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Altered Skin Temperature Patterns in Patients with Idiopathic Syringomyelia and Anold-Chiary Malformation Type I

Teaching Courses on Medical Thermography - a historical perspective

XIV Congress of the Europea Association of Thermology:
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The challenge of objective evaluation of infrared thermal images in health sciences

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SUMMARY

This short editorial overview discusses the increased use of infrared thermal imaging for the detection of heat sources situated in deep tissue layers. Inflammatory processes in major blood vessels, heat generation of skeletal muscles and brown adipose tissue are the targets of these new applications. However, most of this research suffer from expectation bias and disregards basic laws of physics and thermal physiology in fulfilling their wish to see what they want to see. The study method often fails to meet minimum requirements for patient's preparation, setup for thermal imaging, image recording and evaluation.

The lateral cervical region is the anatomical region most often investigated for activated brown adipose tissue. Their anatomical topography, relevant for infrared imaging, is discussed and standard views and regions of interest are proposed. The match of form and localization of activated tissue in PET scans with areas of increased temperature in thermal images was claimed as evidence for the existence of superficial thermal signatures of heat generating brown fat. Based on direct temperature measurements on brown adipose tissue in small animals, it seems unlikely that in humans, hot spots on the skin over brown fat are caused by their heat generation.

KEYWORDS: heat sources, infrared thermal imaging, brown adipose tissue

DIE HERAUSFORDERUNG EINER OBJEKTIVEN BEURTEILUNG VON INFRAROT-THERMOGRAMMEN IN DEN GESUNDHEITSWISSENSCHAFTEN

Diese kurze redaktionelle Übersicht diskutiert den verstärkten Einsatz der Infrarot-Thermographie für den Nachweis von Wärmequellen, die sich in tiefen Gewebeschichten befinden. Entzündliche Prozesse in großen Blutgefäßen, Wärmeerzeugung durch Skelettmuskeln und braunen Fettgewebe sind die Ziele dieser neuen Anwendungen. Jedoch die meisten dieser Forschungen leiden an Erwartungs-Bias, indem grundlegende Gesetze der Physik und Wärmephysiologie missachtet werden, um das zu sehen, was gesehen werden soll. Die Methoden der Studie scheitern oft an den Mindestanforderungen für die Vorbereitung des Patienten, Setup für Thermographie, Bildaufnahme und Auswertung.

Der seitliche Halsbereich ist jene anatomische Region, in der am häufigsten nach aktivierten braunen Fettgewebe gesucht wird. Ihre für Infrarot-Bildgbebung relevante anatomischen Topographie wird besprochen und Standardansichten und Messareale werden vorgeschlagen. Die Übereinstimmung von Form und Position aktivierten Gewebes in PET-Scans mit erhöhter Temperatur in Wärmebildern wurde als Nachweis für die Existenz der oberflächlichen thermischen Charakteristiken von wärmeproduzierenden braunem Fettgewebe beansprucht. Auf Grund direkter Temperaturmessungen an braunem Fettgewebe bei Kleintieren, scheint es unwahrscheinlich, dass beim Menschen, die warmen Stellen an der Haut über braunem Fettgewebe durch deren Wärmeentwicklung verursacht sind.

SCHLÜSSELWÖRTER: Wärmequellen, Infrarot-Thermographie, braunes Fettgewebe

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Introduction

The use of infrared thermal imaging in medicine and related health sciences is currently constantly growing. There exists consensus that infrared thermography provides a map of temperature distribution on the surface of an imaged object. In living beings, particularly in homeotherm mammals, the surface temperature is not homogeneously distributed and the generation of the observed temperature patterns is not well understood. However, it is a primary requirement for objective evaluation of infrared thermal images to understand how the distribution of skin temperature is developing.

Heat is a by-product of all metabolic reactions and temperature is the intensity measure of thermal energy. Whilst removal of generated heat is the main challenge for the thermoregulation system, in case of a pending fall of deep body temperature, heat generation is required. Brown adipose cells are equipped with a unique set of receptors and enzymes that allow to generate heat directly based on deviation of proton gradient energy [1]. Besides its role in arousal from hibernation [2], brown fat is an important source of non-shivering thermogenesis in small animals. The function of brown adipose tissue (BAT) in humans is currently redefined.

Homeotherm animals are equipped with a physiological system that maintains the temperature of deep body tissues within a narrow range. A well-functioning thermal regulation system is the reason that those animals do not equilibrate with the ambient temperature and a temperature gradient between the average deep body temperature and the mean surface temperature is always detectable, although the gradient is varying in magnitude. In humans, the maintenance of the direction of heat flow from deep body tissues to the skin is achieved by the following mechanisms:

Control of the blood flow rate in the skin results in different heat insulation properties of tissues. Cold induced vasoconstriction under control of adrenergic sympathetic nerve fibres reduces the blood volume in the vasculature and thereby the heat conduction coefficient becomes decreased. Activity in sympathetic cholinergic nerve fibres is a response to warm-receptors that elicit vasodilation in skin vessels and a higher volume of fluid within the vascular bed enhances the heat conductive property of the tissue. The so-called thermoneutral zone is defined as a temperature environment in which deep body (core) temperature is maintained solely by the above described variation of the insulative properties of tissues located in the temperature shell.

In case that heat gain cannot sufficiently be counteracted, evaporative cooling of the skin is initiated by adrenergic sympathetic nerve fibres that innervate sweat glands. In case that heat loss cannot be prevented by sole vasoconstriction, heat generation is started.

Obligatory thermogenesis refers to the minimal heat produced by all the processes that maintain the body in a basal state (fasting) at thermo-neutral temperature. Both, the standard metabolic rate and the thermic effect of food contribute to obligatory heat production. The latter represents the heat that is generated during digestion, processing and storing of energy in the organs of the gastrointestinal tract including the liver and white fat [3].

Based on the function and tissues of heat production, thermogenesis can be further classified into seven categories: standard metabolic rate, thermic effect of food, cold-induced shivering thermogenesis, cold-induced non-shivering thermogenesis, diet-induced thermogenesis, non-exercise activity thermogenesis, and thermic and work effect of exercise [3].

Adaptive thermogenesis is defined as regulated heat production in response to environmental temperature or diet. There are three subcategories of adaptive thermogenesis. Cold exposure induces shivering thermogenesis in skeletal muscle, and non-shivering thermogenesis in brown fat. Although current evidence does not indicate a role of muscle in non-shivering thermogenesis, indirect evidence suggests that such mechanisms may exist. Overfeeding triggers diet-induced thermogenesis; this is also a function of brown fat. [3].

Some basic terms and definitions of energy balance such as metabolic rate or oxygen consumption must be mentioned. All definitions are taken from the glossary of terms in thermal physiology [4].

Standard metabolic rate, (SMR) or metabolic energy transformation is calculated from measurements of heat production or oxygen consumption in an organism under specified standard conditions. The conditions are usually such that the amount of work being done on an external system is negligible. The rate of heat production is then an acceptable index of the rate of metabolism. The specified standard conditions are usually that the organism is rested (or as near to rested as is possible), fasting (if possible), awake, and in a thermoneutral environment. The extent to which standard conditions can be achieved varies with species.

Metabolic energy transformation may not all result from aerobic metabolic activities and may therefore exceed that indicated by the rate of oxygen consumption. Part of the metabolic energy transformation may be used to do work on an external system, and therefore the rate of heat production may be less than the metabolic energy transformation.

Terms in the body heat balance equation are often expressed as quantities of energy per unit surface area and per unit time [$W \cdot m^{-2}$], because heat exchange is a function of area. Metabolic rate (M or MR) is given as the total energy production in the organism in unit time [W] or often as the energy production per unit mass of tissue in unit time [W kg-1]. For comparison of metabolic rates of animals of different body sizes, metabolic rate (M or MR) is usually related to (body mass)3/4.

Consequently, metabolic energy transformation can be expressed in the units: W (=J s^{-1})], $W \cdot m^{-2}$, $W \cdot m^{-3}$, $W \cdot kg_{-1}$ or $W \cdot kg^{-3/4}$. Note that the quantity "temperature" does not appear in the units, that quantify metabolic rates. The relationship between temperature and MR is hidden in the definition of the unit Joule (J) which is is expressed as the 1/4.184 part of heat energy required to raise the temperature of a unit weight (1 g) of water from 0°C to 1°C. 4.184 Joules are equal to the traditional unit of 1 calorie.

Metabolic rate can be indirectly estimated by the oxygen consumption, which is the rate at which an organism can take up oxygen (VO_2), expressed in SI units as ml s^{-1}, but conventionally ml per min or l per min are the used units. The oxygen uptake of homogenized tissue or tissue slices can be determined by measuring the partial pressure of oxygen in a closed chamber.

A common measure is maximum oxygen consumption (VO2max) which is the highest amount of oxygen a person can consume during maximal exercise of several minutes' duration. Oxygen is needed to metabolize nutrients such as carbohydrates, fat and protein. The calorific equivalent refers to the amount of heat produced by the reaction of a nutrient with a litre oxygen. It is approximately 20 kJ of heat. The term caloric equivalent must not be confused with caloric value which is defined as the amount of energy per fixed amount of substrate (energy per gram of substrate with variable oxygen consumption).

Infrared thermal imaging of deep heat sources

Some authors believe that heat sources can be seen by an infrared imager at tissue depth of 1 to 3 cm beneath the skin. Skeletal muscles, inflammed major blood vessels and activated brown adipose tissue received the most interest for beeing imaged by an infrared camera.

Skeletal muscle

Skeletal muscles are involved in shivering thermogenesis and in thermic effects of exercise. However, despite increase of muscle temperature during muscle contraction, the skin temperature on top of working muscles is decreasing. Skin temperature starts to increase only after termination of muscle contraction. This sequence of temperature courses is caused by the competition for blood supply. As skin and skeletal muscle are nourished by the same arteries, the nutritional needs of muscular work overrule the thermoregulatory demands for vasodilation.

However, the experimental quantification of heat production in human skeletal during exercise is difficult, time-consuming and expensive as it is not sufficient to just measure temperature inside the muscles and estimate energy expenditure. The complexity of such a research was elegantly demonstrated in a paper from Denmark [5].

Large inflamed arteries.

A recent case report claimed that thermal imaging can see the inflamed aortic arch and left carotid artery in patient suffering from Takayasu arteritis. [6]. However, the quality of the thermal images is poor, they do not show a colour scale and the projection of the supposed vascular structures, particularly of the aortic arch is not compatible with the real anatomical location.

Although the temperatures inside of the aortic arch and of the common carotid artery are close to the temperature of the heart and the coronary sinus (36.7 ± 0.2°C), such high temperatures are invisible on the skin in a healthy state. Heat is an established sign of inflammation since Roman time, but the heat generation rate of inflamed tissue remains unknown. Inflammation is complex, but non-specific defense mechanism of living tissue and heat generating cells involved in the inflammatory process have not yet been identified. It can be questioned whether extra heat production due to inflammation can generate suddenly a large temperature gradient that becomes rapidly visible at the skin.

Brown adipose tissue

In the last decade, several imaging studies such as positron emisson tomography (PET) [7] raised evidence that human brown adipose tissue (BAT) is active beyond the neonatal period. A large portion of active BAT was detected in the supraclavicular region. In the latter region, successful identification of active brown fat with thermal imaging was reported in a single case study [8]. The authors supposed that the skin temperature in lateral cervical regions represents the heat generation of BAT and that the surface temperature in the second intercostal space is a reference of mediastinal temperature. Another case report, published in 1997, recorded thermograms of the human back before, and 1 hour after oral intake of ephedrine (1mg per kg body weight) [9]. Before ephedrine application, the highest temperature was beyond 34.1°C isotherm, which was visible in small areas in the neck region and paravertebral the lower thoracic spine. One hour after taking ephedrine the areas at a temperature have increased but are concentrated between

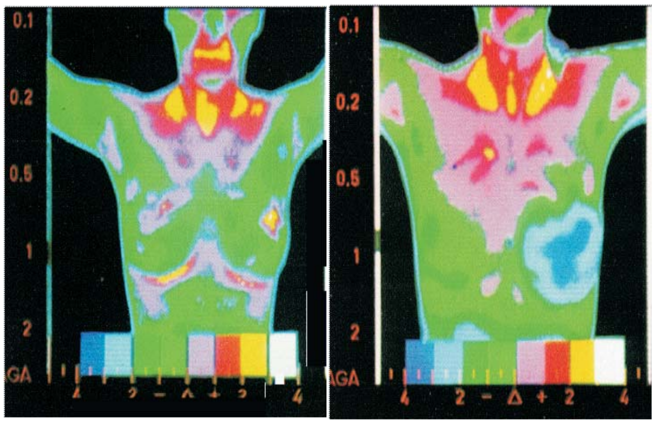

Figure 1
Two examples of breast thermograms published in 1978[10].
Both images show high temperatures in the lateral cervical region.
Original captions
Left image: Isolated external-upper hot spot.
Thermal gradient +3°C, TH4 category
Right image: Global hyperthermia on the right breast.
Thermal gradient +3°C, TH4 category

and above the scapulae and in the neck region. The authors also speculated that the observed skin temperature changes might be caused by brown fat activity.

One argument for promoting infrared thermography for the detection of BAT is the observation, that in infrared images the supraclavicular region shows a higher temperature than the vicinity. However, the occurrence of warm little triangles located in the lateral cervical region is well known phenomenon in medical thermography. Figure 1 shows typical infrared breast thermograms, that have been manifold recorded in France [10] and Germany in the nineteen seventies. All of them present with such a warm area, which is now believed to represent active BAT. Figures 2 clearly demonstrates that a similar temperature distribution can be observed in young female adults (figure 2a), middle aged overweight women suspected to suffer from myalgia (figure 2b) and in young male adults (figure 2c). The colour scale of all images displayed in figure 2 were compressed from an originally 10 degrees scale to a range of 5 degrees.

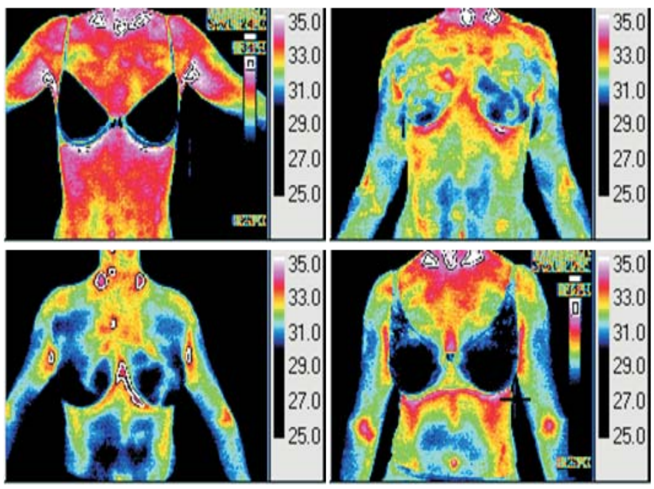

Figure 2a
Spots and small areas of increased temperature located in the lateral cervical region in young female adult

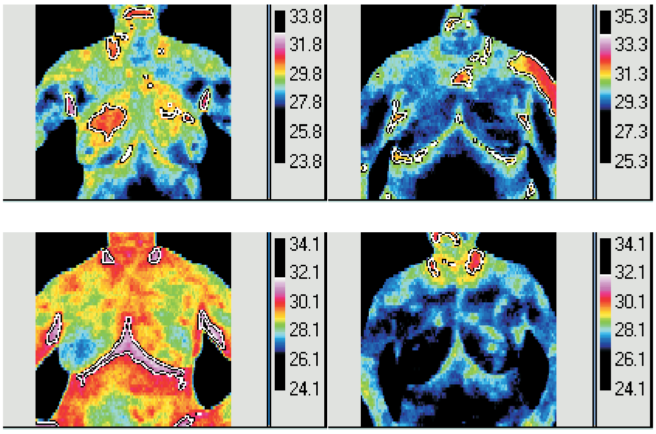

Figure 2b
Spots and small areas of increased temperature located in the lateral cervical region in middle aged females suffering from fibromyalgia

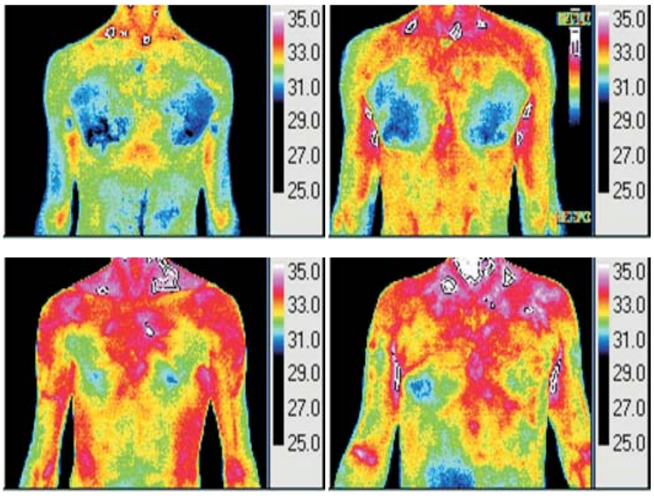

Figure 2C
Spots and small areas of increased temperature located in the lateral cervical region in young male adults(C)

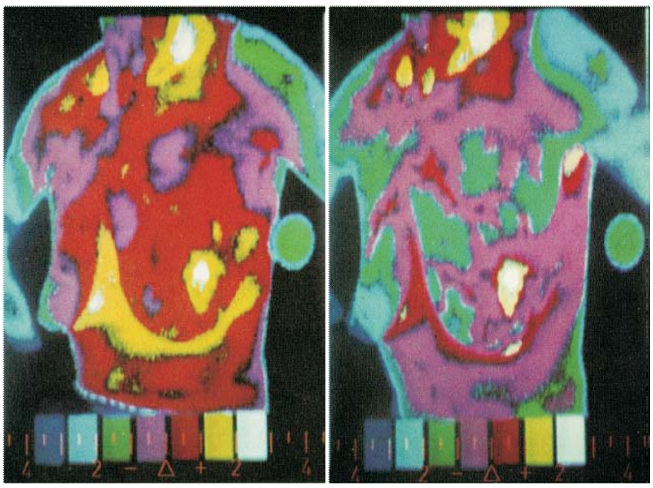

Figure 3
The temperature in the lateral cervical region did not change during 12 minutes acclimation to an ambient temperature of 21° C. [from 10].
Original captions:
Left image: Thermogram immediately after undressing
Right image: Same patient after 12 minutes static cooling in air conditioned room of 21°C.

As breast thermograms were recorded after 15 minutes acclimation to a room temperature of 20-21°C with bare upper body, one may argue that such an ambient temperature is already beyond the lower limit of an thermoneutral environment, and such a condition may initiate non-shivering thermogenesis. The same may be the case for the young adults and the fibromyalgia patient who acclimated totally naked to a room temperature of 23 ± 0.5°C. However, two thermograms of the upper body, the first immediately after undressing and the second after 12 minutes acclimation to room temperature of 21°C do not show much temperature change in the lateral cervical region (figure 3)[11].

It may also be questioned what an infrared camera can see in the supraclavicular region, which is, in terms of anatomy, not well defined, in all studies

In anatomy, the anterior neck is described by the central anterior cervical region and 2 lateral cervical regions. The omoclavicular triangle (alternative name: subclavian triangle, or supraclavicular triangle) has the following boundaries: upper border: inferior belly of the omohyoid muscle; lower border: clavicle; medial border: posterior border of the sternocleidomastoid muscle. Its floor is formed by the first rib with the first digitation of the serratus anterior muscle. The triangle has the same boundaries as the major supraclavicular fossa, which forms a narrow shallow pit behind the clavicle.

The supraclavicular fossa is a complex anatomic region that is contiguous with the neck above and axilla below. Many of the structures in this region, such as the scalene and omohyoid muscles, subclavian vessels, and brachial plexus, course from one of these compartments to another. Other contents of the supraclavicular fossa include small branches of the subclavian vessels, fat, lymph nodes, and the posterior lung apex [12].

The supraclavicular triangle is the lower portion of the lateral cervical region, that is bounded medially by the posterior border of the sternocleidomastoid muscle, above by the anterior border of the trapeze muscle and below by the clavicle. The lateral cervical region forms a slightly ascending plane in an angle of 15 to 20° with the horizontal plane.

A perpendicular view of the supraclavicular region and the lateral cervical region is difficult to achieve as it requires tilting of the camera, and such a position is difficult to repeat. A camera position at the level of the larynx, looking perpendicularly to the neck and the field of inspection is bounded below by a line between the tip of both axillary folds, while the outline of the deltoid muscles is adjacent to the lateral borders. The resulting upper border is determined by the individual proportions of head and neck. A standardised upright posture and position of head and cervical spine are also required for repeatable image recording. The proposal of the field of inspection (figure 4) was croped from a total body thermogram applying a frame with the same proportion that was used for the original image. In addition, figure 4 presents the position of triangular regions of interest for analysing thermal images of the lat-

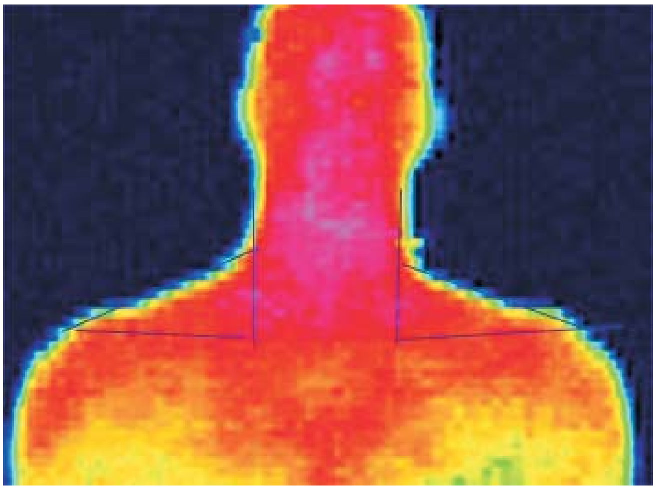

Figure 4
Proposed field of inspection for imaging the lateral cervical region
Lower border: line between the tip of both axiallary folds
Left border: Outline of the right deltoid muscle
Right border: Outline of the left deltoid muscle

eral cervical region. The proposed method of image capture accepts that a portion of the infrared radiation originating from the supraclavicular region is blocked of by the shielding clavicle, and that the radiation from the remaining lateral cervical region is not completely captured.

In case that the assumption is accepted that the hot spot in the lateral cervical region is caused by BAT activity, how much heat generation can be expected? Cannon & Nedergaard reported that in small animals the heat-producing capacity of brown adipose tissue can be calculated to be some 300 W/kg when it is working at its highest intensity [13]. This is 3,5 fold capacity of thyroid tissue and almost the 600 fold heat generation rate of white fat cells [14].

However, the few in vivo measurements of brown fat temperature reported dependent on the stimulus temperature increases between 0.2 and 1.0° C [2,15-17]. Based on micro- cal orimetry, an individual brown fat cell produces 1nJ of thermal energy during stimulation by 1μm noradrenalin and thus leading to an increase of 0.27°C in surface temperature of the adipose cell [18]. As temperature is an intensive quantity meaning the level of temperature is independent of mass, stimulation of 100 or 100000 cells will result in the same temperature increase at the surface.

It seems unlikely that in humans BAT temperature is by 0.2 to 0.6° higher than the temperature inside of central blood vessels. Conduction of thermal energy from BAT to the body surface is out of debate. However, the path of heat conduction remains unexplained and the point of arrival is also unknown. In any volume, heat transfer occurs along temperature gradients and the direction of heat transfer is modified by the geometry of conductive tissue properties. The current knowledge on the geometric distribution of tissue properties such as heat capacity and thermal conductivity does not explain that small depot of heat generating tissue is detectable as an area of increased temperature at the surface directly above the heat source.

Finally, it is assumed the blood supply of supraclavicular BAT depots and the skin of the lateral cervical region is provided by one artery. It is established, that the perfusion rate of active brown adipose tissue is high (15], and if a similar relationship of blood supply exists between BAT and skin as between muscles and skin, heat generation by BAT might result in a temperature decrease of the supraclavicular skin.

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Instructional Courses on Medical Thermography - a historical perspective

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SUMMARY

This document is a review of the courses organised under the name of EAT. The survey aims to develop a solid structure and schedule, which remain unchanged and are independent of the tutors or the venue of the course. Some of the previous courses have been organised solely by the EAT, most, however, were certified by the EAT in cooperation with other institutions/organizations (University of Glamorgan, University of São Paulo, QIRT, Bucharest University, Polytechnic Institute of Leiria, Porto University and Technical University of Madrid).

The duration and the topics that had been covered in the different courses varies depending on where they were taught. Even the courses at the University of Glamorgan showed over the years changed content, not only to reflect the progress of science, but also to adapt certain persons, who ended or started their cooperation with the group.

Based on previous course materials, we developed the structure of a 1 -day course by combining 4 hours theory with a 2-hours practical session, which will take place at the EAT2018 Congress in London, Teddington.

KEY WORDS: instructional course, medical thermography, EAT

EINFÜHRUNGSKURSE IN THE MEDIZINISCHE THERMOGRAPHIE - EIN HISTORISCHER BLICKWINKEL

Dieses Dokument ist ein Rückblick auf die unter dem Namen der EAT organisierten Kurse. Die Übersicht zielt darauf ab, eine feste Struktur und Zeitplan zu entwickeln, die unverändert bleiben und unabhängig von den Tutoren oder dem Veranstaltungsort des Kurses sind. Einige der vorherigen Kurse wurden von ausschließlich von der EAT organisiert, die meisten wurden jedoch von der EAT in Zusammenarbeit mit anderen Institutionen/Organisationen (Universität Glamorgan, Universität São Paulo, QIRT, Universität Bukarest, Polytechnisches Institut Leiria, Universität Porto und Technische Universität Madrid) zertifiziert.

Die Dauer und die Themen, die in den verschiedenen Kursen abgedeckt worden waren, variiert je nachdem, wo sie gelehrt wurden. Auch die Kurse an der Universität von Glamorgan zeigten über die Jahre veränderte Inhalte, nicht nur um die Fortschritte der Wissenschaft zu reflektieren, sondern auch um sich an bestimmte Personen anzupassen, die ihre Zusammenarbeit mit der Gruppe beendet oder begonnen hatten.

Basierend auf früheren Kursmaterialien, entwickelten wir die Struktur eines 1-Tages-Kurs, in dem 4 Stunden Theorie mit einer 2-stündigen praktische Sitzung kombiniert werden. Dieser Kurs wird vor dem EAT2018 Kongress in London, Teddington, stattfinden.

SCHLÜSSELWÖRTER: Einführungskurs, medizinische Thermographie, EAT

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Introduction

Courses for thermal imaging were offered very early in the history of clinical thermography. In the period between 1970 and 1985, liquid crystal paint, and later, crystals enclosed in foils was the preferred technique of thermal imaging and the main indication was breast cancer. Instruction on proper use and evaluation was given by manufacturers, who received very quickly (purchased) assistance from technicians and experienced medical doctors. An atlas on liquid crystal thermography was edited in 1976 in Germany [1] Acta thermographica, the first journal dedicated exclusively to thermography, published a supplement on liquid crystal thermography in1981 [2]. Announcements of liquid crystal thermography courses given M. Gautherie can be found in the first volume (1985) of the journal Thermodiagnostik (later renamed to ThermoMed) [3].

The use of infrared camera was restricted to specialised hospital departments due to the high costs of a thermal imager. Instruction in the use of infrared cameras was provided by manufacturers. Proceedings of symposia in New York 1964 [4] and Leiden 1969 [5] were published and the first textbooks on thermography appeared in the Netherlands [6], Japan [7] and North America [8].

Although Thermology Associations were founded in the nineteen seventies around the world, no printed information is available whether those societies offered educational courses for recording, evaluation and interpretation of thermal images.

Only the German Society of Regulation-Thermography promoted their special technique through an education system consisting of several levels, from beginners to experts and complemented by refresher courses. [3].

The American Academy of Thermology started in 2000 to certify technicians and physicians after they have completed a certification course and an examination [9].

Thermography Courses in relationship to the EAT

The first Thermography Course under the name of the EAT was organised in Vienna on 4th June 1993 at the Hanusch-Krankenhaus. Programme and extended abstracts are available in [10]. In principle, the course followed the structure of the book "Human Body temperature" by Y. Houdas and Francis Ring, with introduction lectures on infrared physics and liquid crystals technology, basic physiology of thermoregulation and a proposal for standardised technique of thermal images. The remaining lectures discussed applications in various medical fields including dermatology, neuromuscular diseases, rheumatology, physical medicine, disorders of the female breast and the vascular system. Speakers included Helena Tauchmannova from Slovakia, Aldo de Carlo from Italy, Guenter Bergmann and Dieter Rusch, both from Germany, Francis Ring from the United Kingdom and Kurt Ammer from Austria. A demonstration of the performance and image quality of the Rank Taylor Hobson Thermal Imager closed the series of lectures.

On 11-13 October 1999, Francis Ring and Kurt Ammer gave a course in São Paulo, on invitation by Antonio Camargo, a physiatrist whom Kurt Ammer met first at the American Academy of Thermology (AAT) Conference 1998 in Ft. Lauderdale. An application form for that course was published in [11]. One of the most interested participants was Marcos Brioschi, currently very active in promoting thermal imaging in Brazil and America and the rest of the world.

The original course announcement was in Portuguese, but a translated version of the programme can be seen in table 1. In this course only Francis Ring and Kurt Ammer were lecturers and it was not clear in the announcement which topics were taught by them. The names of lecturers are based on the memory of Kurt Ammer. Lectures were completed by image recording of real patients, treated for various pain problems at the São Paulo University Hospital.

Table 1
Programme of the III International course about thermography and pain (III Curso internacional sobre termografia e dor), a 2-day course in (São Paulo, October 1999)

- The importance of thermography in Brazil (A physician from Brazil)
- Important aspects of infrared and its detection (Ring)
- Thermoregulation of the human body (Ammer)
- Temperature development and measurement (Ring)
- Infrared detection system (Ring)
- Standardization of thermal imaging technique (Ammer)
- Cold stress test for the hands (Ring)
- Quantification and processing of thermal imaging (Ammer)
- The FLIR-AGA thermographic system for medical applications (FLIR agent)
- Pain and thermographic images (Ammer)
- Fibromyalgia: thermographic images and diagnosis (Ammer)
- Inflammation, therapeutics and thermographic images (Ammer)
- Literature, internet and CDs about thermography (Ammer)
- Type I Complex regional pain syndrome and thermographic images (Ammer)

Figure 1
Teachers and participants of the 5th Course in Summer 2004

Courses at the University of Glamorgan

Between July 2001 and July 2007 courses were organised, recognised and certified by the University of Glamorgan. The first Course on Thermal Imaging in Medicine was given from 3rd-5th July 2001, at the University of Glamorgan, [12]. The course aimed:

1. To provide an understanding of the imaging of the skin temperature

2..To demonstrate the application of standard technique to assess physiological and pathological conditions

3. To understand and apply image processing and analysis techniques

Lectures were presented by Francis Ring, Richard Harding, Bryan Jones and Kurt Ammer and covered the topics: Principles of infrared imaging; technological developments, environmental conditions for quantifiable imaging, thermal physiology and the conduct and interpretation of provocation tests.

The course fee included lecture notes, the book "The thermal Image in Medicine and Biology" and the CDROM "Archive of thermographic papers comprising all issues of Acta thermographica and Thermology".

The course followed and extended the paper "The Technique of Infra Red Imaging in Medicine" by Ring and Ammer, first published in Thermology international [13] and re-published in the book "Infrared Imaging, A casebook in clinical medicine" edited by F Ring, A. Jung and J. Zuber for IOP Publishing in 2015.

Between November 2001 and July 2007 seven other courses were given at the University of Glamorgan. All of them were announced in Thermology international [14-20] and

Table 2
Topics and duration of lectures in the Glamorgan courses

Topic	Lecturer (number of lectures)	Minutes (range)
History of infared thermography	F.Ring (8)	55 (50-60)
Basic thermal physics	B.Jones(1) F.Ring (7)	40 (20-60)
Principles of thermal physiology	K.Ammer (8)	110 (100-120)
Films on thermal physiology	F.Ring (7)	40
Standard protocols	P.Plassmann (1) F.Ring (7)	57 (45-60)
Vascular diseases applications	R.Harding (1)	80
Causes of temperature increase or decrease	K.Ammer (8)	108 (100-115)
Provocation tests	F.Ring (8), K.Ammer (7)	70 (60-80)
Lab demonstration cold stress test	F.Ring (3)	48 (40-55)
Detector and camera systems	R.Thomas (4)	67 (60-75)
Digital cameras and processing	P.Plassmann (3)	15
Calibration and tracability in thermal calibration	G.Machin (2)	60
Image capture	P.Plassman (4)	30
Picture composition, standard views and resolution	F Ring (4)	37 (30-45)
Analysis of thermograms, regions of interest	F.Ring (3), K.Ammer (4)	30
Introduction to CTHERM software	P.Plassmann (8)	45 (30-60)
Archiving, Integration into hospital DICOM systems	F.Ring (5)	32 (15-40)
Archive CD of thermographic papers demo	P. Plassmann (3)	15
Producing a thermographic report	K.Ammer (7)	30 (15-55)
Educational resources	K.Ammer (7)	18 (15-20)
	Total time of theory	987(=16h45min)

the website of Medical Imaging Research Unit of the University of Glamorgan. The topics and attendance of 3 courses were described in short articles, published in Thermology international [21-23]. The 5th Course assembled teachers and students from 8 different nationalities (Austria, Canada, Germany, Norway, Portugal, Romania, Slovenia, United Kingdom, USA)(figure 1). Interesting to note that 40 students attended the 5th-7th courses, a mean of 10 participants per course. The origin of the participants was varied, 17 were from the United Kingdom, 5 from Portugal, 4 from Canada , 3 from Norway, 3 from the United States of America, 3 from Hungary, 2 from Slovenia, 1 from Malaysia, 1 from Pakistan and 1 from Romania. Similar to the 35 participants in the courses 1 to 4, most of the attendants had their professional background in medical physics, some were physicians, nurses or physiotherapists.

Theory lectures

Each course was structured in theoretical lectures and practical sessions. A list of topics, the lecturer, the frequency of the topic presented and the duration of the lecture is shown in table 2. The estimated total time of theory lectures was 987 minutes equal to 16 hours and 15 minutes. The lecture time for "Producing a thermographic report" was increased from originally 15 to 40 minutes and extended by 15 extra minutes for discussion. This change became necessary because in most health systems interpretation of findings is a privilege of medical doctors. Other health professionals are allowed to conduct a thermographic medical investigation on request by a medical doctor. Thermographic findings must be presented in an objective way and no conclusions must be made on an underlying disease or further test procedures must not be proposed.

Practical session

In the practical sessions the attendants learned to record a thermal image of a distinct anatomical region, and to analyse the recorded images by defined regions of interest using the CHTHERM software. The idea behind these exercise was to teach the students

1. that thermal imaging is a method for temperature measurement as infrared thermography images the distribution of surface temperature and does not provide much anatomical details.

2. that the reproducibility and repeatability of temperature readings is dependent on image recording and on the position and shape of regions of interest

Tasks of the practical sessions

3rd course

3 students defined twice rectangular, ellipsoid and hourglass shaped regions of interest (ROI) over the anterior knee and compared the mean temperatures readings between different shaped and same shaped regions. The best repeatabilty of temperature readings was obtained from the hour-glass shaped ROI [24].

4th course

5 students investigated the repeatability of ROI definition at the ankle joint, the forefoot and the soles and compared the forefoot temperatures recorded in a perpendicular view and an 45° angled view. The highest reliabilty coefficent was obtained for the right ankle joint, the lowest for the left ankle joint. Forefoot temperature differed by 0.9 to 1.1°C between perpendicular and angled view [24].

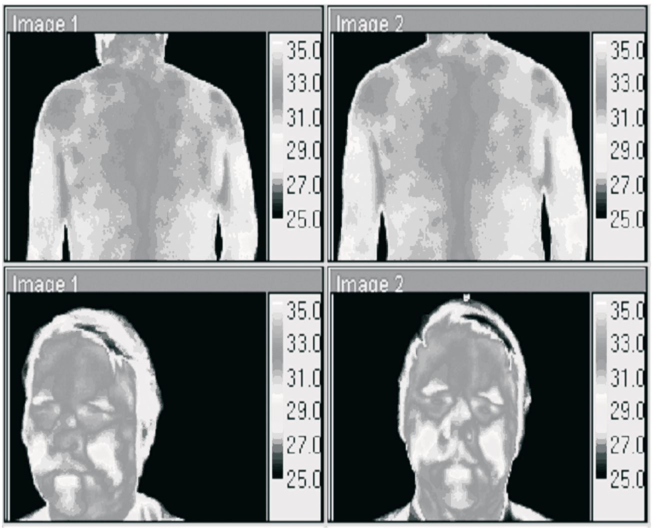

Figure 2
Thermal images showing slight variations in the field of view as used in the practical session of the 6th course

5th course

Repeatability of positioning both hands for image recording and repeatability of temperature readings from ROIs of finger joints was the task for the 14 participants. The mean size of the hands, measured in pixel,was about 40000 and varied in repeated image capture in one group by approximately 2300 pixel, and by 600 in the other group. However, there were individual deviations from the mean size of the hands in the range of 5000 to 7600 pixel. Applying the specified definition for the regions of interest on one of the images recorded, the mean temperatures of small joints of fingers were measured twice. A remarkable small standard deviation of these repeated measurement was obtained. However, individual errors of measurement up to 2.3°C were seen across the group as a whole [25].

6th course

For the determination of the repeatability of ROIs at the face, and differently shaped ROIs in the view upper back, nine participants measured the temperature from thermal images of the face and the upper back of the same subject, but in slightly different field of view (figure 2).The results indicated that temperature readings from the circular region of interest over the left shoulder joint in the standard view "upper back"appeared to be better reproducible than an alternatively polygonal shaped measurement area over the deltoid muscle. It was also obtained that moderate variations in the field of view can lead to significant differencesof temperature readings from these images [26].

7th course

At the 7th course, two separate thermal images using the standard view "Face" were recorded from one subject by 8 participants. In all images the measurement areas were defined as "Right Forehead" to determine the mean temperature of this region of interest.

With respect to the applied method, the size of the imaged field of view varied from 0.2 to 3,7% of the number of pixels within the object imaged. Temperature readings from the right forehead showed small variations between the first and second evaluation. However, in two readers the temperature values were significantly different in repeated evaluation of thermal images [27].

The two other courses of with a duration of 2 and a half days, were a little different in structure and instructors. In both courses the practical sessions was exchanged with demonstrations of operating the equipment, conducting provacations test and performing image analysis. The Short Course on Medical Thermography on 11-13 September 2008 inn Bucharest, was a collaboration of the EAT, the University of Medicine and Pharmacy "Carol Davila" Bucharest and the University of Glamorgan, supported by the Romanian Ministry of Research and Education [28]. F. Ring. R.Thomas, P.Plassmann and K.Ammer presented the course lectures as shown in table 2, and A.Nica and other Romanian thermography experts complemented the course with their personal experience in applications of medical thermography. The course attracted a large audience of 150 people.

On 26-27 July 2011, the 1st Practical course in medical thermography in Portugal, took place at the Polytechnic Institut of Leiria, a collaboration of the EAT and the Polytechnic Institut of Leiria [29]. In this 2 days course James Mercer lectured on thermal physiology, and due to computer problems the practical session was transformed to a demonstration of image evaluation and analysis.

1 day courses

In total, 5 one day courses have been organised, all prior to thermology conferences. In 1993, the first EAT course [10] took place on the day before the 6th Themographic Symposium of the Austrian Society of Thermology.

The 33rd Annual Meeting of the American Academy of Thermology (AAT) 2007 at Auburn University was combined with the 7th (and last) congress of the International College of Thermology, a loose liason between EAT, AAT and the Asian Pacific Federation of Thermology (APFT). The Auburn-Glamorgan Workshop, was the name of the 1-Day Pre-Conference Course on 7th June 2007 [30]. The Glamorgan course programme was presented in compact form within 5 hours net time by F. Ring, P.Plassmann and K.Ammer. Quality assurance and standards for image recording and analysis have been the main focus of this course.

Another Short Course on Medical Thermography was given on 2nd July 2008, prior to the 9th QIRT Conference 2008, in Krakow, Poland, by the same team of lecturers plus R. Thomas in a similar time frame [31].

Prior to the 12th and the 13th Conference of the European Association of Thermology 1-Day Pre-Conference Courses have been organised . The Course in Porto, held on the 5th September 2012, was a collaboration of EAT and University of Porto, Faculty of Engineering (FEUP) [32]. The time for lecturing was reduced to 4 hours, and the remaining 2 hours were allocated to a practical session, that provided instructions on standards for patient preparation, image recording and analysis and guided camera operation. 25 people attended the course.

The most recent course was the 1-Day Pre-Conference Course in Madrid, Spain, organised on 2nd September 2015 in collaboration of the EAT and the Technical University of Madrid (UPM)[33]. 6 hours were combined with 2 hours of practical session. The topics of lectures were thermal physics (R.Vardasca), physiological concepts applied to thermography (J.Mercer), medical thermography (F.Ring), provocation tests (K.Ammer), analysis, reporting and interpretation of medical thermal images (K.Ammer). The practical session was guided by M.Sillero and his team. The emphasis of the practical session was on exercising image capture, data collection and reporting with the software ThermaCam Reporter. Participants received a certificate of attendance to 8.5 lecture hours.

Certification

A certificate of attendance was given to participants on behalf of the Universities of Glamorgan, Auburn, Bucharest, Leiria, Porto, INEF Madrid, the latter 3 universities provided the certificates in cooperation with the EAT. On purpose, certification of skills and knowledge in the technique of medical thermal imaging was avoided.

Some associations promoting thermography in industry such as the UKTA (United Kingdom Thermography Authority), the Austrian Society of Thermography, the infrared training company of FLIR and many commercial distributers of infrared equipment offer training courses and certify thermographers based on requirements defined in ISO 9712 and related national standards (DIN, ÖNORM). Level 1 thermographers require a minimum cumulative duration of 33 hours training. A detailed syllabus of training is available [34]. In addition, a minimum cumulative experience of 12 months is required. Experience is based on 16 hours minimum per month of thermography-based machinery condition monitoring. Elegible candidates must pass a multiple choice examination for receiving certification.

For veterinary thermography quite a lot of courses can be found on the internet, but no information is available on accreditation of this courses by any veterinarian authority. Due to possible legal consequences of an non authorised certification of skills and expertise in medical thermography, it was and still is a wise decision of the EAT-board members to avoid such certifications.

Structure for the pre-EAT 2018 Congress Introductory Thermography Course

After reviewing all the courses that were taught in the past, trying to fulfil the expectations of those searching for a course to learn or increase the skills necessary to use thermal imaging, we presented the information to the EAT Board at the last EAT Board Meeting during the XXIth Meeting of the Polish Association of Thermology in Zakopane. After intensive and constructive discussion, the board accepted unanimousley the following course structure (table 3). The proposed structure reflects what the EAT Board believes to be necessary as an introduction to the use of medical thermal imaging.

Table 3
Agreed course structure for 4th July 2018

9:00 Registration

9:10 Opening of the course (Kevin Howell)

9:15 Physical principles of heat transfer (Ricardo Vardasca)

9:45 Principles of thermal physiology/skin blood perfusion (James Mercer)

10:45 Coffee break

11:00 Standardization of thermal imaging, recording and analysis (Kurt Ammer)

12:00 Quality assurance for thermal imaging systems (Rob Simpson)

12:30 Producing a thermographic report (Kurt Ammer)

13:00 Lunch

Practical Session

13:45 Provocation tests (James Mercer and Manuel Sillero)

14:45 Image analysis (Kurt Ammer and Ricardo Vardasca)

15:15 Coffee break

15:30 Hands-on supervised practice (all course teachers)

16:30 Educational resources (Adérito Seixas)

16:45 Closing

Currently, the course speakers prepare a detailed syllabus of their lectures, particularly a detailed plan for the tasks and teaching aims of the practical session. The information will be collected and intensively discussed during the next EAT Board meeting in November in Vienna.

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Altered Skin Temperature Patterns In Patients With Idiopathic Syringomyelia And Arnold-Chiari Malformation Type I - A Preliminary Subjective Evaluation Using Thermography

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SUMMARY

This retrospective analysis of our surgical patients less than thirty years old with Arnold-Chiari malformation type I and idiopathic syringomyelia reveals that skin temperature, as detected by infrared thermography in three selected axial body areas, has an asymmetric distribution, mostly corresponding to areas of temperature hypoesthesia. The extent of this asymmetry is significantly related ($p < 0.05$) to disease severity, as reflected by the degree of tonsillar herniation and the extension and shape of the syringomyelic cavities on magnetic resonance imaging. Moreover, at the first postoperative follow-up visit after sectioning the filum terminale, thermographic readings improve significantly more ($p < 0.001$) in patients with severe and moderate magnetic resonance findings of Arnold-Chiari malformation type I and idiopathic syringomyelia than in controls.

KEYWORDS: thermography, skin temperature, Arnold-Chiari malformation type I, idiopathic syringomyelia.

VERÄNDERTE MUSTER DER HAUTTEMPERATUR BEI PATIENTEN MIT IDIOPATHISCHER SYRINGOMYELIE UND ARNOLD-CHIARI DEFORMITÄT, TYP 1 -EINE VORLÄUFIGE SUBJEKTIVE BEURTEILUNG MITTELS THERMOGRAPHIE

Diese retrospektive Analyse unserer unter 30 Jahre alten chirurgischen Patienten mit Arnold-Chiari Malformation Typ I und idiopathischer Syringomyelie zeigt, dass die Hauttemperatur, erkannt anhand Infrarot-Thermographie in drei ausgewählten axialen Körperbereichen, eine asymmetrische Verteilung hat, die größtenteils den von thermischer Hypästhesie betroffenen Bereichen entspricht. Das Ausmaß dieser Asymmetrie steht signifikant ($p < 0,05$) mit der Krankheits schwere, auf den Magnetresonanzbildern durch den Grad der Tonsillenherniation und die Ausdehnung und Form der syringo- myelischen Höhlungen wiedergespiegelt, in Verbindung. Ferner verbesserten sich die thermographischen Werte bei der ersten Kontrolluntersuchung nach der Durchtrennung des Filum terminales in Patienten mit schweren und moderaten Magnetresonanz-Befunden für Arnold-Chiari Malformation Typ I signifikant mehr ($p < 0,001$) als bei Kontrollpatienten.

SCLÜSSELWÖRTER: Thermographie, Hauttemperatur, Arnold-Chiari Deformität Typ I, idiopathische Syringomyelie.

Thermology international 2017, 27(3) 104-110

Introduction

Although as early as in 1979, Bernard Williams was already highlighting the alterations detectable by thermography in patients with syringomyelia [1], this matter has received little attention so far. Nevertheless, as infrared camera-mediated acquisition of body temperature distribution advanced greatly through the last decades and has become a more standardized technique with ever more sophisticated data registration and interpretation, we thought that time had come to search whether it could play a role in the diagnosis and follow-up of patients with idiopathic syringomyelia and Arnold-Chiari malformation type I, based on the assumption that the various alterations of spinal cord function in these diseases interfere with local and regional body heat emission and thus determine an asymmetry of body temperature distribution, as opposed to the long established thermographic symmetry of the human body, as revealed by previous research [2, 3]. As we have observed in our own patients and is well known from previous experience, both diseases are frequently associated with extended alterations of pain and temperature sensibility; moreover, many of our patients complain of various anomalies of temperature perception and thermoregulation, such as persistent sensation of cold hand and feet, heat or cold intolerance and inappropriate perceptions concerning ambient temperature. Our surgical approach, the section of the filum terminale, is based on previous research pointing to spinal cord ischemia secondary to medullary traction, as the physiopathologic mechanism underlying similar alterations of spinal cord function in the tethered cord syndrome (4) and also, according to the cord traction theory, involved in the initiation and progression of idiopathic syringomyelia and Arnold-Chiari malformation type I, a fact already shown by some authors [5, 6].

Material and method

At our institution, since September 4th 2013 until January 9th 2017, 389 patients with Arnold-Chiari malformation type I, idiopathic syringomyelia and related diseases, who were to be operated of Filum terminale sectioning the next day, were explored with infrared thermography at the end

Table 1: Classification of syringomyelia severity

Syringomyelia severity	Description	Points
Very severe	Distended cervico-thoracic cavity with dilated spinal cord	4
Severe	Filiform and/or fusiform cervico-thoracic cavity	3
Moderate	Cervical or thoracic filiform and/or fusiform cavity extending more than one vertebral level	2
Minimal	Cervical or thoracic filiform and/or fusiform cavity extending less than one vertebral level	1

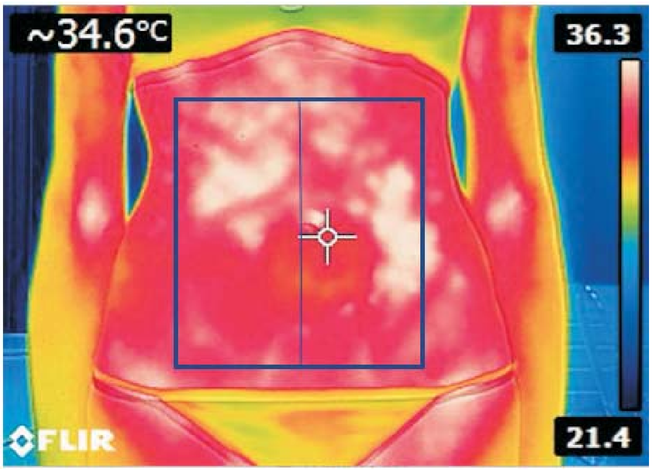
of the neurosurgical consultation, as part of the routine preoperative investigations, as well as during the first postoperative follow-up visit. Our diagnostic criteria of spinal cord traction in patients without overt Arnold-Chiari malformation type I or idiopathic syringomyelia have been recently published elsewhere [7]. The surgical technique consists of a filum terminale sectioning by means of an extradural sacral approach derived from our original technique published before [8, 9].

The thermographic images were captured with a portable infrared thermographic camera model FLIR E8 (FLIR Systems, Inc., Wilsonville, OR, USA) with a thermal resolution of 0.06ºC, a spatial resolution (IFOV) of 2.6 mrad, a field of view (FOV) of 45ºH and 34ºV/0.5 m and a display of 320x240 pixels. The emissivity setting was fixed at 0.95. The patients themselves or their caretakers had signed an informed consent form previously. Only patients who had infrared thermography performed in standard conditions as follows, not only preoperatively, but also during the first follow-up visit, from 7 to 83 days postoperatively, were included in the study.

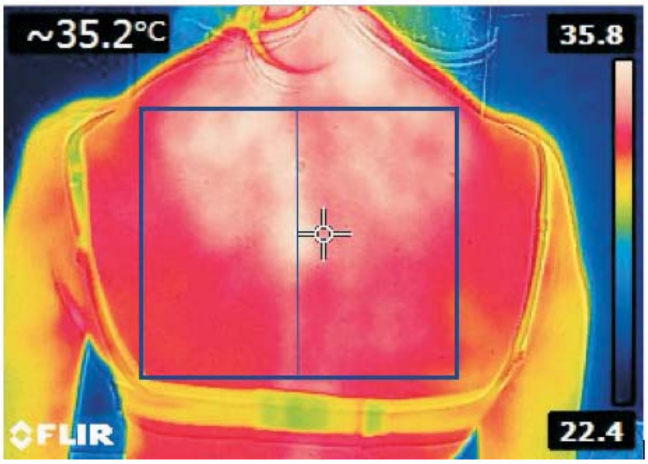
The images were always taken in the same consultation rooms just after completing the neurological examination, which meant at least half an hour of accommodation of the patient to ambient temperature without clothing, avoiding barefoot contact with the floor outside the carpet. As the image capture was part of a preoperative evaluation, the patients were always fasting a few hours before and the procedure took place during morning hours. Of course, it is possible that some of these conditions have not been so rigorously observed during the postoperative follow-up visit. The rooms have relatively constant temperature (between 23-24ºC) and humidity conditions. The distance between camera and patient, although variable, was kept within the optimal range for maximal exposure of the respective region of interest, with minimal presence of surroundings. Images were taken of thirteen regions of interest of the body and extremities from the front and from behind, with the camera's optic axis as perpendicular to the body surface as possible and carefully centered in order to obtain the most symmetrical view afforded by the patient's anatomy.

In an unpublished preliminary analysis, we noticed that patients older than 30 years had a somewhat different skin temperature distribution and postoperative changes, so that, based on the assumption that with advancing age,

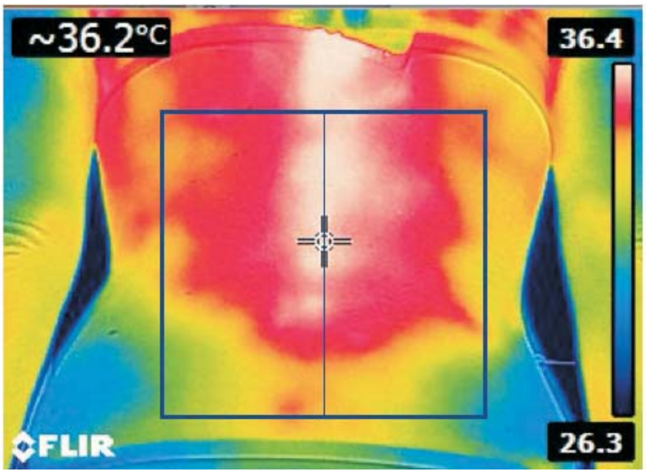
Figure 1, A-C
The three body regions selected for inclusion into the study



1a.Abdomen (case 18194)



1b.Posterior Thorax (case 11994)



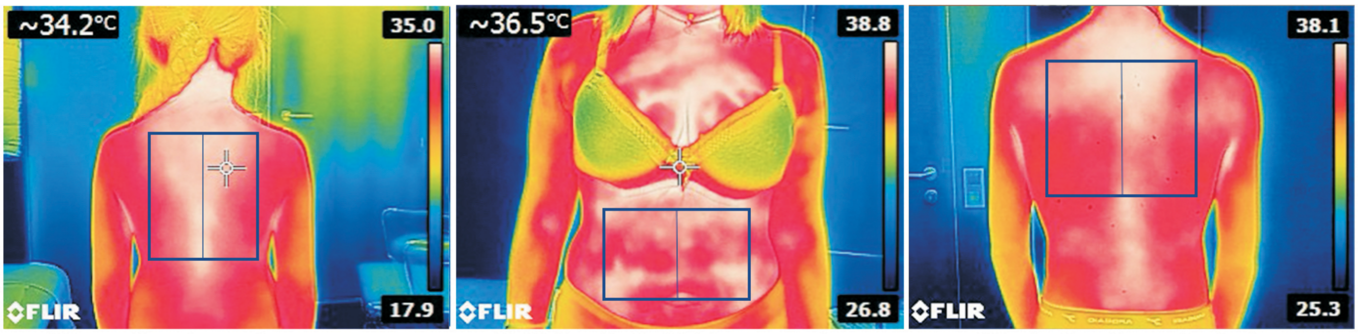
1c. Lumbar (case 18584)

more factors contribute to determine the actual asymmetry of skin temperature, we decided to establish this as the upper age limit. After a comprehensive preliminary analysis of all thirteen body areas, we selected only three of them (abdomen, posterior thorax and lumbar area - Figure 1) which had provided good quality and comparable images, correct technically and respecting the mentioned conditions in a reduced sample of 48 patients, who consequently composed the final group for image and statistical analysis.

For image interpretation and classification, we created a subjective system of direct visual evaluation of the spatial symmetry of the distribution of the isothermic lines in the region of interest, without any strict segmentation method but avoiding to interpret peripheral body parts with surfaces angled more than 30º with respect to the objective lens - an easy task in the selected regions (abdomen, posterior thorax and lumbar area) and one more reason to prefer them. Image analysis was performed by only one of us (HCS) after performing an intra-observer reliability check-up on a small sample of patients. The principal advantages of this method are that, on the one hand, the evaluation is independent of the absolute temperature values recorded and, on the other hand, it gives more spatial information to be eventually correlated with neurologic abnormalities.

This compensates, in our case, the technical weaknesses of image capture, especially the variations in the colour palette, and could aid in establishing a possible relationship between neurological examination findings and the thermographic evaluation. Symmetric areas were given 0 points, slight asymmetry - that is, perceived with some difficulty, involving a subtle difference in color and occupying less than 25% of the evaluated area - 1 point and finally, obvious asymmetry with clear color differences in more than 25% of the area, 2 points (Figure 2). An asymmetry index (between 0-6) was calculated for each patient by simply adding the scores for all three regions. Its variation at the first postop-

Figure 2: Examples of the degrees of asymmetry.



a)Posterior thoracic symmetry. (case 19325) b)Abdominal slight asymmetry. (case 11484) c)Posterior thoracic obvious asymmetry. (case 10805)

Table 2: Classification of Arnold-Chiari malformation type I severity.

Arnold-Chiari I malformation severity	Description	Points
Obvious	5 mm or more of tonsillar descent from the foramen magnum, tapering form of the tonsils, obstructed CSF spaces within the foramen magnum	2
Incipient	Less than 5 mm of tonsillar descent from the foramen magnum, rounded form of the tonsils, free CSF spaces within the foramen magnum	1

a b c d

Figure. 3 Examples of the degrees of severity of syringomyelia:
a) very severe (case 14935), b) severe (case 15245), c) obvious (case 11135) and d) minimal (case 11445)

Figure 4:
Examples of the degrees of severity of
Arnold-Chiari malformation (ACM) type I

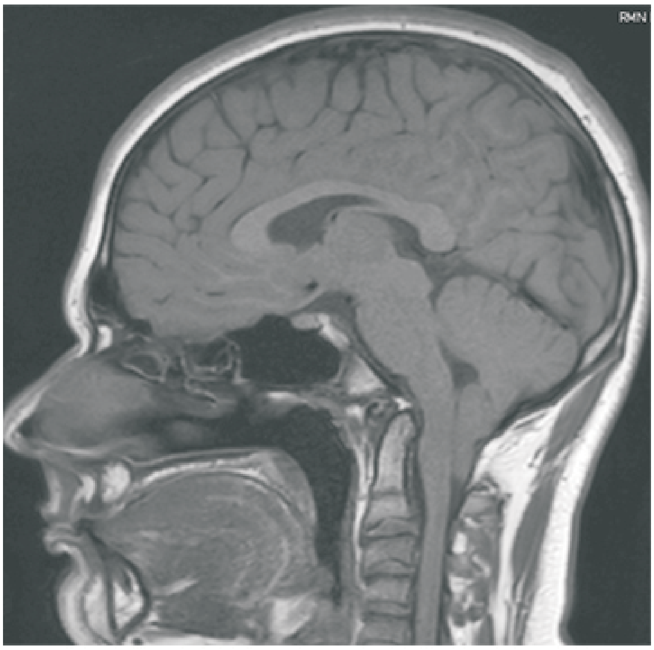


Figure. 4a: obvious ACM (case 15215)

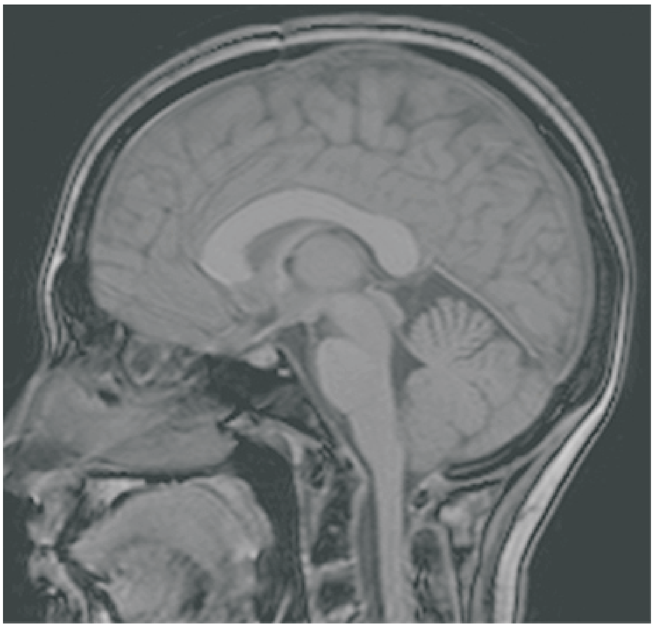


Figure 4b) incipient ACM (case 19905).

erative visit was registered as a separate variable, being given a conventionally negative value if asymmetry worsened and a positive one if it improved after sectioning the filum terminale.

The different forms of idiopathic syringomyelia as seen on magnetic resonance imaging were classified in four types of increasing extension both longitudinally and transversely, that is: minimal, obvious, severe and very severe, corresponding to scores from 1 to 4 points in the disease severity category (Table 1 and Figure 3). Similarly, Arnold-Chiari type I malformations were divided into two groups, incipient and obvious, scoring 1 to 2 points within disease severity, depending on the magnitude and morphology of the tonsillar displacement (Table 2 and Figure 4). Disease severity was considered as composed by the sum of the two scores, with a total between 0 and 6 points, with 0 corresponding, of course, to the absence of that feature on magnetic resonance imaging. The group of 32 patients with a global score of 2-6 points was defined as "obvious disease" and included cases harboring clear-cut pathological features on magnetic resonance imaging, while the rest composed the smaller "minimal disease" category and constituted the control group.

Besides basic epidemiological data, we collected all those clinical data which were reliable and complete in the selected patients and amenable to statistical analysis, having at the same time a plausible relationship with the putative pathophysiology of skin temperature asymmetry or influence by some other means the results: the length of the time interval until the first follow-up visit, the presence and severity of scoliosis (1 point assigned if less than 10º Cobb and 2 points if more), the presence and extension of pain (except headache), paresthesias and temperature hypoaesthesia, each of them being assigned a score of 1 if unilateral and 2 if bilateral in the trunk, upper and lower limbs, respectively. We did not record the body mass index and physical activity level of the patients; meanwhile, data concerning smoking history were incomplete and we decided not to use them.

In order to check our hypothesis concerning the relationship between local and regional temperature sensibility alterations (hypo- or hyperaesthesia) and skin temperature asymmetry, we confronted their distribution in 26 samples of the above-mentioned three body areas in fifteen patients in whom they were superimposed, in order to check in this way whether there really was any correspondence between diminished cutaneous sensibility to temperature and increased skin temperature in the same area. Each of these 15 patients had one, two or all three regions associating hypo- or hyperaesthesia to temperature with some kind of thermographic asymmetry. Our method of neurological testing for temperature sensibility consists of applying a frozen metallic object (a tuning fork) on 52 symmetrical cutaneous body areas from the forehead to the soles, asking to the patient to ascertain whether there is an increased, normal, diminished or absent cold sensation at touch.

The images were analyzed in Vista Previa, version 8.1 (Apple, Inc., Cupertino, CA, USA), the resulting data were registered on Excel 2011 for Mac, version 14.1.0 spreadsheets (Microsoft, Inc., Redmond, WA, USA), and the statistical analysis was performed with SPSS Statistics 21 software (IBM, Inc., Armonk, NY, USA). We performed univariant and bivariant analyses for comparison of the two mentioned groups, applying the Student t test for quantitative variables and the chi-square test for qualitative variables. We considered values of $p < 0.05$ as statistically significant.

Results

According to magnetic resonance imaging criteria of disease severity, there were thirty-two patients with obvious idiopathic syringomyelia and/or Arnold-Chiari type I malformation and sixteen control cases with minimal forms of these diseases. There were 18 female and 14 male patients in the Arnold-Chiari-I-syringomyelia group, aged from 4 to 29 years (mean 16.8 +/- 7.7 SD) and 12 females and 4 males in the control group, aged from 14 to 29 years (mean 21.5 +/- 4.9 SD); thus, the control group was older ($p < 0.03$) and it included significantly more female cases ($p < 0.0005$). The time interval between surgery and the first follow-up visit was not significantly different between patients and controls (45.5 days +/- 16.5 SD in the former versus 49.2 days +/-23.4 SD in the latter, $p = 0.53$).

Table 3 summarizes the results concerning the comparison of thermographic variables between the two groups. The asymmetry index was significantly higher in obvious-disease cases than in minimal-disease controls ($p < 0.05$). There was no significant difference between the two groups regarding the various clinical variables analyzed as to their absence or presence unilaterally or bilaterally ($p = 0.83$-0.87). Last but not least, early after filum terminale sectioning, the asymmetry index improved slightly in the obvious-disease group, while in the minimal-disease group this parameter, on the contrary, showed a tendency to worsen, resulting in a negative mean ($p < 0.001$).

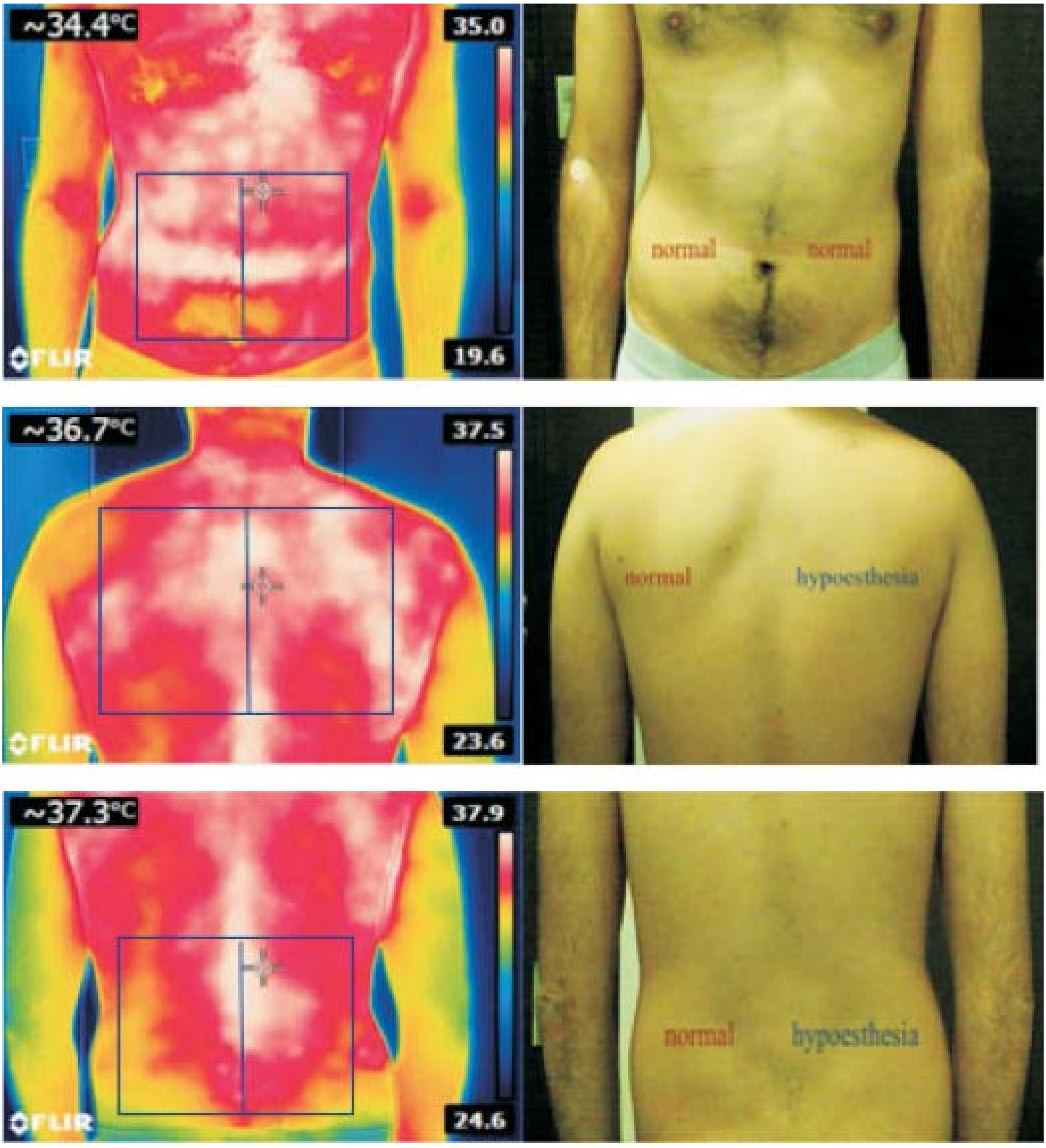


Figure 5
Correlation between thermographic asymmetry and temperature hypaesthesia (case 13405)

Table 3:
Results of group comparison of thermographic variables. SD=standard deviation

Group	Asymmetry index mean+/-SD	Postoperative change of asymmetry index mean+/-SD
Obvious disease (cases)	4.6 ± 1.5	0.4 ± 1.4
Minimal disease (controls)	3.7 ± 1.2	- 1.0 ± 1.1

In the fifteen patients with alterations of temperature sensibility in the same mentioned three body areas, we found 26 samples of abdominal, posterior thoracic and lumbar regions with superimposed altered sensibility to temperature and thermographic abnormalities (Figure 5); there was a more or less complete skin surface area with concordant temperature hypoaesthesia and thermal elevation - as compared to the opposite side - in 16 out of 18 body areas (88.9%) of Arnold-Chiari-I-Syringomyelia cases and in 6 out of 8 (75%) of the control group.

Discussion

Infrared thermography has been used for a long time to study various pathological conditions (3, 10) and has well demonstrated its safety in humans, although time has shown that in order to obtain useful information from this technique, strict protocols of execution and interpretation have to be put forth and respected throughout (3, 12, 13). Clinical thermography has proven its usefulness in many pathological conditions which alter skin temperature distribution and has shown promising results in various medical disciplines, having been used to study osteoarthritis, muscle and tendon injury, fibromyalgia, complex regional pain syndrome, Raynaud's phenomenon and other peripheral vascular disease, febrile conditions, etc., besides the well-known applications in breast cancer (3, 12).

Skin temperature distribution is the result of complex mechanisms of body temperature homeostasis (13). For this reason, we assumed that the most plausible pathophysiologic mechanism of the relationship between syringomyelia and skin temperature distribution consists of an altered thermoregulation. Thus, in areas of diminished temperature sensibility, the reflex adaptation of the cutaneous blood flow would fail to provoke vasoconstriction as a consequence of an ambient temperature lower than 37º (which uses to be the case indoors) and thus heat loss through the same area would increase and this could be detected by infrared thermography as locally increased temperature emission. Of course, other putative pathophysiologic mechanisms could be neurovegetative disturbances by alterations of sympathetic or parasympathetic spinal cord nuclei and/or pathways and/or sustained superficial muscle spasms related to chronic pain or pyramidal tract dysfunction.

Thermographic abnormalities in patients with Arnold-Chiari malformation type I-syringomyelia complex have received quite a scarce attention so far, if any. Apart from being mentioned by Bernard Williams as we pointed out in the beginning, there has been a very limited insight into this field, at least with respect to English language publications. Moreover, lately, since modern infrared cameras have started to be widely used in medicine, this subject seems to have been largely ignored. Nevertheless, some investigators contributed to shed some light over regional skin temperature changes in scoliosis and attributed them mainly to sustained muscular spasms in the back and the heat produced in those muscles (12, 13). The tempting relationship that - concerning thermographic values - can intuitively be established not only with back muscle activity, but also with altered sensibility to temperature and neurovegetative disturbances potentially associated to syringomyelia, prompted us to practice preoperative and postoperative infrared thermography in our patients at the end of the physical examination. As already mentioned, a separate analysis of some of our cases revealed that indeed, there is a positive correlation of temperature hypoesthesia, a frequent finding in syringomyelia, with an increased regional heat loss through all or part of the same skin area in 88.9% of the involved body areas in patients with Arnold-Chiari type I malformation and idiopathic syringomyelia.

As the hypothetical physiopathological mechanism suggested by us would suppose, there was a significantly more pronounced skin temperature asymmetry in patients with idiopathic syringomyelia and Arnold-Chiari type I malformation than in the control group ($p < 0.05$). Moreover, skin temperature distribution improved early after filum terminale sectioning, and it did so significantly more in patients with Arnold-Chiari-I-syringomyelia complex than in control cases ($p < 0.001$). Interestingly, the skin temperature distribution pattern was relatively constant and characteristic in most patients before and after surgery, despite the mentioned changes in asymmetry: this was as if every person had an individual and specific "thermographic signature" of various body parts. We preferred this method of evaluation of thermographic images because although it is highly subjective, it provides not only isolated temperature measurements in certain points but rather more complex spatial information concerning extended body areas and reflecting better the sensitive, muscular and vegetative alterations possibly involved in the physiopathology of these thermographic changes; besides, it could be the basis for more exact and sophisticated objective methods of detection of thermographic asymmetry based on special image segmentation and analysis software (14).

Conclusions

The limitations of this study are obvious, starting with its retrospective nature and going through the technical difficulties of image capture, which requires clearly a stricter pre-established protocol, the weaknesses of which we had to compensate by a highly demanding process of patient and image selection, which reduced the number of cases and prevented us from performing more complicated statistical analyses. Moreover, relatively few clinical data could be collected and organized from patients' files in order to be reliably analyzed. Also, the follow-up period was quite brief, on account of the worldwide location of our patients, which makes many of them miss later visits and would require, sooner or later, the implementation of a self-administered outcome questionnaire, allowing us to appreciate the eventual prognostic value of thermography. We are also well aware that our method of image evaluation is quite subjective and is amenable to important future improvements. Nevertheless, our data confirm a certain relationship between Arnold-Chiari I malformation, syringomyelia, loss of sensibility to temperature and regional skin temperature asymmetry detected by means of infrared thermography, as well as a certain positive early effect of filum terminale sectioning over the latter, in patients less than thirty-years-old. These findings prompted us to design a future prospective study with a better standardization of infrared thermography, a more complete and objective follow-up evaluation and an improved data collection which would include a more objective analysis of thermographic images and more clinical and surgical details, to enable a deeper insight into the pathophysiology of these diseases and put the foundations of a new clinical test, with diagnostic and prognostic value in these patients.

Acknowledgements

We thank all the personnel of the Institut Chiari & Siringomielia & Escoliosis de Barcelona for their participation in the capture of thermographic images of the patients, especially Mrs Samantha Meir for her contribution to the initiation of the infrared camera use, Miss Katharina Kühn for her help in preparing the submission of the article for publication and Mr Anoop Tiwari for his contribution in the preparation of the figures.

Declaration of conflicts of interest

The authors have no conflict of interest to declare.

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News in Thermology

A strong expert in infrared thermal imaging

Jozef Gabrhel is a hard-working medical doctor, specialist in rehabilitation with a private practice in Trencin, Slovakia. Doc. Dr. Helena Tauchmannova was the tutor of his specialist training and introduced him to infrared thermal imaging. In 1993, they described for the first time that skin temperature distribution varies in intensity and location between athletes practising different disciplines of sports. Weight lifters, wrestlers, rowers, handball and football players can be differentiated by different similarities of mean skin temperatures on the anterior and posterior side of the trunk and the extremities [1]. 2 years later, a retrospective study collected data over a period of 5 years and reported thermographic findings in the knees of adolescent athletes [2]. Dr Gabrhel uses infrared thermal imaging regularly in the evaluation of his patients who are often athletes suffering from and treated for the sequelae of injuries. In the last 7years, papers were published describing thermographic findings in the lower back [3], the pelvic region [4], the knees [5] and the elbow [6].

However, Jozef Gabrhel does not only successfully care for sportsmen, he is himself an active athlete. As previous member of the Slovak Olympic Weightlifter Team, he continuously practises powerlifting and participate regularly in competitions. From June 25th to July 1st 2017, the GPC European powerlifting championship took place in Biala Podlaska, Poland. Dr Gabrhel started in the weight category to 75 kg and age category from 60-64 years. He lifted 150 kg (squat), 100 kg (benchpress)and 175 kg (deadlift) and achieved the first rank in his category.

We congratulate Dr Gabrhel to his championship!

Squat: 150 kg

Benchpress: 100 kg

Deadlift: 175 kg

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2017

September 15th -17th, 2017
AAT Annual Meeting
in Greenville, South Carolina, USA

September 15th , 2017
AAT Physician Member Certification Qualification

Course Outline

- Didactic Training and Educational Presentations on:
  - Paradigms of care and patient care algorithms for diagnosis and treatment
  - Clinical Objective Criteria for Related NMSK Disorders (areas of specific interest will be audience focused)
  - Clinical Approach to Vasomotor Pain Syndromes Thermographic Vasomotor Mapping and Differential Diagnosis Sympathetic Skin Response Generators Studies and RSD Look Alikes
  - AAT Clinical Guidelines for the Use and Applications of NMSK Thermography
  - AAT Clinical Guidelines on Breast Thermography
  - AAT Clinical Guidelines on Oral-Systemic Thermography
  - Thermography Specific Uses and Applications
  - Review of NMSK, Breast, and Oral-Systemic Thermographic Test Protocols
  - Reading of NMSK, Breast, and Oral-Systemic Thermographic Studies
  - Interpretation of NMSK, Breast, and Oral-Systemic Thermographic Findings
  - Report Generation for Thermal Imaging Studies
- Individually Directed Break Out Sessions
- Administrative and Office Based Thermography Issues: Third PartyCoverage issues
  - Workers Compensation Coverage Patient Support Groups Professional Staffing and Training
  - Professional Associations (American Academy of Thermology) Future Developments for Thermal Imaging
- • Resource Materials to be Provided to Participants
  - Articles, Publications, Journals
  - Certificate of Participation

2017 Program and Events

Saturday, September 16th, 2017

08:00am - Registration

08:30am - *Welcoming Remarks*
Jeffrey Lefko, Greenville, SC, Executive Director, American Academy of Thermology

8:35-9:20am *Keynote Address*: Thermal Patterns in Disease and Condition Monitoring
Marcos Brioschi, M.D., Professor of the Department of Neurology, Hospital das Clinicas da Universidade de São Paulo, Brazil.

9:20am - 10:45am *Session 1: Community Education - Promulgating Thermal Imaging Inside and Outside*

9:20am-9:40am Update on the AAT Thermography Atlas of Medical Conditions
Jan Crawford, BSN,
Member, AAT Board of Directors

9:40-10:00am Equilibration and Cold Challenge Testing Techniques
Robert Schwartz, MD, Greenville, SC,
Chairman, American Academy of Thermology

10:00am-10:30am Bridging the Thermography Gap- Public and Physician Outreach
Christine Horner, MD, San Diego, CA,
Member, AAT Board of Directors

-10:30-10:45am Panel Discussion

10:45am -11:15am Break

11:15am -12:30 pm *Session 2: Advancements in Infrared Imaging Cameras, Equipment, and Translational Applications*

11:15-11:30pm Physics-Importance of Sensivity in Camera Selection
Robert Schwartz, MD,
Chairman, AAT Board of Directors

11:30-11:50am Adsorption/Absorption Thermography-Concurrent Use with Steam for Finger Print Identification
Michael L. Myrick, PhD., Professor, Department of Chemistry and Biochemistry, University of South Carolina, Columbia, SC

11:50am-12:20pm Forensic and Sports Medicine Applications for Thermal Imaging
Marcos Brioschi, MD, President of Brazilian Medical Thermology Association

Q&A/ Panel Discussion

12:30pm - Lunch (provided)

1:30pm -3:00pm S*ession 3: Clinicians Corner: Thermography as an Extension of the Physical Exam for Use in Diagnosis and Treatment*

1:30-2:00pm Breast Cancer Prevention
Christine Horner, MD,
Member, AAT Board of Directors

2:00- 2:20PM Integrating a Thermal Imaging Lab Within a Medical Practice: Clinical Applications and Practical Pitfalls
George Schakaraschwili, MD, Aurora, CO,
AAT Atlas Editor

2:20-2:40PM How I Learned to do Interpretations
Eric Ehle, DO, Amarillo, TX, Member, AAT

2:40-3:00pm Thermal Imaging: How It Changed My Approach to Patient Care
Matthew Terzella, MD, Greenville, SC, Member, AAT

Panel Discussion

3:00pm - Break

3:30pm -5:00pm *Session 4: Thermal Imaging Advances and Development Issues and Challenges*

3:30-4:00pm "Picture This.." The Independent Technician's Role in Properly Conducting Exams Which Contribute to Physician Diagnostic Information
Jan Crawford, BSN, Member, AAT Board of Directors

4:00- 4:20pm Thermal Images among Different Animals
Dr. Tracy Turner, DVM, Elk River, MN,
Member, AAT Board of Directors

4:20-4:40pm Use of Thermographic Imaging: An Internist's Perspective
Tashof Bernton, MD, Aurora, CO,
Member, AAT Board of Directors

4:40-5:00pm Integration of Thermography into PMR, Educational Components of Medical Residency Programs
Bryan O'Young, MD, Geisinger, PA.,
President, AAT Board of Directors
Sam Wu, MD, Geisinger, PA.,
Member, AAT Board of Directors

5:00pm - Annual Scientific Session Wrap Up and Remarks

5:30pm - Session Ends

Shuttle back to Crowne Plaza Hotel

6:30- 7:30pm - Meet and Mingle Reception with the Leadership at the Crowne Plaza Hotel

Presentation of AAT 2017Achievement Award

Sunday September 17th, 2017 Committee Meetings

07:30am - Shuttle from Crowne Plaza Hotel

08:00am - SPECIAL THERMOGRAPHERS WORKSHOP: How to Build and Grow Your Thermology Practice - Open for all Attendees

Marketing/Promotion/ Communication Tactics and Plans
Office Practice Issues and Challenges
Website Development
Q&A Session
Networking, Information Exchange

09:30am -10:30am *Open General Session (for all attendees)*

Topics to be Discussed -Membership, Education, Advocacy, Website Development

10.30 Shuttle returns to Crowne Plaza Hotel

10:45am - 12:45pm Board of Directors Meeting (Board Members Only)

Further information

American Academy of Thermology

500 Duvall Drive

Greenville, SC 29607

Info@aathermology.org

website: http://aathermology.org/annual-session-program/

September 27th - 29th, 2017
14th AITA 2017 (International Workshop on Advanced Infrared Technology and Applications) in Québec City, Canada

Conference venue: Université Laval

In the 14th AITA edition, special emphasis will be given to the following topics:

Advanced technology and materials
Smart and fiber-optic sensors
Thermo-fluid dynamics

Biomedical applications

Environmental monitoring
Aerospace and industrial applications
Nanophotonics and Nanotechnologies
Astronomy and Earth observation
Non-destructive tests and evaluation
Systems and applications for the cultural heritage
Image processing and data analysis
Near-, mid-, and far infrared systems

AITA 2017 is pleased to announce the following keynote speakers:

Dr. Paolo Bison, CNR - ITC, Italy on "IR thermography applied to assess thermophysical properties of Thermal Barrier Coatings".

Dr. Roman Maev, University of Windsor, Canada on "Cultural Heritage, an IR Perspective".

Dr. Andreas Mandelis, University of Toronto, Canada on "Photothermal Coherence Tomography (PCT): Three-Dimensional Imaging Principles and Non-Invasive Biomedical, Dental and Engineering Materials NDI Applications"

Information: http://aita2017.gel.ulaval.ca/home/

AITA Secretariat
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29th September 2017

Developments in Microvascular Imaging at IPEM inYork, UK

This meeting intends to bring together and promote discussion between clinicians and academics of the microvascular imaging community.

Full details
including the programme and online registration can be found on our website here:
https://www.ipem.ac.uk/ConferencesEvents/ForthcomingConferences/EventDetails.aspx?dateid=402

For any queries, email conferences@ipem.ac.uk
or ring +44 (0)1904 550598.

18th-20th October 2017
VipIMAGE2017,
VI ECCOMAS Thematic Conference on Computational Vision and Medical Image Processing in Porto, Portugal

Thematic Sessions

Application of Image Analysis in Musculoskeletal Radiology
Organizers:
Silvana Dellepiane, Universita' degli Studi di Genova, Italy
Angel Alberich-Bayarri, QUIBIM SL - Quantitative Imaging Biomarkers in Medicine, Spain
Waldir Leite Roque, Universidade Federal da Paraíba, Brazil
Zbislaw Tabor, Cracow University of Technology, Poland

Computer Vision in Robotics
Organizers:
António J. R. Neves, Universidade de Aveiro, Portugal
Luís Teixeira, Universidade do Porto, Portugal

Computational vision and image processing applied to Dental Medicine
Organizers:
André Correia, Catholic University of Portugal, Portugal
J.C. Reis Campos, University of Porto, Portugal
Mário Vaz, University of Porto, Portugal

Infrared Thermal Imaging in Biomedicine
Organizers:
Ricardo Vardasca,
Joaquim Gabriel,
Faculdade de Engenharia, Universidade do Porto
Rua Dr. Roberto Frias S/N, 4200-465 Porto, Portugal
Emails: rvardasca@fe.up.pt, jgabriel@fe.up.p

Imaging and Image processing in Ophthalmology
Organizers:
Radim Kolar, Brno University of Technology, Czech Republic
Koen Vermeer, Rotterdam Ophthalmic Institute, The Netherlands
Jolita Bernataviciene, Vilnius University, Lithuania
Povilas Treigys, Vilnius University, Lithuania

Imaging of Flows in Lab-on-Chip Devices: trends and challenges
Organizers:
Susana Catarino, University of Minho, Portugal
Rui Lima, University of Minho, Portugal
Graça Minas, University of Minho, Portugal
Mónica Oliveira, The University of Strathclyde, UK

Advances in Lung CT Image Processing
Organizers:
Paulo Eduardo Ambrósio, Universidade Estadual de Santa Cruz, Brazil
Marcelo Costa Oliveira, Universidade Federal de Alagoas, Brazil
Susana Marrero Iglesias, Universidade Estadual de Santa Cruz, Brazil

Emotions classification from EEG signals
Organizers:
Paolo Di Giamberardino, Sapienza University of Rome, Italy
Daniela Iacoviello, Sapienza University of Rome, Italy
Giuseppe Placidi, University of L'Aquila, Italy

Imaging and Simulation Techniques for Cardiovascular Diseases
Organizers:
A J Narracott, University of Sheffield, UK
J W Fenner, University of Sheffield, UK

Meta-learning in Deep Learning: New Trends and Directions
Organizers:
André Carlos Carvalho, Universidade de São Paulo, Brazil
João Paulo Papa, Universidade Estadual de São Paulo, Brazil
Carlos Manuel Milheiro de Oliveira Pinto Soares, Universidade do Porto, Portugal
Claudio Rebelo de Sá, Universiteit Leiden, The Netherlands

Image Analysis and Machine Learning for Skin Ulcers
Organizers:
Sylvie Treuillet, Ecole Polytechnique de Université d'Orléans, France
Benjamín Castañeda Aphan, Pontificia Universidad Católica del Perú, Perú
July Andrea Galeano Zea, ITM Laboratory of Advanced Materials and Energy, Colombia

Advanced Techniques for Image-based Numerical Simulation in Biomedical Applications
Organizers:
Domenico Borzacchiello, Ecole Centrale de Nantes, France
Luisa Silva, Ecole Centrale de Nantes, France
David Gonzalez, University of Zaragoza, Spain

Shape Analysis in Medical Imaging: From Math to Clinics
Organizers:
Paolo Piras, Sapienza Università di Roma, Italy
Paolo Emilio Puddu, Sapienza Università di Roma, Italy
Luciano Teresi, University Roma TRE, Italy
Valerio Varano, University Roma TRE, Italy

Bio-inspired Computing in Medical Image and Data Analysis
Organizers:
Amit Joshi, Sabar Institute of Technology for Girls, India
Nilanjan Dey, Techno India College of Technology, India

The proceedings book will be published by Springer under the book series "Lecture Notes in Computational Vision and Biomechanics" and indexed by Elsevier Scopus

A special issue of the Taylor & Francis international journal "Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization", indexed in ISI Thomson Reuters, Elsevier Scopus and dblp, will be published. All authors of works presented in VipIMAGE 2017 will be invited to submit an extended version to the special issue

Further information

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Web.fe.up.pt/~vipimage/nav/conference/sessions.htm

2018

13th - 15th April 2018
XXII Meeting of the Polish Society of Medical Thermography Combined withThe European Association of Thermology, Zakopane, Poland

All are warmly invited to the annual meeting in Zakopane.

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

Abstract form will be published in Thermology International
Abstract should be submitted to a.jung@spencer.com.pl.

Abstract deadline is 15thMarch 2018

Registration fee:

Accommodation (2 nights) / meals, welcome dinner 120 E per person (participant, accompaning person) will be paid in cash/credit card on arrival in hotel reception.

EARLY RESERVATION FOR ACCOMMODATION before March 15th to ensure hotel reservation by email: a.jung@spencer.com.pl

Scientific Committee

Dr Kevin Hovell Ph.D (UK)
Prof.Kurt Ammer MD,Ph.D (AUT)
Prof.Sillero-Quintana Manuel Ph.D (SPA)
Aderito Seixas MSc. (POR)
Prof. Ricardo Vardasca Ph.D (POR)
Prof.Boguslaw Wiecek Ph.D,Eng (Poland)
Prof.Francis Ring Dsc (UK)
Prof.Anna Jung MD,Ph.D (Poland)
Prof.Antoni Nowakowski Ph.D,Eng (Poland)
Dr.Janusz Zuber MD,Ph.D (Poland)
Prof.Armand Cholewka Ph.D, Eng (Poland)

PROGRAMME AT A GLANCE.

13th April, Friday - 7 p.m. Welcome Dinner (HYRNY Hotel)

14th April, Saturday

9.00 - 11.00   Session I
11.00 - 11.20 Coffee break
11.20 -13.00   Session II
13.00 - 14.15   Lunch
14.30 - 16.00 Session III
16.00 - 16.15 Coffee break

16.15 - 18.00 EAT board meeting

24th - 29th June 2018
QIRT 2018 in Berlin ; Germany

14th Quantitative Infrared Thermography Conference

Venue :
Bundesanstalt für Materialforschung und - prüfung (BAM) in Berlin-Adlershof and
Ramada Hotel, Berlin Alexanderplatz

Contact:
German Society for Non-Destructive Testing (DGZfP e.V)
Steffi Dehlau
Email: tagungen@dgzfp.de

QIRT Conferences http://qirt.gel.ilaval.ca
QIRT 2018: www.qirt2018.de

CALL FOR ABSTRACTS

XIV European Association of Thermology Congress

"Thermology in Medicine: Clinical Thermometry and Thermal Imaging"

4th – 7th July 2018

National Physical Laboratory, Teddington, London
United Kingdom

LONDON 2018

XIV E.A.T. Congress, 4-7 July

Co-sponsored by:

IPEM Physiological Measurement SIG (www.ipem.ac.uk)

RPS Imaging Science Group (www.rps.org)

www.eurothermology.org

The EAT and the National Physical Laboratory are delighted to invite you to participate in the XIV EAT Congress in Teddington, London, United Kingdom from 4th to 7th July 2018.

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

Following on from the most recent meetings in Porto (2012) and Madrid (2015), the Congress heads back to northern Europe for 2018 to the National Physical Laboratory (NPL) in the United Kingdom.

The EAT Board looks forward to welcoming you to NPL's world class conference facilities in the summer of 2018.

Dr. Kevin Howell
EAT President
Chair, 2018 EAT Congress Organising Committee

VENUE.

The National Physical Laboratory (NPL) is the United Kingdom's National Measurement Institute and is located in Teddington, south west London, approximately 30 minutes by taxi from Heathrow Airport and a 30 minute train journey from London Waterloo. www.npl.co.uk/location.

LONDON 2018
XIV E.A.T. Congress, 4-7 July NPL

XIV EAT CONGRESS 4th – 7th July 2018, NPL.

ORGANISING COMMITTEE.

Kevin Howell (GBR), Chair
Kurt Ammer (AUT)
Roger Hughes (GBR, NPL)
Anna Jung (POL)
Graham Machin (GBR, NPL)
Francis Ring (GBR)
Adérito Seixas (POR)
Rob Simpson (GBR, NPL)
Manuel Sillero-Quintana (SPA)
Ricardo Vardasca (POR)

INTERNATIONAL SCIENTIFIC COMMITTEE.

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Manuel Sillero-Quintana (SPA)
Adérito Seixas (POR)
Maria Soroko (POL)
Rob Simpson (GBR)
Dieter Taubert (GER)
Rod Thomas (GBR)
Ricardo Vardasca (POR)

KEY DATES.

Abstract submission will open online on 17th August 2017, and authors will be notified of acceptance for oral or poster presentation by 29th January 2018.

17th August 2017. Opening of abstract submission and registration.
29th November 2017. Abstract submission deadline
29th January 2018. Acceptance notification to authors.
26th February 2018. End of Early Registration and deadline for registration of presenting authors.

LONDON 2018
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KEY MEETING THEMES.

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

REGISTRATION FEES

	Early Registration (Until 26 FEB 2018)	Late Registration (After 26 FEB 2018)
EAT/IPEM/RPS MEMBER	£200	£250
Non-Member	£250	£300
Student	£170	£220

Registration includes access to all congress sessions, congress lunch and coffee breaks, and the Congress Gala Dinner. Guided visit to the historic Hampton Court Palace on 7th July for a small additional fee. Register online at the congress registration website from 17th August 2017 at https://www.regonline.co.uk/XIVEATcongress2018

ACCOMMODATION

There are a number of hotels within walking distance of the National Physical Laboratory and Teddington railway station, and even more choice within a 15-minute radius by train, taxi or bus. Further information about local hotels can be found at http://www.npl.co.uk/contact-us/local-hotels. Early booking in 2018 is advisable!

ACCOMPANYING PERSONS

With central London just 30 minutes away by rail, Teddington is an excellent base for accompanying persons to enjoy the capital city of the UK without the need for an organised tour. All accompanying persons are invited to join the Congress Gala Dinner and social programme upon payment of the appropriate fee.

ABSTRACT SUBMISSION

Online abstract submission opens at www.eurothermology.org/congress2018 on 7th August and closes on 29th November 2017. Abstracts should be limited to a maximum of two sides of A4, using the template supplied online. All abstracts will be peer reviewed by the International Scientific Committee, with the decision on acceptance notified by 29th January 2018. The Committee reserves the right to allocate abstracts to oral or poster presentation, but will consider any preference expressed at the time of submission.

PROVISIONAL CONGRESS SCHEDULE

<u>Wednesday 4th July (evening)</u>:

Registration desk opens, followed by opening keynote address –

"Cardiovascular and thermoregulatory responses to heat therapy" – Prof. José González-Alonso, Centre for Human Performance, Exercise and Rehabilitation, Brunel University, UK

Welcome drinks reception

<u>Thursday 5th July</u>:

Keynote address –

"The Kelvin redefinition and its implications" – Prof. Graham Machin, Head of Temperature Standards, National Physical Laboratory, UK

Science sessions – day 1

Evening – EAT 2018 Congress Gala Dinner

<u>Friday 6th July</u>:

Science sessions – day 2

EAT General Assembly

<u>Saturday 7th July</u>:

Guided visit to Hampton Court Palace (morning, additional entrance fee payable)

Close of Congress

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European Association of Thermology

Short Course on Medical Thermography

Wednesday 4th July 2018, National Physical Laboratory, Teddington, UK

Following on from successful courses in Porto and Madrid, the next EAT Short Course on Medical Thermography will take place immediately prior to the EAT 2018 Congress at the National Physical Laboratory. The course aims to deliver a thorough introduction over one full teaching day to basic thermal physiology and the principles of infrared thermography for human body surface temperature measurement. It will be taught by an experienced faculty of EAT clinicians, biomedical researchers and imaging scientists, along with metrology experts from NPL. Aspects of reliable thermogram capture will be demonstrated in a laboratory session, and students will have the opportunity to practice thermal image analysis in a supervised "hands-on" session.

Syllabus

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

Registration

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

Register online from 17th August 2017 at www.eurothermology.org/congress2018/course

Questions? Contact Dr. Kevin Howell at k.howell@ucl.ac.uk

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