monitoring the response to treatment of morphea skin lesions.

SYMMETRY OF TEMPERATURE DISTRIBUTION IN THE UPPER AND THE LOWER EXTREMITIES

Ricardo Vardasca, Prof. Francis Ring
Medical Imaging Research Unit, Faculty of Advanced Technology University of Glamorgan, Pontypridd, RCT, CF37 1DL, United Kingdom

Infrared thermal imaging is being increasingly utilised in the study of neurological and musculoskeletal disorders. In these conditions data on the symmetry (or the lack of it) of skin temperature provides valuable information to the clinician. The fist suggestion of usage of this indicator was made by J. Freeman in 1937 measuring it with contact thermocouples. The first measuring using imaging was performed by Lloyd-Williams on an experiment dated of 1964. Some other studies had been carried out since then but with the appearance of current generation of higher resolution cameras and a lack of comparison between total body views with close-up regional views in both anterior and dorsal visualisations existed.

In this study skin temperature measurements have been carried out using thermograms of 39 healthy subjects. Measurements were obtained from an infrared camera using the CTHERM application developed at the authors' research unit. CTHERM is capable of calculating statistical data such as temperature averages and standard deviation values in corresponding areas of interest on both sides of the body. Results show that in healthy subjects the overall temperature symmetry difference was at most 0.37ºC ± 0.25ºC in total body views and 0.36ºC ± 0.11ºC in regional views. Total body views and regional views produced comparable results although better results were achieved in regional views. Using a high-resolution camera the study achieved better results on thermal symmetry in normal subjects than previously reported. Symmetry assumptions can therefore now be used with higher confidence when assessing abnormalities in specific pathologic states.

ATTENUATION OF INFRARED RADIATION BY HUMID ATMOSPHERE

Boguslaw Wiecek
Technical University of Lodz, Institute of Electronics, Poland

IR radiation transmission of the atmosphere is an important factor during the thermovision remote sensing and measurement. Transmission coefficient of the atmosphere depends on its content and it is attenuated mainly due to the vapor concentration. Every calibrated thermal camera should be equipped with the digital system which implements the transmission model of the atmosphere. The model presented in this work is based on Beer and Bouguer laws (Fig.1, eqn. 1).

In order to calibrate the model, a single measurement or data from the literature has to be used. The model allows evaluating the transmission coefficient versus distance, relative humidity,

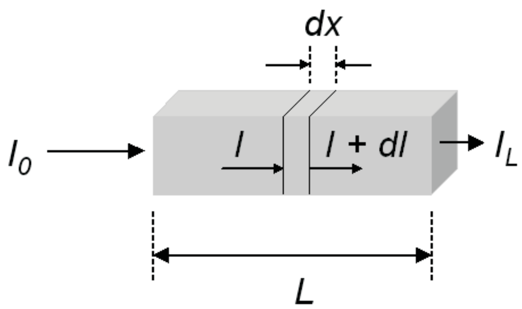

Figure 1
Attenuation of radiation intensity passing through the gas

gases contents and wavelength. The model for the water vapor is based on the fundamental relation (1)

$$\tau(RH, T_a L) = e^{-\alpha(\lambda)\frac{p_s RH}{k_B T_a} L}$$

where: L –distance, p –saturation pressure, T –temperature of the atmosphere, and $\alpha(\lambda)$ – the expermentally tuned factor stronly dependent on the wavelenght

The exemplary results of the model are presented in Fig. 2

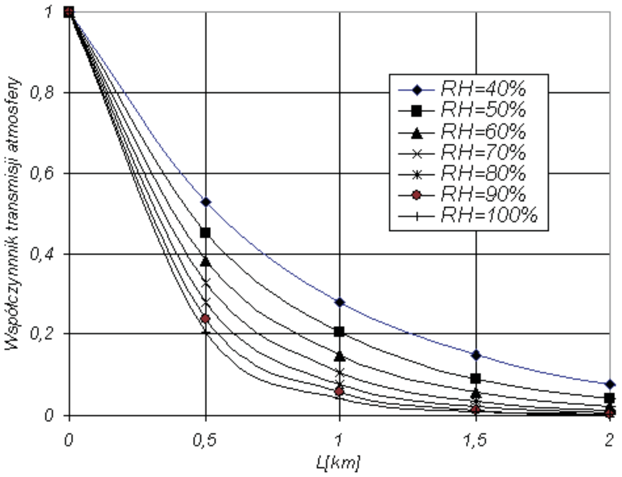

Figure 2
Transmission coefficient of the atmosphere for T_a=295,15K, $\lambda = 5\mu m$

The proposed simplified model of transmission atmosphere is suitable for implementation in the thermal cameras. A simple digital controller of the camera can calculate the transmission coefficient and correct the temperature measurement. The model takes in account both scattering and absorption due the quantum effects when the photons are interacting with the molecules.

THERMOGRAPHY STUDY OF THE PACIENTS WITH STROKE IN THE POST-ACUTE AND CHRONIC STAGE TREATED IN A REHABILITATION DEPARTMENT

Adriana Sarah Nica, Gilda Mologhianu, Andreia Murgu, Florina Ojoga, Brindusa Sirghii, Lili Miron
University of Medicine and Pharmacy, Bucharest, Romania

Introduction:The pacient with stroke develops, after the central neurological injury, secundary problems related to the central and especially peripheral thermal adaptation system in the affected area of the body. In the same time, some of them have multiple pathologies, particularly degenerative jpont dsisorders and disturbed peripheral perfusion due to vascular disease.

The consequences are clinical, symptomathical and objective and they can be studied in the vasomotor and thermic context.

Infrared thermography of the patient with stroke is a new area of interest in Romania and we explored the upper and lower limb temperature by thermography to observe different types of peripheral thermoregulation in connection with that pathology. The systemic and local context of the pacient with stroke were also analysed in the complex thermological analysis.

Material: We have studied 57 in-patients with recent stroke, using an FLIR ThermaCam medical thermograph in standard evaluation conditions.

Method: We have applied a standard program of physical therapy using electrostimulation, ultrasounds, massage and kinesotherapy.

We recorded thermographies in the beginning and in the end of the treatment for each patient. We studied temperature gradients for single areas, we have compared the temperature gradients between the left and the right part of the body, and finally we have observed the therapy effect in time.

Results: The results were biostatistical transformed and interpreted and they underline different degrees of circulatory problems and the different types of answer and reaction in connection to the intensity of the neurological injuries.

HEAT TRANSFER BASIS USEFUL FOR INFRARED THERMOGRAPHY

Boguslaw Wiecek,

Technical University of Lodz, Institute of Electronics, Poland

Heat can be transferred by conduction, convection and radiation. Convective heat transfer is described by Newton law:

$$q_k = \alpha_k (T - T_a) \qquad (1)$$

where: q – heat flux [W/m], a – heat transfer coefficient [W/mK], T – ambient temperature [K], T – heat transferred surface temperature [K].

Thermodynamics describes convection by dimensionless Nusselt number. For natural convection it takes a form:

$$N_U = 0.135 (G_R \cdot P_R)^{\frac{1}{3}} \qquad (2)$$

where: Nu – Nusselt number. GrPr – product of Grasshoff and Prandtl numbers. From above equations, heat transfer coefficient can be express as:

$$\alpha_k = 1.66 (T - T_a)^{\frac{1}{3}} \qquad (3)$$

For forced convection, when the air moving along the surface Nusselt number depends on gas velocity and Reynolds number:

$$N_U = 0.032 R_e^{0.8} \qquad (4)$$

where: Re – Reynolds criterion number.

Radiation heat transfer is based on emission and absorption. The bodies can be heated or cooled even in the vacuum. The basic Planck's law describes the monochromatic hemispherical emissive power of the black body.

$$e_{\lambda c}(T) = \frac{2\pi h c^2}{\lambda^5 \left(e^{\frac{hc}{\lambda k T}} - 1 \right)} \qquad (5)$$

where: *h=6,6260755×10J×s* – Planck's constant, *c* – light velisity in vacum, *k =1,3806×10J/K* – Boltzmann constant, *T[K]* – black body temperature.

The energy transferred between two bodies in temperature T i T, having surface S can be presented using Stefan-Boltmann law.

$$Q = \sigma S (T_1^4 - T_2^4) \approx 4\sigma S T_0^3 (T_1 - T_2) = \alpha_r (T_1 - T_2)$$

where: T_0 is the mean value of the temperature of these two bodies (T_1 i T_2), and a_r denotes the radiation heat transfer coefficient, very similar to the convective one α_k.

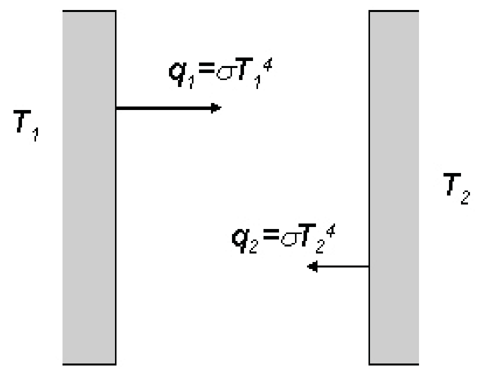

Figure.1.
Radiation heat transfer between 2 surfaces

PROBLEMS OF PHYSICS IN THERMOGRAPHIC STUDIES

Stanisław J. Kłosowicz

Instytut Fizyki Technicznej Wojskowej Akademii Technicznej,
00-9088 Warszawa, ul Kaliskiego 2,

The general physical problems interesting for an interpretation of thermographic studies will be presented. The special attention will be paid to thermal properties of patient's body and the techniques of thermal image processing in respective thermal devices. As a conclusion the advantages and limitations of thermography will be described from medical doctor point of view.

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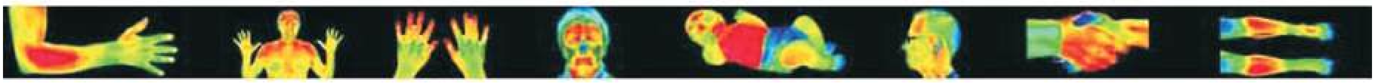


News in Thermology

Web-Page of the EAT

Prof. James Mercer from Tromso University designed the new website of the European Association of Thermology (EAT) and launched the site at www.europeanthermology.com The sitemap, shown above, lists a number of subpages and may be used as tour guide throughout this site.

The welcome page defines for the first time since the re-construction of the EAT the mission, aims and goals of the Association. They are

1] to encourage the exchange of ideas and experiences between national thermological associations.

[2] to assist in improving scientific research in the area of thermology and related disciplines in basic research, technology, industry, medicine and biology.

[3] to improve the respective understanding between practitioners of thermological techniques.

[4] to disseminate scientific results in the area of thermology within Europe.

[5] to initiate and support European research groups in the area of thermology.

[6] to create and expand contacts with non-European associations of thermology.

[7] to organise a European Congress of Thermology ever 3 years.

More detailed information about the EAT are available from the subpages **EAT Board, Statutes**, **Membership**. **History** contains a power point presentation on the European Thermology Conferences since 1974 and **Logo** contains a version of the logo designed for the Association in 1974 which can be downloded.

Upcoming Events announces meetings and conferences , particularly the next 11th European Congress of Thermology in Mannheim in September 2009.

The link to the journal **Thermology international** is the first of five subpages in the educational section of the website. **Image Gallery** is self explaining, **Glossary** contains a PDF-File of the third edition of the glossary of terms for thermal physiology. **Guidelines** include ISO-Standards for screening thermographs for human febrile temperature screening and guideline for infrared equipment testing. **Reference literature** provides a link to the RESOURCES page on the web site of the Medical Imaging Research Group, Faculty of Advanced Technology, Dept. of Computing and Mathematical Science, University of Glamorgan, Wales. On this site an archive of infrared papers, i.e the complete volumes of the journals Acta thermographica and Thermology can be accessed.

Links is a collection of webadresses of Thermology Associations around the world and **Contacts** provide information to contact the webmaster of the EAT page or the General Secretary of the EAT respectively.

The EAT website contains a number of useful information, has a pleasant design and may become an important forum for exchanging ideas about the diagnostic and therapeutic use of heat in medicine and biology.

16th THERMO in Budapest

The 16th International Conference on Thermal Engineering and Thermogrammetry (THERMO) will be orgnised on behalf of the Branch of Thermal Engineering and Thermogrammetry (TE and TGM), Hungarian Society of Thermology (HST) at MATE and the European Association of Thermology (EAT) from the 1st to 3rdof July, 2009 in the House of Technology Budapest, V., Kossuth Lajos tér 6-8.,Hungary.

Since 1977 a successful series of Symposia has been organised by the Hungarian Society of Thermology.. At the beginning these events were named "Symposium on Thermogrammetry" after a newly developed branch of thermal mapping methods which played a significant role in the programme. As the scope of the symposia widened in 1982 they received the new name "Symposium on thermotechnical measurements".

Due to the broad and increasing interest shown by the international thermal engineering and physician community, the meeting was already organised as International Conference on Thermal Engineering and Thermogrammetry (THERMO) in 1987. This conference runs now in a biennial cycle.. The Conference is intended to be an event worthy of the attention of all engineers, scientists, physicians and researchers who are involved in the solution of thermal or energy related problems, as well as in the application of thermal imaging.

Objectives

The developments in measurement theory and technologies support both the energy-conscious design of thermal engineering equipment and processes and also a better understanding of thermal phenomena in living organisms.

The Conference will cover topics both the field of theory and application including new measurement concepts; transducer technique; thermal mapping; contact, optical and IR imaging; biomedical and biotechnological applications; thermal informatics, automatic methods and systems for industrial energy management and process control; heat loss detection and analysis; heat and mass transfer; utilization of alternative energy; thermophysical properties as well as the common practice of thermal engineering.

This Conference will provide the latest information on the above topics together with a good opportunity for personal discussions among experts in the fields of energy conservation, control of energy release and loss, protection of human environment, medical and veterinary applications, remote control through infrared sensors.

Technical Issues

The language of conference and abstracts is English. Together with oral presentation of papers a poster session will be organized. **The preliminary programme (until April, 2009) includes more than 40 papers from 21 countries** (Canada, Czech Republic, France, Greece, Hungary, India, Iran, Italy, Japan, Morocco, Poland, Portugal, Romania, Spain, Sweden, Tajikistan, Tunisia, Turkey, United Kingdom, Ukraine, U.S.A.). Duration of each presentation will be limited to 15 minutes and additional time for discussion will also be provided. The English translation of lectures not read in English should be submitted at the registration desk on the spot. LCD projector and computer with Windows OS for Microsoft Power Point format presentations is available. (Please note, that using your own computer is not permitted).

11th European Congress of Thermology

The next European Congress of Thermology takes place in Mannheim from 17th to 20th of September 2009. The Conference combines the European Congress with the 55th Annual Meeting of the German Society of Thermology Regulation Medicine and the 22nd Symposium of the Austrian Society of Thermology into one big event. The European Association of Thermology will have ist General Assembly and Election of a new board prior to the congress on Thursday evening.

The venue of this meeting is the Hotel Wartburg in the city of Mannheim. A form for registration and hotel booking can be found on page 63 of this issue and on the website of the EAT at www. europeanthermology.com Dead line for room reservations is July 15., 2009

A draft of the scientific programme includes the following
11 sessions.

History, presence and future of thermology societies

Prof Ring : Thermology Symposium in New York 1963,

Prof Usuki: History of the Scientific Meetings of the Japanese Society of Thermology

Prof Berz 55th Anniversary of the German Society of Thermography

Prof Nica Romanian Society of Thermology,

Prof Ammer European Association of Thermology

Standards for thermal imaging

Prof. Machin: Standards for temperature measurements

Prof Ring ISO Standards for fever screening infrared cameras,

Prof Usuki Constructing diagnostic criteria for breast thermograpy by the Japanese Society of Thermology

Prof Ammer Proposal for standards of performing infrared imaging in patients with suspected Raynaud´sphenomenon

Tim Conway Cold challenge test in patients with CRPS

Thermography in surgery

Prof Mercer Infrared imaging in plastic surgery,

Prof Usuki: Comparison of body temperature in laparoscopic surgery with that in open surgery and the usefulness of body thermal image in surgery

Infrared imaging in botany and zoology

Prof Lamprecht; Use of infrared thermography in botany

Prof Mercer. Recent results of infrared thermography in semi-free ranging domesticated african elephants

Infrared imaging in breast disease

Prof Usuki: Mechanisms leading to an abnormal breast thermogram

Prof Schulte-Uebbing Comparing established breast examinations with IR imaging

Prof Berz. Standardization, fine tuning and increase of reliability of breast IR imaging

H.Sauer Typical patterns of breast cancer (case reports)

L.de Weerd , Prof Mercer Thermographic assessment before, during and following autologus breast reconstructive surgery in cancer patients

Thermotherapy

Prof Ammer Effects of Thermotherapy Determined by Infrared Measurement

Prof Mercer:	Improvement of wound healing by water-filtered infrared-A (wIRA) in patients with chronic venous leg ulcers including evaluation using infrared thermography
Prof Demmink:	Heating effects of ultrasound
J Tonks; J Selfe	Therapeutic effect of ultrasound in lateral epicondylitis
Miyazaki Met al.	Comparison between chilling effects by the difference of the material of the pillow
E.F.J. Ring, et al	Monitoring Cooling Agents Applied to the Skin of Normal Subjects by Quantitative Thermal Imaging

Infrared imaging in dermatology

Laino L, Di Carlo A.	Thermographic evaluation of Patch Test : the two patterns
D. Mikulska.	Thermographic findings in localised skleroderma of adults
K.Howell	Thermographic assessment of morphea in children
ML. Brioschi et al	Normalized methodology for medical infrared imaging.

Other clinical applications of thermography

C Hildebrandt	Thermal imaging as a screening tool for knee injuries in professional junior alpine-ski racers inAustria
S. Steinlein	Experiences with IR imaging of knees in an orthopaedic hospital
Prof Nica et al	Infrared imaging for monitoring stroke patients on a rehabilitation ward
EFJ. Ring, et al	Detecting Fever in Polish Children by Infrared Thermography
R- Vardasca:	Infrared imaging in vibration induced cold fingers
Prof Ammer	Main applications of diagnostic thermography in the last 21 years: a chart review

New developments in infrared imaging equipment

R.Thomas	Minimum Specifications for medical infrared imagers
P.Plassmann	Quality Assurance of Thermal Imaging Systems in Medicine
J.Grodowski	Performance of a new infrared camera

Infrared in veterinary medicine

D.von Schweinitz	Thermographic diagnostics in equine back pain
A von der Wense	Complementary Therapy for horses
Prof Berz :	Educational Course in Equine thermography. Results and future directions

Regulation thermography

H. Berz	Combining quantitative infrared thermography with the principles of regulation thermography
H. Sauer:	Rost's contact thermography and Sauer's infrared spot measurement

Abstract submission

Papers outside the topics mentioned above are also welcomed. Deadline for the submission of papers is 15th May 2009. Abstracts should be structured into Background, Objective, Method, Results and Conclusion and must not show more than 300 words at maximum. A template for the abstract is provided on page 66 of this issue. Electronic submission is preferred and strongly suggested.

Abstracts should be sent to one of the following email addresses

Prof R. Berz reinhold.berz@inframedic.de

Prof F- Ring efring@glam.ac.uk

Prof. K.Ammer KAmmer1950@aol.com

Workshop on infrared imaging at the Annual Assembly of the American Academy for Physical Medicine and Rehabilitation (AAPMR)

Dr Jeffrey Cohen from the Rusk Institute of Rehabilitation Medicine, NYU Medical Center, was invited to participate in the 70th Annual Meeting of the American Academy for Physical Medicine and Rehabilitation in Austin in October. Dr Cohen will organize a workshop on October 24, entitled "Computerized Infrared Imaging/ Thermography in the evaluation of patients with acute and chronic pain syndromes-A Practical Approach".

This is another sign of the increase awareness of infrared imaging in the field of Physical Medicine and Rehabilitation. Dr. R.Schwartz´s engagement in the Practice Guideline Committe of the AAT and Dr Cohen´s book "Rehabilitation Medicine and Thermography" indicated already the reestablishment of thermal imaging in rehabilitation medicine. Physiatrists like A. Pavot, S.Tshou and A Fisher have been in leading positions of the American Academy of Thermology in the past. Last year´s meeting at NYU and the the upcoming workshop in Austin may be helpful to establish thermography in medicine as a valid and reliable technique to assist diagnosis and monitor treatment.

Meetings

2009

1st-3rd July, 2009

16th International Conference on Thermal Engineering and Thermogrammetry (THERMO), Budapest, Hungary

Information
Application Forms and abstracts/papers should be sent to:
Dr. Imre BENKÖ,
MATE Secretariat, House of Technology, III. 318.
H-1372 Budapest, POB. 451., Hungary
Fax: +361-353-1406, Phone: +361-332-9571.,
E-mail: mate@mtesz.hu

/eng/Pages/2009/Thermo2009/index.php and for previous 15th THERMO
/eng/Pages/2007/Thermo2007/index.php

17th September 2009

General Assembly of the European Association of Thermology

Venue: Hotel Wartburg, F4, 4-11, 68159 Mannheim

Time: 18.30

Agenda

Report of the president
Report of the treasurer
Statement of the auditors
Election of a new board
Miscellaneous

Nominations for Board membership and other applications to the General Assembly must reach the Board in writing at least 3 days beforehand

17th -20th September 2009

Combined Conferences

11th European Congress of Medical Thermology

55th Annual Congress of the German Society of Thermography and Regulation Medicine

22nd Thermological Symposium of the Austrian Society of Thermology

Venue: Hotel Wartburg, F4, 4-11, 68159 Mannheim

Main theme: Temperature Measurement in Humans and Animals

Topics

History, presence and future of thermology societies

Standards for thermal imaging

Thermography in surgery

Infrared imaging in botany and zoology

Infrared imaging in breast disease

Thermotherapy

Infrared imaging in dermatology

Other clinical applications of thermography

New developments in infrared imaging equipment

Infrared in veterinary medicine

Regulation thermography

Further information:

Prof Dr med Reinhold Berz
President of the German Society of Thermography and Regulation Medicine (DGTR)
International Medical and Veterinary Thermographers IMVT
Harbach 5
D-36115 Hilders / Rhön

Tel +49 (0) 66 81 - 72 70, Fax +49 (0) 66 81 - 85 51
Email: reinhold.berz@inframedic.de

or

Prof Dr med Kurt Ammer PhD
Austrian Society of Thermology
Hernalser Hauptstr 209/14
A-1170 Wien, Österreich

Tel & Fax: +43 1 480 54 23
Email: KAmmer1950@aol.com

22th-25th October 2009

2009 Annual Assembly & Technical Exhibition of American Academy of Physical Medicine and Rehabilitation (AAPM&R) in Austin, Texas

Venue: Hilton Austin and Austin Convention Center

October 24, 2009. Session: W428, 7:30am to 9am

Jeffrey Cohen: Computerized Infrared Imaging/ Thermo. graphy in the evaluation of patients with acute and chronic pain syndromes-A Practical Approach

Further Information:

http://www.aapmr.org/assembly.htm

Combined Conferences
11th European Congress of Medical Thermology

55th Annual Congress of the German Society ofThermography and Regulation Medicine

22nd Thermological Symposium of the Austrian Society of Thermology

17th-20th September 2009

Last Name..First Name... Title ....

Institution ....

Street ....

ZIP Code ....City...Country ....

Phone.. Fax .... E – mail...

Title Autors Abstract

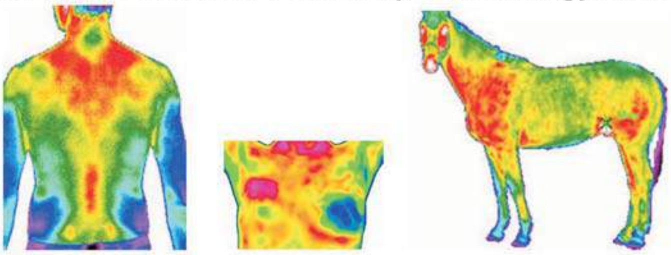
Return this form not later than May 15th, 2009 to:

Prof. Reinhold Berz
Harbach 5; D-36115 Hilders / Rhön
Email: reinhold.berz@inframedic.de

Submission by email to the following adresses is also possible:

Prof F. Ring: efring@glam.ac.uk
Prof K. Ammer: KAmmer1950@aol.com

International Conference of Medical and Veterinary Thermology and Infrared Imaging



11th European Congress of Medical Thermology
55th Annual Congress of the German Society of Thermography and Regulation Medicine
22nd Thermological Symposium of the Austrian Society of Thermology

17th-20th September 2009, Mannheim, Germany, Hotel Wartburg

REGISTRATION FORM

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REGISTRATION FEE	payment until April 30	payment until July 15	payment after July 15
Members of EAT, DGTR or ÖGT	O € 200	O € 250	O € 300
Non-members	O € 250	O € 300	O € 350
One day registrations	(only available on site and not including meals)		O € 125

HOTEL ACCOMODATION All rates are per room/night . Deadline for reservations is July 15, 2009.

I wish to book:	Single Room	Double Room	
Hotel Wartburg Mannheim	O € 50	O € 100	O deposit € 100
Hotel Steigenberger	O € 75	O € 150	O deposit € 150
City Hotel Mannheim	O € 40	O € 80	O deposit € 80

Arrival: ______*______ Departure: ______*______

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It serves as the official publication organ of the the American Academy of Thermology, the Brazilian Society of Thermology the UK Thermography Association Thermology Group) and the Austrian Society of Thermology.

An advisory board is drawn from a panel of international experts in the field.
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ISSN -1560-604X
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- ☐ Brazilian Society of Thermology

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Diese Zeitschrift ist eine gemeinsame Publikation der Österreichischen Gesellschaft für Thermologie und der Europäischen Assoziation für Thermologie (EAT)

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