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Intra-Examiner Reliability Study of Knee Temperature Pattern

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Infrared Camera Signal Conversion to Temperature

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Contents (INHALTSVERZEICHNIS)

Editorial

Review (ÜBERSICHT)

Original article (ORIGINALARBEIT)

Reports (BERICHTE)

News in Thermology (THERMOLOGISCHE NACHRICHTEN)

Meetings (VERANSTALTUNGEN)

Fever screening and infrared thermal imaging: concerns and guidelines

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SUMMARY

The aim of the document is inform those either using or considering using infrared thermal imaging mass screening systems for fever detection of recent developments surrounding this concept. The recent publicity surrounding the Swine influenza outbreak (H1N1 strain of influenza type A) has spurred interest in the use of this technology. However, the publicity has also sparked a debate concerning the effectiveness of using infrared thermal imaging for this purpose. It is important to note that this document is not intended to answer the question as to the reliability of infrared thermal imaging for fever screening. Clearly opinions will vary depending on the interests and experience of the reader. Nevertheless, the European Association of Thermology (EAT) feel that there are some basic facts that need to be taken into account when either using and/or designing specialized infrared thermal imaging installations for mass screening of human subjects.

FIEBERSUCHE UND INFRAROT-THERMOGRAPHIE: PROBLEME UND LEITLINIEN

Ziel diese Beitrages ist es alle, die bereits die Infrarot Thermographiezur Massensuche nach Fieber einsetzen oder planen, dies zu tun, über neuere Entwicklung im Zusammenhang mit diesem Konzept zu informieren. Das öffentliche Interesse am Ausbruch der Schweingrippe (H1N1 Stamm des Influenza type A) hat zusätzlich die Diskussion des Einsatzes dieser Technologie gefördert. Allerdings wurde dadurch auch eine Debatte über die Sinnhaftigkeit des Einsatzes der Infrarrotthermographie für diesen Zweck entfacht. Es wird darauf hingewiesen, dass die Beantwortung der Zuverlässigkeit der Infrarotthermographie zur Fiebererkennung nicht die Intention dieses Beitrags darstellt. Verständlicher Weise werden die Meinungen dazu in Abhängigkeit von den Interessen und der Erfahrung des Lesers variieren. Trotzdem ist die Europäische Assoziation für Thermologie (EAT) der Meinung, dass einige grundlegende Fakten berücksichtigt werden müssen, wenn der Einsatz bzw. die Installation spezieller Infrarotkameras zum Zweck der Massensuche nach Personen mit Fieber geplant wird.

Thermology international 2009; 19: 67-69

Introduction

In light of the recent events surrounding the Swine flu pandemic interest in the use of infrared thermal imaging for fever screening has been widely publicised and many authorities have implemented or are considering implementing thermal imaging installations for mass screening purposes. For example, airport screening for fever is often illustrated with infrared thermal cameras mounted on a wall or ceiling to record thermograms of the face. The intention is to stop people with a high body temperature from travelling during periods of high infection risk. Manufacturers of thermal cameras are finding heightened demand as airport authorities are preparing for screening should a pandemic fever be announced by the World Health Organisation.

The concept of using infrared thermal imaging in fever detection arose in connection with the outbreak of severe Acute Respiratory Syndrome SARS in China in 2002-3, where infrared imaging was used in some airports as a means of screening passengers who may endanger others by travelling whilst suffering from a fever. Some papers have reported the value of infrared imaging for fever screening in an hospital environment [1, 2]. In 2004 the Singapore Standards authority SPRING produced two documents as technical references [3,4]. These were the first documents to focus on the required information for the application of this technology for fever screening.

The content of the Singapore documents were recently updated and expanded and used as the basis for a new working group for the International Standards Organization (ISO). This has resulted in a new standard for the correct deployment of thermal imaging for fever detection (see section 3 below).

The recent publicity has also spurred debate concerning the effectiveness of using infrared thermal imaging for this purpose. Basically the debate is concerned with 3 main points.

1. The exactness of the relationship between deep body temperature and infrared thermal images of selected skin areas on the head.

In medicine, invasive methods of measuring body core temperature such as rectal temperature and oesophageal temperature are considered two of the most reliable and easily accessible sites for measuring body core temperature. Oral (sub-lingual), axillary and inguinal temperatures are perhaps the most common alternative measuring sites and in recent years a large variety of infrared thermometers for measuring auditory canal and forehead temperature have become available. All of these latter mentioned measuring sites will normally underestimate the true body core temperature, and in the case of modern infrared thermometers various algorithms have to be employed to calculate the supposed true body core temperature. Furthermore, all of the above require that the thermometry device have direct contact with the subject which is undesirable in a mass screening situation due to fear of spreading infection. For a recent comparison of different body temperature measuring sites see Pascoe & Fisher. [5].

As there is no completely reliable method for measuring body core temperature non-invasively the possibility of using non-contact infrared thermal images of the head (face) to determine body core temperature is clearly very attractive. A major problem in using infrared thermal imaging to determine whether a person is in a febrile state (has an elevated body core temperature) is that until recently there was practically no available scientific data on the relationship between body core (for example rectal temperature) and thermal images of the head (especially the facial area) in either non-febrile or febrile subjects. Indeed the question as to which skin site on the head one should be measuring has also been debated, although the general consensuses of opinion, also supported by recent data, indicate that the temperature of the inner canthus of the eye is consistently warmest area on the head and the most suitable site for use in fever detection [6]. There are several recent reports in the scientific literature from scientists trying to address this lack of information [5,7].

From the outset, it is important to keep in mind that the temperature of the inner canthus, or any other skin site, is not the same as deep body temperature and will always be somewhat less and, unfortunately, not always by a constant amount. To further complicate the issue it has recently been shown that infrared based temperature measurements at the inner canthi of the eye are also affected by climatic conditions. For example it has been shown that increasing air temperatures from 15.5ºC to 26.6ºC caused the inner canthi surface to increase from 35.7ºC to 37.6ºC, even though deep body temperature remained unchanged [5]. The same authors have also demonstrated that changes in relative humidity may also affect temperature measurements at this site. Such problems clearly illustrate that it is important that the room environment for imaging must be controlled.

In subjects with a high fever the increase in the temperature of the inner canthus of the eye is relatively easy to detect. However, the relationship between the temperature of the inner canthus of the eye and body temperature is not a clear cut linear relationship and the lower the fever the more difficult it is to detect a significant increased of the inner canthus due to data scatter. As a result it is necessary to select relatively high “threshold skin temperatures” in mass screening camera installations to avoid too many false positives. In a recent study on febrile children a threshold of 37.5ºC was suggested based on simultaneous measurements of forehead and axilla temperatures [7]. Most existing camera installations seem to have arbitrarily chosen threshold temperatures that are relatively high, with the risk that one only detects those persons with the highest fevers.

2. The inability to detect infected persons during the early/late stages of fever development.

There will be always be situations when infectious persons may not have an elevated body core temperature and will therefore not be picked up by a screening system. For example it may take several days for a newly infected person to develop an increase in body temperature (fever), the so called incubation period. Likewise there will be persons who have regained normal body temperature following a bout of fever yet who may still be infectious or who have suppressed their elevated body temperatures with pharmaceutical agents such as acetylsalicylic acid (asprin) or paracetamol. These situations are well known to all public health authorities. Despite this some authorities, for example the USA, maintain that fever screening may reduce spread statistics by up to 50%.

3. Camera quality and camera usage in fever screening installations.

The incorrect use of IR-cameras and flaws in camera installations and failure to follow recent international (ISO) guidelines for camera use are also causes for concern. From recent televised events it is clear that most camera installations are incorrect due to problems such as too long distance from the subject, poor focus, and poor camera resolution.

Strict protocols, as in medical thermography, are the key to reliable and reproducible use of the technique. Proper understanding of the conditions for installation and use are essential, as are the regular testing of camera performance and training of personnel involved. The new ISO standard is called “Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening” IEC80601-2-59and ISO subcommittee SC3 and was published after an international vote in September 2008. It provides many performance and calibration requirements for devices used in this application.

A second document based on the SPRING document Part 2, was published in March 2009. This is not an international standard as such, but a technical guide to the “deployment, Implementation and operational guidelines for identifying humans using a screening thermograph”. ISO/IEC TC 121/SC 3 N. It bears directly on this use, and while not perfect, does represent a major milestone completed since SPRING Singapore began their effort to create workable standards in 2003.

The standards may be purchased and downloaded online (see figure 1).

The ISO standard sets out the technical minimal performance required for a thermographic system used for fever screening. It refers to a number of existing standards relating to calibration of cameras, use of black body radiators

Figure 1 URL for the download of ISO-Standards:

www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_ detail.htm?csnumber=51236 or www, webstore.ansi.org RecordDetail.aspx? Sku= IEC+8060 1-2-59 + Ed.+1.0+b%3a2008

etc. and the optimal performance needed to image to face and measure as accurately as possible.

The inner canthi area of the eyes is a preferred and recommended site to represent core temperature. However, it is very important that there must be an adequate number of pixels in that area to register temperature, and indicate the small difference between a normal healthy person and someone with a fever. The procedure requires correct positioning so that the face fills the majority area of the image. It also requires a minimal number of pixels in the measured area. As with any camera or imaging system, attention to detail, focus and in this case close up frontal; face imaging is required. This is in contrast to many of the pictures recently shown in the media where cameras have been, for example, directed at groups of people, and where the maximum temperature displayed in a thermogram may be based on a single pixel. Many images shown in thermograms drawn from image libraries by the media are of low resolution, probably out of focus, and the subject is too far away to measure temperature.

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Infrared Camera Signal Conversion to Temperature

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SUMMARY

The increased number of new Infrared (IR) cameras available has resulted in a wide range of possible applications including medical. Underpinning this need is the desire to enhance the software capability of the capturing system. Sometimes this desire is driven to create specific software analysis tools that are not available in the camera manufacturer's software programs. Therefore this paper considers those aspects important when considering the IR camera signal conversion to temperature.

KEY WORDS: infrared signal, signal conversion, temperature

DIE UMWANDLUNG DES INFRAROTSIGNALS IN TEMPERATURWERTE

Die wachsende Zahl der zur Verfügung stehenden Infrarot (IR)-Kameras hat zu einer breiten Palette von möglichen Anwendungsgebieten geführt, wobei auch der medizinische Einsatz eingeschlossen ist. Dadurch gestützt entstand der Wunsch, die Software dieser Aufnahmegeräte zu verbessern. Manchmal ist dieser Wunsch auch dadurch bedingt, spezielle Auswerteprogramme zu entwickeln, die in den Standardprogrammen der Hersteller nicht vorhanden sind. Deshalb werden in dieser Übersicht einige Aspekte besprochen, die für die Umwandlung von Infrarotsignalen in Temperaturwerte besonders wichtig sind.

SCHLÜSSELWÖR TER: Infrarotsignal, Signalumwandlung, Temperatur

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Introduction

Whilst the development of infrared camera as instruments has seen major technological advancements recently the process of camera signal conversion to temperature is an area that has not seen developed significantly. There have been developments to enhance image quality such as more and larger pixels, fusion of digital and thermal images as a useful diagnostic tool but the need to address signal conversion and subsequently the accuracy of infrared cameras has yet to be developed, especially with reference to medical thermography commonly known as thermology

Signal conversion to temperature

Many assume that this conversion is fairly straight forward when, in fact it can be quite complex. Infrared cameras do not measure temperature. They measure spectral radiance that is leaving a surface, modified by the atmosphere and optics of the camera. To transform this signal to an accurate surface temperature requires a mathematical model involving four fundamental considerations:

- calibration against known radiant sources (blackbodies) over the entire detector temperature range;
- empirical modeling of detector/optic/atmosphere response within a specific spectral range;
- subtraction of the potion of the signal due to background irradiance; and
- correction of signal to that equivalent to a blackbody.

Radiometric accuracy of an IR camera as an instrument is defined as the accuracy of the temperature measurement obtained by the radiometric device compared to that of the true undisturbed surface temperature. Repeatability defines the consistency of this accuracy from measurement to measure- ment. Uniformity means the deviation of a single measurement when measured from different points over the entire field of view. Another factor is stability and offset variations not just variations which can also reduce the repeatability of results as indicated by Ring et al [1]. Sensitivity is the detectable temperature difference on a surface. It is important not to mix these concepts. When a manufacturer states an accuracy figure they will often confuse these issues, or at least not define them in a manner that makes it easy to compare instruments. All figures of merit produced by manufacturers are usually defined only for blackbody surfaces, and will usually be the best-case numbers at a specific absolute temperature (typically 303°K; 30°C; 86°F).

Those involved with analog IR cameras before 1986 will recall that the above conversion was performed external to the camera with manual calculations, involving calibration curves and a calculator. Today the process is the same, but the calibration curve has been programmed into the camera memory, and calculations to convert signal to temperature are performed internally by a microprocessor in a split second.

It is still important to understand the conversion process especially if one is to re-calculate the temperatures because incorrect values of emissivity, background, or optical transmission (like through an IR window) were initially used. If new universal analytical software techniques are to be developed independent of specific camera models, then em-

Table 1
Energy increase versus temperature for a blackbody at 0, 20 and 40 °C

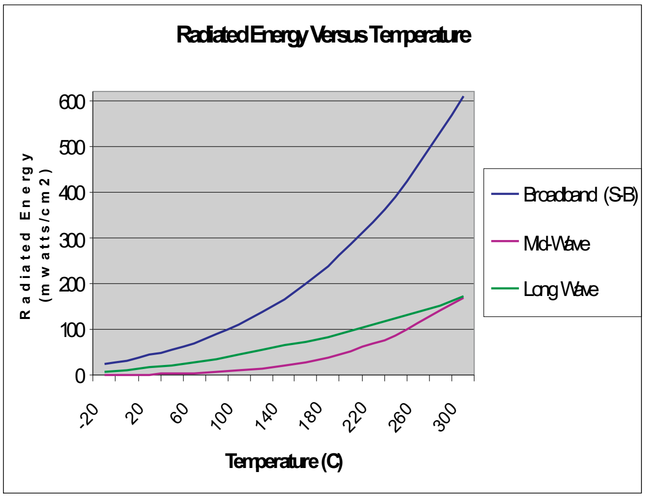
Temperature	Broadband	Mid Wave		Long Wave		
	Emission milliwatt/cm^2	% Increase	Emission milliwatt/cm^2	% Increase	Emission milliwatt/cm^2	% Increase
0°C (273 K)	31.5		0.38		11.0	
20°C (293 K)	41.8	33%	0.83	121%	15.7	42%
40°C (313 K)	54.5	30%	1.68	101%	20.7	32%

ulating this process is essential because changing these values are often fundamental to an analysis.

Stefan-Boltzmann relationship

There is a widespread belief that infrared camera response is a direct function of the Stefan-Boltzmann relationship. (i.e., Signal = constant · emissivity · $T_K{}^{4)}$ This assumption would be correct if the camera was a 100% efficient energy detector over an extremely wide band of wavelengths, and no spectral modification of the signal by the atmosphere and optics took place. The reality of most commercial cameras is that:

Figure 1
Energy increase versus temperature for a blackbody between -20 to 300 °C



1) they are only detecting a very small percentage of the overall energy emitted;

2) many detectors and optics do not have a combined flat response over their bandwidth; and

3) as the temperature changes the % of energy falling in the particular camera band changes.

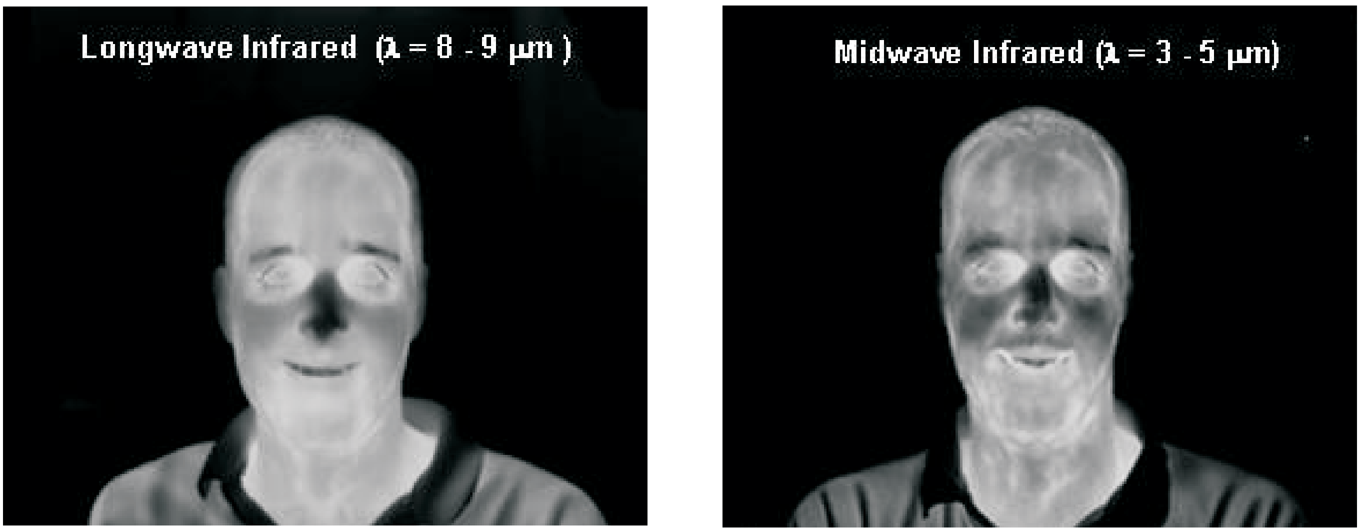
The net result is that as the surface of an object increases the resultant detector signal response may be a function of that temperature ranging from a linear to a power function. Table 1 shows the energy increase versus temperature for a blackbody at 0, 20 and 40 °C.

The curve in Figure 1 illustrates this same change but over a wider range of Blackbody temperatures. Calculations were obtained using an EG&G infrared radiation calculator slide rule.

Figure 1 illustrates this same change but over a wider range of Blackbody temperatures.

Ultimately it is the instrument response which determines its measurement sensitivity to such things as emissivity difference, background temperature, and atmospheric attenuation. This percentage increase in signal in mid-wave versus long-wave is one of the reasons that many thermographers will report that long-wave camera will have 'less contrast' than an image taken of an identical object with a mid-wave camera.

Figure 2
IR camera sensitivity to wavelength, Courtesy Dr.Austin Richards, taken from his book Alien Visions [2]



The temperature difference is the same but the image appears to have more contrast since the signal is increasing at a faster rate. It may also mean that the mid wave camera is less sensitive to errors in emissivity. Why does this happen? Because mid-wave cameras (looking at objects less than about 250ºC) are working on the left side (the steep slope) of the peak of the Planck curves while long-wave cameras are working at the right side (the gentle slope) of the peak of Planck curves.

Now that we have dispelled the 4th Power myth about spectral emission in either long or mid wave what is the proper relationship? Unfortunately it is not as straightforward as curve-fitting the above response. Generally the mathematical model used is of the form Blackbody Signal = some function of temperature, shown in the following as $f(T)$. Since camera manufacturers calibrate IR instruments against Blackbody simulators and we must measure the temperature on real-bodies, taking emissivity and reflected background into account, the basic formula to correct for temperature becomes:

$$\text{Signal} = e_{object} \cdot f(T_{object}) + (1 - e_{object}) \cdot f(T_{background})$$

We also may have absorption and re-emission, of the atmosphere, and/or an IR window, which can have a varying spectral response with wavelength. Fortunately, however in long-wave, and at distances under 3 meters this does not significantly alter the shape of the above curves. In mid wave and at longer distances it will need to be corrected. A simplified LOWTRAN (LOWTRAN was developed by the US military to empirically model atmospheric absorption at low altitudes, [3,4]) model is often used to correct for atmospheric absorption. Typically transmission shows up as $\boldsymbol{\tau}$ in the equation:

$$\text{Signal} = e_{object} \cdot \boldsymbol{\tau} \cdot f(T_{object}) + \boldsymbol{\tau} \cdot (1 - e_{object}) \cdot f(T_{background}) + (1 - \boldsymbol{\tau}) \cdot f(T_{medium})$$

But what mathematical function best describes is the $f(T)$ relationship: should it be linear, exponential, a polynomial, etc.? Depending on how wide a variance of temperature range is required any of these could provide a good curve fit. To cover the entire temperature range of a detector, however, a complex equation has to be used. As an example the following curve-fit equation was published by AGEMA (now FLIR Systems) in its Thermovision® 900 Series operating manuals

$$\text{Camera Signal} = R / (e^{(B/T)} - F)$$

Where:

T = the absolute blackbody temperature in Kelvin, R = a response factor

B = a spectral factor, F = a shape factor

Typically a camera manufacturer will measure the camera signal against a series of blackbody temperatures and a best fit of their specific mathematical model is used. In the case above a unique value for R and F is calculated since the spectral factor will be determined by the mid point of the spectral response for that model of camera. Whilst best-fit formulas like this have evolved and been perfected over the years by various manufacturers it is illustrative of the empirical, rather than theoretical nature of instrument performance.

Current challenges

First the conversion to temperature from signal remains in the realm of the manufacturer's proprietary information. As they strive to produce instruments of higher measurement accuracy (currently evolving to better values than ± 2 °C or ± 2%) they are maintaining proprietary control of their signal data conversion algorithms and hence their software. For example, one manufacturer has sold more than 15 different software programs, most of which had data formats not directly compatible with each other, and some of which could not even be converted with a utility. Some view this as positive marketing, maintaining control over customer base and increasing profit margins on camera sales by selling high priced software. Yet this philosophy is inhibiting the development and growth of generic specialty analysis software especially for medical, electrical apparatus, machine, and building diagnostics.

Conclusion

The need for proprietary control of signal conversion up to a certain extent is recognized, and probably essential. But if this industry is to mature, a universal standard 14 bit image format needs to be developed, at least allowing users to have generic software analysis capability to change values of emissivity, background, and optical transmission. Only then will we see powerful industry wide software analysis tools emerge.

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An Intra-Examiner Reliability Study of Knee Temperature Patterns With Medical Infrared Thermal Imaging

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SUMMARY

The aim of the present study was to evaluate the day-to-day repeatability of temperature patterns with thermal imaging from the anterior knee in a sample of symptom-free subjects (n=10) and subjects with a previous history of knee injuries (n=5). One tester performed temperature readings of the anterior knee on two consecutive days. Intra-examiner reliabilities, standard errors of measurement, and 95% confidence intervals were determined for mean temperature of the right and the left leg. A marker system on the subjects was applied to ensure measurement consistency of the region of interest. Temperature readings showed normal range for healthy subjects. Intra-examiner reliability was good for the right leg (ICC= 0.85) and moderately good for the left leg (ICC= 0.75). The present study indicated a good reproducibility of day-to-day measurements within subjects when examined from one observer with the same equipment.

KEY WORDS: Thermal Imaging, IntraExaminer-Reliability, Knee Temperature Pattern

EINE INTRAEXAMINER RELIABILITÄTS-STUDIE VON TEMPERATURPROFILEN DER KNIE MITTELS INFRAROT THERMOGRAFIE

Das Ziel der vorliegenden Studie ist die Evaluierung der Infrarot-Thermografie als eine reliable Messmethode von Temperaturmustern der Knie. Inkludiert wurden sowohl Probanden ohne frühere Knieverletzungen (n=10), als auch jene mit früheren Verletzungen. An zwei aufeinander folgenden Tagen wurden Temperaturmessungen der Knievorderseite von einem Untersucher aufgenommen. Die Berechnung des Intra-Klassen-Korrelationskoeffizienten (ICC) erfolgte auf Grundlage der Durchschnittstemperaturen der gemessenen Areale und diente zur Evaluierung der Tagesschwankungen. Markersysteme sicherten standardisierte Vergleiche der Thermogramme. Die interne Reliabilität zwischen den Tagesmessungen kann für das rechte Knie als gut (ICC= 0,85) und für das Linke als mäßig (ICC= 0,75) angesehen werden. Die vorliegenden Ergebnisse legen den Schluss nahe, dass infrarotthermografische Messungen an den Knien unter standardisierten Bedingungen an zwei aufeinanderfolgenden Tagen reliable Ergebnisse liefern.

SCHLÜSSELWÖRTER: Thermografie, Reliabilitätsmessung, Temperaturvariation, Knievorderseite

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Introduction

More than 2000 years ago, Hippocrates stated: "…should one part of the body be hotter or colder than the rest, then disease is present in that part…." Infrared thermal imaging (ITI) is widely used as a diagnostic tool to visualise and quantify changes in skin temperature [1]. The application of ITI was proven to be beneficial in sports medicine practice when examining musculoskeletal injuries [2]. Exact diagnosis of pathophysiological processes demands reliable data. Reliability is defined as the consistency of repeated measurements [3]. However, the focus on preliminary research has been on validity [4] and inter-examiner reliability [5]. To date, there are few intra-examiner reliability studies on infrared thermography using modern equipment.

The knee is one of the most frequently affected joints in sporting activity [6]. The reproducibility of knee thermal patterns is crucial if ITI is to be used as a screening tool for the management of injuries. A new generation of high resolution cameras have been developed, leading to improved diagnostic capability. Changes in thermal pattern which may be very small but still meaningful can be properly assessed under the assumption of quality assurance [7]. Nevertheless the temperature measurements errors should be small enough to detect changes in what is being measured.

Previous reports about thermal imaging reliability have been made by different researchers with mixed results [5, 8-11] which are assumed to be due to variations in environmental conditions, equipment and statistical analysis.

Good sensitivity was shown in a study of regional pain syndrome [9] whereas poor reproducibility was found in a study of reflex sympathetic dystrophy over time [12].

ZAPROUDINA et al [11] examined the reproducibility of skin surface infrared thermography measurements in healthy subjects and found stable temperature measurements on the trunk, but unstable measurements on the extremities. These findings were based on regional side-to-side differences, determining the symmetry of temperature distribution, rather than absolute values of the same body region. SELFE et al [5] conducted a study of inter-rater reliability of anterior knee thermal images by using an anatomic marker system. Based on 9 healthy subjects their findings indicated an adequate inter-rater reliability. However, results about the intra-rater reliability were not shown. These findings were based on temperature readings of the patella. Most physiological variations exist in muscle and tendons and should be included in the assessment as well. Another study examined the inter-examiner and intra-examiner reliability of paraspinal skin temperature [10]. They used computer- aided location tracking, leading to higher reproducibility and concluded that the reliability of paraspinal thermal scans is very high. However, these findings cannot be generalized for other, more distal body parts, which may have more physiological variations, leading to poor reliability of day-to-day measurements. Ultimately, the assessment of healthy subjects may differ from those with a history of injuries. To date, little is known about the variability of thermal patterns of the knee.

The specific aim of the present study was to measure the day-to-day variations of thermal patterns of the knee from healthy subjects and subjects with previous knee injuries to examine the intra-examiner reliability.

Methods And Materials

Equipment

The examination was conducted according to the guidelines from the GLAMORGAN PROTOCOL for quality assurance [13, 14]. We used a camera (TVX200, GORATEC GmbH, Germany) capable of detecting radiation in the infrared range of electromagnetic spectrum of 8µm-14 µm. The thermal resolution is denoted with ≥ 0.065°C at 30°C and an error rate of ± 2% or at least 1°C. The camera was turned on 90 minutes before testing to stabilise the electronics. A stability test was also performed as suggested by PLASSMANN et al [7] to define the offset variation over the range of the camera. The camera was calibrated by Goratec using a black body source for temperature reference 3 weeks prior to the tests. A self constructed background (black mat surface) was constructed to avoid interferences caused by background radiation.

Subjects

Data were captured from 15 staff members of our department (10 female, 5 male) who provided informed consent. Their characteristics can be found in Table 1. 10 healthy subjects and 5 subjects with a history of knee injuries were included to obtain deviant thermal patterns. Neither treatment nor physiotherapy was administered.

Each subject had a 15 minute acclimatisation period with legs undraped to achieve an adequate stability in skin temperature and blood pressure. This time was used to fill in a questionnaire, including information about health status, nutritional status, use of crèmes, menstrual cycle, history of training, subjective feeling and the dominant leg.

Table 1
Subjects characteristic

Variables	Female (n= 10)	Male (n= 5)
Age (y)	34.3 (± 11.4)	45.2 (± 11.1)
BMI (kg/m2)	21.4 (± 1.9)	23.7 (± 1.6)
Weight (kg)	58.6 (± 5.1)	76.2 (± 3.9)
Height (m)	1.65 (± 4.9)	1.79 (± 5.7)
Resting heart rate (bpm)	68.6 (± 10.2)	62.8 (± 12.6)

They were well informed about the procedure with each receiving an information sheet prior the study. All subjects were asked to avoid changes in nutrition, training, use of skin crèmes and medication during the two examination days.

Procedure

To provide consistency for repeated measure, the following anatomical landmarks were marked on the subject which delineated the region of interest used in the study (see Figure 1).

(1) 3 cm to the right and to the left from the midpoint of the upper edge of the patellae

(2) tuberositas tibiae

(3) 3cm to the right and to the left of the tuberositas tibiae.

This region of interest was chosen to include temperature readings from bones, muscles and tendons.

A predefined marker system was fixed on the floor to get a standard view for the capture analysis. To avoid movements during image recordings all subjects used crutches to maintain position. Recordings of the anterior aspect of the knee were done in a standing position on two consecutive days.

Images were taken at the same time within an hour on each day to avoid differences due to circadian rhythm. The distance between the camera and the subject were adjusted in accordance to the alignment of the anatomical landmarks, ranging from 73-91cm.

The room temperature remained constant, ranging from 22.2 - 22.6°C. Equally the relative humidity showed stable values over time (34-36%)

Data analysis

Data were stored and analysed with the software iREPORT 2007, provided from the Company GORATEC GmbH. All images were corrected by using an emissivity factor of 0.97. Image fusion was used to identify the marker position and the area of interest (Figure 1).

Statistics

For each individual mean, minimum and maximum temperature readings of day one and two from each leg were assessed. Descriptive data were analysed in Excel.

To assess the intra-examiner reliability the first measurement of the defined region was correlated with the second measurement made from the same leg by the same tester. Test-rest reliability was calculated for the mean temperature of the area of interest by using intra-class correlation (ICC 1/1) one way random, as this value of correlation reflects the percentage of variance among the day-to-day measurements.

A paired t-test was utilized to determine differences of minimum, maximum and average temperature readings within subjects between testing days. Statistical significance was set at a p value of < 0.05. Inferential statistics were conducted by using SPSS statistical software 15 for windows.

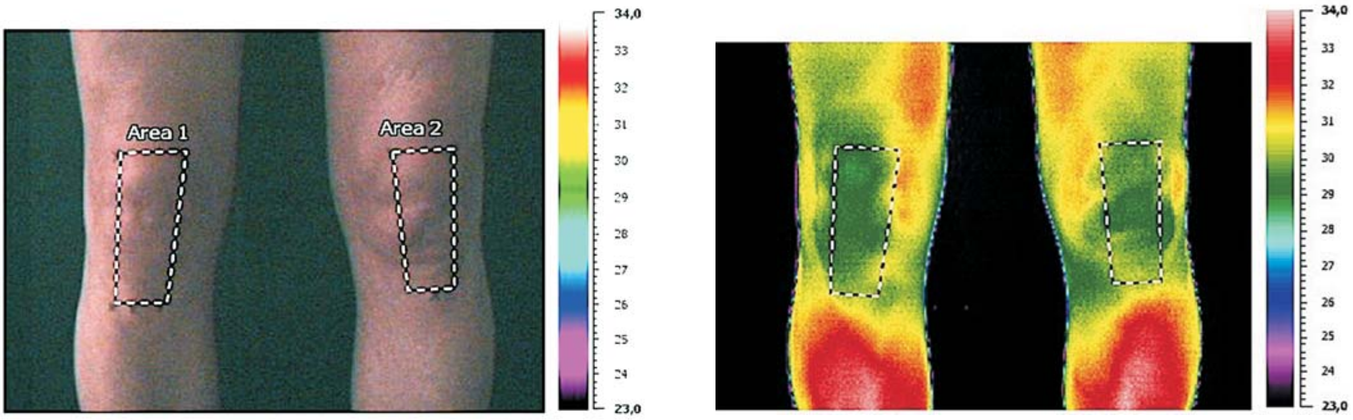

Figure 1
Anatomical image (left) and Infrared image (right) representing the region of interest

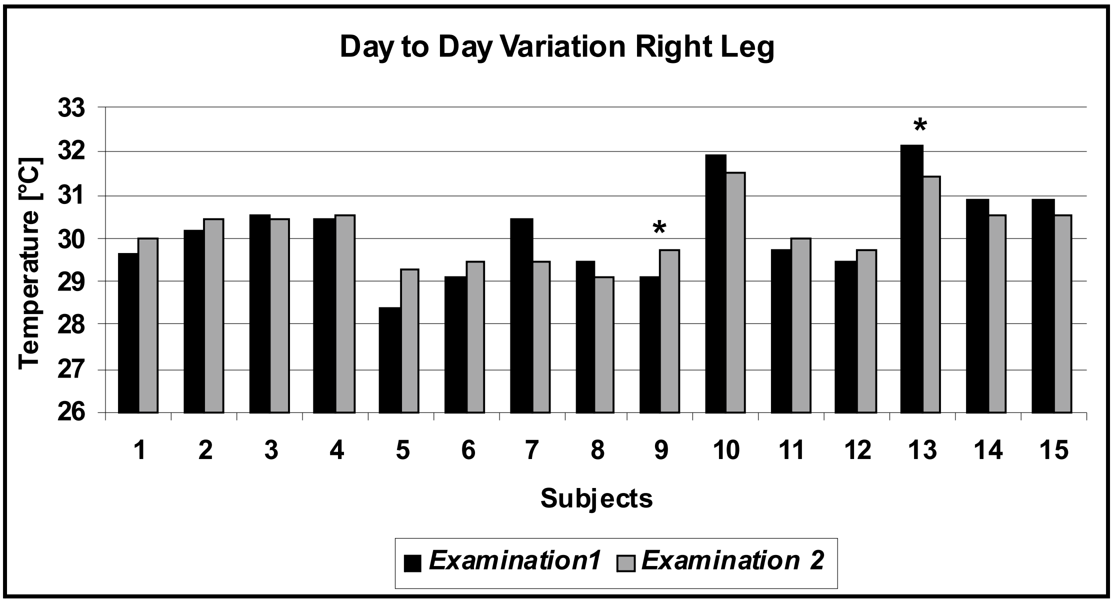

Figure 2
Reproducibility of mean temperature (right leg) of all subjects.
* illustrates subjects with a history of knee injury

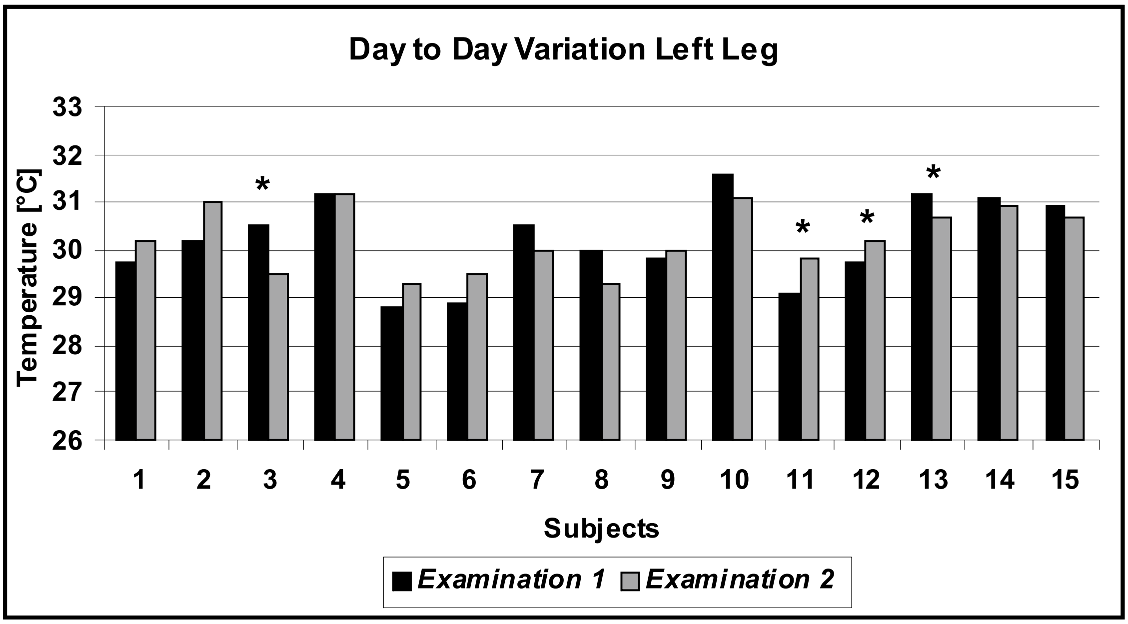

Figure 3
Reproducibility of mean temperature (left leg) of all subjects.
* illustrates subjects with a history of knee injury

Table 2
Mean, minimum and maximum temperature (°C) readings of the anterior knee from all subjects including standard deviation. Paired t-test showed no statistical difference between days.

	Mean Temperature		Minimum Temperature		Maximum Temperature	
	right leg	left leg	right leg	left leg	right leg	left leg
Day 1	30.2 (± 0.5)	30.2 (± 0.6)	29.2(± 0.9)	29.2 (± 0.8)	32.2 (± 1.2)	32.1 (± 1.0)
Day 2	30.1 (± 0.7)	30.2 (± 0.7)	29.1 (± 0.8)	29.1 (± 0.7)	32.4 (± 0.9)	32.2 (± 0.9)

Results

While high individual variations in knee temperature between the subjects were noted low variations between day-to-day measurements indicated stable overall temperatures of the knee (Figure 2 and 3).

Absolute values of mean knee temperature ranged from 29.0°C to 32.1°C for the right leg and from 28.8°C to 31.6°C for the left leg. The mean of day-to-day variations showed only small changes for both legs (0.02°C). Temperature readings of minimum, maximum and mean values from all subjects are presented in Table 2.

The one-way random intra-class correlation coefficient (ICC) indicated good intra-examiner reproducibility for absolute values of mean temperature of the right leg (0.85) and moderately good reproducibility for the left (0.75) (Table 3).

The reproducibility of mean, minimum and maximum measurement for all subjects is presented in table 2 with low variability in mean temperature. Maximum and minimum values had higher standard deviation on both days compared to the mean values.

Table 3
Intraexaminer reproducibility of mean knee temperature of both knees [a]95% confidence intervals

Intra-examiner reliability of the mean Temperature (n=15)		
	ICC	Range[a]
Right leg	0.85	0.61-0.94
Left leg	0.75	0.41-0.90

Discussion

Previous research revealed that the variability in surface temperature is relatively constant in healthy subjects [15]. ITI is a useful research tool when examining changes in body temperature and health status [1].

Reliable measurements have a substantial impact on the diagnosis and interpretation of pathophysiological abnormalities. Before applying this technique in clinical settings, day-to-day reproducibility needs to be examined on healthy subjects. In the present study we aimed to show that Infrared Imaging is a reliable measurement for temperature readings when one person administers the test over time.

Errors in measurement cannot be avoided but they should be minimised by applying appropriate standardisation methods [16].

RING and AMMER [13] described errors in ITI measurement due to the lack of standardised methods and AMMER [17] reported about the misuse of ITI. In the present study we standardised the measurement readings as much as possible. The subjects were asked to restrict influencing factors such as caffeine ingestion, use of skin crème, exercise, medication and alcohol during the examination days. To ensure a precise temperature comparison a marker system on the subjects and the floor ensured a standard image analysis over time and minimised structural asymmetries as suggested by SELFE et al [5]. Differences were calculated solely between measurements made on one leg on the two days. According to OWENS [10] left and right side temperature scans should be aligned separately due to structural diversity. Comparison measurements between right and left leg require an exact definition of the examined area. The values of all temperature readings are in agreement with the findings from FISHER et al [18].

Minimum and maximum temperatures showed high standard deviations in contrast to the mean temperature. The calculation of the mean temperature is based on temperature readings of certain pixels but minimum and maximum values are based on punctual measurements, leading to more inaccurate readings.

The present study included healthy individuals and subjects with previous knee injuries (isolated ACL ruptures, unhappy triad and pre-patellar bursitis) but all were pain free during the study. High individual temperature differences between the subjects may have been related to the fact that the group was inhomogeneous. These findings are in agreement with previous studies showing high inter-subject variations in the extremities [11, 15].The knee is a distal part of the body and more influenced by changes in peripheral circulation in comparison to more proximal parts [19].

The day-to-day mean temperature readings demonstrate a good reproducibility (ICC= 0.85) within the subjects, notably for the right leg. This is in contrast with the results from ZAPROUDINA et al [11] partly to the reason that they examined day-to-day variations based on side-to-side differences. Furthermore, the visual assessment of the area of interest lacks quantification and is likely to be influenced by the opinion of the examiner.

Intra-class correlation are often used for reliability studies and DeBOER et al [8] first utilised ICC´s to assess the intra-, and inter-rater reliability of paraspinal infrared images with good results in 1985.

In the present study temperature readings for the left leg produced lower reproducibility (ICC = 0.75). One possible explanation could be that the affected knee of the subjects with previous injuries was mostly the left one. The amount of heat emitted from the knee is a complex phenomenon affected by many factors and blood flow is one of these. Even though the subjects reported no pain previous injuries can have a lasting effect on blood circulation, causing temperature variations on the knee. However, no trend between warmer or colder patterns and previous injury was found.

There was also no trend between dominant and non-dominant leg. Images from the lateral, medial and posterior side of knee may provide further helpful information.

By analysing images from in vivo studies, random error due to other biological variations needs to be considered. The menstrual cycle is known to induce thermal changes [20]. Having menstruation during the measurement period may contribute to higher variations as seen for subject five and nine. However, subject five reported a subjective feeling of "too cold" during the examination which may be related to the low knee temperatures.

Next to biological variations, the equipment may also contribute noise to the measurements [21].

Overall it needs to be mentioned that the relatively small sample size limits the statistical power and a larger number of subjects is required to confirm these findings.

We can conclude that the present study has provided deeper inside into the potential reliability of thermal imaging. It can be assumed that ITI is a promising evaluation tool when administered under standardised conditions. However, these findings can not be generalized for other body parts which may be more difficult to measure due to physiological variations.

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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

Programme

Friday 18th September 2009

Opening

Saal Mannheim

8.15 -8.30 Welcome Adresses

R.Berz, President of the German Society of Thermography and Regulation Medicine

A.Jung, President od the European Association of Thermology

K.Ammer, President of the Austrian Society of Thermology

History, presence and future of thermology societies

Saal Mannheim, Chair. A.Jung (Poland) F.Ring (UK)

8.30 - 8.50	*EFJ Ring & RVardasca(UK)*	Thermography And Its Clinical Applications – New York 1963
8.50 - 8.55	Discussion	
8.55 - 9.15	*H Usuki (Japan):*	History of the Japanese Society of Thermology
9.15 - 9.20	Discussion	
9.20 - 9.35	*R. Berz (Germany)*	55th Anniversary of the German Society of Thermography
9.35 - 9.40	Discussion	
9.40- 9.55	*K. Ammer(Austria)*	European Association of Thermology
9.55-10.00	Discussion	
10.00- 10.20	Coffee Break	

Standards for thermal imaging

Saal Mannheim, Chair: J. Mercer (Norway), G.Machin (UK)

10.20 - 10. 45	*G. Machin (UK)*:	Standards for temperature measurements
10.45 - 10.50	Diskussion	
10.50 - 11.10	*E.F.J. Ring (UK)*	ISO Standards for fever screening infrared cameras
11.10 - 11.15	Discussion	
11.15 - 11.30	*N.N.(Germany)*	The European Medical Devices Directive and its impact on medical infrared thermography – a lawyer's view
11.30 - 11.40	*Discussion*	
11.40 - 12.00	*H. Usuki (Japan)*	Constructing diagnostic criteria for breast thermograpy by the Japanese Society of Thermology
12.00 - 12.05	Discussion.	
12.05 - 12.25	*K.Ammer (Austria)*	Proposal for standards of performing infrared imaging in patients with suspected Raynaud´s phenomenon
12.25 - 12.30	Discussion	
12.30 - 13.30		Lunch

Fever Screening by a Infrared Thermography

Saal Mannheim , Chair; J. Mercer (Norway),

13.30-13.50	*D.D. Pascoe & G. Fisher*	Comparison of Core and Surface Skin Measuring Sites for the Assessment of Body Temperature
13.50-.14.10	*Ring EFJ et al (UK/Poland)*	Detecting Fever In Polish Children By Infrared Thermography
14.10-14.30	*R.Berz (Germany)*	Fever screening for travelers By Infrared Thermography
14.30-14.45	*J. Mercer (Norway)*	Fever detection by infared thermography: Concerns and guidelines
14.45-15.30	*Panel discussion*:	with J.Mercer, R.Berz, F.Ring, D.Pascoe, M.Brioschi

15.30 -16. 00 Coffe break

Thermography in surgery

Saal Manneim, Chair. K.Ammer (Austria)

16.00- 16.20	*J. B. Mercer, L. de Weerd, Å. Odden A.O.Miland, S.Weum (Norway)*	Dynamic infrared thermography of perforator flaps provides valuable information on skin perfusion for both reconstructive surgeons and physiologists
16.20.16.25	Discussion	
16.25-16.45	*H. Usuki (Japan)*	Comparison of body temperature in laparoscopic surgery with that in open surgery and the usefulness of body thermal image in surgery
16.45-16.50	Discussion	

Infrared imaging in botany and zoology

Saal Mannheim, Chair. Francis Ring (UK)

16.50-17.20	I. *Lamprecht (Germany)*	Use of infrared thermography in botany
17.20-17.25	Discussion	
17.25- 17.55	*N Torrao, A Fuller, P Hidden, J.B. Mercer((South Afrika/Norway)*	Skin temperatures of the African elephant (Loxodonta africana) in the heat.
17.55-18.00	Discussion	

20.30 Concert Music by G.F.Händel for organ

Saturday 19th September 2009

New developments in infrared imaging equipment

Saal Mannheim, Chair: K.Ammer (Austria)

8.00-8.20	*R.Vardasca, T.Vardasca (Portugal)*	Automated comparison of three methods for cold stress analysis of the hands
8.20 - 8.25	Discussion	
8.20 - 8.40	*P.Plassmann (UK)*	Quality Assurance of Thermal Imaging Systems in Medicine
8.40 - 8.45	Discussion	
8.45-9.05	*R. Berz (Germany)*	MammoVision – a standardized semi automated breast imaging and evaluation system
9.05-9.10	Discussion	

Infrared imaging in breast disease

Saal Mannheim, Chair: R.Berz (Germany), H.Usuki (Japan)

9.10 - 9.25	*H. Usuki (Japan)*	Mechanisms leading to an abnormal breast thermogram
9.25 - 9.30	Discussion	
9.30 - 9.45	*ÅO Miland, JO Frantzen, R Mortensen, Y Bremnes, P Eldevik, E Traasdahl, , M Kumle, JB Mercer (Norway*	Dynamic infrared thermography (DIRT) and early detection of breast cancer -a double-blind investigation
9.45 - 9.50	Discussion	
9.50 - 9.55	*Alexander Mostovoy*	Breast Thermography and its use in the prevention of breast disease.
9.55 - 10.00	Discussion	
10.00 - 10.15	*Nicola Hembry (UK)*	2 years of experience with breast thermography
10.15 - 10.20	Discussion	
10.20 - 10.35	*M. Godfrey (New Zealand)*	Thermal imaging as a means of monitoring interventions in breast pathology
10.35 - 10.40	Diskussion	
10.40 - 11.10	Coffee break	

Infrared imaging in dermatology

Saal Mannheim, Chair: S.Govindan (USA)

11.10 - 11.30	*Laino L, Di Carlo A (Italy)*	Thermographic evaluation of Patch Test : the two patterns
11.30 - 11.35	Discussion	
11.35 - 11.55	*K.J. Howell et al (UK)*	The value of infrared thermography for childhood localised scleroderma (LS):experience over twenty years
11.55 - 12.15	*ML. Brioschi et al (Brazil)*	Normalized methodology for medical infrared imaging.
12.15 - 12.20	Discussion	
12. 20 - 13.20	Lunch	

Thermotherapy

Saal Mannheim, Chair. J Demmink (Norway), F.Ring (UK)

13.20 - 13.50	*K. Ammer (Austria)*	Temperature effects of thermotherapy determined by infrared measurements: an updated review

13.50-13.55	Discussion	
13.50-14.10	*G. Hoffmann (Germany)*	Water-filtered infrared-A (wIRA) can improve the healing of acute and chronic wounds
14.10-14.15	Discussion	
14.15-14.35.	*J. B. Mercer(Norway), S. P. Nielsen (Denmark) G. Hoffmann (Germany)*	Improvement of wound healing by water-filtered infrared-A (wIRA) in patients with chronic venous stasis ulcers of the lower legs including evaluation using infrared thermography
14.35-14.40	Discussion	
14..40-15.00	*J. Demmink (Norway)*	Thermal effects of dry heat pack in physiotherapy, thermography as an educational approach
15.00-15.05	Discussion	
15.05-15.25	*J. Joensen et al (Norway)*	Thermal effects from Low Level Laser Therapy (LLLT) on the Human Skin
15.26-15.30	Discussion	
15.30-16.00	*M.Miyazaki et al (Japan)*	Comparison between chilling effects by the difference of the material of the pillow
16.00-16.05	Discussion	
16.05-16.25	*E.F.J. Ring, et al. (UK)*	The Effects Of Cooling Agents Applied To The Skin In Normal Subjects
16.25-16.30	Discussion	
16.30-17.00	Coffee break	

Other clinical applications of thermography

Saal Mannheim , Chair: D.D.Pascoe (USA). A.Nica (Romania)

17.00 -17.20	R. *Vardasca et al* (Portugal):	Thermal symmetry of limbs on healthy subjects
170.20-17.25	Discussion	
17.25-17.45.	*K. Ammer* (Austria)	Main applications of diagnostic thermography in the last 21 years: a chart review
17.25-17.30	Discussion	
17.30-17.50	*C Hildebrand*t (Austria)	Thermal imaging as a screening tool for knee injuries in professional junior alpine-ski racers in Austria
17.50-17.55	Discussion	
17.55-18.15	*A. Nica et al* (Romania)	Correlation between the thermographic assess and the clinical and functional rehabilitation in patients with posttraumatic ankle-foot sequelae
18.20-18.40.	*E Lyzhko*	The model of heat removal in zone Zahariina-Gaeda
18.40-18.45	Discussion	

Sunday 20th September 2009

Vascular Thermal Imaging

Saal Mannheim Chair; K.Howell (UK), T.Conwell (USA)

8.00 - 8.20	*S. Govindan.(USA)*	Imaging Cranial Angiosomes in Sleep Apnea
8.20 - 8.25	Discussion	
8.25 - 8.45	*R. Brantner (Germany)*	Visualisation of Carotis–Plaques by Infrared –Measurement – A basic methodological study and preliminary results
8.45 - 8.50	Discussion	
8.50 - 9.10.	*H.Cohen et al (UK)*	Thermography in Complex Regional Pain Syndrome (CRPS): pitfalls and progress
9.10 - 9.15	Discussion	
9.15 - 9.35.	*TD. Conwell et al (USA)*	Cold Water Autonomic Functional Stress Testing Utilizing Real Time Dynamic SubtractionIR Imaging In the Diagnosis of Complex Regional Pain Syndrome Cold challenge test in patients with CRPS
9.35 - 9.40	Discussion	
9.40 - 10.00	*P. Getson (USA)*	Utilizing Thermography to Predict the Spread of CRPS
10.00-10.05	Discussion	
10.05-1025	*KJ Howell et al (UK)*	Finger temperature in Raynaud's phenomenon (RP) in sufferers identified in a hospital and those drawn from the general population: a meta-analysis
10.25-10.30	Discussion	
10.30-10.50	*J Foerster,S Fleischanderl, S. Wittstock,A Storch, H Meffert, G Riemekasten, M Worm (Germany)*	Infrared-Mediated Hyperthermia Is Effective in the Treatment of Scleroderma-Associated Raynaud's Phenomenon
10.50-10.55	Discussion.	

10.55-11.15 Coffe Break

Thermography and Regulation Medicine

Saal Mannheim, Chairr: R.Berz (Germany)

11.15 - 11.35	*H. Sauer (Germany)*	Regulation Medicine and Regulation Thermography – Basic Priciples
11.35 - 11.40	Discussion	

Infrared imaging in veterinary medicine

Saal Mannheim, Chairr: R.Berz (Germany), RC.Purohit (USA)

11.40 - 12.00.	*RC Purohit (USA)*	Legality Associated with use of Infrared Thermography in Veterinary Medicine to Enforce Laws to Protect Animals
12.00 - 12.05	Discussion	
12.05 - 12.25	*R. Berz (Germany)*	Educational Course in Equine thermography: Results and future directions
12.25 - 12.30	Discussion	
12.30 - 12.50	*RC Purohit (USA)*	Standards for thermal imaging in Veterinary Medicine.
12.50 - 12.55	*Discussion*	

13.00 Close

11th Europen Congress of Thermology

Abstracts

History, presence and future of thermology societies

THERMOGRAPHY AND ITS CLINICAL APPLICATIONS-NEW YORK 1963

EFJ Ring[1], R.Vardasca[1,2]

[1]Medical Imaging Research Unit, Faculty of Advnaced Technology, University of Glamorgan, Pontyridd, UK

[2] Polytechnic Institute of Leiria (Portugal)

From 1940 until the late 1950's infrared imaging had been classified as a military technology. In 1963, early cameras used for medical research were in use, and the New York Academy of Sciences announced a special conference for a number of pioneers. Engineers, physicians and physiologists came together for that first meeting in the USA, which was published by the Academy. This book provides a detailed account of that conference and is well illustrated. From this we have a record of the early technology available, but more especially it provides a very useful appraisal of the background science, human physiology of temperature, and expectations of the future.

Some significant pioneers were present, including J.Gershwin Cohen and R Bowling Barnes. The Barnes thermograph was one of the first imaging systems made available for medical trials in the USA. Another pioneer was Dr Ray Lawson who not only reviewed the potential applications in medicine, but presented his early work in breast cancer thermography. His work has been widely recognized across the world in this area. A new British camera called The Pyroscan was developed in the UK, and preliminary medical studies had been carried out in London by Lloyd Williams in breast cancer and Bath by Ring et al. in rheumatology. There are several papers in the proceedings outlining very good principles for understanding localized temperature changes shown by thermography. The anatomy, physiology and pathology of a number of clinical conditions where thermography had shown useful information was expertly discussed. These principles are of continuing value today. The section of the proceedings dealing with the different clinical applications takes up over 200 pages of this 300 page book.. A good paper on the value of thermography in medical research was given by Lloyd Williams. The applications include varicosed veins and venous insufficiency, peripheral vascular diseases, orthopaedics trauma medicine, neurology thoracic and abdominal conditions. Obstectrics, rheumatology and breast diseases wwere also included. Breast screening potential and early diagnosis of breast cancer to improve the results of surgery were presented. Veterinary medicine was presented by Wendall Smith.

The camera technology used was of course slow and difficult to use. A major problem of that pre-computer era was in attempts to measure temperature from a thermogram. A group of thermal references was often included in the scanning area, and several different devices were used to make comparison of density in the monochrome image with the references to derive temperatures. There were however many problems with this method. Scanning times were slow, and a single image could take many minutes to acquire.

A striking feature at this time however, is that with all the limitations of the technology, most of the clinical applications of thermography today were investigated. There were just a few areas of medicine that have not been continued. Today we have modern high speed and higher resolution systems, with the outstanding advantages of computer technology and image processing.

HISTORY OF JAPANESE ASSOCIATION OF THERMOLOGY

Hisashi Usuki

Kagawa University Hospital. Kagawa, Japan

Japanese association of thermology had been established as "Thermography Study Group" at the beginning. It was 1984 that the study group was promoted to the academic society. Its name was "Japanese Association of Thermography" at that time. Then, the name was changed to "Japanese Association of Thermology" in 1987. The number of papers presented in the annual meeting in those days was more than 70. There were many kinds of papers presented in the meeting in those days. But, the number of papers presented in the annual meeting has been diminishing after the function of the medical equipment becoming to plateau. The average number of the papers presented in the recent four annual meetings was 21. The number of active members has also decreased. It is two-thirds of members belonging to the association in 2004. In this presentation I will demonstrate the history of Japanese Association of Thermology and the transition of the papers presented in the annual meetings.

55th ANNIVERSARY OF THE GERMAN SOCIETY OF THERMOGRAPHY

R.Berz

German Society of Thermography & Regulation Medicine, Waldbronn, Germany

55 years ago, the physician Schwamm and the physicist Reeh founded the very first society of thermography, named "Medical-physics Work Group of the County Unterlahn". The name changed several times, from "Society for Thermodiagnostics" to " German Society of Thermography" to the current " German Society of Thermography & Regulation Medicine". Originally based on infrared radiometry, the major progress in standardisation of the method was achieved by Rost, who used contact thermometers vor measurements in well defined body regions.

Although contact measurements are still the predominant method of temperature measurements in regulation medicine, infrared cameras are often applied nowadays. This techno- logy provide the facility to combine the principles of regulation thermography with mainstream evaluation of thermal images which is based on quantitation of temperature distribution on the body surface in a quasi steady state of heat exchange with the environment. Most recently the German Society of Thermology and the German Society of Thermograpy & Regulation Medicine have merged..

EUROPEAN ASSOCIATION OF THERMOLOGY HISTORY AND FUTURE

K. Ammer
Institute for Physical Medicine and Rehabilitation, Hanuschkrankenhaus, Vienna , Austria

Objective: To describe the history of the EAT.

Method: Reports and protocols of General Assemblies, Board Meetings and Proceedings of European Conferences were retrieved and information on the executives and members of the Association was extracted.

Results: The number of members in national thermology societies varied over the years and the focus of research in thermology migrated from western to central Europe. Spain and Italy reduced their activities in the early nineteen eighties, most of the activities in France and the Netherlands stopped in the late nineteen eighties, Great Britain continued its interest in Thermal imaging, although with a reduced manpower. Germany decreased also the research in thermology by the early nineties. At the same time new interest in the subject raised in Austria and in Poland. In the last decade valuable input came from Norway and recently from Romania.

In total 10 presidents from 7 different countries served the EAT which currently has 8 society members and some individual members. Until now, 11 European conferences of thermology were organized, and this year´s congress has more papers than the last meeting. The journal Thermology international is the official publication organ of the EAT and 7 other national thermology societies around the world. A website at supports the publication activities of the EAT.

Conclusion: After a numerous membership in the EAT and high interest in thermal imaging in the seventies and eighties, a difficult time followed in the nineties and the beginning of the 21st century. Currently the interest in thermology seems to revive and the EAT might grow again in the future.

Standards for thermal imaging

STANDARDS FOR TEMPERATURE MEASUREMENTS

G. Machin
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The current temperature scale established throughout the world is the International Temperature Scale of 1990 (ITS-90). While this is generally recognized in trade and industry it is not so widely promulgated in other sectors such as healthcare. This paper will begin with a discussion of how the temperature scale is established and then how the general user community can access that scale through applying the principles of calibration, traceability and accreditation.

Recent developments will then be described that have taken place in the practice of medical thermometry and how NPL is helping to validate these new methods and techniques putting them on a firm metrological footing. The following areas of medical thermometry will be addressed:

- The establishment of techniques for the calibration and validation of ear thermometers
- Improving the practice of quantative clinical thermal imaging
- Validation studies of in-situ probes for brain temperature measurement
- Validation of internal temperature measurement studies based on magnetic resonance imaging spectroscopy

One of the recurrent themes of this talk will be the deployment of fixed-point temperature references, as suitable secondary standards for medical thermometry.

ISO STANDARDS FOR FEVER SCREENING

EFJ Ring
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Influenza virus infections form a regular part of life, but periodically a more virulent strain occurs with sometimes rapid and fatal consequences for humans. Since the outbreak of severe Acute Respiratory Syndrome SARS in China in 2002-3, infrared imaging has been used in some airports as a means of screening passengers who may endanger others by travelling whilst suffering from a fever. In 2004 Singapore Standards authority SPRING produced two excellent documents as technical references. Thermal Imagers for Temperature Screening part1 requirements and test methods, and Part 2 Implementation Guidelines, were the first documents to focus on the required information for the application of this technology for fever screening. These were used as the basis for a new working group for the International Standards Organization. The content of the Singapore documents were updated and expanded to provide a new standard for the correct deployment of thermal imaging for fever detection.

Many of the first installations were (and still are) positioned in a way that reduces the efficiency of temperature measurement. Strict protocols, as in medical thermography, are the key to reliable and reproducible use of the technique. Proper understanding of the conditions for installation and use are essential, as are the regular testing of camera performance and training of personnel involved. The new standard is called "Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening" IEC80601-2-59and ISO subcommittee SC3. and was published after an international vote in September 2008.

A second document based on the SPRING document Part 2, is being published in 2009. This is not an international standard as such, but a technical guide to the "deployment, Implementation and operational guidelines for identifying humans using a screening thermograph". ISO/IEC TC 121/SC 3 N.

The ISO standard sets out the technical minimal performance required for a thermographic system used for fever screening. It refers to a number of existing standards relating to calibration of cameras, use of black body radiators etc. and the optimal performance needed to image to face and measure as accurately as possible. The inner canthi area of the eyes is a preferred and recommended site to represent core temperature. The procedure requires correct positioning so that the face fills the majority area of the image. It also requires a minimal number of pixels in the measured area, to derive the temperature. This contrasts with many of the pictures shown in the media where the camera may be directed at groups of people, and maximum temperature displayed in a thermogram may be based on a single pixel. Many images shown in thermograms drawn from image libraries by the media are of low resolution, probably out of focus, and the subject is too far away to measure temperature. The main items of these documents will be described and their importance to the future use of medical thermography will be discussed. At the present time the H1N1/A virus alert has resulted in more thermography installations, although it is not yet clear if they will be used in compliance to the new standard.

THE IMPACT OF THE EUROPEAN UNION'S MEDICAL DEVICES DIRECTIVE FOR MEDICAL INFRARED IMAGING AND MEASUREMENT

N.N., R.Berz

German Society of Thermography & Regulation Medicine, Waldbronn

The Impact of the European Union's Medical Devices Directive for medical infrared imaging and measurement

The EU's MDD is binding law for all countries of the union and ensures a high quality of security, accuracy and reliability of medical devices. Thermal measurement by infrared cameras or other devices is classified as class 1m equipment. This means that all thermal measurement has to undergo the whole process of certification, comparable to class 2 equipment. Only thermal imagers without any temperature reading (in °C) are class 1, where a simple CE sign is sufficient. Class 1 m as well as class 2 needs the participation of a "notified body", an external certification expert independent of the manufacturer of the equipment. This is documented by the addition of the ID number of the notifying body behind the CE sign.

PROCESS OF STANDARDIZATION OF BREAST THERMOGRAPHY IN JAPAN

Hisashi Usuki

Kagawa University Hospital. Kagawa, Japan

Many kinds of diagnostic criteria and conditions for thermographic examinations had been published over twenty years ago. However, some factors did not suit to Japanese. Because, the room temperature recommended for the examination was too cold for Japanese. So, the temperature of the examination room had to be changed. Changing the room temperature influence to diagnostic accuracy, then, we had to create a new standard adapting to Japanese. Some teams were constituted for standardizing several thermographic fields. A working group for breast disease was one of those teams.

The standardized factors were "Conditions of patients, examination rooms and taking thermogram", "Terminology" and "Diagnostic criteria". At first we made standardization of the conditions at the time of examination. The temperature of examination room was determined to be 24 centigrade. This was warmer than the temperature recommended in the foreign study. The warmer temperature might depress the diagnostic accuracy rate. Then, the terminology of thermographic findings was standardized. And we began to create the diagnostic criteria suitable to Japanese women. The positive rates of many findings were calculated in breast cancer patients and patients with benign diseases. Some findings were selected, because, the positive rate in the breast cancer patients was differ from that in the patients with benign diseases. In the last stage of creating the criteria quantitative factor was removed from the diagnostic factors. The reason of this was that there was no breast cancer, which was detected only by quantitative finding

PROPOSAL FOR STANDARDS OF PERFORMING INFRARED IMAGING IN PATIENTS WITH SUSPECTED RAYNAUD´S PHENOMENON

K.Ammer

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Background: Raynaud´s Phenomenon is characterised by 3-phasic colour changes of fingers and toes caused by vasospam of the digitial arteries due to low temperature and/or psychological stress. These colour changes may be accompanied by decreased skin temperature which can be identified by infrared thermal imaging.

Objective: To identify procedures which address patient´s preparation, temperature of the examination room, temperature and duration of the immersion bath, position of hands, time of follow-up after the cold challenge and method of evaluation

Method: A computer assisted literature search was performed for publications related to thermographic investigations of patients with suspected Raynaud´s phenomenon in Embase and the literature archive of the author.

Results: The information on procedures performed is incomplete in the identified studies. In addition there is a wide variation in water temperature of the immersion bath and also of duration of immersion. At least 3 different approaches for evaluation of hand temperatures were used. The following proposal for performing thermography for the identification of Raynaud´s phenomenon is given:

The patients is sitting with freely hanging arms which are undressed below the elbow on a chair at a room temperature of 24° C for at least 15 minutes without moving the fingers. A thermal image of both hands in the dorsal view is recorded following the position described in the Glamorgan protocol. Then both hands, covered with plastic gloves, is immersed in water of 20°C for 60 seconds. Immediately and at an interval of 10 minutes three other images are recorded. Circular regions of interest were defined and placed on the tip of each finger and over the mid of the metacarpal bones. The temperature difference between the distal and the proximal measurement area is calculated for each finger on the images recorded prior, 10 and 20 minutes past the cold challenge. The combined temperature gradient is computed from the temperature difference from the images prior and 10 minutes or 20 minutes past the cold challenge repectively. A combined negative temperature gradient greater than 1 degree represents a pathological finding. The diagnosis of Raynaud´s phenomenon is based on pathological combined gradients prior and 20 minutes past cold challenge.

Fever Screening by a Infrared Thermography

COMPARISON OF CORE AND SURFACE SKIN MEASURING SITES FOR THE ASSESSMENT OF BODY TEMPERATURE

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Background: 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.

Objective: 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.

Method: 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 (R2= 1) as the temperature of the environment increased.

Conclusion: 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.

DETECTING FEVER IN POLISH CHILDREN BY INFRARED THERMOGRAPHY

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Background: Recent attention on the need to detect fever during a pandemic influenza outbreak has shown that thermography of the face, tympanic radiometry, and other methods of clinical thermomety have limited documentation. Few papers on temperature values in thermographic examination for potential detection of fever have been published and very little on the expected normal values in children.

Objective: This study was designed to apply thermographic investigation of the face in children who are at high risk of infection during any virus outbreak, and compare the data from other measurement methods. We were unable to find normal data, so have studied a cohort of young patients at the hospital clinic in Warsaw, of whom a small percentage presented with a confirmed fever.

Method: 264 Children aged 1-16 years were seated in a room (ambient 22-230C) and thermographic recording of the frontal face was made with a FLIR camera (T400 and P400). Axilla thermometry and tympanic radiometry was also recorded in 254 afebrile and 10 febrile children. The sample size of tympanic ear measurements was smaller and the method was not always achievable in the youngest children.

Results are shown in the following table

normal non febrile children (n=253)			
	Mean ± SD (C°)	1-ANOVA	
eye maximum temperature	36.4 ±0.5	eye vs axilla	p = 0.000 sigf
Mean forehead (from thermogram)	35.0 ±0.64	forehead vs axilla	p = 0.044
axilla (from thermometer)	36.3 ± 0.7	ear vs axilla	p = 0.26
ear (tympanic) (n=141)	36.0 ± 0.76		
febrile group (n=10)			
eye maximum temperature	37.80 ± 0.4	eye vs axilla	p = 0.012
Mean forehead (from thermogram)	36.1± 0.8	forehead vs axilla	p = 0.038
axilla (from thermometer)	38.2 ±. 0.4	ear vs axilla	p = 0.092
ear (tympanic)(n=7)	36.9 ±1.3		

No differences were found in these data relating to either sex or age.

Conclusion: A high correlation was found between inner canthus eye temperatures and the underarm axilla, but forehead and ear temperature measurements were less well correlated. Temperature values from the non febrile children were all below the febrile, and in this study we included axilla temperatures of >37.8 as febrile, as all cases were confirmed clinically, and accounting for measurement errors of the individual systems used.

FEVER SCREENING FOR TRAVELERS BY INFRARED THERMOGRAPHY

Reinhold Berz
InfraMedic GmbH. Moerfelden bei Frankfurt am Main, Germany

Airports are the entry gates of global infectious diseases such as SARS, "avian flu" or recently "swine flu ". There is cur-rently no effective method to identify individuals already infected. While there are some Asian airports using thermal imaging cameras, however, the applied method of the investigation does not comply with the required standards.

InfraMedic, the European provider of medically approved infrared thermography examination systems, has developed FeverScreen, a new device for instant fever measurement. It is based on recent scientific studies and was developed by a team of experts from medicine and computer science. Using special high-precision infrared cameras, the system can detect passengers with fever or elevated body temperature. The measurement of a person lasts only a few seconds, and a green or red signal (with optional warning) shows the measured value and its relevance.

If FeverScreen indicates a conspicuous result, further investigations, advice or other means by the medical service of the airport will follow. Admittedly, not all infected individuals are already fevering, but at least the potentially very contagious virus carriers with elevated body temperature are well recognized.

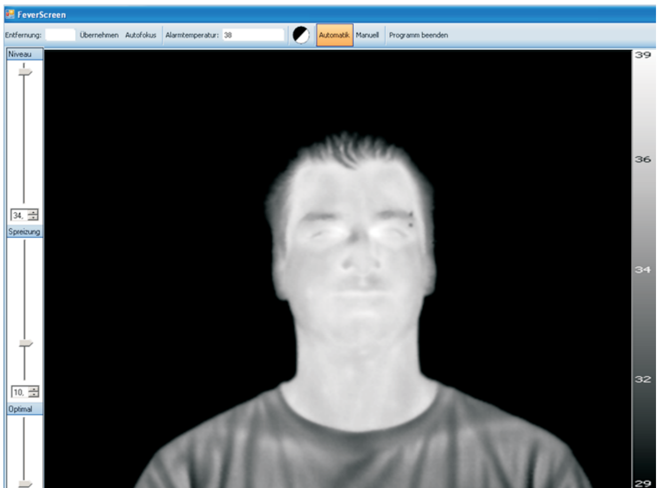

Figure 1
Body Temperature: 38, 7° C

FEVER SCREENING AND INFRARED THERMAL IMAGING: CONCERNS AND GUIDELINES

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The aim of this presentation is inform those either using or considering using infrared thermal imaging mass screening systems for fever detection of recent developments surrounding this concept. The recent publicity surrounding the Swine influenza outbreak (H1N1 strain of influenza type A) has spurred interest in the use of this technology. However, the publicity has also sparked a debate concerning the effectiveness of using infrared thermal imaging for this purpose. It is important to note that this document is not intended to answer the question as to the reliability of infrared thermal imaging for fever screening. Clearly opinions will vary depending on the interests and experience of the reader. Nevertheless, the EAT feel that there are some basic facts that need to be taken into account when either using and/or designing specialized infrared thermal imaging installations for mass screening of human subjects

PANEL DISCUSSION

FEVER SCREENING AND INFRARED IMAGING

Chaired by the physiologist James.Mercer, Norway,
the panel members R. Berz, Germany,
Francis Ring, United Kingdom,
David Pascoe, United States and
Marcos Brioschi, Brazil
will discuss recent developments, standards, pitfalls and special needs for applying infrared cameras in mass screening for fever detection.

Thermography in surgery

DYNAMIC INFRARED THERMOGRAPHY OF PERFORATOR FLAPS PROVIDES VALUABLE INFORMATION ON SKIN PERFUSION FOR BOTH RECONSTRUCTIVE SURGEONS AND PHYSIOLOGISTS

James B. Mercer [1], Louis de Weerd [2], Åshild Odden Miland [1], Sven Weum[3]

[1] Institute of Medical Biology, Dept of Medical Physiology, University of Tromsoe; [2] Department of Plastic Surgery and Hans Surgery. [3]Department of Radiology, University Hospital North Norway, Tromsoe, Norway

Large defects due to trauma, tumour resection and pressure sores are nowadays preferably closed with so-called perforator flaps. A perforator flap is defined as a flap of skin and subcutaneous tissue, which is supplied by an isolated perforator, which is in contrast to its musculocutaneous counterpart that is based on a large number of perforators originating from the source artery. One of the reasons for the popularity of perforator flaps is that they are associated with low donor site morbidity. The use of perforator flaps requires meticulous surgical technique and understanding of the vascular anatomy. Preoperative planning includes selection of the most suitable perforator to supply the flap. This can be done intraoperatively. However, this requires time and may easily lead to damage of the vessels due to inadvertent traction. Therefore it is recommended to perform a preoperative mapping of suitable perforators. In cases of free flaps, the microsurgical anastomosis is one of the most important aspects for adequate perfusion of the flap. A suitable monitoring technique that allows evaluation of the patency of the anastomosis would be very beneficial. During the postoperative phase perfusion problems may lead to partial or total flap failure, a devastating experience for the patient. A close monitoring of flap perfusion is therefore important since early recognition of impaired perfusion makes early intervention possible and increases flap survival. We have been using dynamic infrared thermography (DIRT) in the preoperative, intraoperative and postoperative phase of perforator flap surgery during the last 5 years. The results from the DIRT examinations have contributed to a better understanding of the perfusion of perforator flaps. In addition, new questions have been raised on the function of perforators on skin perfusion and thermoregulation. Recent results illustrating these points will be presented

COMPARISON OF BODY TEMPERATURE IN LAPAROSCOPIC SURGERY WITH THAT IN OPEN SURGERY AND THE USEFULNESS OF BODY THERMAL IMAGE IN SURGERY

Hisashi Usuki, Hiroshige Sutou, Hirotaka Kashiwagi, Ryuusuke Takebayashi, Takanori Sano, Shintarou Akamoto, Tatsushi Inoue, Keitarou Kakinoki, Masanobu Hagiike, Keiichi Okano, Kunihiko Izuishi, Yasuyuki Suzuki

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It is reported that there is a close relationship between the hypothermia of patients undergoing operations and the risk of surgical site infection. Then, it seems to be important to keep patients warm in peroperative period. In this report body temperature of the patients undergoing laparoscopic surgery were compared with those of the patients with open surgery. The subjects of this study were 14 colon cancer patients. Ten of them were male and four were female. The age of them were 73.6±7.2 years old. Eight of them underwent open surgery and six did laparoscopic surgery. There was no significant difference between operation periods of laparoscopic surgery and those of open surgery. The body temperature of the patients with laparoscopic surgery was almost same as the patients with open surgery at the starting point of the surgery. But, the temperature of the patients with laparoscopic surgery at the middle point of surgical period was 35.8±0.50 degree centigrade. This tended to be lower than the patients with open surgery (36.4±0.5) (p=0.0545). The temperature of the patients with laparoscopic surgery at the point of one-hour prior to the finish of the operation was 36.1±0.7, and that of the patients with open surgery at the same point was 36.9±0.6. This difference was statistically significant (p=0.0496). The reason of this difference seems to be influenced by pneumoperitoneum used in laparoscopic surgery. For diminishing surgical site infection and avoiding hypothermia, that is uncomfortable for the patients just after the anesthesia, it is important to observe the body temperature of the patients undergoing surgery, especially in laparoscopic surgery.

Infrared imaging in botany and zoology

BOTANICAL APPLICATION OF THERMOLOGY

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Institute for Zoology, Free University of Berlin, Germany

Botanical applications of thermography concern investigation of structural changes of leaves by many different external parameters like drought, cooling, light induced heat, stimulation by salicylic acid, stress tolerance, virus infection and stomatal resistance, to mention just a few of them.

But a considerable part of the botanical investigations – and the most spectacular ones – focus on so-called "Thermogenic Plants", plants that heat up during inflorescence for various reasons. They are found in different families and extend from a few centimetres up to about three meters of height. Again, their thermal effects reach from a few degrees up to about 40 K against ambiance. Some members produce a constant increase of temperature and thus vary with the environment, other become independent of the environmental values and keep constant temperatures ("thermoregulating") from hours to days and even weeks. Thermogenic plants have impressive flowers; the most beautiful ones are that of the water lily Victoria amazonica and V. cruziana, the sacred lotus Nelumbo nucifera, the dragon root Dracunculus vulgaris and the Philodendron selloum.

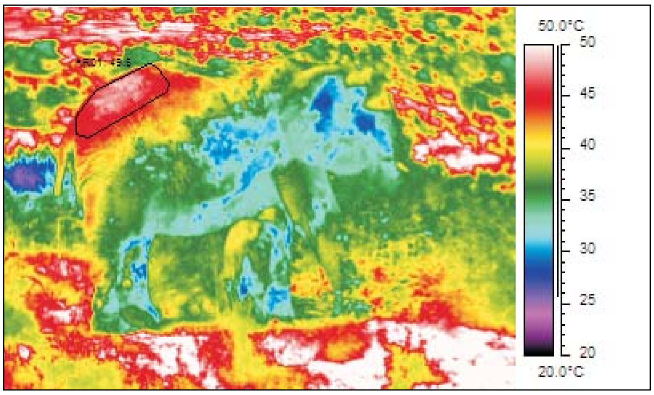
Both sections will be touched, experiments described and results explained and – in spite of the sentence above – some pretty pictures shown on Victoria and Co.

SKIN TEMPERATURES OF THE AFRICAN ELEPHANT (LOXODONTA AFRICANA) IN THE HEAT.

N.Torrao [1], A.Fuller [1], P.Hidden [1], J. Mercer [2]
1 School of Physiology, University of the Witwatersrand, Johannesburg. South Africa
[2] Institute of Medical Biology, Dept of Medical Physiology, University of Tromsoe; Norway

In endothermic homeotherms appropriate vasomotor control of skin blood vessels is important in regulating body temperature (Tb). Infrared (IR) thermography makes use of this fact where a warm skin temperature is accepted as indicating increased peripheral circulation and vice versa. If ambient temperature exceeds Tb mammals risk gaining heat from the environment, especially if peripherally vasodilatated. Evaporative heat loss is the main avenue for heat dissipation in such circumstances. Elephants, which do not sweat, could avoid such heat gain by reducing peripheral circulation. A consequence of this peripheral vasoconstriction is that the skin may become very hot, especially in the presence of strong solar radiation. To investigate the vasomotor state of the skin of African elephants under varying heat loads IR-thermal images were taken at regular intervals over a 24 hour period during summer (March). The animals belonged to a small domesticated herd maintained at the Letsatsing Game Reserve, North West Province, South Africa. Tb was also measured using ingested temperature data loggers. Meteorological data were measured from a local field station.

We found that the skin of adult elephants shows a great deal of local variation due to factors such as intensity of incident solar radiation, which, among other factors, is dependent on the shape of the animal. Skin temperature measured during the most intense periods of solar radiation on the most directly exposed skin areas attained values close to 50°C indicating reduced peripheral circulation at these sites. In the heat the temperature of the back side of the ears was consistently several degrees lower than that on the outside, mostly likely due to trans-cutaneous evaporative water loss. Although water loss from the ears and behavioural modifications probably assisted the elephants in maintaining Tb within a daily range of about 1.5°C, peripheral vasoconstriction also appears to play a role in allowing elephants to withstand high environmental heat loads.



Elephant in the afternoon. The mean surface temperature of the buttocks 46±1.5 °C (range 38.1 to 49.5)

New developments in infrared imaging equipment

AUTOMATED COMPARISON OF THREE METHODS FOR COLD STRESS ANALYSIS OF THE HANDS

Ricardo Vardasca, Tomé Vardasca

University of Glamorgan (UK), Polytechnic Institute of Leiria (Portugal)

Background: Cold Stress Test (CST) on hands has been used as a standard in thermography for assessing Raynaud's Phenomenon (RP) for years. This test has shown to be relevant for assessing specific vascular and neurological conditions when used in combination with other provocation tests. Different temperatures of water and recovering times have been used. Three methods to grade the test have been suggested; Ring suggested in 1980 the method of areas (Method 1), where the mean temperature of fingers excluding the thumb was subtracted to the mean temperature of the dorsal palm of the hand. The index values were calculated for the thermogram before the CST and from the final one (normally 10, 15 or 20 minutes depending on the recovery), for a final index both thermograms indexes were added for each hand, in case of an index value below -2.0ºC the hand was considered hypothermic. Ammer recently suggested two methods based on thermal gradients/profiles, one using a thermal spot of at least 16 pixels on the middle of each finger (excluding thumb) distal phalanx and another spot of the same size on a proximal region of the respective metacarpal (Method 2) computing the mean temperatures of those spots, subtracting the finger spots from the metacarpals obtaining a index per finger. The other suggested method from the same author was to draw a line from the middle of each finger (excluding thumb) distal phalanx to the proximal part of the correspondent metacarpal (Method 3) calculating the mean temperature of each part of the line, corresponding the distal part of the line to the finger and proximal to the metacarpal, once again to obtain the index per finger by subtraction.

Objective: Compare the three methods of assessing CST of hands and investigate the values of thermal symmetry on healthy volunteers on recovering of CST.

Method: The CST were performed according to the Glamorgan thermogram capture protocol using exposure of 1 minute to water at temperature of 20 ºC. 10 healthy volunteers were examined. Two types of CST were recorded, one combined with mechanical provocation before and another without previous provocation. A computational application using an anthropometric model of hands was developed allowing standardization of thermal images of hands based on anatomical landmarks and preserving its thermal values per hand area of interest (AIO). This tool also produces statistical values per hand AIO's. Another complementary tool was developed implementing the three methods of assessing CST generating each statistics per minute of recovery.

Results:

	Thermal indices			
	post CST	Possible RP	Post mechanical provocation + CST	Possible RP
Method 1	-7.48 to 2.94	4	-7.89 to 1.92	3
Method 2	-13 to 4.08	4	-10.26 to 1.99	3
Method 3	-7.41 to 2.11	4	-6.19 to 1.72	3

Thermal symmetry on hands after CST:

5 min: mean $\Delta T = 0.62$ºC ± 0.56, Δ SD. = 0.17 ºC ± 0.12
10 min: mean $\Delta T = 0.65$ºC ± 0.53, Δ SD. = 0.1 ºC ± 0.08

Conclusion: The method that provides better discrimination is the Method 2. All methods seem to be sensitive to false positive cases of RP.

QUALITY ASSURANCE OF THERMAL IMAGING SYSTEMS IN MEDICINE

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Background: Standardisation is important for reliable use of infrared thermal imaging in medicine. Infrared camera systems are now of higher performance with improved reliability, which can lead the operator to assume that the system is continually giving optimal performance. This, however, is not the case.

Objective: This contribution proposes a series of simple experiments based on inexpensive and easy to acquire materials, which a thermographer can use under normal clinical conditions to monitor the performance of thermal imaging equipment in order to maintain confidence in the measurements made.

Method: 5 Tests are proposed that identify: a) offset drift after switching on, b) long-term offset drift, c) offset variation over the observed temperature range, d) image non-uniformity and e) the thermal 'flooding' effect. These tests are not intended to replace those performed by manufacturers or calibration laboratories, but to provide valuable information on both short and long-term camera performance

Results: Measurement results based on the above experiments will be presented which demonstrate that cameras may drift over several degrees centigrade in less than 2 hours after switching on. They also show that imaging equipment can produce a varying amount of measurement error (up to 1.5 degrees centigrade), which depends on the temperature range observed. It is also demonstrated that equipment may be prone to non-linear errors (in the region of 1 degrees C), which are caused by deficiencies of the optical system and will manifest themselves if the equipment is not calibrated regularly.

Conclusion: Although the methods and materials used in the proposed 5 tests are simple and inexpensive they will reliably detect equipment errors. They are useful to characterize the performance of a thermal imaging systems and to identify their individual strengths and weaknesses. They can not replace calibration by manufacturers or notified bodies such as national standards laboratories.

MAMMOVISION: STANDARDIZED INFRARED REGULATION IMAGING OF THE FEMALE BREAST

R.Berz

German Society of Thermography & Regulation Medicine, Waldbronn, Germany

MammoVision is based on the principles of regulation medicine. The female breast is exactly measured by a highly precise medically suited infrared camera before and after the application of a cooling stimulus. The images taken recorded before (comfort temperature) and after exposing the undressed women to an ambient temperature of 20 °C are evaluated and compared by a specially designed computer program.

After ten years of application of MammoVision thousands of examinations have been conducted, and the results so far evaluated demonstrate the clinical use: The method is highly specific and able to detect healthy women without breast diseases. The specificity depends on the end point. The rate of women with suspicious and abnormal results is much higher than the prevalence of breast cancer. This is due to the fact that many breast diseases are characterized by an up regulated breast metabolism leading to increased blood distribution and, in some cases, neo angiogenesis.

MammoVision offers tools to differentiate between minor and major symptoms that often occur together with breast cancer. Visual and automatically calculated items ensure that all thermal criteria are included into the evaluation.

Infrared imaging in breast disease

MECHANISM OF ABNORMAL FINDINGS IN BREAST THERMOGRAPHY

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Thermography is a functional examination of breast cancer. It is well known that there is close relationship between thermographic findings and the prognosis of breast cancer patients. The reason of this is that the thermographic findings relate with the tumor progressive stage and the malignant grade of breast carcinoma. In my previous study it was revealed that thermographic findings of breast cancers are influenced by some histological findings. And it was also proved that the thermographic findings had intimate association with the malignant grade of tumors investigated by mitotic index, DNA index and neo-angiogenetic factor. The next study was performed for elucidating the mechanism of abnormal thermogram. In the results it was revealed that the nipple hyperthermia was related to the distance from tumor to nipple. This shows the heat produced in the tumor conducts to the nipple through the mammalian tissue. This hypothesis is inferred by the characteristics of mammalian tissue with good thermal conductivity. On the other hand, hyperthermia of tumor covering skin could not explained by direct thermal conductivity. Because, the adipose tissue exist between the tumor and the tumor covering skin does not have such thermal conductivity. In the results of studies the thermal abnormality of tumor covering skin was related to the dilatation not of the peri-tumorous vessels, but of the subcutaneous vessels. This shows that some chemical mediator is involved in hyperthermia of tumor covering skin.

DYNAMIC INFRARED THERMOGRAPHY (DIRT) AND EARLY DETECTION OF BREAST CANCER - A DOUBLE-BLIND INVESTIGATION

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Background: Breast cancer (BC) is the type of cancer with the highest incidence in Norwegian women. In Norway, a nationwide mammography screening programme was introduced in 2004 offering screening every two years to women aged 50-69 years. The current diagnostic method used when results from mammography screening are non-specific or suspicious is called the "triple test" (TT) and its components are mammography, clinical breast examination (with ultrasound), and biopsy. At our breast diagnostic clinic (BDC) about 20% of these patients will have a positive diagnosis for breast cancer. The use of thermography in early breast cancer detection is well known for over 50 years. However, due to problems such as high false-positive rates and lack of large randomized studies in the last 25 years, the use of this technology has not been universally accepted. Our TT patients present a unique opportunity to carry out a double-blind study, using a modern infrared camera to investigate the diagnostic accuracy (sensitivity/specificity) of DIRT for diagnosing BC.

Objective: The main objective of the study is to investigate whether DIRT, using modern equipment can be used as an adjunctive diagnostic tool in the detection of BC in patients called in for follow-up TT examination, due to a non-specific or suspicious mammographic finding.

Method: Ca. 300 women will be examined with DIRT before undergoing the TT. Specifically trained technical staff at BDC will carry out the DIRT examination, which includes a local skin cooling and recovery protocol. The anonymised DIRT images will be independently examined by two experienced thermographers with no knowledge of the outcome of the TT. Only after completion of the examination of all subjects when we compare the outcome of the TT and DIRT results will the diagnostic accuracy (sensitivity/specificity) for DIRT in diagnosing BC be determined.

Results: Some preliminary findings will be presented.

BREAST THERMOGRAPHY AND ITS USE IN THE PREVENTION OF BREAST DISEASE.

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Background: Breast Thermography has been in use since the 1970s, and was approved by the US Food and Drug Administration (FDA) in 1982. Over the years, many international studies have proven the usefulness of this non-invasive technique for the detection of breast abnormalities. However, the clinical application of breast thermography in the prevention of breast disease has yet to be fully realized.

Objective: To discuss uses of breast thermography in clinical practice. Particular emphases will be placed on understanding the clinical applications of thermographic breast imaging, its grading system and related terminology.

Method: In our clinical practice in Toronto, we have imaged thousands of women using standardized imaging and qualitative TH reporting methods. This will be discussed along with quantitative methods of evaluation. Over the years, certain risk factors relating to breast cancer have been seen in our practice, and we have subsequently initiated further study of these patterns.

Results: Our findings show that a very high percentage of women presenting with a history of breast mastectomy have suggestive same-sided dental pathology. A simple infrared image of the patient's face is able to identify this connection. In addition to these findings, the use of breast thermography to monitor the effectiveness of HRT treatment, diet intervention and life-style changes has been utilized in our practice and will be discussed.

Conclusion: Additional investigations and studies will be helpful to evaluate the connection between dental pathology and breast cancer. Breast Thermography is an effective tool in these evaluations.

EXPERIENCE WITH THE MAMMOVISION SYSTEM 3 CASE STUDIES

Nicola Hembry
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Since we introduced MammoVision into our clinical practice, we could study a number of patients in cooperation with our radiologist and other colleagues at the Litfield Medical Centre in Bristol, UK. We combined different examination methods with MammoVision, the standardized breast thermography.

Three cases of women with breast cancer and the important role of breast thermography in the diagnostic procedure are presented and discussed.

THERMAL IMAGING AS A MEANS OF MONITORING INTERVENTIONS IN BREAST PATHOLOGY

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Background: Routine thermographic breast screening was used to monitor breast health in 2000 women over a 6 year period. Abnormal findings were closely monitored during interventions.

Objective: To determine the clinical value of thermal imaging as a means of assessing the benefits or otherwise of interventions.

Method: Three, six and 12 month serial thermograms were used in cases showing pathology.

Results: Either earlier diagnosis of breast cancer was achieved or evidence of reversion to normal following naturopathic and other interventions was observed

Conclusion: Thermal imaging is a clinically useful adjunctive investigation in breast disease including breast cancer where clinical progress can be monitored. Protocol standardisation is needed in order that wider acceptance by the profession can occur.

Infrared imaging in dermatology

THERMOGRAPHIC EVALUATION OF PATCH TEST : THE TWO PATTERNS

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Background: The Infrared Thermography or Telethermography (TT) is a non-invasive imaging technique by which it is possible to evaluate the thermal gradients of the bodies. In the recent past, TT has been employed as a diagnostic tool in many field of medicine and in particular in dermatology for its peculiar position of the superficial organ. The last generation thermographic instruments have a high performance and lead to reproducible and comparable data.

Objective: To demonstrate that TT is an objective and useful tool to differentiate allergic contact dermatitis patch tests from irritant contact dermatitis.

Patients/Method: A group of 34 allergic patients (19 F, 15 M, and aged 23 to 62) with a history of delayed Nichel hypersensitivity (demonstrated by a positive patch test) was enrolled, and, as control, a group of 30 non-allergic patients was studied. In the subjects of the first group, a patch containing NiSO4 on a side of the back was applied (exposure time of 48 hours). Symmetrically, on the other side, a patch containing Sodium-Laureth-Sulphate (SLS) 1% was applied (24-h exposure time). In the group of non allergic subjects, only LSL 1% was applied on a side of the back. The tests were evaluated by TT after 30 minutes from patch removal. Because of the very low thermal gradients in this particularly field, TT with thermal stimulation method was performed.

Results: Patch tests elicited positive Nichel reactions in all of 34 patients of the first group, while SLS 1% patch test was positive in 26/34 of these individuals. Among the non-allergic group, 23/30 subjects showed a positive reaction to SLS 1%. On thermographic evaluation, a very clear difference between $NISO_4$ and SLS responses was seen. In fact, the allergic pattern was characterized by a *hyperthermal are*a with a lymphocentric pseudopod, or a *hypotermal area* surrounded by *pseudo-polypoid strong hyperthermal halo,* while irritant pattern (SLS1%) showed a *hypothermic area* fully corresponding to the area of patch site.

Conclusion: Thermographic analysis of patch test can be considered not only an objective and very useful tool to the evaluation of patch test, but also to differentiate allergic test from irritative responses.

THE VALUE OF INFRARED THERMOGRAPHY FOR CHILDHOOD LOCALISED SCLERODERMA (LS): EXPERIENCE OVER TWENTY YEARS.

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Background: The detection of active LS lesions in children and the evaluation of response to therapy both presuppose objective and reliable measures of disease activity.

Objective: Our presentation will review the compelling evidence that infrared thermography has a role to play in the assessment of childhood LS, beginning with the earliest case report (1), progressing to pilot studies of the utility of thermography for active lesion detection (2-4), and culminating in our recent work in London using infrared measurements in conjunction with laser Doppler flowmetry (5).

Conclusion: High frame rates (near-instantaneous imaging) and wide fields of view make thermography an effective tool for detecting skin inflammation in early LS. In older lesions the skin (and subcutaneous fat layer) may be thinned. Increased heat conduction through thinned skin may limit the utility of thermography in these older lesions. Novel laser blood flow imaging techniques may prove to be an important adjunct to thermography in the evaluation of atrophic lesions.

NORMALIZED METHODOLOGY FOR MEDICAL INFRARED IMAGING

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A normalized procedure for medical infrared imaging is suggested, and illustrated by a leprosy and hepatitis C treatment follow-up, in order to investigate the effect of concurrent treatment which has not been reported before. A 50-year-old man with indeterminate leprosy and a 20-year history of hepatitis C was monitored for 587 days, starting from the day the patient received treatment for leprosy. Standard therapy for hepatitis C started 30 days later. Both visual observations and normalized infrared imaging were conducted periodically to assess the response to leprosy treatment. The primary end points were effectiveness of the method under different boundary conditions over the period, and rapid assessment of the response to leprosy treatment. The patient achieved sustained hepatitis C virological response 6 months after the end of the treatment. The normalized infrared results demonstrate the leprosy treatment success in spite of the concurrent hepatitis C treatment, since day 87, whereas repigmentation was visually assessed only after day 182, and corroborated with a skin biopsy on day 390. The method detected the ffectiveness of the leprosy treatment in 87 days, whereas repigmentation started only in 182 days. Hepatitis C and leprosy treatment did not affect each other.

Thermotherapy

EMPERATURE EFFECTS OF THERMOTHERAPY DETERMINED BY INFRARED MEASUREMENTS: AN UPDATED REVIEW

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Background:. Infrared technology for temperature measurements was used for the evaluation of the effects of heat or cold treatment

Objective:To update a previous review of infrared based temperature measurement after thermotherapy (1).

Method: The existing literature search in the databases Medline, Embase and the archive of the author was extended to all publications included in the databases until May 1st 2009.

Results: The literature search identified 10 new papers which were added to the existing database of 43 publications. Temperature changes due to cryotherapy were most frequently assessed by infrared based measurements, followed by ultrasound and balneotherapy.

Infrared temperature measurements was used after application of various forms of cryotherapy such as cold air, ice cubes, cold packs or cooling cuffs in both animals and humans. The effects of balneotherapy on skin temperature was investigated after thermo-neutral ,hypo- and hyperthermic baths. The temperature course of hot packs used for medical treatment was studied. The effect of infrared A-irradiation was monitored by infrared imaging. The depth of warming after application of ultrasound of different frequencies and various ways of application were clearly demonstrated by thermal imaging in recent studies. Older studies have used radiometers for measuring skin temperature after short wave application.

Conclusion: Infrared based temperature measurement is an increased used technique for the evaluation of physical treatment modalities that apply or remove thermal energy.

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WATER-FILTERED INFRARED-A (WIRA) CAN IMPROVE THE HEALING OF ACUTE AND CHRONIC WOUNDS

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Water-filtered infrared-A (wIRA) as a special form of heat radiation with a high tissue penetration and with a low thermal load to the skin surface can improve the healing of acute and chronic wounds both by thermal and thermic as well as by non-thermal and non-thermic effects. wIRA increases tissue temperature (+2.7°C in a tissue depth of 2 cm), tissue oxygen partial pressure (+30% in a tissue depth of 2 cm), and tissue perfusion. These three factors are decisive for a sufficient tissue supply with energy and oxygen and consequently for wound healing and infection defense.

wIRA can considerably alleviate the pain (pain reduction throughout 230 irraditions) with remarkably less need for analgesics (57-70% less in the groups with wIRA compared to the control groups) and diminish exudation and inflammation. The overall effect of the irradiation as well as the wound healing and the cosmetic result (assessed on visual analogue scales) were markedly better in the groups with wIRA compared to the control groups. wIRA can advance wound healing (median reduction of wound size of 90% in severely burned children already after 9 days in the group with wIRA compared to 13 days in the control group; on average 18 vs. 42 days until complete wound closure in chronic venous stasis ulcers) or improve an impaired wound healing (reaching wound closure and normalization of the thermographic image in otherwise recalcitrant chronic venous stasis ulcers) both in acute and in chronic wounds including infected wounds. After major abdominal surgery there was a trend in favor of the wIRA group to a lower rate of total wound infections (7% vs. 15%) including late infections after discharge from hospital (0% vs. 8%) and a trend towards a shorter postoperative hospital stay (9 vs. 11 days).

Even the normal wound healing process can be improved. The mentioned effects have been proven by six prospective studies, most of the effects with an evidence level of 1a/b.

IMPROVEMENT OF WOUND HEALING BY WATER-FILTERED INFRARED-A (WIRA) IN PATIENTS WITH CHRONIC VENOUS STASIS ULCERS OF THE LOWER LEGS INCLUDING EVALUATION USING INFRARED THERMOGRAPHY

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Water-filtered infrared-A (wIRA) is a special form of heat radiation with a high tissue-penetration and with a low thermal burden to the surface of the skin. wIRA is able to improve essential and energetically meaningful factors of wound healing by thermal and non-thermal effects. In this prospective study wIRA was used in the treatment of patients with recalcitrant chronic venous stasis ulcers of the lower legs. The progress of wound healing as well as skin temperatures before and during irradiation therapy were documented with the help of IR-thermography. 10 patients (median age 62 years) with recalcitrant chronic venous stasis ulcers of the lower extremities were irradiated two to five times/week for 30 minutes (approximately 140 mW/cm2 wIRA and approximately 45 mW/cm2 visible light). Treatment continued for a period of up to 2 months (typically until closure or nearly closure of the ulcer). The main variable of interest was "percent change of ulcer size over time". Additional variables of interest included thermographic image analysis and evaluations of wound pain, wound healing, and cosmetic state.

A complete or nearly complete healing of lower leg ulcers occurred in 7 patients and a clear reduction of ulcer size in 2 patients. In addition there was a clear reduction of pain and of the consumption of analgesics and a normalization of the thermographic image (before the beginning of the therapy typically hyperthermic rim of the ulcer with relative hypothermic ulcer base, up to 4.5°C temperature difference). Failures of complete or nearly complete wound healing were seen only in patients with arterial insufficiency, in smokers or in patients who did not have venous compression garment therapy.

This study shows that wIRA can alleviate pain considerably and accelerate wound healing in chronic venous stasis ulcers of the lower legs. It is concluded that wIRA can be used to improve wound healing, to reduce pain, exudation, and inflammation and to increase quality of life.

THERMAL EFFECTS FROM LOW LEVEL LASER THERAPY (LLLT) ON THE HUMAN SKIN

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Background: Early reports about LLLT speculated that clinical effects were induced by increased temperature, while newer reports point out that the clinical effects of LLLT may rather be based upon modulation of photo-chemical and photo-biological processes. Little is known of whether irradiation with LLLT increases skin temperature, and whether demographic variables such as age, gender and skin color affects this outcome.

Objective: To investigate the thermal effect in human skin after different doses of LLLT in healthy persons of three different age groups, both genders and white, colored and dark skin.

Method: Subjects received six different laser doses from two laser units. The skin thermographs were filmed during laser irradiation and until 60 seconds after each laser dose were delivered. Data were analyzed for differences in three age groups, sex, and three skin colors.

Results: The thermal effect is conditioned by skin color, where the laser energy generates more heat in darker skin. Regardless of the laser doses, there were no differences in thermal effects between the sexes.

THERMAL EFFECTS OF DRY HEAT PACK IN PHYSIOTHERAPY, THERMOGRAPHY AS AN EDUCATIONAL APPROACH

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Background: Physiotherapy students have problems in understanding what kind of effects heat exposed on a human skin can have, especially in learning interaction of dose response of the thermal impulse in proportion to time and their own senses. Thermography gives an important addition to the educational impact in learning basic thermotherapy for physiotherapy students.

Objective: To investigate the thermal effect on human skin after a 10 minutes exposure to heat pack on healthy persons.

Method: Subjects received 10 minutes of heat exposure. The skin thermographs were filmed before, during and after heat exposure. Sensing data of the “patient” and of the therapist were compared to the thermal images and summarized to knowledge based learning.

Results: The thermal effect is conditioned by time, where the senses of the “patient” and of the therapist are in alteration by the heat in the skin.

COMPARISON BETWEEN CHILLING EFFECTS BY THE DIFFERENCE OF THE MATERIAL OF THE PILLOW

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A purpose of this study is compare with a usually used urethane pillow and the pillow which can be inserted a cold insulation agent about head chilling effect at the sleep. The artificial climate chamber has been controlled at the environment of temperature 30°C? and 65% related humidity. The subject has slept in this chamber for eight hours and measured temperature and humidity at that time. Naturally the pillow which coolant was inserted in was lower in the temperature, and head chilling effect has been found. Also, with the difference of the cooling time, it developed that cold insulation time was different. It was found that chilling effect during the sleep continued by cooling off for ten hours in this refrigerant.

THE EFFECTS OF COOLING AGENTS APPLIED TO THE SKIN IN NORMAL SUBJECTS

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Topical agents are now available for localised skin cooling. These are particularly useful in minor trauma, often occurring through sporting injuries. In the past packs of ice were the only practical ways of applying localised cooling, but commercial products are more convenient. In order to quantify the effects of cooling we have tested different methods for applying cooling products to the skin.

Methods After a stabilisation period, six subjects received an ice pack application to the lumbar back for 10 minutes, and the skin temperature over the area was monitored for 60 minutes at 3 minute intervals. The results were compared to twelve subjects who received a gel (Deep Freeze Cold gel, Mentholatum Co. Ltd.U.K.) applied to a 10x10cm area also to the lower back monitored for 60 minutes. In this study each region of interest was analysed to generate graphs of the cooling effects of the two treatments. All procedures were carried out in a controlled temperature 230C and under strict laboratory conditions.

In a further experiment, a new gel dressing (Deep Freeze Cold Patch, Mentholatum Co Ltd. designed to adhere to the skin) was applied to one forearm and one thigh of 12 normal volunteers for 3 hours. The same environmental conditions were used. An A40 FLIR infrared imaging system connected by firewire to a computer with CTHERM image processing software was used.

Results Temperature decrease of 3.50C was found in comparing the treated mid thigh area, with the contra lateral control area. In the forearms of the same subjects, similar findings were obtained. The cooling effect of a single cold patch dressing was significant for up to two hours. For the patch study, the dressings were peeled back from the skin for each image to be recorded, and sampled at 15 minute intervals for one hour, then 30 minutes for the remaining two hours. The two sites were tested on different days in each volunteer.

Conclusion Modern preparations localised cooling to the skin are effective, and more comfortable than ice packs. Aerosol application is convenient for immediate application, with the cold patch gel more convenient for longer term home application. The objective data from these studies supports the conclusion that Deep Freeze products when applied to the skin are better tolerated, and can be used for longer periods than conventional icepacks where localised skin cooling is found to be beneficial.

Other clinical applications of thermography

THERMAL SYMMETRY OF LIMBS IN HEALTHY SUBJECTS

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Background: 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 first suggestion of usage of this indicator was made by J. Freeman in 1937 measuring it with contact thermocouples. The first measurement using imaging was performed by Lloyd-Williams in an experiment in 1964. Some other studies had been carried out since then but with the appearance of newer generations of higher resolution cameras a lack of comparison between total body views with close-up regional views in both anterior and dorsal visualisations existed.

Objective: Establish a value for Sagital and Coronal thermal symmetry of the human body, to be used as indicator in clinical assessments.

Method: In this study skin temperature measurements have been carried out using thermograms, of hands 75 healthy volunteers and for other body 39 healthy subjects were imaged. Measurements were obtained from an infrared camera (FLIR A40) using the CTHERM application developed at the authors' research unit. A computational analysis application was developed to standardise and optimise the time of analysis. This tool performs thermal image morphing based on anatomical landmarks preserving the temperature values associated with the regions of interest(ROI) and generates statistics about mean temperature, standard deviation, kurtosis and skewness of those ROI's.

Results: Sagital Thermal Symmetry using regional views:

Region	mean Δ T (C°)	ΔSD (C°)
Dorsal hands	0.33 ± 0.34	0.12 ± 0.15
Anterior arms	0.49 ± 0.29	0.28 ± 0.29
Dorsal arms	0.23 ± 0.16	0.33 ± 0.23
Anterior forearms	0.44 ± 0.24	0.47 ± 0.28
Dorsal forearms	0.34 ± 0.25	0.39 ± 0.29
Anterior thighs	0.14 ± 0.13	0.07 ± 0.07
Dorsal thighs	0.17 ± 0.12	0.07 ± 0.06
Anterior lower legs	0.2 ± 0.16	0.08 ± 0.05
Dorsal lower legs	0.23 ± 0.18	0.11 ± 0.07
Dorsal feet	0.34 ± 0.34	0.16 ± 0.15
Planar feet	0.38 ± 0.36	0.14 ± 0.16

Conclusion: 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.

MAIN APPLICATIONS OF DIAGNOSTIC THERMOGRAPHY IN THE LAST 21 YEARS: A CHART REVIEW

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Background: The Institutes for Physical Medicine & Rehabilitation of the Hanuschspital and the Out-Patients Clinic for Physical Medicine, Andresgasse offer a thermographic services sind 1988.

Objective: To review the charts of thermal images recorded since 1988 and analyse the main indications for thermal imaging.

Method: Thermal images stored on floppy disks were retrieved. Biographic data (age, sex, diagnosis for referral) the body region imaged of investigated subject, and temperatures of the region of interest were recorded. Thermal images that were already reported in papers were marked. Descriptive statistics were performed

Results:The database contains 16000 images from more than 2500 different subjects, 200 images were recorded from non living material such as various heating pads. 66% of investigated subjects were females, 44 % males. Hands were the most frequently imaged body region, followed by knees, elbow, upper back, lower back, gluteal region, ankles, shoulder, total upper extremity and total leg. Raynaud`s phenomenon has the first rank in referral diagnosis, followed by thoracic outlet syndrome, fibromyalgia and chronic regional pain syndrome (CRPS). More than 80 percent of thermal images were reported in a total of 45 full papers

MEDICAL INFRARED THERMOGRAPHY AS A SCREENING TOOL FOR KNEE INJURIES IN PROFESSIONAL JUNIOR ALPINE-SKI-RACERS IN AUSTRIA

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Background: Medical Infrared Imaging (IFT) has been successfully utilized for injury prevention in veterinary medicine (PUROHIT et al 1980; TURNER et al 2001). Despite similar anatomical and physiological conditions there is a lack of evidence, demonstrating the successful use in human athletes with the advantage of twenty first century technology. The knee is frequently affected in alpine skiing (PUJOL et al 2007). According to TECKLENBURG et al, 53.8% of all female skiers in the Austrian National Team have already sustained an ACL rupture. These injuries usually involve a long, costly rehabilitation period and often are career ending.

Objective: To evaluate the outcome of IFT when used as a screening tool for knee injuries in alpine skiing. Moreover future application in the field of prevention, diagnostic and rehabilitation will be defined.

Method: We conducted a pre-season measurement of 35 female and 52 male junior alpine ski racers (non-injured, previous injury and acute injury) aged 14-19 years from the "Skigymnasium Stams". With an infrared camera (TVS200EX) baseline images of four aspects of both knees were recorded. In addition each non injured subject performed 40 countermovement jumps to assess the local haemodynamics. The software Studio Report (Goratec GmbH) was used to analyse the images. A physiotherapist examined the functional aspect of the knee.

Results: Intra-individual thermal asymmetries over the tibia revealed overuse reactions (Osgood- Schlatter disease, Sinding-Larsen-Johansson lesion). The clinical examinations confirmed these findings. The evaluation of athletes with an operation of the knee over the last 6 months clearly demonstrated the localisation and extent of the affected area. Images taken after the countermovement jumps showed local cooling of the knees.

Conclusion: This study clarified the potential of IFT for a more objective and uncomplicated evaluation of knee injuries. Future pathophysiological images will be analysed with more structural measurements such as magnetic resonance imaging and X-ray.

CORRELATION BETWEEN THE THERMOGRAPHIC ASSESS AND THE CLINICAL AND FUNCTIONAL REHABILITATION IN PATIENTS WITH POSTTRAUMATIC ANKLE-FOOT SEQUELAE

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Posttraumatic pathology of the lower limb regarding sprain, strain or bi/trimaleolae fracture can develop after orthopedic/surgical treatment multiple chronic pain sequelae, prolonged edema, trophic disorders and complex vegetative reactions, changes that can be measured indirectly by thermography.

The aim of the study was to highlight the thermographic dynamics and to identify issues or discord in consistent correlation between clinical functional assessment, ultrasound investigation and thermography during the rehabilitation program.

We have studied a group of 20 patients with pain and functional sequelae in the posttraumatic ankle-foot complex, also having other clinical or functional consequences in the kinematic chain of the affected lower limb, which we have treated in a rehabilitation program.

Initially, we have evaluated the epidemiological, clinical functional context, and highlight the biological and potential metabolic events (diabetes mellitus) concurrently. Laboratory evaluation included radiological examination, ultrasonography and thermography. Thermographic assessment was made under the Glamorgan Protocol at the beginning, at 5 days of treatment and at the end of treatment, under a uniform rehabilitation program with physical and kinetic therapy, the patient being monitored in the hospital.

At the end of treatment we have compared clinical data with functional result, we have analyzed their correspondence and studied other biostatistic parameters.

Because of the skin temperature assessment we could make thermographic correlation between evolution and significance in treatment of the statistics collected by thermography as a method for a clinic evaluation of the vascular functionality, and indirectly, in posttraumatic pathology, very efficient and nonaggressive especially in patients with dermatological disease, long term posttraumatic inflammatory reaction or hypersimpaticotony.

THE MODEL OF HEAT REMOVAL IN ZONE ZAHARIINA-GAEDA

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Many diseases are connected with change the metabolism, this produces change of the skin temperature. So analysis of the skin temperature allows to realize the diagnostics. The result of the work is a model, describing heat removal in zone Zahariina-Gaeda. Modeling was realized in program MathCad. By means of models possible to value the deflection an metabolism rate diseased organ on the temperature and area of the zone. For this was designed algorithm, allowing build the dependencies of the deflections of the temperature from area of the zone. Experimental given required for identification of the models. The metabolism value in size consumptions of the oxygen. The temperature of the skin in the field of Zahariina-Gaed value by means of thermal imager. For estimation of the deflection of the temperature of the skin and metabolism necessary to know the values, corresponding to normal condition of the organism. After successful identification model can be used for diagnostic and therapeutic integer. The value of the deflection of the metabolism corresponds to the certain dose medicinal preparation. On zone Zahariina-Gaeda possible to influence raised and lowered by temperature. This causes the physiological changes to organ, corresponding to zone Zahariina-Gaeda. This change the value of blood flow. Increased blood flow enlarges delivery of the medicinal preparation to internal organ, but overweening increase the value of blood flow causes its overweening cooling. Lowered of blood flow reduces delivery of the medicinal preparation to internal organ, but reduction of the value blood flow causes the reduction of heat removal, this causes increasing of its temperature. Consequently necessary to estimate the permissible the influence of low temperature and high temperature on zone Zahariina-Gaeda. This possible realize by means of offered to models.

One more field of the study is modeling of the temperature of core and skin depending on parameter surrounding ambiences. This model has allowed to analyze continuing reduction of the temperature core in thermoneutral zone after cooling. In this work the phenomena was explained by influence of the thermoreg ulation system. In work P. Webb "Afterdrop of body temperature during rewarming: an alternative explanation" this is explained by other influence (persistence).

Vascular thermal imaging

IMAGING CRANIAL ANGIOSOMES IN SLEEP APNEA.

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Objective: To image the effect of CPAP (Continuous Positive Airway Pressure) treatment on facial/cranial angiosomes skin temperature in sleep apnea.

Materials and methodology. Six Caucasian subjects, ages 33-58 yrs, (mean age 45.5 yrs), three males and three females, five under CPAP treatment at night for sleep apnea and one non sleep apnea control participated in a committee for the protection of human subjects approved protocal for extracranial facial perfusion imaging using a infrared/ Agema Camera. All participants were seated and had thermograms done before and after CPAP during the daytime, while awake. The participants were allowed to equlibrate for 20 minutes, in temperature controlled, draft free laboratory. They did not have recent trauma, sunburn or sinusitis.

Baseline facial thermograms were obtained. The participants were fitted with the cushion side of the CPAP mask (Respironics Inc, Nasal CPAP Mask 50 D size medium), mask is checked to make sure there is no leak. The CPAP mask has a Respironics Sanders non breathing valve (NRV2). The end of the NRV2 Valve is attached to a 22 mm standard flex tubing 5 feet non conducting hose with 7/8 " cuffed ends (Kings system Corporation). The tubing is attached to CPAP Aries Model (Mountain Medical Equipment incorporated). End Tidal CO 2 monitor (Lifespan 100 Model), ear oximeter (Biox 11A Model) and/or trancutaneous oxygen monitor (Model TCM2) are also connected to the patient or volunteer. End Tidal CO2 and oxygen values were recorded in the room air.

The CPAP is started and over a 10-15 minute period the participant is allowed to acclimatize to CPAP and reach a pressure of 10 cm or more of water. The CPAP is maintained for 15 minutes at that pressure, following which the CPAP is discontinued. Immediate and 3-5 minutes post CPAP, facial/ extracranial angiosomes thermograms are carried out. During the CPAP, End Tidal CO2 and oxygen values are recorded periodically. Baseline and Post CPAP thermograms are reviewed to document changes of 0.5 degrees C or more change in the facial temperature following CPAP treatment (compared to baseline) was documented.

Results:Vasoconstriction in facial/cranial angiosomes by thermograms following CPAP was correlated with benefit with CPAP at night per sleep lab CPAP testing on patients sleep apnea.

Discussion.Sleep disorders have been associated with altered skin temperature regulation and activation of pro-inflammatory pathways. Studies of endothelial function in sleep apnea has shown altered levels of biochemical markers of endothelial function including circulating levels of vasoactive mediators. Long-term effect of CPAP on inflammation markers of patients with obstructive sleep apnea syndrome (OSAS) has shown the selective reduction of soluble and cellular immune response factors, providing further evidence for an ongoing systemic immune process in OSAS.

Vasomotor reactivity of facial/ cranial angiosomes is sensitive to CPAP and vasoactive mediators. Hayakawa studied changes in cerebral oxygenation and hemodynamics during obstructive sleep apnea and indicated the role of extracranial factors. Cranial vasculature are innervated by trigeminovascular system. Onodera and Ide reported identification of arterial baroreceptors associated with arteriovenous anatomoses innervated by trigeminal nerve. Molyneux found AVAs innervation is more dense and can react to vasoactive mediators. Thermography images of facial microcirculation -arteriovenous anatomoses (AVAs), representing shunting in the extra cranial circulation under trigemino- vascular control. This can compliment data on pulmonary shunting reported in sleep apnea to correlate with clinical improvements.

Conclusion: Methodology presented gives thermographers the ability to image facial/ cranial angiosomes temperature changes due to CPAP. This can be correlated with long-term effect of CPAP therapy on altered cranial angiosomes vasomotor reactivity related to inflammation markers in patients with obstructive sleep apnea syndrome and correlate it clinically.

VISUALISATION OF CAROTIS– PLAQUES ON THE BODY SURFACE BY INFRARED –MEASUREMENT - A BASIC METHODOLOGICAL STUDY AND PRELIMINARY RESULTS

Regina Brantner
Department of Angiology, Heart Centre Bad Krozingen, Germany

Novel high precision infrared cameras measure and calculate accurately thermal surface patterns. Tissues vary in their thermal absorption coefficient and modify thereby the heat flow to the epidermis.

Objective: Plaques show a characteristic ability for heat absorption with respect to its construction and composition. The thermal pattern projected to the surface may vary due to makeup and infrared emission of the plaque.

Method: The maximum infrared emissionfrom the neck skin (at a temperature between 30 and 35 °C) occurs at a wavelength of 10 µm. Measurements were performed with an infrared system, (InfraMedic OptiRes D, sensitivity 30 mK), which was certified as a medical device. Firstly, optimum conditions for this measurement (environmental temperature, direction and distance of measurement, stimulation) were tested.

In a first series 4 groups of 10 subjects each, with unaffected carotis or solid or fibrotic or soft plaques were investigated under standardised conditions (room temperature 20 °C, measurement distance 30 cm, angle of the measureing device 45 degrees, 10 min adaptation with undressed upper body, abstinence from vasodilating drugs). Mesurements were performed without any thermal stimulus and after a short cold stimuls (20 sec of a wet towel arund the neck). After the infrared examination all patients received an ultrasound duplex test of the carotid arteries..

Results: Preliminary evaluation showed clear differences between normal and pathological findings (solid, fibrotic and soft plaques of the carotide arteries, It was possible to relate th e thermal patterns with the ultraound findings. The discrimination power between different composed plaques needs further improvement of the methodology.

Following studies may show, if beyond the visualisation of the intravascular changes on the body surface, a clear differentiation of plaque morphology can evolve which is simple in application , reproducible and independent from the investigator. This may have an impact for monitoring of treatment and for decision making in acute cases. The clinical importance d will be related to the performance of this method.

THERMOGRAPHY IN COMPLEX REGIONAL PAIN SYNDROME (CRPS): PITFALLS AND PROGRESS

H.Cohen, N.Harris, C.McCabe, D.Blake
Royal National Hospital for Rheumatic Diseases, Bath, UK

Background: Whilst the use of thermography as a diagnostic aid in CRPS is well recognized, other conditions can mimic the symptoms and thermographic signs. Thermography can be utilized in clinical research and is helping to advance understanding of this condition.

Method: Case reports.

Results: 1). A 46 year old lady presented with a severely painful left leg and colour and temperature changes consistent with possible CRPS. Thermography confirmed that the affected limb was cooler by 2°C. Clinical examination revealed a necrotic ulcer on the left great toe, and upon closer questioning the pain was more typical of critical ischaemia. Subsequent angiography demonstrated a femoral artery occlusion which was treated successfully with balloon angiography. Thermography 12 months later showed excellent reperfusion with no significant temperature difference.

2). A 45 year old lady presented with severe CRPS of the left upper limb of 10 years duration. Thermography confirmed significant cooling of 2.1°C between the arms. Detailed quantitative sensory testing revealed allodynia (non-noxious tactile stimulation perceived as painful) over the affected limb. A well demarcated area of allochiria (tactile stimulation in the area is only perceived in the analogous location on the contralateral limb) was present on the right unaffected forearm. A cold stimulus (menthol) was applied to the allochiric area. The patient reported cold sensation on the right arm, but felt severe pain in the analogous location on the affected forearm and developed erythema and oedema in this area. Thermography confirmed a contra-lateral inflammatory response which reactivated 3 days later after autonomic testing precipitated worsening pain.

Conclusion: Thermography can be utilized to investigate autonomic and inflammatory responses in CRPS but clinicians should be aware of potential mimics.

COLD WATER AUTONOMIC FUNCTIONAL STRESS TESTING UTILIZING REAL TIME DYNAMIC SUBTRACTION IR IMAGING IN THE DIAGNOSIS OF COMPLEX REGIONAL PAIN SYNDROME

Timothy D. Conwell [1], William B. Hobbins[2], James Giordano[3]

[1] Colorado Infrared Imaging Center, Denver, Colorado, USA
[2] Woman's Breast Care Center, Madison, Wisconsin, USA
[3]Georgetown University Medical Center, Washington, DC, USA

Background: Complex Regional Pain Syndrome is a potentially disabling condition characterized by regional pain that is often disproportionate to, or occurs in the absence of an identifiable inciting event. The condition is associated with hyperalgesia, allodynia, spontaneous pain, abnormal skin color, changes in skin temperature, abnormal sudomotor activity, edema, active and passive movement disorders and trophic changes of nails and hair.

Complex Regional Pain Syndrome is diagnosed clinically based on modified International Association for the Study of Pain (IASP-Bruehl) criteria. Diagnosis for CRPS is complicated by the fact that neuropathic and somatic conditions can mimic this complex condition. Internal and external validation research suggests problems with over and under diagnosis using the IASP criteria.

Design: Retrospective file review.

Setting: Colorado Infrared Imaging Center (established 1983), Denver, Colorado

Objective: Determine the sensitivity, specificity and Cohen's kappa index of concordance for cold water autonomic functional stress testing utilizing real time dynamic subtraction IR imaging medical software. The cold water autonomic functional stress test index (test results) was compared with the modified International Association for the Study of Pain (Bruehl) criteria for the presence of CRPS.

Participants: One hundred forty-three (n-143) consecutive patients referred to Colorado Infrared Imaging Center to evaluate for presumptive CRPS/RSD utilizing functional infrared imaging ((f)IR) that included cold water autonomic functional stress testing as part of the IR battery of tests performed during (f)IR imaging.

Methods: Prior to (f)IR imaging each patient underwent a physical examination with particular attention paid to signs and symptoms of CRPS utilizing the modified IASP (Bruehl) criteria. Following physical examination, (f)IR imaging was performed, which included as part of the IR test battery, cold water autonomic functional stress testing.

Outcome Measures: Sensitivity, specificity and kappa statistical analysis for the cold water autonomic functional stress test index utilizing modified IASP criteria (Bruehl) as the gold standard.

Results: Sensitivity 72%, specificity 94%, kappa index of concordance 0.69.

Conclusions: Cold water autonomic functional stress testing, utilizing real time dynamic subtraction imaging medical software, is a valuable and objective IR index for evaluating patients with presumptive CRPS and demonstrates substantial agreement with the modified IASP criteria (Bruehl).

UTILIZING THERMOGRAPHY TO PREDICT THE SPREAD OF CRPS

Philip Getson

Thermographic Diagnostic Imaging, Southampton, NJ 08053, USA

BACKGROUND: Thermal imaging has been used to evaluate patients with RSD/CRPS for decades. It is, in my estimation underutilized in that regard and has been shown to be the BEST diagnostic test to confirm this diagnosis. Over the past 10 years it has accurately "predicted" the spread of the disease in patients, who at the time of imaging had symptoms in only one limb with thermal abnormalities in another. In all cases reported, the patients became symptomatic with 6-8 months of the study in the "predicted" areas.
OBJECTIVE: To initiate interventional pain management treatment to patients who fall into this category to observe whether or not we can forestall or at least minimize spread of symptoms
METHOD: Combining infrared imaging in a pre-and post fashion with sympathetic blockade to monitor patients without symptoms and to clinically assess them as well for subjective complaints as well as objective clinical signs of spread
RESULTS: To date the research has been only in diagnostics without therapeutics
CONCLUSIONS: The preliminary findings suggest a proactive approach to the treatment of spread. There are no conclusions offered as to the effects of interventional treatment. However, early treatment of appearing symptoms has produced a more positive outcome

FINGER TEMPERATURE IN RAYNAUD'S PHENOMENON (RP) IN SUFFERERS IDENTIFIED IN A HOSPITAL SETTING AND THOSE DRAWN FROM THE GENERAL POPULATION: A META-ANALYSIS

Howell KJ [1], Cherkas LF [3], Carter L [3], Spector TD [3], Smith RE [2], Black CM [1], Denton CP [1], MacGregor AJ [3,4]

Departments of [1] Rheumatology and [2] Medical Electronics, Royal Free Hospital, London, UK
[3] Department of Twin Research and Genetic Epidemiology, King's College, London, UK
[4] School of Medicine, University of East Anglia , Norwich, UK

Background Whilst cold challenge of the hands with infrared temperature measurement is of proven utility for diagnosis of hospital-referred RP, little is known about finger temperature in RP sufferers in the general population.

Method Using a radiometer we measured baseline finger temperature in RP sufferers. The drop in mean finger temperature after cold water challenge of the gloved hands (15°C, one minute), and the subsequent rewarming after ten minutes was also measured.

RP sufferers were drawn from two settings.

The first was a group of patients attending the rheumatology clinic at the Royal Free Hospital, recruited to a study to validate the radiometer against thermography. Hospital staff members without RP symptoms also underwent the protocol as controls.

The second RP group comprised volunteers recruited to a twin study at St. Thomas' Hospital who were identified through their responses to questions about RP symptoms in a health questionnaire. Volunteers who were negative for RP symptoms on the questionnaire formed a control group.

All subjects were female, and gave informed consent to participate.

Results Summary data are shown in the table below

		RP		Non RP	
		Mean	Range	Mean	Range
Hospital setting		n=18		n=19	
	Baseline "C	23.8	20.9 – 27.2	29.9	23.1 – 33.9
	Drop °C	3.9	2.6 – 6.1	7.5	4.0 – 10.5
	Rise °C	1.6	0.3 – 3.6	5.7	-0.4 – 10.3
Population setting		n=175		n=404	
	Baseline C	28.3	20.3 – 35.0	30.0	22.0 – 35.3
	Drop °C	6.6	2.3 – 12.8	6.9	0.3 – 11.4
	Rise °C	4.6	-1.1 – 12.5	5.3	-1.6 – 12.0

Conclusion Mean finger temperature, drop and subsequent rise in temperature after cooling were all similar in the two control groups. In contrast, hospital based RP sufferers showed lower values for all three temperature parameters than their counterparts drawn from the general population. RP sufferers referred to hospital have lower finger temperatures than those in the general population, reflecting the greater severity of symptoms

INFRARED-MEDIATED HYPERTHERMIA IS EFFECTIVE IN THE TREATMENT OF SCLERODERMA-ASSOCIATED RAYNAUD'S PHENOMENON

John Foerster [1], Susanne Fleischanderl [1], Stefan Wittstock [1], Annegret Storch [1], Hans Meffert [1], Gabriela Riemekasten [2], Margitta Worm [1]

1 Klinik für Dermatologie and 2 Klinik für Innere Medizin mit Schwerpunkt Rheumatologie, Berlin, Germany

Scleroderma is a systemic autoimmune disease featuring variable organ involvement as well as Raynaud's phenomenon (RP). To date, no studies exist on the effect of systemic body temperature elevation on the severity of RP. Water-filtered near-infrared (infrared A (IRA)) irradiation is particularly effective in transdermal heat delivery. Prompted by preliminary findings we here examined the effect of IRA treatment on RP. We employed fingertip rewarming in response to cold challenge as well as a clinical activity score as outcome variables. In addition, we explored the effect of IRA treatment on skin thickness and scleroderma-associated joint pain.

Results: This study demonstrated that IRA-mediated hyperthermia reduced the severity of RP, and indicated that IRA-mediated hyperthermia may exert a transient beneficial effect on skin thickness. IRA-mediated hyperthermia transiently improved arthralgia in scleroderma patients.

In conclusion, IRA-mediated mild hyperthermia is effective for the treatment of scleroderma-associated RP and may be therapeutically effective for other disease manifestations.

Infared imaging in veterinary medicine

LEGALITY ASSOCIATED WITH THE USE OF INFRARED THERMAL IMAGING IN VETERINARY MEDICINE

Ram C Purohit [1,2]

1. Professor and Director of Large Animal Medicine and Surgery Program, School of Veterinary Medicine, St. George's University, Granada, West Indies.
2. Professor Emeritus, Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, Alabama, USA

In 1970 the Horse Protection Act was passed by the United State Congress to ban use of chemical and mechanical means of "soring" of shores. It was common practice in the 1960's and 1970's, with Tennessee Walking horses, to use mechanical (boots, rollers, chains) on the horse's front legs to enhance their performances. The chains of various weights were put on the mid pastern region of the thoracic limbs during the horse show. There was also some evidence that mustard oil was applied to the skin region of the mid pastern to further enhance the horse's performance. Use of these devices induced irritation of the skin and caused lesions and also produced scars in pastern areas.

To prevent this abuse the horse protection act was passed. Just to use physical examination, including digital palpation was not a reliable enough source to prosecute the horse owner or the trainer in the court of law. This promoted the USDA-APHIS (United State Department of Agriculture and Animal Public Health Inspection Services) to fund studies for the diagnosis of "Soring". Thermal imaging was then used by Nelson and Osheim in Iowa (1) and Purohit et. al (2, 3) at Auburn to perform studies for the diagnosis of inflammatory processes in horses in response to various chemical and physical factors.

Auburn University studies resulted in revising the Horse Protection Act in 1983 This was also followed by implementing new guide line by the USDA-APHIS.

As time went by use of thermography was discontinued and horse inspection for horse shows was then done by physical examination that also included digital palpation.

Since 1970's to present day there were and are several court cases. APHIS taken a position in late 1980's to early 1990's that palpation by itself is sufficiently reliable to accurately determine whether a horse has been sored or not. Horses which were written up and not allowed to appear in show, some of those cases ended up in litigation in federal courts. In recent ruling by federal Law Judge Peter M. Davenport, he questioned that whether palpation alone was sufficient "scientific" means to allow expressing an expert opinion. (4). He cited a Supreme Court Case which set forth four factors to determine that reliability. His recent ruling caused APHIS to lose the court case. Now USDA-APHIS went back this April and reinstitutes the use of thermography as an additional means to document if horse was sored or not. During conference further details and discussion will be presented.

Author wish to acknowledge the contribution by Federal Administrative Law Judge Peter M. Davenport., United States Department of Agriculture, Washington DC. 20250

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EDUCATIONAL COURSE IN EQUINE THERMOGRAPY: RESULTS AND FUTURE DIRECTIONS

R.Berz

German Society of Thermography & Regulation Medicine, Waldbronn, Germany

The development of a curriculum for veterinary thermography was the main task of the 2005 founded Medical Infrared Academy (MIRA). Since 2006 the German Society of Thermography offers a certified course for equine thermography. The course participants learn in three sessions, each lasting 2 days, basics of infrared physics, methodology of measurement, equine physiology and practice standardised image recording, evaluation and interpretation of infrared thermal images. The content of the forth session is written test combined with an practical examination of a horse and a structured report of the findings.

Until now 50 thermographers have participated in a total of 5 course cycles and have received their certificates. The sixth course is under the way and the interest in this educational facility is continuously growing.

STANDARDS FOR THERMAL IMAGING IN VETERINARY MEDICINE.

Ram C Purohit, [1, 2]

1. Professor and Director of Large Animal Medicine and Surgery Program, School of Veterinary Medicine, St. George's University, Grenada, West Indies.
2. Professor Emeritus, Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, Alabama, USA.

Thermography provides accurate, quantifiable measurements of skin surface temperature. The value of thermal imaging is well demonstrated by its sensitvity and ability to detect temporal and spatial changes in thermal skin responses that corresponds to temporal and spatial changes in blood flow. Its efficacy has been demonstrated in numerous clinical and research studies as a diagnostic tool for veterinary medicine. There have been some published studies that have not adhered to reliable standards and equipment prerequisites thereby detracting from the acceptance of thermography as a valuable research and clinical diagnostic technique. In some cases a simple cause-effect relationship was assumed to demonstrate the diagnosis of a disease or syndrome based on thermal responses captured by thermographic images.

Internal and external factors have a significant effect on the skin surface temperature. Therefore, the use of thermography to evaluate skin surface thermal patterns and gradients requires an understanding of the dynamic changes which occurs in blood flow at systemic, peripheral, regional and local levels. Thus, to enhance the diagnostic value of thermography in veterinary medicine, we recommend the following standards be used:

1. Minimized environmental factors which can and do interfere with the quality of thermograms. The room temperature should be maintained between 21 to 26C. Slight variation in some cases may be acceptable, but room temperature should always be cooler than the animal's body temperature and free from air draft and bright lights.

2. Outdoor thermography: Normally outdoor thermography is not recommended, because direct air draft, sunlight, and extreme variation in temperature will provide unreliable thermograms in which thermal patterns and gradients may be altered. Such observation is meaningless so as to the accuracy of data collection.. There are a few cases in which initial out door observation may be of help to perform further studies in a control environment.

3. Animals should be equilibrated at least for 20 minutes or more in a room with controlled temperature. Longer period of equilibration may be required in cases where animal was transported from extreme cold or hot environment. Equilibration time is considered adequate when the thermal patterns and temperature gradients are consistently maintained over several minutes.

4. Other factors affecting the quality of thermograms are exercise, sweating, body position and angle, body covering, systemic and topical medication, regional and local blocks, sedatives, tranquilizers, anesthesia, vasoactive drugs, skin lesions such as scars, surgically altered areas, etc. Body hair coat may also be an issue in some cases where uneven hair length and/or thick hair coat will have adverse effects on thermal emission. Thus providing unreliable thermograms.

5. It is recommended that the infrared imaging should be performed using electronic non contact thermographic equipment which meets the requirement for medical imaging and can be effectively calibrated. Proper equipment use standards should also be followed.

In conclusion, the value of thermography can only be realized if it is used properly. All species studied thus far have provided remarkable bilateral symmetrical thermal patterns. The high degree of right-to left symmetry provides a valuable asset in diagnosis of unilateral problems associated with various inflammatory disorders. Thermography has also been efficacy for early detection of an impending problem. Thus early detection and treatment can prevent financial losses associated with delayed diagnosis and treatment.

Thermography and Regulation Medicine

THERMOGRAPHY IN REGULATION MEDICINE

H. Sauer

Private Clinic of Complementary and Alternative Medicine (CAM), Waldbronn, Germany

Regulation medicine is characterized by the application of a defined stress test and the study how the organism does cope with the stress. Famous regulation tests are ECG triggered by physical training or EEG with acoustic or visual evoked potentials.

For a long period cold water stress tests have been used. Actually most physicians prefer air cooling (10 minutes of exposition to 20 °C ambient temperature, subject undressed).

Regulation thermography provides additional information evaluating the local and regional thermal patterns and the extent of cooling (or paradoxical heting). It is an important aid for more precise diagnostic efficiacy

Index of authors

ABERNATHY, Margaret R., M.D

Philip P. Hoekstra, III,

President, American Academy of Thermology

Margaret R ABERNATHY 1926-2009

Margaret Roberts Abernathy, born March 23, 1926, passed away peacefully surrounded by family on March 16, 2009. She was born in Washington, D.C., to Floyd Roberts and Catherine Dooley Roberts. She and Brad Abernathy were married on October 30, 1947, and had a long and happy marriage, a true partnership of two people who were made for each other, which did not end until Brad's death in June of 2002.

Dr. Abernathy attended undergraduate and graduate school at Catholic University of America, Northwestern University, and the American University. She taught briefly in the Washington Public School System and at Catholic University. She began medical school at the Medical College of Virginia in Richmond (one of only two women in her class), on the same day her youngest daughter started first grade. She graduated with an M.D. degree in June of 1964, thus fulfilling her lifelong dream of becoming a doctor. She completed internships at the Washington Hospital Center and the Washington Veterans Administration Hospital, and then joined the Department of Neurology of Georgetown University, where she remained for over 30 years. She was the first director of the Breast Cancer Screening Center at Georgetown University Medical Center, and was a pioneer in the field of infrared thermography, particularly in its applications for cerebrovascular disease and breast cancer. She was a founding member of the American Academy of Thermology. She lectured worldwide in the field of medicine, and was dearly loved by the medical students at Georgetown. She and her husband established the Abernathy Plan, by which Georgetown's empty-nest faculty members provided room & board to medical students, and in fact had students living with them in Vienna, Virginia, for several years. Dr. Abernathy retired from Georgetown in the mid-1990s and maintained a private practice in Vienna until 2000, when she and her husband moved to Swarthmore, PA. She was always happiest when she was with her family, but the hospital and her patients ran a close second.

She was preceded in death by her parents, by her brother, Thomas Roberts, and her sister, Ann Roberts Nance, and by her husband, Thomas Bradford Abernathy. She is survived by her daughters, Mary Seal, and husband, Vee, of Albuquerque, New Mexico; Anne O'Rourke, Swarthmore, and Catherine Abernathy, Swarthmore; and by three grandchildren, Mary Catherine O'Rourke, Teigh O'Rourke, and Christen Bradford Seal.

Her family will miss her, but we are grateful for the life of this remarkable woman who profoundly impacted her family, her friends, and every patient who passed under her hands over the years. Dr. Abernathy was a guiding hand to the science and practice of medical thermology and a mentor to many of us in the field including Dr. Govindan and me.

Meetings

2009

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

September 21st, 2009, Monday,

Combined Workshop on MammoVision and Full Body Thermography

09:00 to 16:30

Venue Private Practice of Complementary and Alternative Medicine (CAM)

Dr. med. Helmut Sauer, MD
Rheinstrasse 7
76443 Waldbronn near Karlsruhe

The workshop is limited to 20 participants, the workshop fee is 25, including breaks and lunch. Reservation can be made by Fax or E-mail to Prof. Berz.

Due to some request the German Society of Thermography and Regulation Medicine (International Medical and Veterinary Thermographers) offers a full day intensive workshop focused on the application of standardized breast thermography (MammoVision) and full body thermography (ReguVision, FlexiVision) in a GP's practice.

This workshop is a part of the Society's education and training programme to achieve the DGTR/IMVT certification.

The venue is situated 50 km south of the conference hotel. There is a good train connection to Karlsruhe and a local bus or tramway to Waldbronn. A shuttle from Karlsruhe train station can be organized

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

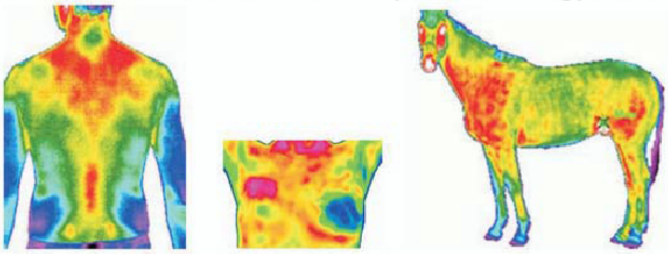
October 24, 2009. Session: W428, 7:30am to 9am

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

Further Information:

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

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

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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.

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