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Somatotype and Infrared Imaging

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Organ of the American Academy of Thermology
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# Theme issue: Cryotherapy

**K. Ammer**

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The term cryotherapy covers a wide range of therapeutic applications of cold for heat removal. Various techniques of cryosurgery use the destructive power of low temperatures on cells to destroy skin tumours such as warts (1) or to treat metastatic neoplasms in internal organs (2). The more traditional form of cold treatment applies ice, cold packs or cold air or gas to alleviate pain, reduce swelling after trauma or decrease rheumatic inflammation. Temperature changes on the surface of the human body, internal soft tissues and the intra-articular cavity during heat removal are investigated for 6 decades. Some of theses studies used infrared thermal imaging for the determination of temperature changes (3). However, there are still gaps in our knowledge with respect to the relationship between physiological changes and clinical effectiveness. New cooling devices have been recently developed which may be more effective than traditional methods of cryotherapy (4). The effectiveness of ice treatment in acute soft tissue injury is still under debate (5). Soft tissue thermodynamics before, during, and after cold therapy are not fully understood and require further research (6)

3 papers in this issue of Thermology international report the response to various cooling procedures. A group of Polish medical physicists and physiatrists describe the effect of whole body cryotherapy on the skin temperature of the back in healthy subjects and in back pain sufferers (7). They found more variations in the pattern of temperature distribution immediately after cryotherapy than prior to the cold treatment. They conclude, that cooling with nitrogen gas may increase the diagnostic power of infrared imaging in back pain syndromes. Whole body cryotherapy, originally developed in the eighties in Japan as a treatment option for rheumatoid arthritis (8), has recently gained new interest. A group from Finland described the changes of mean skin temperature and core temperature after a two minutes stay in a cold chamber at –110 °C (9). Skin temperature was determined by insulated thermometers taped to the skin. Very low temperatures were recorded in the forearm and the calf. Another group from Poland have reported preliminary results of whole body cryotherapy showing an alleviating effect on depression (10).

The Medical Imaging Research Group of the University of Glamorgan has investigated the temperature lowering effect of a topical agent containing menthol (11). They observed a slightly longer lasting cooling effect of the gel if it was evenly spread on the skin than after rubbing a fixed quantity into the skin. The volunteers described the subjective effect of the gel as comfortable cooling. The authors have also compared the cooling effect of the gel to topical treatment with ice (12). The full version of this investigation is already submitted and will appear in the next issue of this journal. The abstract (12) clearly stated, that ice treatment results in a rapid decrease of temperature and quick recovery after removal, whilst the temperature fall induced by the cold gel is more gradual but long lasting. Finally, the clinical effect of the treatment with a cold gel in sports-related soft tissue injury was reported from a prospective randomised double-blinded controlled study (13). The cold gel group showed significantly more pain reduction, less disability and more satisfaction with treatment than the placebo group.

In the third paper (14) a different response to a cold challenge applied to the hands was observed in young and elderly people. This study from Norway clearly shows that elderly people have colder hands and feet than young subjects, and need also more time to recover their skin temperature after cold stress. Further investigation is required to show if a similar response can be expected after cryotherapy .

These three papers demonstrate nicely various physiological effects of local and more generalized heat removal. The resulting changes of skin temperature can easily recorded by infrared thermal imaging. This technique has many advantages compared to local contact thermometers and is recommended for future investigations in thermal physiology.

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# Somatotype and infrared thermographic imaging

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**SUMMARY**

**It is possible that skin surface body temperature may be a better representation of the state of health of the body, than the currently used single 'core' temperature measures. As such the composite skin surface body temperature could be of medical benefit in diagnosis and for objectifying the progression of neurovascular abnormalities, such as in complex regional pain syndrome type I (CRPS 1). However, before any determination of medical potential can be made, it is important to determine those factors that can affect the normal thermal image characteristics. To the authors' knowledge, there have been no reported studies on the effect of anthropomorphic variations on average whole body skin surface temperature. We therefore investigated the possibility of such a relationship in a group of asymptomatic male subjects.**

**Forty-one subjects volunteered for and gave written consent to undertake this ethically approved study. The subjects were requested not to have any manual therapy, exercise or even shower before imaging. Upon arrival at the environmentally controlled laboratory, they disrobed and waited twenty minutes to equilibrate, before infrared images were taken. The anthropomorphic data (height, mass and skin-fold thickness) was obtained following imaging.**

**The data shows a significant correlation ($p<0.05$) between percentage body fat and the average whole body skin surface temperature. The relationship between somatotype and average whole body skin surface temperature was borderline significant ($p=0.05$). The trend implies that ectomorph-mesomorphs have the highest average whole body skin surface temperature and that endomorphs appear to have the lowest. Therefore, if the subject increases their body mass, any reduction in "thermal body print" may not be the effect of a clinical dysfunction but more likely is because of the increased body mass. The implications from these results are that it would appear necessary to consider somatotype or at least percentage body fat assessment in the standard imaging protocols. This would become an imperative for any medical analysis of whole body temperature or whole body temperature distribution using infrared thermometry.**

**Key words: infrared thermal imaging, mean skin temperature, somatotype, skin fold thickness, percentage body fat**

**KÖRPERTYP UND INFRAROTTHERMOGRAPHIE**

**Möglicherweise repräsentiert die Hauttemperatur der gesamten Körperoberfläche den aktuellen Gesundheitszustand besser als die derzeit verwendete, einmalig erhobene Kerntemperatur.Eine derartige generelle Hauttemperatur könnte von Vorteilin der medizinischen Diagnose sein und das Fortschreiten neuromuskulärer Veränderungen wie beim complexen regionalen Schmerzsyndrom Typ 1 objektivieren. Jedoch bevor irgendein medizinisches diagnostisches Potential bestimmt wird, müssen die Einflussfaktoren erkannt werden, welche die normale Temperaturverteilung beeinflussen. Die Autoren kennen keine Studien in der Literatur, welche den Einfluss anthropomorpher Varianten auf die mittlere Hauttemperatur untersucht haben. Deshalb haben sie derartige Zusammenhänge in einer Gruppe von gesunden Männern erforscht.**

**Einundvierzig Freiwillige gaben ihr schriftliches Einverstädnis zu dieser von einer Ethikkomission gebilligten Studie. Die Teilnehmer wurden angeleitet vor der Untersuchung weder eine Manual- oder Übungstherapie durchführen zu lassen und auch nicht zu duschen. Sie entkleideten sich nach dem Eintreffen in einem temperaturkontrolliertem Raum und akklimatisierten sich 20 Minuten lang, bevor die Thermograhie durchgeführt wurde. Nach der Thermographie wurden anthropomorphe Befunde (Größe, Gewicht, Hautfaltendicke) erhoben.**

**Als Ergebnis wurde eine signifikante Korrelation ($p<0.05$) zwischen dem Körperfettanteil und der mittleren Hauttemperatur gefunden. Der Zusammenhang zwischen Körpertyp und der mittleren Hauttemperatur war nahezu signifikant ($p=0.05$). Aus diesem Trend gehet hervor, das ectomorph-mesomorphe Personen die höchste mitteler Hauttemperatur und Endomorphe die Geringste zeigen. Daraus folgt , dass bei Vermehrung der Körpermasse, die Verminderung der "thermischen Körper-Markierung" nicht als Ausdruck einer verminderten Körperfunktion, sondern als Effekt der Gewichtszunahme interpretiert werden sollte. Weiters weisen unsere Ergebnisse darauf hin, dass bei thermographischen Standarduntersuchungen der Körpertyp oder zumindest das perzentuelle Körperfett erhoben werden soll. Dies ist eine Forderung für jede medzinischen Analyse der Gesamtkörpertemperatur oder der infrarotthermographisch bestimmten Temperaturverteilung am Körper.**

**Schlüsselwörter: Infrarotthermographie, mittlere Hauttemperatur, Körpertyp, Hautfaltendicke, perzentuelles Körperfett**

Thermology international 2004: 14: 51-56

## Introduction

It is generally agreed that medical thermography has the potential to be widely used as a clinical tool for example in facilitating medical diagnosis and the monitoring of patients. Indeed, it has already been shown to have use in the diagnosis and monitoring of patients with vascular pathologies such as Raynaud's phenomenon, deep vein thrombosis [1,2] and neurovascular pathologies such as complex region pain syndrome type I (CRPS 1)[3,4,5,6], repetitive strain injuries[6] and associated disorders such as hand-arm vibration syndrome and vibration white finger [7, 8, 9].

However, to the authors' knowledge there is a dearth of studies considering the variations in 'normal' physiological temperature and the factors that can affect it.

Body temperature can be assessed using either point source devices (infrared thermometers and thermocouples, such as oral or tympanic ones) or composite of surface measurements made by infrared thermographs.In the past, thermocouples were considered the most reliable, because of their traceability. A fairly good correlation between an infra-red thermometer and a thermocouple has been reported, but this was site specific [10]. However, the concept that a few points on the skin can be representative of the whole is weak, unless there is an even distribution of temperature over the body. In addition to this, there is variation in the reliability of methods used to calculate temperature, with a poor (7%) to good (80%) agreement being found between the different formulae used to calculate the mean skin temperature when compared with that obtained by infrared thermography [11]. Indeed, the local skin temperature for many sites does not appear to coincide with the regional average skin temperature. The better forms of calculation used formulae involving seven or more skin measurement sites, including the hand and foot, at which point there was good agreement between these results and thermogram derived average skin temperature [11].

Whole body skin temperature assessment may be of medical benefit in non-invasively aiding diagnosis or monitoring of those disorders where a decrease or increase in body temperature is an associated clinical feature (e.g., hypo or hyperthyroidism). Furthermore, differences in somatotype might obscure bilateral thermal abnormalities. In this respect, we need to appreciate those non-pathological factors that might affect the infrared image. Physiological factors are likely to be the main sources of variance in the infrared image when measured in a controlled environment. The radiated heat from the body primarily depends upon the degree of tone in the vascular system. This is a complex mix of autonomic nervous system activity, local metabolism and dermatological factors such as sub-dermal fat layer. All of these appear to be acted upon by the factors that relate to a person's percentage body fat and muscle, which equates to their somatotype [11].

Somatotype is a quantitative description of the present shape and composition of the human body [12]. This is based upon body measurements that represent sub-dermal fat distribution and width of bones. It is used by sports scientists to direct young athletes into particular sports based upon their body form and by medical professionals in the determination of a patient's relative risk of cardiovascular disease. Heath and Carter [13] based their somatotype classification upon three ascending numerical scales (1 to 7+) based on endomorphy (relative fatness), mesomorphy (musculoskeletal) and ectomorphy (linearity). During early to late adolescence (11-18 years old) all boys changed their somatotype rating at least once and two thirds changed their component dominance (i.e., from being more of an ecto-morph to being more meso-morph)[14]. Indeed, during the change from adolescence to adulthood (18 to 24 years old), subjects changed their somatotype from ecto- morph- mesomorph to endomesomorph [15]. During adulthood people's somatotpye is related to age and the difference between their calorific intake and expenditure. The factors taken into consideration for determining the different components of somatotype are as follows:

- ectomorph number is height verses mass (cubic relationship);
- mesomorph number relates to humerus and femur breaths, girths of arm and calf in relation to the subjects height and
- endomorphy, the sum of three skinfolds multiplied by a height ratio.

Fat in the younger adult and children tends to be deposited sub-dermally, particularly around the abdomen in males (the android form) and around the hips and thighs of females (the gynoid form). In contrast, fat in the older subject tends to be deposited deeper in the body around the internal organs. Any difference in sub-dermal fat distribution would be expected to alter the conduction of heat from the deeper lying structures, such as muscles. However, results of earlier studies led to the conclusion that differences in somatotype would not affect the thermogram [16]. It was argued that differences in somatotype would not change arteriole blood flow to the dermal capillary network. More recently it has been reported that obesity is related to altered activity in the hypothalamic-pituitary axis and contributes to an increase in the post-ganglionic sympathetic nerve activity. This increase in sympathetic activity can affect the vascular tone and thus the blood flow to the skin [17]. As the emphasis in previous studies has been on bilateral thermal differences and not on the actual temperature of the region, this may have reduced the importance of recognising general changes in thermographic emissions when interpreting the images.

We have chosen to study the effects of anthropomorphic factors such as somatotype, on the thermographic image produced following a standardised protocol. Here we report the results of our study into somatotype and its relationship with whole body skin temperature.

## Method

Ethical approval was obtained from the University's ethics committee. Signed informed consent was obtained from the subjects prior to inclusion. The study recruited asymptomatic males with no known cardiovascular or dermatolo gical problems. Subjects had the protocol fully explained to them before they signed the consent form. They were then given an information sheet. This sheet explained both the procedure and that thermography is a non-invasive passive modality. Subjects were expected to not: shower, bathe, sauna, or whirlpool within four hours of their appointment or have undertaken any exercise sessions within at least eight hours of the appointment; if they performed regular exercise then they were requested to inform the thermographer. They were also asked to minimise their en route energy expenditure. In addition they were requested to not consume alcoholic beverages or a large meal within four hours of the appointment and not have a heavy alcoholic drinking session the day before. They were also requested not to have physiotherapy, (electrotherapy, ultra-

sound, heat treatment, cryotherapy, massage, acupuncture, hydrotherapy) or shave within eight hours of the appointment. Subjects were to be fully hydrated and to wear lose fitting clothes, no jewellery and or cosmetics to the appointment. Long hair was tied up on top of the head, if possible.

Upon arrival at the laboratory the protocol was again fully explained to the subject along with the postures they were to adopt during imaging. Subjects were given an opportunity to withdraw at that point, if they wished, and were informed that they could withdraw at any time and their images would then be removed from the database. Those that accepted the protocol went into the cubicle and undressed fully. They waited for twenty minutes while their bodies equilibrated within the climate controlled laboratory (22.0°± 1.5°C), during which time they completed the medical and the EQ-5D questionnaires (www.euroqol.org). Subjects were requested not to sit down, lean against any surface, cross their legs or fold their arms during acclimatisation, instead they were asked to keep their legs apart and their arms away from their torso.

During the equilibration time the infrared camera (FLIR ThermaCAM SC500 24 lens) was standardised against a traceable standard black body source (LAND, Sheffield, UK). The camera was set with the temperature range 25° to 35°C, span 10°C, level 30°C,emissivity 0.97 and the distance 1.6m. For the whole body images the camera was equipped with the 45° wide-angle lens and the distances between camera and subject varied from 2.0 to 2.8m depending upon the height of the subject.

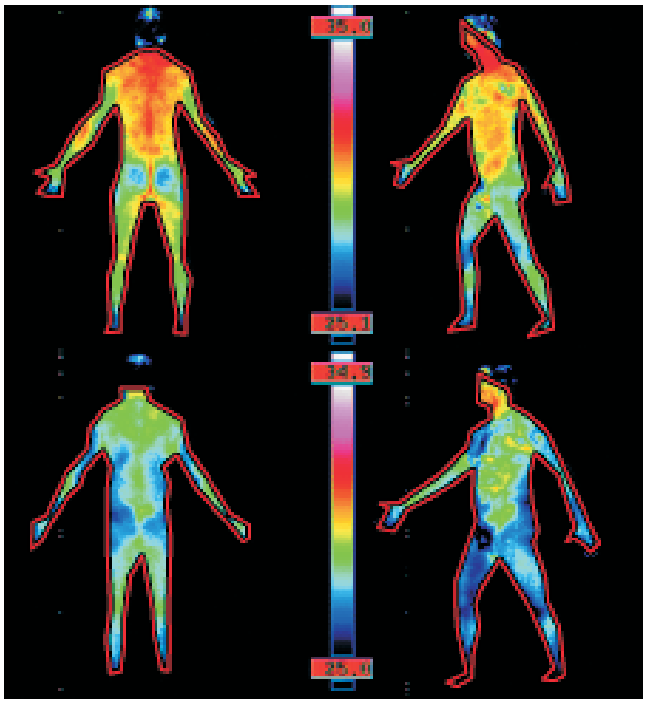



Figure 1
The posture of the subjects with area for analysis marked out in red. The top subject has 15.9% ±3% body fat and the lower subject has 25.8% ±3% body fat
A) The dorsal view, (the ventral view was 180° rotation)
The sinistral view, (the dextral view was 180° rotation) the furthest limb was always in front of the subject and the nearest limb to the camera also behind the subject. The upper limbs were always 'hanging' downwards so as to minimise blood pressure changes in the limb.

After twenty minutes the subject was asked to stand on the dais in front of the camera, at which point four standard thermal images were recorded (whole body: Anterior, Posterior, Dextral and Sinistral lateral views: Figure 1).

Average temperature of the body (whole body skin temperature) was obtained from the stored images using CTHERM [18,19], by averaging the mean temperatures for each of the 4 images.

The subjects were weighed in their shorts and their body mass recorded to the nearest tenth of a kilogram[20]. For height assessment, the subjects stood erect, barefoot with heels together and arms hanging naturally by their sides. They were then told to look straight ahead and take a deep breath. Their height was measured from the balance platform to their vertex, at the end of a maximal inspiration using a stadiometer (SECA beam balance and stadiometer, Cranlea & Company). The vertex is the highest point on the skull when the head is held in the Frankfort plane: the orbitale to the tragon is horizontal and at right angles to the long axis of the body [20]. Subjects were classified according to their Body Mass Index (BMI: see Table 1), which was calculated by dividing the mass in kilograms of the subject by the square of their height in metres.

The subject's percentage body fat was calculated from the sum of four skinfolds (Harpenden Skinfold Calliper, Cranlea & Company)[20,21,22,23,24]. The skin-fold sites were Biceps, Triceps, subscapular and Supraspinale. The Triceps skinfold site is a vertical fold on the posterior midline of the upper arm, halfway between the acromion and olecranon processes when the arm is freely hanging beside the torso. The Bicep skinfold site is also a vertical fold, but on the anterior side, over the belly of the Biceps, 10mm above the mark used for the Triceps site. The subscapular skinfold is a diagonal fold (at 45°) 10 to 20mm below the inferior angle of the scapular. The suprailiac skinfold is a diagonal fold in line with the natural angle of the iliac crest on a line drawn from the anterior superior iliac spine and the axillary fossa [20,21]. Each site was measured by drawing-up a layer of skin (pulling the skin together and slightly away from the body), with the thumb and forefinger of the left hand. The callipers were placed perpendicular to the fold, approximately 10mm distally from the examiner's left hand. The pressure on the callipers was released and readings were obtained once from each site before being repeated. At least two readings were obtained from each site, but if these were different by more than 1mm, extra mea-

Table 1:
The relationship between body mass index (BMI) and obesity classification [21]

| | BMI, (kg.m) |
|---|---|
| **Underweight** | < 18.5 |
| **Normal** | 18.5 - 24.9 |
| **Overweight** | 25.0 - 29.9 |
| **Obesity, class I** | 30.0 - 34.9 |
| **II** | 35.0 - 39.9 |
| **III** | ≥ 40.0 |

Table 2:
The correlation between percentage body fat and whole body skin temperature for all subjects.
* and bold text indicates a statistical significant correlation between these two variables (p value of <0.05)

| Age range (years old) | EuroQol | Number of subjects | Whole body skin temperature Mean±SD (C) | % body fat Mean±SD | Body Mass Index Mean±SD(kg.m) | Pearson's rho | p -level |
|---|---|---|---|---|---|---|---|
| 8 – 45 | 0 - 2 | 30 | 29.27 ± 0.99 | 16.04 ± 5.95 | 23.31 ± 5.15 | -0.396 | **<0.030*** |
| 8 – 45 | 0 | 25 | 29.25 ± 1.02 | 15.83 ± 6.40 | 23.15 ± 5.61 | -0.405 | **<0.044*** |
| 21 – 45 | 0 | 20 | 29.27 ± 1.06 | 16.01±6.75 | 24.69 ± 5.17 | -0.399 | <0.082 |

surements were taken of that region [21]. Girths of the Biceps and calves (Triceps surae) were measured at the widest point. Breadths of the humerus and femur were measured at the epicondyles using a Harpenden Condyle Calliper, (Cranlea & Company)[20]. These measurements were then used to calculate the subjects somatotype using the Heath Carter chart [12]. The chart works in a similar way to that of a nomogram for each of the ecto-, meso- and endo- components. This is then plotted on a chart to determine the overall somatotype. All measurements were taken on the right side of the body, with the subject standing in a relaxed posture.

The data was analysed using STATISTICA 4.1 for Apple Computers, (StatSoft Inc).

## Results

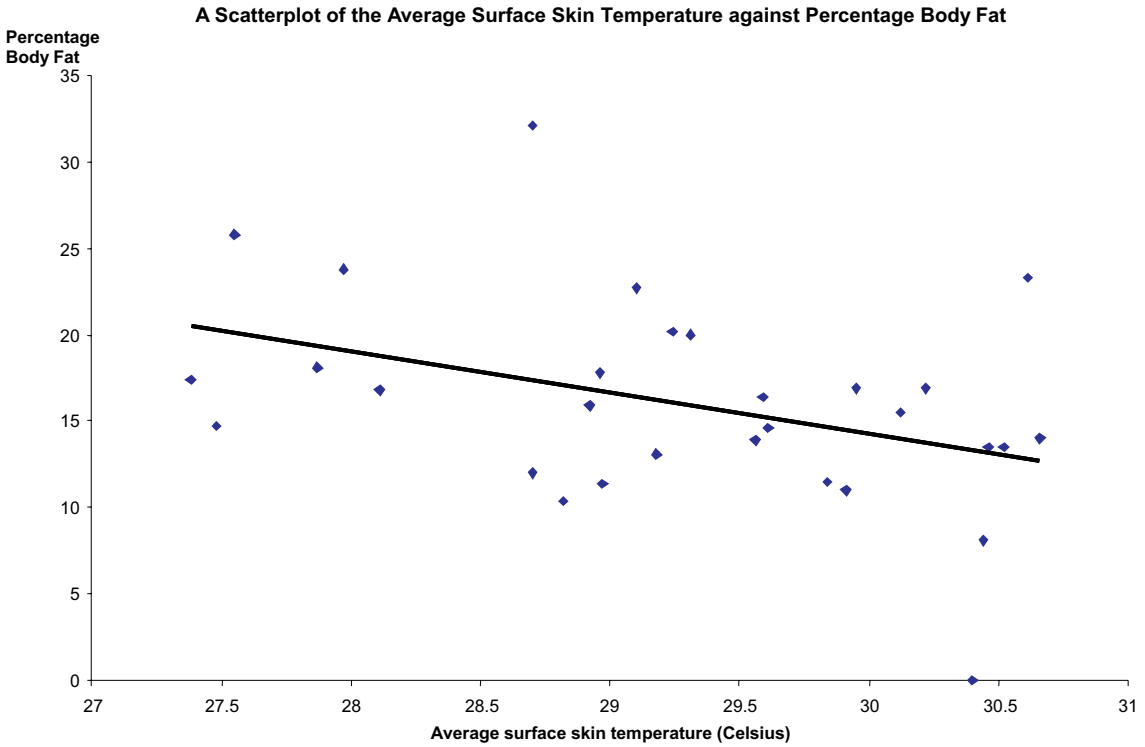
Forty-one male volunteers took part, of these a complete set of data was only available for 30 subjects (age range 8 to 56 years old). The data was determined to be normally distributed, so parametric statistics were used. A negative correlation was found between percentage body fat and whole body skin temperature for the total data set (see Figure 2 and Table 2).

With respect to the group of 'normal' body mass subjects alone (18.5= normal BMI<25.0 kg.m), they were not found to be normally distributed and therefore non-parametric statistics were used (Spearmans rho). There was no significant relationship between BMI and whole body temperature found within this group (see Table 3).

Using the Heath Carter [12] formula, their somatotypes were calculated and the subjects categorised in one of the following 4 groups: central, ectomorph, mesomorph and endo- morph. Although relatively few subjects were available, further separation was attempted into the 13 group Heath Carter categories (please see Figure 3: ANOVA p=0.053, although there were no significant differences between the classes,).

The subjects in the central group were more mesomorph or endomorph than ectomorph and this could be partly responsible for the lower average skin surface temperature within the class.

Figure 2
A line of best fit is drawn, indicating the possible relationship between these two factors.



As some of the classes of somatotype had only a few subjects. The classes were grouped together under the major divisions: central, ectomorph, mesomorph and endomorph, (ANOVA p=0.085, there were no significant differences between the classes)

## Discussion

Previously, we have reported that there appears to be a relationship between somatotype, body surface temperature and the paraspinal temperature patterns [25]. This finding has led to the suggestion that there might be a general relationship between a physical component of somatotype and whole body temperature as assessed by infra-red thermometry (IRT). The data reported here supports the presence of a relationship and specifically links the body fat estimate (as calculated here) with whole body standard temperature. Specifically, the data confirms the supposition that increasing body fat is related to a decrease in whole body skin tem-

**Table 3**
The correlation between percentage body fat and whole body skin temperature for subjects that have a 'normal' BMI (18 .5= normal BMI<25.0 kg.m$^{-2}$).
* and bold text indicates a statistical significant correlation between these 2 variables (p value of <0.05)

| Age range (years old) | EuroQol | Number of subjects | Whole body skin temperature Mean±SD (C) | % body fat Mean±SD | Body Mass Index Mean±SD(kg.m) | Pearson's rho | p -level |
|---|---|---|---|---|---|---|---|
| 19 – 45 | 0 - 2 | 17 | 29.53 ± 0.89 | 13.84 ± 4.50 | 23.00 ± 1.16 | -0.316 | 0.216 |
| 21 – 45 | 0 | 13 | 29.56 ± 0.88 | 13.06 ± 4.73 | 22.85 ± 1.29 | -0.275 | 0.363 |

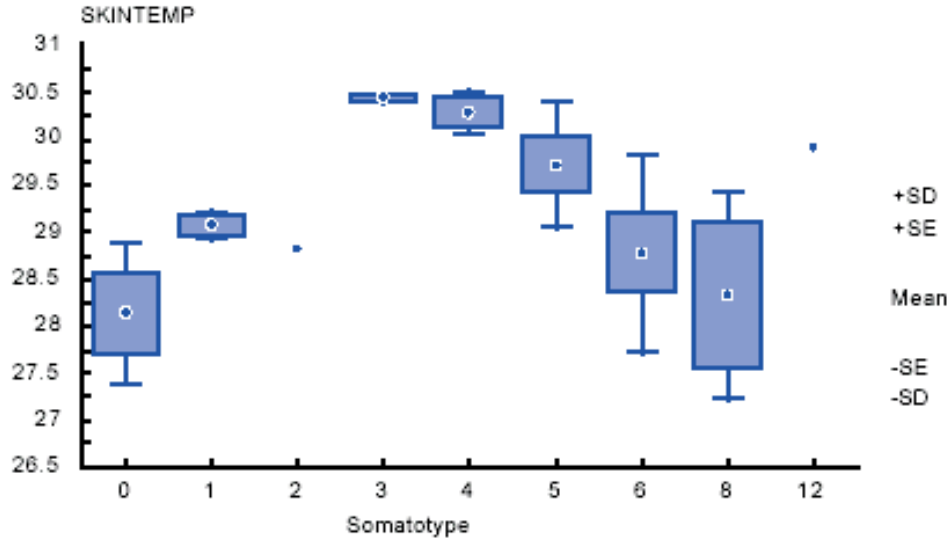



Figure 3
The mean is central to the box whose upper and lower boarders represent to the standard error. The standard deviation is represented by error bars as usual.
**Key to the group numbers on the abscissa:**
**Central** = 0;
**Ectomorph**: ectomorphs = 1; mesoectomorphs = 2; endoectomorphs = 12
**Mesomorph**: mesomorph/ectomorphs = 3; ectomesomorph = 4; mesomorphs = 5; endomesomorphs = 6
**Endomorph** : endomorphs/mesomorphs = 7; mesoendomorphs = 8; endomorphs = 9; ectoendomorphs = 10, ectomorph/endomorph = 11.

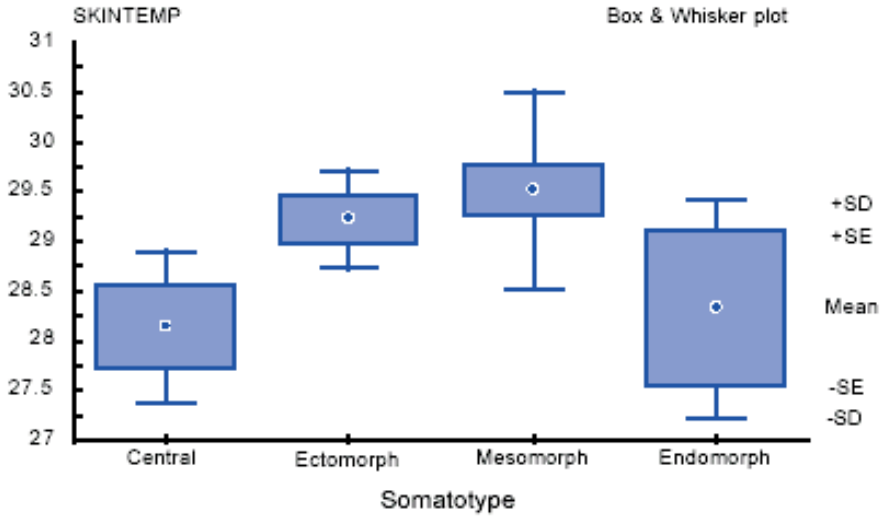



Figure 4:
A Box and Whisper plot of the four main somatotypes and their average skin surface temperature.

perature, thus extending our original findings concerning the relationship between somatotype and whole body skin temperature[25]. Mesomorphs tended to have the highest skin surface temperature due to their muscular frame generating heat and their smaller body surface area to volume ratio with respect to the ectomorphs. The ectomorphs probably have the highest metabolic activity [17], but as their surface area is relatively large in relation to their body volume they lose heat quicker than the mesomorphs and therefore less blood is past into the skin's capillary network. Correspondingly, the endomorphs tended to have the lowest whole body surface temperature[17], the lowest metabolic activity, the greatest insulatory skin property.

The increase in general obesity in the population makes it important to incorporate some form of percentage fat assessment into the standard imaging protocols. This is necessary to both compensate for any associated changes in whole body skin temperature, and to ensure that regional thermographic changes due to disease are standard across the spectrum of somatotypes.

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# Temperature Effects of Whole Body Cryotherapy Determined By Thermography

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**Summary**

**The skin temperature response to whole body cryotherapy for a group of volunteers (6 female and 24 male) age 41.2 ± 13.3 has been studied by quantitative infrared thermography. The group consisted of 22 patients suffered from low back pain (5 female and 17 male in age 47.1 ± 10.1) and 8 health young people (1 female and 7 male in age 25 ±4.1). Lower lumbar regions (selected areas and temperature profiles) were taken into consideration. A marked decrease of skin temperature after whole body cryotherapy was observed. These studies showed that cold impact doubles the range of temperature inside the region of interest. For this reason the slight changes of skin temperature before cryotherapy became more visible after whole body cryotherapy. The statistical analysis of temperature parameters (mean, maximum and minimum temperature) derived from thermal imaging after cryotherapy confirmed the significant differences between healthy men and patients with low back pain.**

**Thermal evaluation showed that whole body cryotherapy induced significant changes of local blood flow dependent on tissue, degenerative processes and inflammatory states. An enhancement of the skin temperature profile could therefore increase the diagnostic sensitivity of infrared imaging in patients suffering from back pain.**

**Key Words: whole body cryotherapy, infrared imaging**

**THERMOGRAPHISCH ERFASSTE TEMPERATURÄNDERUNGEN NACH GANZKÖRPERKRYOTHERAPIE**

**Die Veränderung der Hauttemperatur nach Anwendung der Ganzkörperkryotherapie wurde in einer Gruppe von Freiwilligen (6 Frauen und 24 Männer) im Alter von 41.2 ± 13.3 Jahren mittels Infrarotthermographie untersucht. TheGruppe setzte sich aus 22 Patienten mit Rückenschmerzen (5 Frauen und 17 Mäner im Alter von 47.1 ± 10.1 Jahren) und 8 gesunden jungen Erwachsenen (1 Fraue und 7 Männere im Alter von 25 ±4.1 Jahren) zusammen. Messareale im Lumbalbereich (flächen und Temperaturprofile) wurden untersucht. Eine deutliche Verminderung der Hauttemperatur wurde nach der der Ganzkörperkryotherapie beobachtet. Die Untersuchungen zeigten das die Kälteexposition den Temperaturbereich innerhalb der ausgewählten Messareasle verdoppelt. Das hat zur Folge, dass vor der Kryotherapie nur gering ausgeprägte Unterschiede der Hauttemperaturverteilung nach der Behandlung deutlich ausgeprägte sichtbar werden. Die statistische Analyse der Messparameter (mittlere, maximale und minimale Temperatur) bestätigte signifikante Unterschiede in den gewonnenen Temperaturwerte zwischen Gesunden und Rückenschmerzpatienten.**

**Die thermische Beurteilung nach Ganzkörperkryotherapie fand in Abhängigkeit von degenerativen und entzündlichen Veränderunge der Gewebe relevante Veränderungen der lokalen Durchblutung nach der Behandlung. Die beobachtete Erhöhung des Temperatur-Kontrastes der Haut könnte die diagnostische Sensitivität der Infrarotthermographie bei Rückenschmerzpatienten verbessern.**

**Schlüsselwörter: Ganzkörperkryotherapie,Infrarot-Thermographie**

## Introduction

The use of cold treatment has been recognised for centuries, but the development of new forms of cryotherapy dates back to the end of the 19th century when physicists developed techniques for condensing gases. In the beginning, cold therapy was used only for localised treatments. Cryotherapy usually assists the typical treatment in various medical specialities (1-6). New applications of cryotherapy such as endoscopic cryotherapy for the use in gastroenterology, or radiofrequency resection of bronchial tumours in combination with cryotherapy have been reported (5). In local cryotherapy, low temperature affects the treated part of the body either from the outer or the inner surface in the examples citied above. Over the last few decades whole body cryotherapy has developed rapidly. In whole body cryotherapy a patient is subjected to low temperature in a special room called the low temperature chamber. The technique requires an application of a temperature lower than -100°C on the body surface for a period of 2-3 minutes in order to cause physiological reactions and to observe the adapting reactions of the organism. Relatively few investigations have been made on whole body cryotherapy (7-9). It has been reported that whole body cryotherapy was used for rheumatism and low back pain treatment (8,9). Low back pain is common; the main cause for low back beeing a strain of the muscles, or other soft structures connected to the spine. Sometimes it is the intervertebral discs, which are strained, and which bulge out and presses on the adjacent nerves (10). The purpose of this study is to detect and analyse infrared heat radiation in the lower lumbar region after whole body cryotherapy.

## Materials and methods

The studies were performed on a group of 30 volunteers (6 female and 24 male) aged 41.2 ± 13.3. The experimental

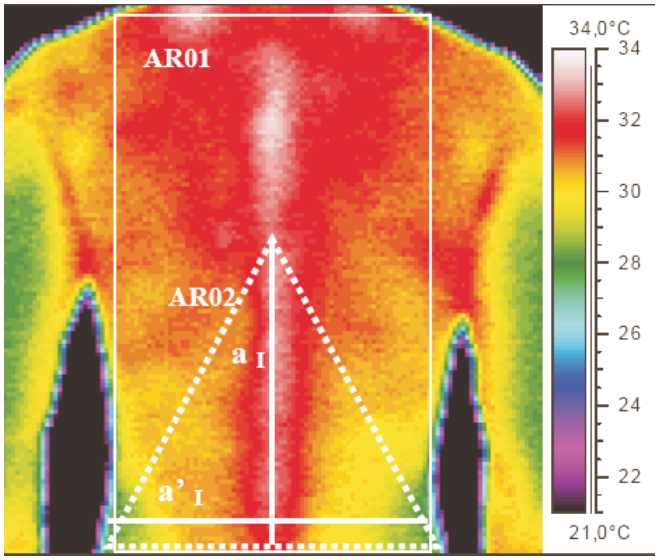



Figure 1a
Thermogram of the back of a healthy man performed prior to whole body cryotherapy

| Area | Mean temp | Max. temp | Min.temp |
|---|---|---|---|
| AR01 | 31.3°C | 33.7°C | 27.6°C |
| AR02 | 31.0°C | 33.0°C | 28.1°C |

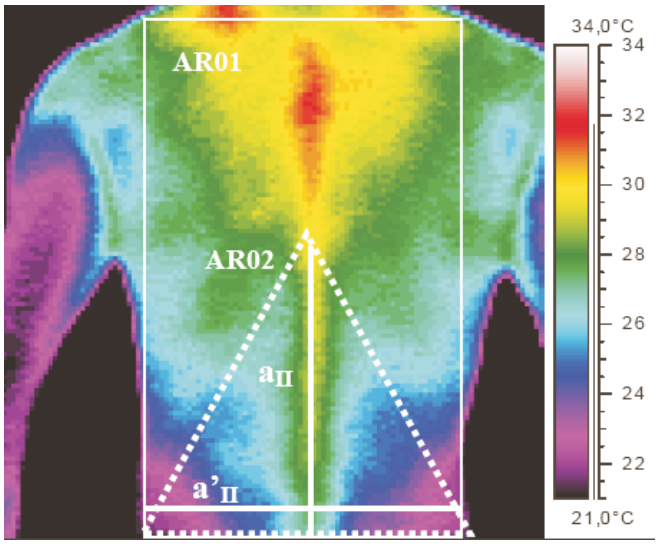



Figure 1b
Thermogram of the back of a healthy man performed after whole body cryotherapy

| Area | Mean temp | Max. temp | Min.temp |
|---|---|---|---|
| AR01 | 27.3°C | 31.7°C | 18.9°C |
| AR02 | 25.9°C | 30.1°C | 21.0°C |

group consisted of 22 patients and 8 health young people (1 female and 7 male in age 25 ± 4.1), mostly students of the School of Physical Education. The patients suffered from the *sciatica* (2 female and 4 male in age 47,3 ± 10.2), *spondyloarthrosis* (1 female and 5 male in age 46,0 ± 12.8) and other types of back pain (2 female and 8 male in age 47,5 ± 9.3). Prior to participation in the experiment a physician examined all the subjects. The data from all subjects is shown in Table 1. All participants gave their informed consent on the experimental procedure. They were requested not to smoke, drink alcohol or hot drinks for 4 hours prior to thermal imaging.

The investigations were carried out at the Silesian Centre of Rehabilitation and Physical Medicine, where a two-level cryogenic chamber KN-01 (Hansped) was installed in 2000. The chamber consisted of two rooms: a preparation chamber and the main chamber. To achieve very low temperatures in the cryogenic chamber, liquid nitrogen was used. The whole cooling process was automatically controlled. After cooling the subjects in the preparation chamber, the therapy was applied in the main chamber. The temperature in the preparation and the main chamber was -60 and -120°C, respectively. Whole body cryotherapy requires special preparation of the subjects. Men were asked to wear shorts, and women were dressed in swimsuits. Everybody had to wear a mask, woollen socks and clogs to protect the face and feet against the cold. They were asked to report any discomfort or pain during their stay in the cold chamber.

Infrared temperature measurements were performed in patients before and after whole body cryotherapy with a Thermovision Camera AGEMA Type 470 with black body calibration. The emissivity was set in the range of 0.97 to 0.98. Thermal images were recorded in a special measurement room outside the chamber fulfilling established standards (11, 12). In order to record the dynamic response of skin temperature to cold impact, thermal imaging of the patients was performed immediately after cryo- therapy.

Statistical analysis of the results was performed with Statistica 5.1 using Students' t-test for the independent variables. Differences with a $p<0,05$ were regarded as significant.

Ethical approval was obtained from the Ethical Committee of the Silesian Medical University (No.NN- 013-144 /I/02). Studies were performed during the normal programme of rehabilitation in the Centre.

## Results

Figures 1 and 2 demonstrate thermograms of the back performed before (a) and after whole body cryotherapy (b) in a healthy male and a male suffering from low back pain. There are some areas (*trapezius muscle* and *spinal vertebrae*) with higher temperatures than other back areas. As expected, an essential drop of skin temperature was observed after cryotherapy. In ROI AR02, the mean decrease of temperature $\Delta T_{mean}$ was 5.1 °C for healthy men, and 9,5°C in subjects suffering from low back pain. Moreover, it can be seen (Figure 1) that the cold impact doubles the range of temperature inside the region of interest e.g. for ROI AR 01 difference between maximum and minimum temperature ($T_{max} - T_{min}$) is 5.1°C before, but 12.8°C after cryotherapy.

The figures 1-3 clearly show, that the body skin surface temperature varies depending on the body area and the health condition of the subject. Figure 4 shows the plots of the temperature along vertical line characterizing spinal vertebrae in the range Th8/Th9 to L5/S1 in a healthy male (a), a male with sciatica (b) and a male suffering from spondyloarthrosis (c) before (I) and after (II) cryotherapy. Slight changes of skin temperature were observed along the spine in the healthy subject before (aI) as well as after

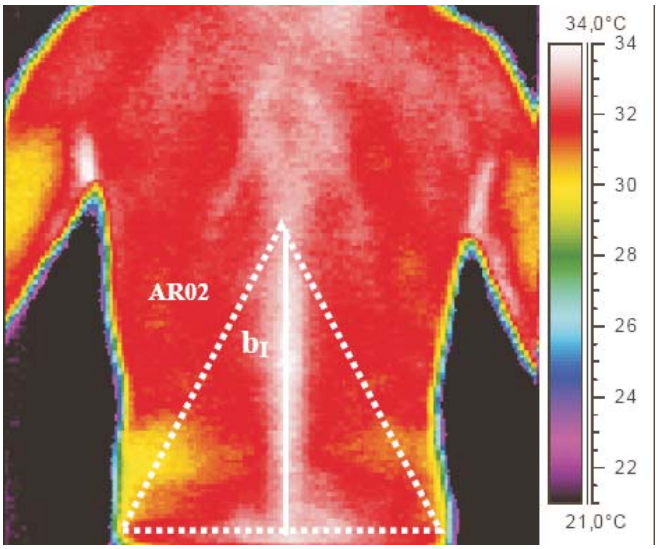



Figure2 a
Thermogram of the back of a male suffering from low pack pain, performed prior to whole body cryotherapy

| Area | Mean temp | Max. temp | min.temp |
|---|---|---|---|
| AR02 | 32.2°C | 34.1°C | 29.9°C |

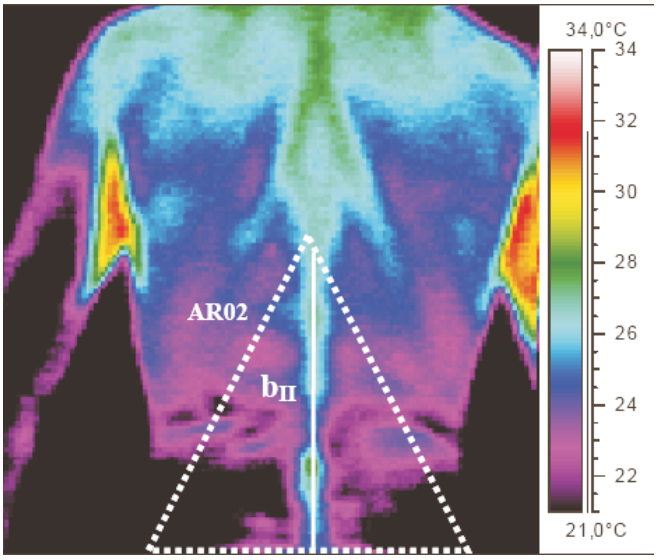
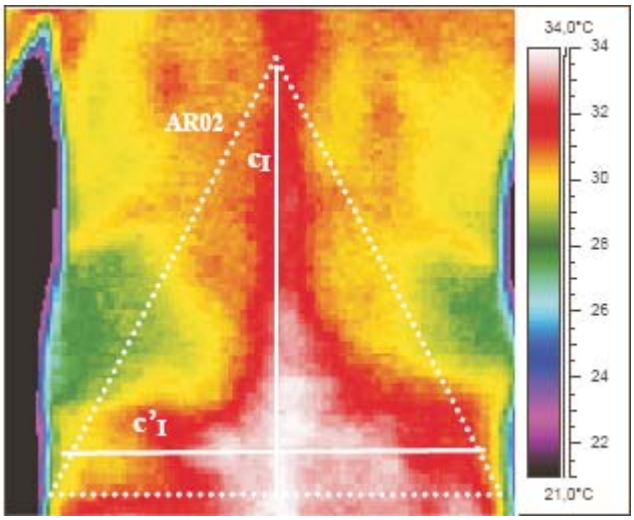
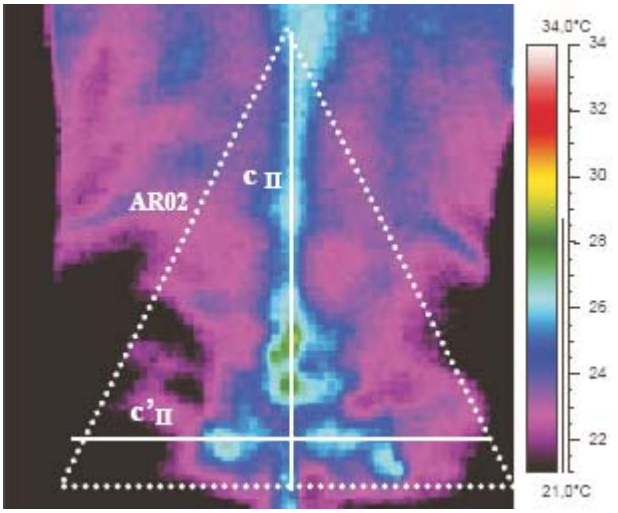
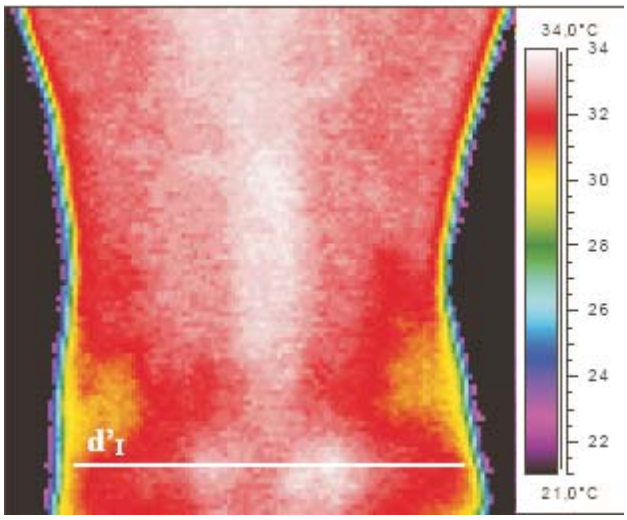



Figure 2b
Thermogram of the back of a male suffering from low back pain, performed after whole body cryotherapy

| Area | Mean temp | Max. temp | min.temp |
|---|---|---|---|
| AR02 | 22.7°C | 28.3°C | 16.1°C |



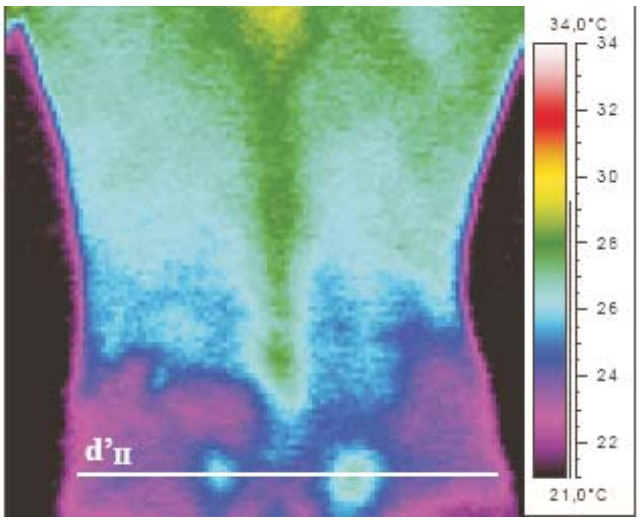




Figure 3
Thermograms of the back of males sufferingd from *spondyloarthrosis* and *low back pain* performed before (left:a,c) and after (right: b,d) whole body cryotherapy, respectively

(aII) whole body cryotherapy. In patients, the temperature registered after cryotherapy indicate a marked variation in the lumbar region, which could be related to the underlying disease. Curve bII shows a decrease of temperature on the line of L1-L2 and increase of skin temperature on the level of L2-L3 which might be related to a degenerative process or an inflammatory state. These temperature patterns were not visible in the thermograms performed before cryo-

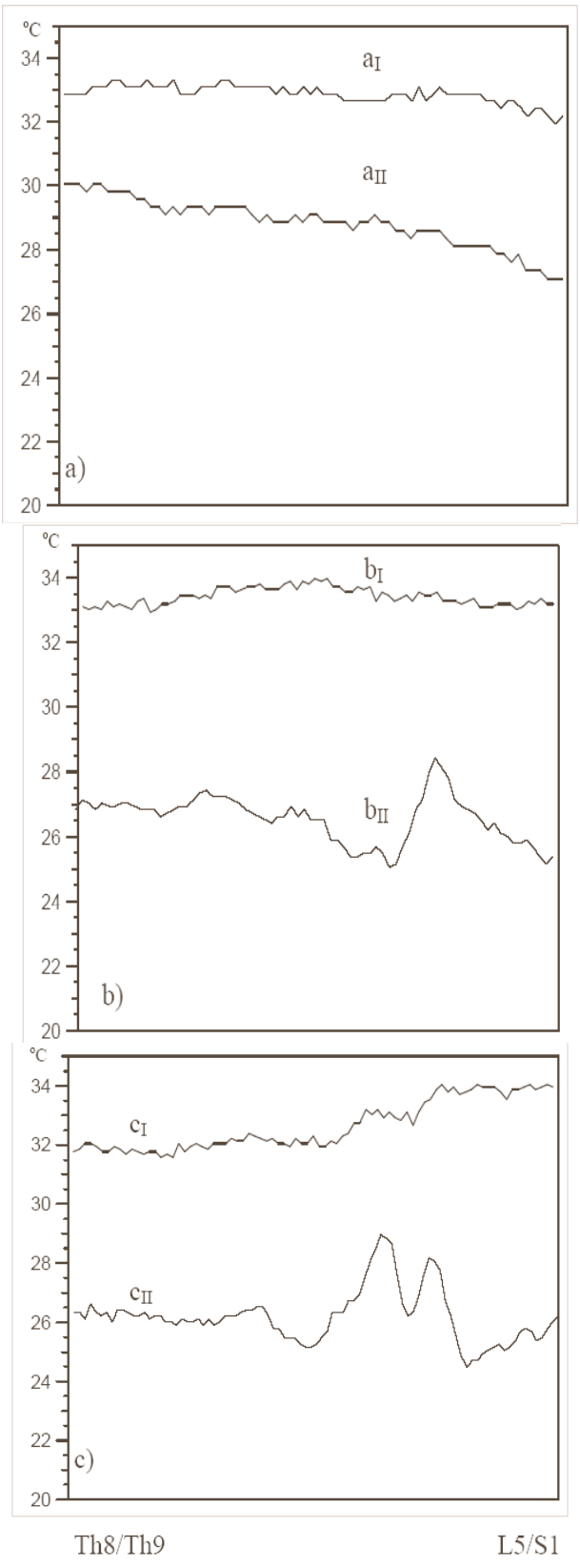



Figure 4
The plots of temperature along the line of *spinal vertebrae* at Th8/Th9 to L5/S1 performed before (I) and after (II) cryotherapy in healthy male (a) and a male suffering from low back pain (b and c).

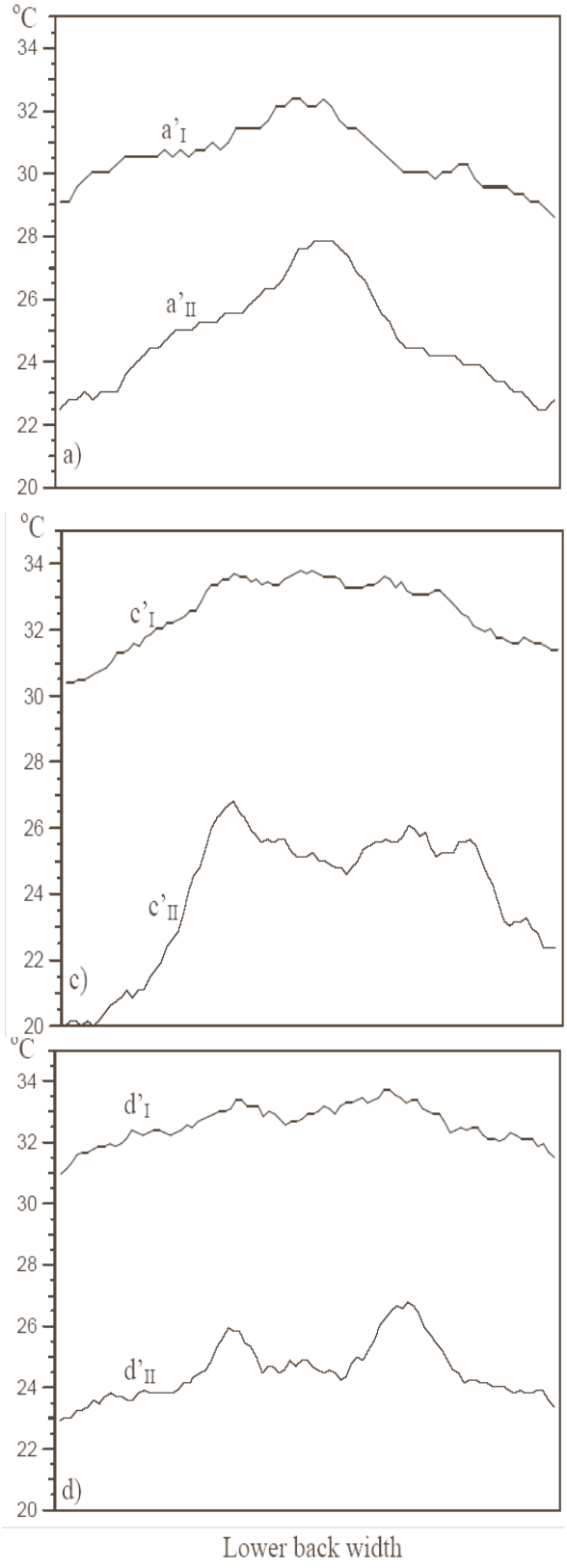



Figure 5
The plots of temperature along horizontal line perpendicular to the *spinal vertebrae* at the level of L5-S1 for healthy men (a), men suffering from *spondyloarthrosis* (c) and from *sciatica* (d) obtained before (I) and after (II) whole body cryotherapy

therapy (bI). Similar changes of skin temperature induced by cryotherapy were also observed in other cases. For example, curve cII shows the skin temperature changes along the spine of a male suffering from spondyloarthrosis.

Some temperature measurements were performed in the lower lumbar region (Figure 3 a-d). Variations in skin temperature over the tissues adjacent to the spine were observed. Figure 5 shows temperature plots along a horizontal line perpendicular to the spinous processes of level of L5 in a healthy subject (a') and two patients (c' and d'), all recorded before (I) and after (II) whole body cryotherapy. Plots obtained after cryotherapy (II) appeared with a high variation of temperatures.

Statistical analysis was performed: the temperature parameters (mean, maximum and minimum temperature before and after cryotherapy) with standard deviation (SD) for the chosen lines in the vertebrae Th8/Th9 – L5/S1 are listed in Table 1. Differences in the temperature parameters presented in Figure 6 for patients and healthy people before whole body cryotherapy are not statistically significant. However, after cryotherapy the differences (see also Figure

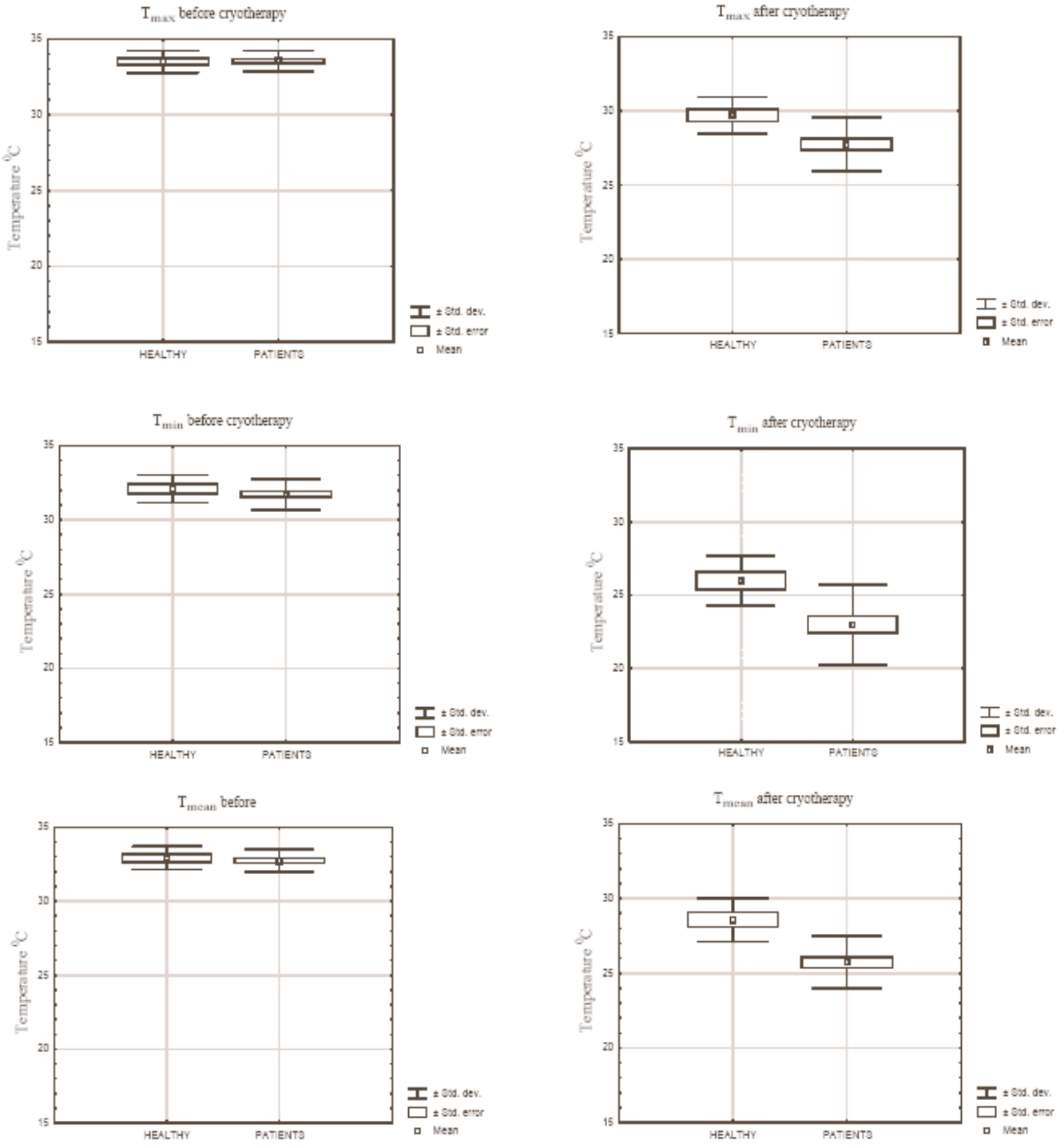



Figure 6
Differences between $T_{min}$, $T_{max}$ and $T_{mean}$ patients and healthy people before and after whole body cryotherapy.

6) became statistically significant (p=0.0078; 0.0079; 0.0003 for Tmin, Tmax and Tmean respectively).

## Discussion

It is known that skin temperature effects can be evaluated by infrared imaging (11, 12, 14, 15). The heat exchange between the organism and the external environment function through the skin and thus skin temperature reflects the dynamic balance of heat loss to the environment and heat deposited by muscular and metabolically active tissue. In particular, skin temperature changes are associated with local blood flow in the most superficial skin layers.

Our results confirm that infrared measurements are helpful in monitoring the skin temperature changes resulting from whole body cryotherapy. Thermal imaging showed the effect of whole body as a decrease of skin temperature. Moreover, it follows from our studies that cold impact dou-

**Table 1**
Information about studied objects (age, gender and $T_{min}$, $T_{max}$, $T_{mean}$ and SD) for vertical line characterizing spinal vertebrae in the range Th8/Th9 to L5/S1 before and after cryotherapy.

| | Gender | Age (years) | $T_{mean}$ before cryotherapy [°C] | $T_{mean}$ after cryotherapy [°C] | $T_{max}$ before cryotherapy [°C] | $T_{max}$ after cryotherapy [°C] | $T_{min}$ before cryotherapy [°C] | $T_{min}$ after cryotherapy [°C] |
|---|---|---|---|---|---|---|---|---|
| **I. Healthy** | | | | | | | | |
| MK | male | 23 | 33.9 | 29.7 | 34.3 | 31 | 33 | 26.6 |
| MK1 | male | 23 | 33.9 | 30.5 | 34.5 | 31.2 | 33.1 | 29.1 |
| BK | male | 23 | 32.3 | 27.5 | 32.6 | 28.4 | 31.5 | 25.3 |
| FF | male | 23 | 33.5 | 30.4 | 33.9 | 31.2 | 32.8 | 27.4 |
| ŁW | male | 23 | 32.4 | 28.3 | 33 | 29.3 | 31.7 | 24.5 |
| MA | female | 22 | 32.8 | 26.8 | 33.7 | 28.9 | 32.1 | 23.9 |
| DN | male | 33 | 32.8 | 27.3 | 33.3 | 28.4 | 32.1 | 25.8 |
| JDz | male | 30 | 31.7 | 28 | 32.6 | 29.3 | 30.3 | 25 |
| Mean | | | 32.91 | 28.56 | 33.49 | 29.71 | 32.08 | 25.95 |
| SD | | | 0.8 | 1.45 | 0.73 | 1.23 | 0.93 | 1.69 |
| **II. Patients with low back pain** | | | | | | | | |
| **II.a. Spondyloarthrosis** | | | | | | | | |
| WB | female | 62 | 32.8 | 22.3 | 33.4 | 25.2 | 31.8 | 19.3 |
| KJ | male | 54 | 30.6 | 24.8 | 31.5 | 27.3 | 30 | 20.7 |
| MF | male | 30 | 32.9 | 24.9 | 33.4 | 26.4 | 31.3 | 22.7 |
| JS | male | 45 | 32.8 | 26.1 | 34.1 | 28.8 | 31.6 | 24.4 |
| KS | male | 32 | 33 | 25 | 33.7 | 26.8 | 32.4 | 23 |
| PJ | male | 53 | 32.7 | 23.8 | 33.6 | 25.3 | 31.6 | 22.1 |
| Mean | | | 32.47 | 24.48 | 33.28 | 26.63 | 31.45 | 22.03 |
| SD | | | 0.92 | 1.3 | 0.91 | 1.35 | 0.8 | 1.8 |
| **II. b. Sciatica/Ischias** | | | | | | | | |
| BP | male | 52 | 33.5 | 25.7 | 34 | 28.2 | 33 | 22 |
| PD | male | 30 | 33.1 | 26.6 | 33.7 | 28.3 | 32.6 | 23.7 |
| MM | female | 60 | 33.7 | 25.4 | 34.1 | 27.6 | 33.3 | 22.9 |
| MC | male | 44 | 32.7 | 29.3 | 33.5 | 30.8 | 31.9 | 27.4 |
| TM | female | 52 | 32.7 | 28.3 | 34.3 | 31.9 | 30.5 | 23.9 |
| MP | male | 46 | 32.3 | 25.6 | 33.3 | 28.8 | 30.4 | 18.1 |
| Mean | | | 33 | 26.82 | 33.82 | 29.27 | 31.95 | 23 |
| SD | | | 0.53 | 1.62 | 0.38 | 1.69 | 1.25 | 3.02 |
| **II.c. Other back pain** | | | | | | | | |
| PK | male | 45 | 32.8 | 24.5 | 33.8 | 26.2 | 31.9 | 22.8 |
| MZ | female | 48 | 32.4 | 26.9 | 33.5 | 28.9 | 31.5 | 25.3 |
| AH | male | 46 | 32.1 | 25.6 | 32.8 | 27.9 | 31.2 | 24.5 |
| SzF | male | 35 | 33.1 | 26 | 33.6 | 27.7 | 32.5 | 25 |
| KP | male | 65 | 31.5 | 27.9 | 32.5 | 29.2 | 29.3 | 25.6 |
| FJ | male | 35 | 34.2 | 23.9 | 34.6 | 25.9 | 33.6 | 20.6 |
| SA | male | 46 | 32 | 23.7 | 32.5 | 25.1 | 31.5 | 21.8 |
| WR | male | 56 | 32.7 | 25.2 | 33.8 | 26.8 | 31.1 | 23 |
| ZD | male | 44 | 33.5 | 29 | 34.1 | 30.1 | 32.6 | 28.1 |
| RG | female | 55 | 32.8 | 25.2 | 33.9 | 27 | 31.9 | 21.9 |
| Mean | | | 32.71 | 25.79 | 33.51 | 27.48 | 31.71 | 23.86 |
| SD | | | 0.78 | 1.71 | 0.7 | 1.58 | 1.13 | 2.25 |

bles the range of temperature inside the selected region of interest. Slight variations in skin temperature before cryo-therapy become more obvious after treatment.

During the time spent in the cryogenic chamber skin temperature follows the low environment temperature but simultaneously natural defence mechanisms are triggered.

Homeothermy involves an automatically regulated balance between heat production and heat loss from the surface. Thus, among other things, increased metabolic activity is anticipated due to exposure in the cryogenic chamber. Heat transfer to the surface occurs by conduction, radiation and convection, and is influenced by thermal parameters of anatomical structures. Thus, skin temperature can give some information on the thermodynamic processes taking place below the body surface. We expect that inflammation and degenerative states depending on their intensity and location may be partly reflected in the skin thermal mapping as an increase and decrease of temperature.

Back pain may be related to degenerative processes of the spine, which are characterized by decreased temperature, or with elevated temperature in inflammation, which may originate in the spinal vertebrae and also in the surrounding tissues (13). Therefore temperature reduction due to cryo-therapy is dependent on the variations of local thermo- regulation induced by degenerative or inflammatory changes of the local tissues. Whole body cryotherapy causes an increase of the temperature differences in the selected region of interest and these variations in skin temperature can be easily detected by infrared imaging.

Comparison of the thermograms with magnetic resonance imaging or computer tomography of patients with back pain is planned for future studies

## Conclusion

Whole body cryotherapy increases the temperature contrast related to localised degenerative or inflammatory processes of body tissues. Such enhancement of the profile of skin temperature could increase the diagnostic sensitivity of infrared imaging in patients suffering from back pain.

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# Cooling effects of Deep Freeze Cold gel applied to the skin, with and without rubbing, to the lumbar region of the back

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**SUMMARY**

**A topical agent Deep Freeze Cold Gel has been used in a study to objectively evaluate the degree and duration of cooling by application to the skin of normal volunteer subjects. The gel was applied to the forearm, and continuous monitoring of skin temperature was achieved by infra red thermal imaging in a thermally controlled laboratory. Two methods of application were used, applying a layer of gel to the skin, and rubbing a fixed quantity into a defined area of the forearm of the subjects. The temperature decrease from both methods did not reach statistical difference, although the treated area remained cold for longer using the layering application. A pilot study showed that the emissivity of the gel was high and close to that of the human untreated skin. Subjective assessments confirmed that the subjects experienced a comfortable level of skin cooling. Thermal imaging is a suitable technique for non contact and dynamic assessment of topical agents applied to the skin.**

**KEY WORDS: Thermal imaging, Skin Temperature, Cold Gel, Cryotherapy**

**KÜHLEFFEKT VON DEEP FREEZE COLD GEL AUF DIE RÜCKENHAUT IN ABHÄNGIGKEIT VOM EINREIBEN DES GELS.**

**Das topisch eingesetzte Deep Freeze Cold Gel wurde hinsichtlich des Ausmaßes und der Dauer seiner kühlenden Wirkung nach Anwendung an der Haut von gesunden Freiwilligen untersucht. Das Gel wurde am Unterarm aufgetragen und die Hauttemperature wurde mitttels einer Infrarrotkamera unter kontrollierten Umfeldbedingungen kontinuierlich aufgezeichnet. Zwei Varianten der Anwendung des Gels wurden untersucht, einerseits die Erzeugng eines dünnen Gelfilms an der Haut und andererseits das Einreiben einer bestimmten Gelmenge in die Haut des Unterarms. Im Temperatureabfall fand sich kein signifukanter statistischer Unterschied zwischen den beiden Methoden, auch wenn bei der Anwendung als Gelfilm einelänger andauerende Abkühlung beobachtete wurde. In einer Bvoruntersuchung konnte gezeigt werden, dass das Gel eine ähnliche Emissivität wie unbehandelte Haut zeigt. Die subjektive Beurteilung durch die Probanden bestätigte einen angenehmen Kühleffekt an der Haut. Die Thermographie ist eine geeignete Methode berührungsfrei die dynamiaschen Veränderungen durch topisch eingesetzte Substanzen zu beurteilen.**

**Schlüsselwörter: Thermographie, Hauttemperatur, Kaltes Gel, Kryotherapie**

Thermology international 2004:, 14: 64-70

## Introduction

Cryotherapy or cold treatment removes heat from the body. Coldness is a physiological term and the sensation of coldness is generated by the activation of cold receptors in the skin that are active in the temperature range between 15 and 34°C. Cold receptors are similar to warm receptors, and are also sensitive to change of temperature.

Cryotherapy is common treatment option for sports injuries (1), inflammatory changes of joints, tendon sheads or enthesopathies.

Pain reduction based on delayed conduction of pain fibres is a generally accepted effect of cooling. Reduction of inflammation might also contribute to the analgesic effect of cooling by reduction of inflammation mediators due to vasoconstriction. However, anti-inflammatory action of cold can only be observed in the very early stages of the inflammation process. This has been confirmed in a number of animal experiments performed by KL Schmidt in the late seventies (2,3). An American study clearly showed that the evolution of oedema is inhibited within the first 30 minutes after injury and promoted when cryotherapy has been applied 60- 120 minutes after trauma (4). In gout attacks, reduction of swelling and pain has been observed in the initial phase of treatment, but not 6 days after the flare up of the uric acid induced arthritis (5). Local tenderness was reduced in patients suffering from rheumatoid arthritis after ice massage was applied for 1-3 minutes to their finger joints (6). Patients suffering from knee osteoarthritis showed an increased threshold for mechanically or electrically provoked pain after treatment following the application of an air-nitrogen mixture for 1 minute (7). The threshold for electrically provoked pain at the elbow joints was found to increase after the application of cold air, nitrogen gas or cold packs (8).

Heat removal from the body is achieved with a variety of therapeutic methods such as cold sprays (usually containing some alcohol, previously ethyl chloride, 9), cold air, air-gas mixtures (nitrogen or carbon dioxid), ice, cold gel packs or even frozen peas, cabbage leaves or soft cheese. The mechanism of cooling is either convection in the case

of cold air or immersion in water, conduction, when the body is cooled by cold packs or ice, or evaporation as in the use of alcohol or wetting the skin with water (10).

Ethylic alcohol, sprayed in the region of interest (11, 12, 13) or immersion of hands in ethanol (15) has been used a cold stimulus in order to increase contrast in thermal images. Evaporation of alcohol is the reason that most of anti-rheumatic ointments show a transient cooling effect after application to the skin (15). However, this reduction of skin temperature may be overruled by simultaneous drug actions such as from nicotinic acid (15) resulting in a increase of the local skin temperature.

Deep Freeze Cold Gel is a UK licensed medicine that is available to the public as a General Sales List product that contains 2% Menthol and Isopropyl Alcohol. A cooling effect due to Menthol and Isopropyl Alcohol which is available in most antirheumatic ointments can be expected.

To investigate the amount of skin temperature decrease following the application of Deep Freeze Gel a pilot study and finally the main study was performed with the aim to compare the objective and subjective cooling effects of Deep Freeze Cold Gel by applying with and without rubbing into the skin.

## Pilot Study

### Temperature determination of the gel

At a room temperature of 20°C, some gel was put on the wire of a thermo element resulting in a temperature decrease of approximately 8°C (figure 1). Simultaneous measurement with the thermo element and the infrared imager revealed temperature readings, being close together (0.7-0.9) over period of 30 minutes, indicating a high emissivity close to that of human skin.

Therefore, the temperature of surface of the gel is approximately 12°C within the first 20 minutes after application.

### Skin cooling after application of Deep Freeze Gel for 2, 4 or 8 minutes.

A total 6 experiments was performed to investigate the cooling effect of Deep Freeze Gel.

Thermal images of both forearms were taken prior to the application of the gel and at a 1-minute interval for 20 minutes. Gel was applied in a circular area of 1inch diameter on

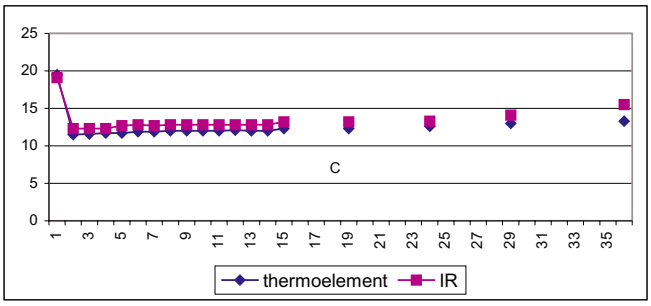



Figure 1
Cooling effect of "Deep Freeze Gel": Comparison thermolement and Infra Red Imaging

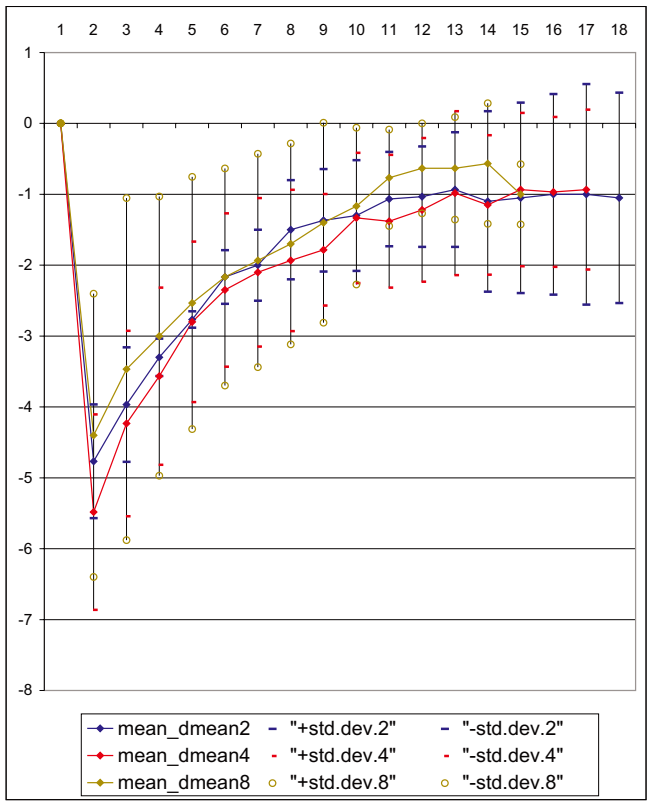



Figure 2
Mean temperature recovery ± std.deviation comparing 2 min (3 subjects), 4 min (6 subjects) and 8 min (3 subjects) cooling

each forearm of the subjects; the thickness of the layer was approximately 1 cm.

In 3 subjects the cooling agent was put on the right forearm for two minutes, and for 8 minutes in another 3 subjects. All 6 subjects received the gel on the left arm for 8 minutes. The gel was removed after the 2, 4 and 8 minutes and the skin temperature recovery was recorded for 12 minutes after removal.

On the first and last image taken, additional regions of interest were used to investigate the skin temperature outside of the treated area. Any temperature difference found between the first and the last image was uses as correction for the initial temperature measured in the treated area in order to be able to assess temperature recovery.

Although some differences of temperature were observed at the time of removal of gel, an identical tmperature course can be seen 5 minutes after removal of the gel independently from the duration of application (Figure 2).

### Skin cooling after thin layer applicationof Deep Freeze Gel for 2 or 8 minutes

In two subjects the gel was applied after spreading it over the skin in a thin layer for 2 or 8 minutes. All other methodology was identical to the experiments described above.

No significant difference in the course of temperature was observed (figure 3).

### Cooling effect of thin layer gel in different sized areas

In one subject the gel was thinly spread on the skin in areas of 1*1 inches and 1*2 inches. The gel stayed on the skin for

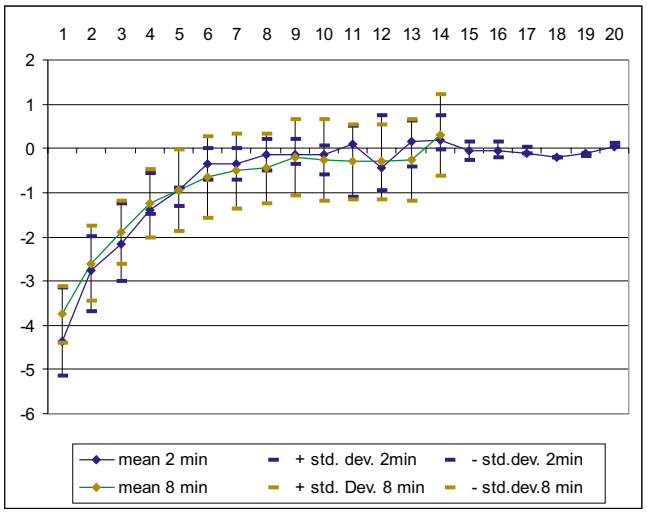



Figure 3
Mean temperature recovery ± std deviation comparing 2 min and 8 min cooling

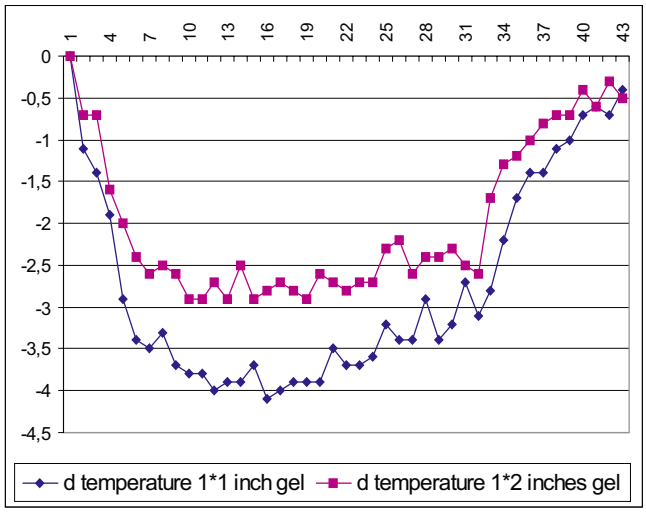



Figure 4
Skin cooling comparing 1*1 inches and 1*2 inches gel

30 minutes and was than removed. Thermal images and correction of the initial temperature readings were performed as described in the first series of experiments (Figure 4 and 5).

Temperature readings showed a similar course over time with higher values over the larger area.

## Main Study

Six healthy volunteers between the ages of 20 and 45 years were recruited to take part in one measurement session. The volunteers were asked to declare that they were in normal health and were not hypersensitive to any of the ingredients in Deep Freeze Cold Gel.

The study was described in outline in a subject information sheet given to each volunteer, who was also shown the Deep Freeze Cold Gel pack. It was made clear to each volunteer that Deep Freeze Cold Gel was to be used in the study in a manner similar to how it is used by a normal consumer. Volunteers were given time to read the information about the study and then asked to sign the consent form before undertaking the tests.

Figure 5
Series of thermal images showing skin cooling by comparing 1*1 inches and 1*2 inches gel

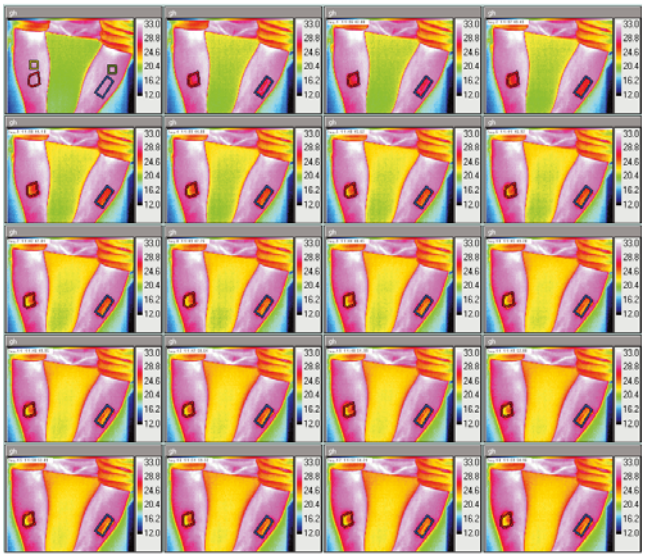
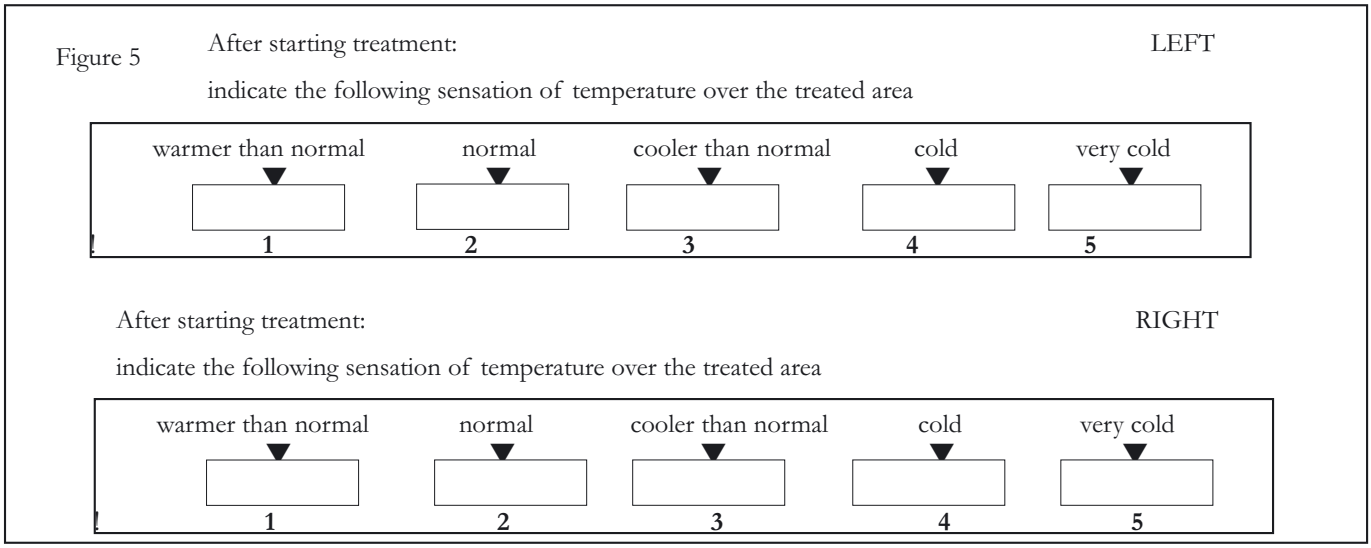


Figure 5



## Method

The subjects were given two equal areas of a dose of Deep Freeze Cold Gel to the back in the region of L2-4, using a 4cm strip layered on an area of 10x10cms. On one area to the left of the spine, the gel was evenly spread over the skin area, while on the other to the right, the gel was rubbed into the skin for 1 minute. The distance between the two applied areas was 8cms.

The temperature distribution of the skin was recorded by remote IR sensing using a FLIR thermovision camera. One investigator applied the gel to all volunteers to reduce variable technique. To prevent misunderstanding of the side to side differences that may be subjectively described by the volunteer, a card with two boxes drawn either side of a centre line to represent the spine was placed before the subject throughout the test. This was marked left and right to correspond with the volunteer's left and right side as a visual reminder.

### Procedure

All tests were carried out in the temperature controlled laboratory. (temperature limits 23 ± 1°C). The subject was asked to remove clothing from above the waist and remained in a cubicle for the first five minutes, without contact between the subject's back and the chair, or any other surface.

The subject was then asked to lie down in the prone position and a short series of thermograms were recorded for approx. 10 minutes until the images showed that lumbar skin temperature had reached stability i.e. change at less than 3% of the initial temperature.

The gel was then applied to the skin and the two areas were monitored continuously from application of the gel for 60 minutes. Images were captured by the automatic software of the imaging system (CTHERM) every 3 minutes exactly from the start of the experiment.

Each subject was asked to record the estimated degree of cooling selected from a scale as in figure 5. and to report any changes in sensation at immediately and 10 minutes after application of the gel . The subject was also asked to record the sensory observations at 20 minutes and again at 60 minutes . This involved the use of a line analogue scales of pleasant to unpleasant sensation on completion of treatment .

## Standardised Technique for Thermal Imaging

The procedure as described, required each volunteer to remain in the temperature controlled laboratory for at least 20 minutes before the start of the study. The subject with clothing removed from the upper part of the body, was asked to lie face down on a couch for the duration of the test. No movement was allowed, and the infrared camera was positioned on a stand to image from the vertical position over the subject's lumbar spine area. This allows for the automatic image capture using the special software CTHERM so that every image is in exact registration from the previous and subsequent images.

The areas measured are defined regions of interest placed in a fixed position on the image. This results in a set of data which is well defined in terms of both position and timing. Each image was recorded at exactly three minute intervals. Each region of interest was set to record the temperature of the treated area and varied slightly between subjects. This was fixed in size for each subject, and the minimum number of pixels used for each subject was in the order of 20,000. Therefore a single plot for a given time point on any one subject is calibrated in degrees centigrade, and is the mean temperature of these 20,000 temperature points in the measured area.

A single graph on one subject is a plot of the changes in this mean temperature measured by computed analysis of all the images recorded over one hour.

This study protocol was agreed by the University Ethics Committee.

## Analysis of results

All thermograms were analysed to estimate the pre and post cooling temperature changes. Regions of interest over

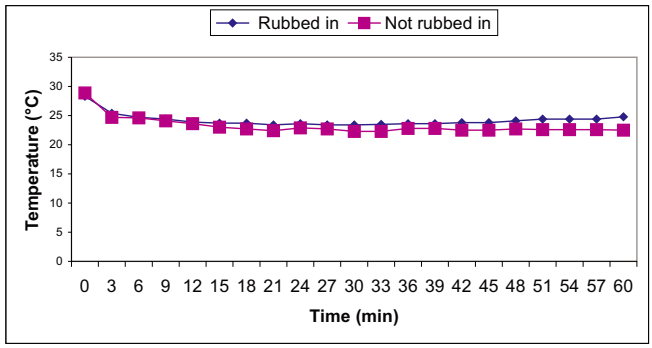



Figure 6a
Subject 3 - trend in mean temperature

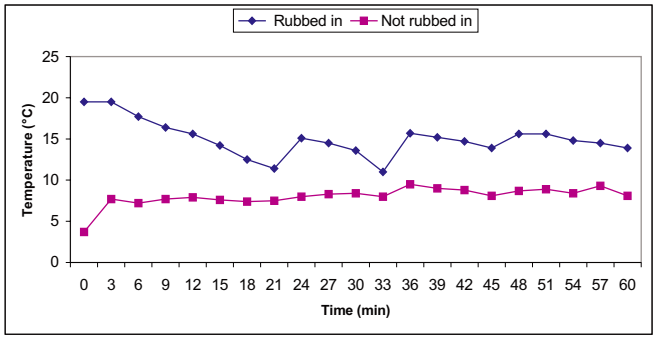



Figure 6b
Subject 3- trend in (Max-Min )temperature

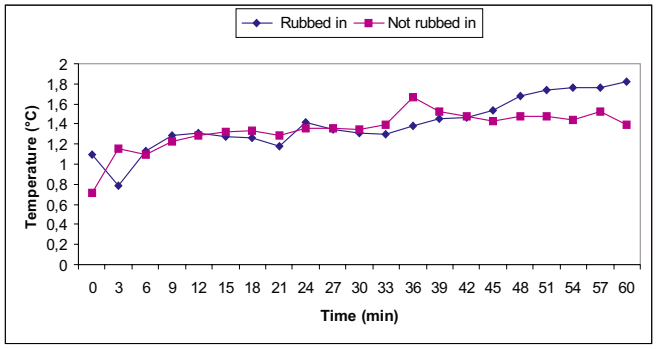



Figure 6c
Subject 3- trend in SD of mean temperature

the treated and non-treated area were analysed to record the maximum, mean and minimum temperature, with the standard deviation of the mean measured to show the variation across the region.

## Results

### Skin Temperature

The individual temperature records extracted from the regions of interest of the thermal images are shown below. The thermograms from each subject were analysed by selecting a region of interest over the marked areas of the lumbar region of the back on which the gel had been applied. The thermal data, maximum, minimum mean and andard deviation of temperature within each region was calculated, and plotted to separate graphs. The initial point on each graph is of the last record made before the gel was applied following the establishment of a stable skin temperature pattern.

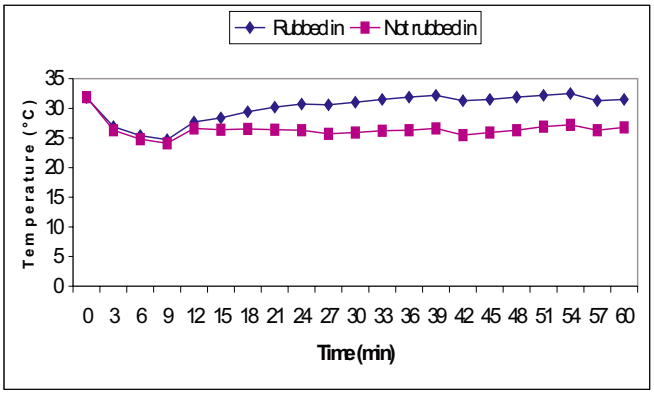



Figure 7a
Subject 5 - trends in mean temperature

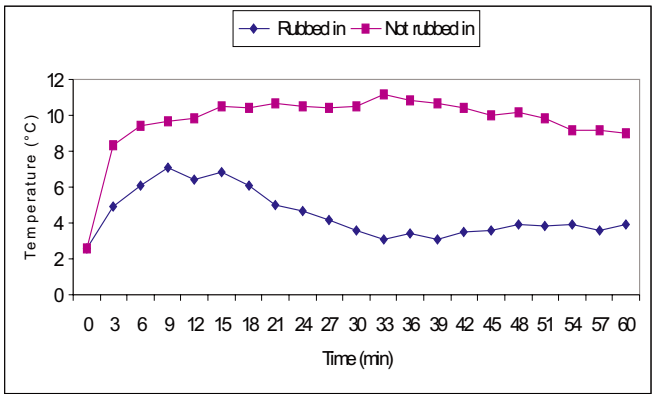
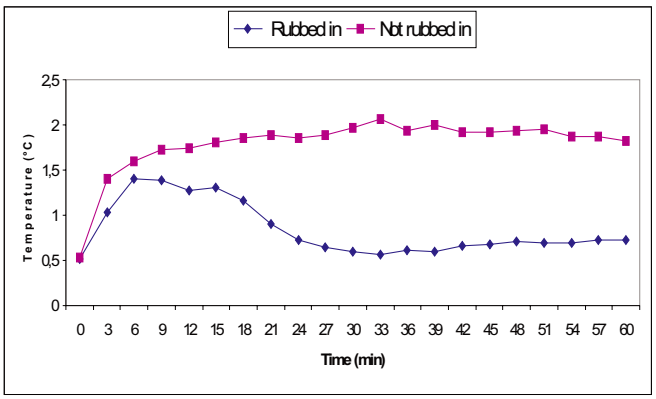



Figure 7b
Subject 5 - trend in (Max-Min )temperature




s Figure 7c
t Subject 5 - trend in SD of mean temperature

### Individual Temperature Response to the Gel

Three of the six subjects numbers 1,3 and 4, showed little difference between to two methods of application viz, applying the gel to the skin *without rubbing* and applying the same quantity *with rubbing* into the skin. Figure 6 shows the temperature measurements of subject 3.

The other three subjects did have a greater cooling effect from having the gel left on the skin without rubbing. Figure 7 shows the results of subject 5.It is interesting to note that these subjects had a slightly higher starting skin temperature than the others. These subjects also tended to have a lower standard deviation of the temperature data from the area where the gel was rubbed in, from the alternative treatment. This may indicate a more even distribution of the gel is achieved by rubbing the product into the skin. It is not clear if such an observation based only on three subjects is of relevance to this study.

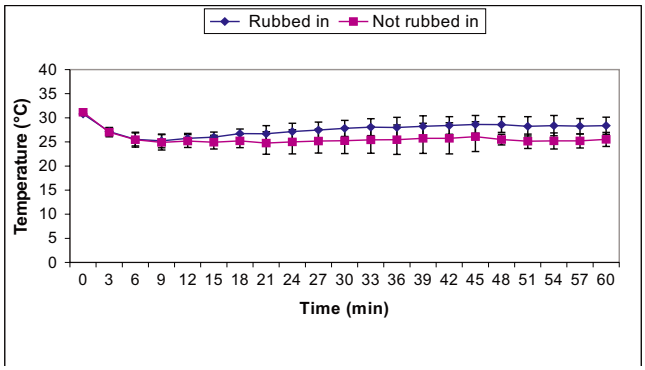



Figure 8
Skin cooling after application of Deep Freeze Gel

However all subjects except number 1 showed a significant difference in temperature between the two methods of application of the gel.

The final graph (Figure 8) shows the mean data from all six subjects plotted over time. In this graph there is a trend towards a difference between the two methods of application of the gel. However this was not significant when a binomial non-parametric test was applied. The two tailed significance is 0.219. This result is at odds with the individual temperature graphs, but is probably related to the small sample size.

Table 1
Analysis of the difference between applications of the gel rubbed in and not rubbed into the skin for each subject for all measurements following gel application.
Paired-Samples T-Test

| Subject | df | t | P (2-tailed) |
|---|---|---|---|
| 1 | 13 | -0.1039 | 0.919 not signif. |
| 2 | 18 | 13.1992 | 0.000 |
| 3 | 18 | 8.0813 | 0.000 |
| 4 | 18 | 2.8239 | 0.010 |
| 5 | 18 | 10.0821 | 0.000 |
| 6 | 18 | 8.2264 | 0.000 |

### Subjective Scores

The plots for changes in subjective scores are shown in figure 9 and figure 10.

### Temperature sensation

The definitions warmer than normal, normal, cooler than normal, cold and very cold were numbered one to five as shown in figure. A separate request for scoring was made to each subject for both left and right sides of the back in the area of the gel application. Two points for each subject are plotted: baseline (straight after application) and 10 minutes later. The higher the score plotted from these scales, the greater the degree of cold experienced by the subject.

### Comfort/discomfort

Line analogue scales were used to record the subjective sensation from gel application to the back from very pleasant to totally unpleasant. These are measured in cms. From the left,i.e. very pleasant. Thus the higher this score the greater the degree of unpleasantness. Two records for each subject are plotted at 20 minutes and 60 minutes after application of the gel.

These results show some discrepancy from the objective temperature measurements indicating that the subjects are unable to differentiate these changes in temperature at the lumbar spine region.

### Side Effects

None were reported.

### Subjective Scores

Data taken from the line analogue charts in cms from left are shown in figures 9 and 10.

## Discussion

The data presented in this report shows that there is a sustained cooling effect from application of the gel onto the skin. Some differences were found in temperature effects between the two methods of gel application in individual subjects. However, overall these differences were not statistically significant when compared as a group.

The maximum minus minimum data indicate the variation in temperature across the regions of interest. This is also indicated by the Standard deviation graphs on each subject. Even application of the gel is not easily achieved, especially when the quantity of gel is being applied without rubbing.

The subjective data indicate that most subjects did not find the gel unpleasant and did experience the cooling effects from application. There was no noticeable difference between the two methods of application of the gel based on the subjective assessments.

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Figure 9a
Temperature sensation 6 subjects
Even spread of a film of deep freeze gel

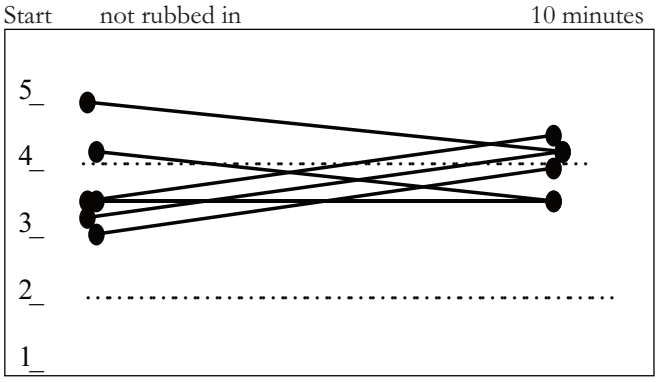



Figure 9a
Temperature sensation 6 subjects

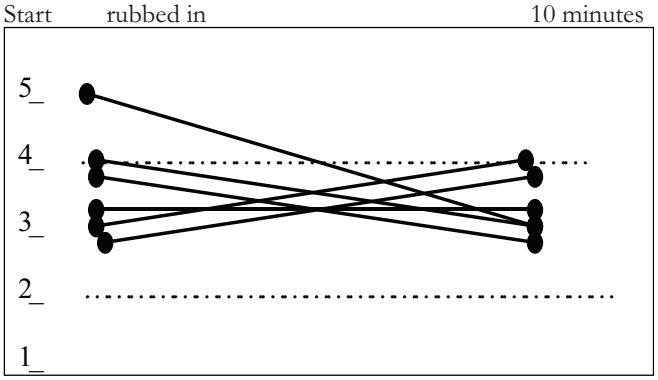



Figure 10a
Comfort Assessment in 6 subjects
Even spread of a film of deep freeze gel

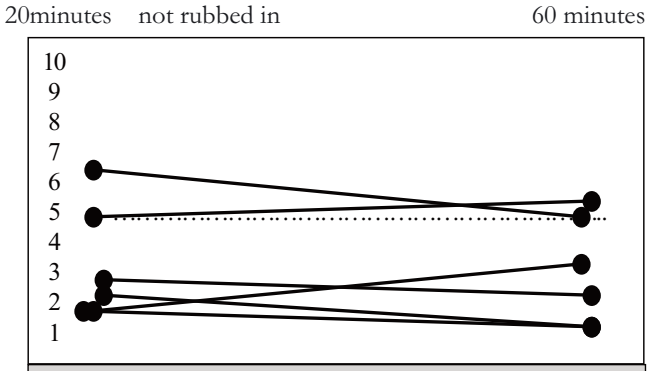
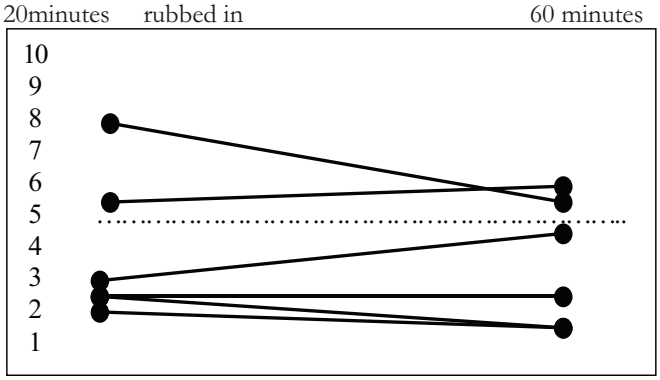



Figure 10b
Comfort Assessment in 6 subjects
Rubbed in deep freeze gel



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# A comparison of thermal responses in hands and feet of young and elderly subjects in response to local cooling as determined by infrared imaging

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**Summary**

**1. An experimental method involving the use of infra-red thermal image analysis for measuring skin temperature ($T_{sk}$) in the extremities (hands and feet) following a short period of local cold exposure is described. Results from test experiments in 12 young subjects (mean age 25 years) and 12 elderly (mean age 76 years) are presented.**

**2. Under control conditions prior to cooling $T_{sk}$ on the feet was lower than on the hands in both young and elderly subjects.**

**3. Under control conditions prior to cooling $T_{sk}$ in the young subjects was always higher than in the elderly subjects both for the hands and feet.**

**4. Recovery time after cooling was more rapid in the hands and feet of the young subjects compared to the elderly subjects**

**5. The sensitivity of the method indicates that it may be a suitable model for the early detection of blood flow disturbances associated with peripheral arterial disease.**

**Keywords Infra-red thermal imaging; skin temperature; cooling; skin blood flow; temperature regulation**

**THERMOGRAPHISCH ERFASSTE ANTWORT DER HÄNDE UND FÜSSE AUF EINE LOKALE ABKÜHLUNG BEI JÜNGEREN UND ÄLTEREN PERSONEN**

**1. Ein Experiment wird beschrieben , das die Infrarotthermographie zur Bestimmung der mittleren Hauttemperatur $T_{sk}$ an den Extremitäten (Händen und Füßen) nach einer kurzen Kälteeposition verwendet hat. Die Ergbenisse dieses Experiments bei 12 jüngeren (Durchschnittsalter 25 Jahres)u and 12 älteren Personen (Durchschnittsalter 76 Jahre) werden dargestellt.**

**2.Die mittlere Hauttemperatur $T_s$ der Füße war unter kontrollierten Bedingungen vor der Kühlung bei jüngeren und älteren Personen geringer als die mittlere Temperatur der Hände.**

**3. Die mittlere Hauttemperatur $T_s$ der Hände und Füße war unter kontrollierten Bedingungen vor der Kühlung bei jüngeren Personen höher alser bei älteren Patienten,.**

**4.Die Wiedererwärmung nach der Kühlung war bei jüngere Personen rascher als bei Älteren.**

**5. Die Empfindlichkeit dieser Methode empfiehlt dieses Vorgehen möglicherweise als passendes Modell Durchblutungstörungen vei peripheren Gefäßerkrankungen frühzeitig zu entdecken.**

**Keywords Infrarot-Thermographie; Hauttemperatur; cooling; Hautdurchblutung; Thermoregulation**

Thermology interantional 2004; 14: 68-74

## Introduction

An important component in the regulation of body temperature is skin blood flow, especially in peripheral sites such as hands and feet. Any impairment of vasomotor control in these skin areas can, in addition to causing tissue damage, compromise thermoregulation and may, under certain circumstances, be detrimental for health. For example, In addition to natural age related changes in the control of blood blow to peripheral tissues (1,2,3,4) which support the well described a impairment in sensitivity of the elderly to environmental temperatures changes (see 5 for references), there are many patho-physiological related impairments of skin blood flow associated with, for example, peripheral arterial diseases (PAD) (6).

Under both experimental and clinical situations there is often a need to monitor thermal responses in peripheral tissue to cold stimuli. Infar-red (IR) thermal imaging provides an ideal non-invasive technique for measuring skin temperature and there are many published reports in which this technique has been used to examine how skin temperature changes following cold exposure. However, the majority of these studies relate to clinical situation in diseased subjects (7).

A comparison of the thermal responses to local cooling in both the hands and feet of young and elderly healthy subjects using infra-red thermal imaging has not been previously described. In this study, we describe a non-invasive technique involving the use of infrared thermal imaging which provides a sensitive and reliable experimental method for examining changes in skin temperature in the extremities (hands and feet) in responses to local cooling

The method involves monitoring skin temperature changes with a high resolution infra-red (IR) thermal imaging cam-

era before, during and after a short period of local cold exposure. As infrared is above the visible light spectrum and is considered non-invasive, this technique provides us with a non-invasive tool which enables one to assess accurately and quickly both qualitative and quantitative changes in skin circulation (8). Infrared thermal imaging poses absolutely no danger to patients and tests can be run as often as desired without fear of complications.

**Methods**

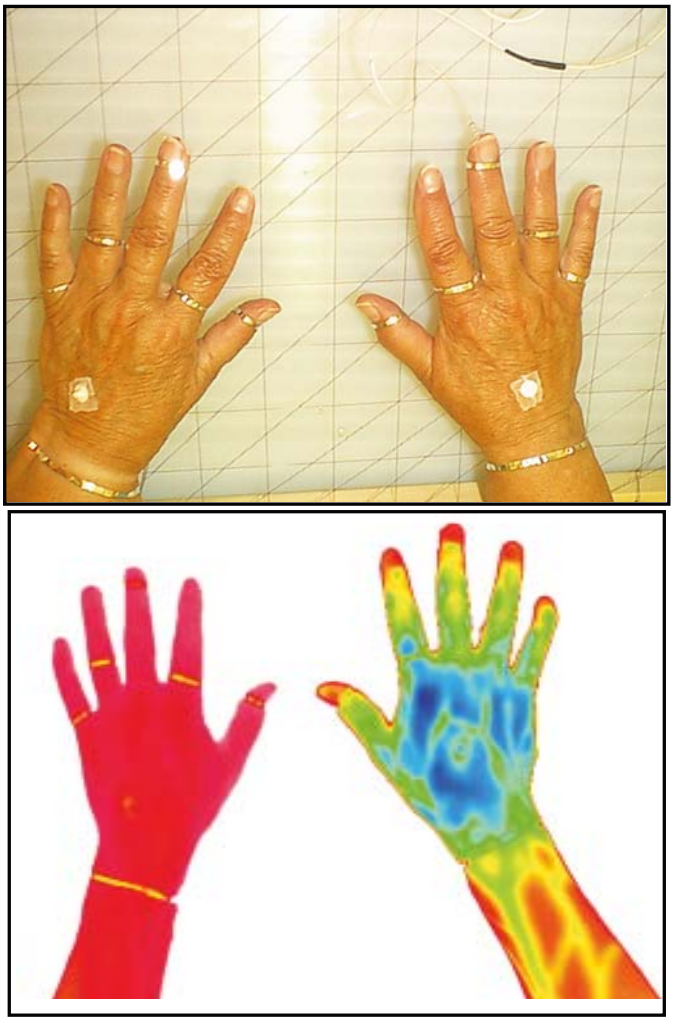
The experiments, which took place in a climatic chamber under thermoneutral ambient conditions (T 26 -28°C), were carried out in 12 young (24.8 ±3.0 years) and 12 elderly (76.9 ±1.0 years) healthy volunteer subjects (see table 1 for personal details). All the subjects were non-smokers without any chronic diseases and none were on permanent medication. During the experiments, the lightly clothed subject sat in a comfortable stool while resting either their hands or their feet (palm/sole down) on a special framework which consisted of a grid made of thin nylon netting (diameter 0.4 mm) strung between a rectangular shaped wooden frame (40 cm x 50 cm). The open spaces in the grid were triangular in shape and each had an area of ca. 8 cm. The purpose of the nylon grid was to minimize skin contact with the surface supporting the hands or feet. In order to have a background temperature that was different than the object being viewed by the IR-camera, a rectangular shaped thermostatically controlled heating plate (40 cm x 50 cm) was placed at a distance of 5 cm below the grid. The temperature of the plate was controlled at 40°C.

Figure 1:
Experimental set-up showing subject sitting in climatic chamber inside the Plexiglas wind break. The subject's hands, with are resting on the nylon grid. The white plate beneath the grid is the water perfused heating plate. The silver tape used to mark reference points can be seen on the hands.

Table 1.
Personal data subjects: All subjects were non-smokers, had no chronic diseases and were not on permanent medication. Values mean ± S.D.

| | Sex | Age (yrs) | Height (m) | Weight(kg) | BMI |
|---|---|---|---|---|---|
| Young subjects | 12 m | 24.9 ±0.9 | 1.79 ± 0.02 | 77.5±2.7 | 24.2±0.6 |
| Elderly subjects | 48 m | 76.9±1.0 | 1.62 ±0.03 | 76:1± 4.0 | 29.1±1.4 |

Following a 30 minute control period to establish base line values the right hand or the left foot was immersed to a predetermined level (wrist/ankle) for a period of 2 minutes in 10°C water. In each subject cooling of the hand and the foot took place during the same experimental session, the hand always being tested first. A thin plastic bag was worn during the immersion period to avoid skin wetting. Throughout the experiments measurements of the dorsal skin temperatures of the hands or the feet were made using infra-red thermal imagery using a Nikon Laird S270 IR-camera. This camera is a so-called 2 generation IR-camera which is capable of producing high-definition digital infrared images at a high speed (30 Hz). During each experiment a time series of ca. 30 still images of the dorsal surface of both hands and feet were taken. Prior to cooling several im-



ages were taken to establish base line values. It was not possible to take images during the immersion period. The first post-cooling image was taken 20 seconds after end of cooling and thereafter every 30 seconds for the next 7 minutes. During the following 8 minutes an image was taken every minute and thereafter every 2 minutes for the rest of the experiment. For processing of the digital images we used a software package (PicWin-IRIS), which could produce measurements of skin surface temperatures to an accuracy of 0.1°C. Prior to each experiment small pieces of silver tape were attached to the hands or feet at pre-determined points. These acted as visual reference points during the

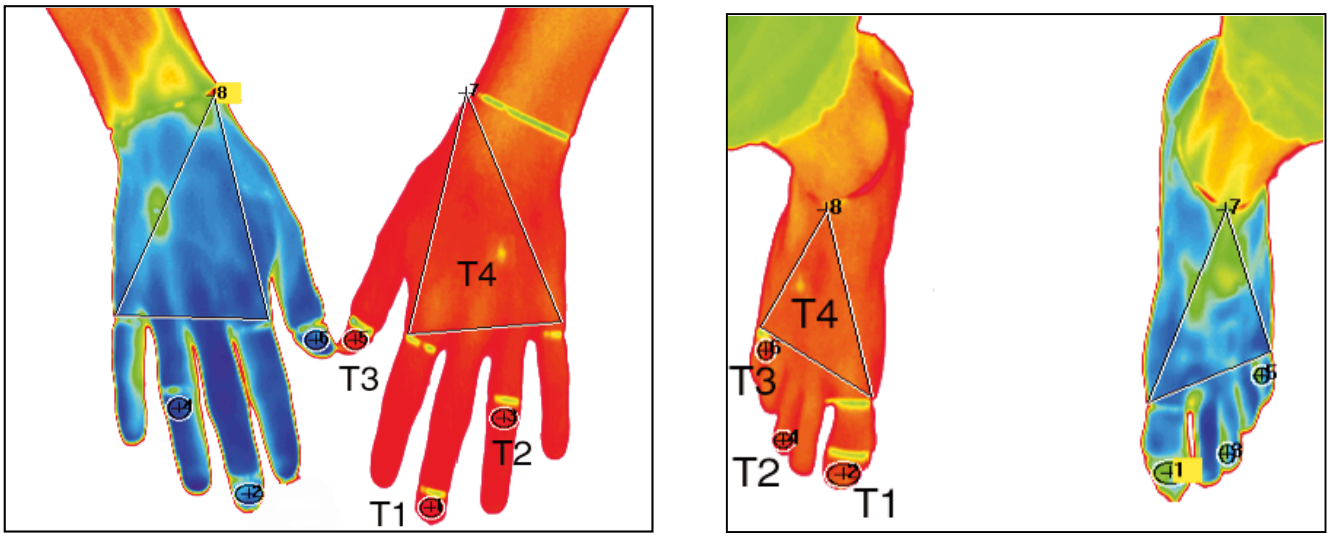



Figure 2
IR-images of a hand and feet showing the marked areas used in the calculation of the average dorsal surface temperature. The following formulas were used for calculating the average surface temperature of each hand (Thand) and foot (Tfoot).

$T_{hand} = (0.046 \pm T_1) + (0.31 \pm T_2) + (0.015 \pm T_3) + (0.63 \pm T_4)$

$T_{foot} = (0.1 \pm T_1) + (0.14 \pm (T_2 + T_3)\ )\ 2) + (0.76 \pm T_4)$

Where $T_4$ represents the average temperature within the marked triangular area and $T_1$ - $T_3$ represents the average area within the marked circles. The weighting factors in each formula were determined gravimetrically in which paper silhouettes of each hand and foot were cut up into areas and weighed.

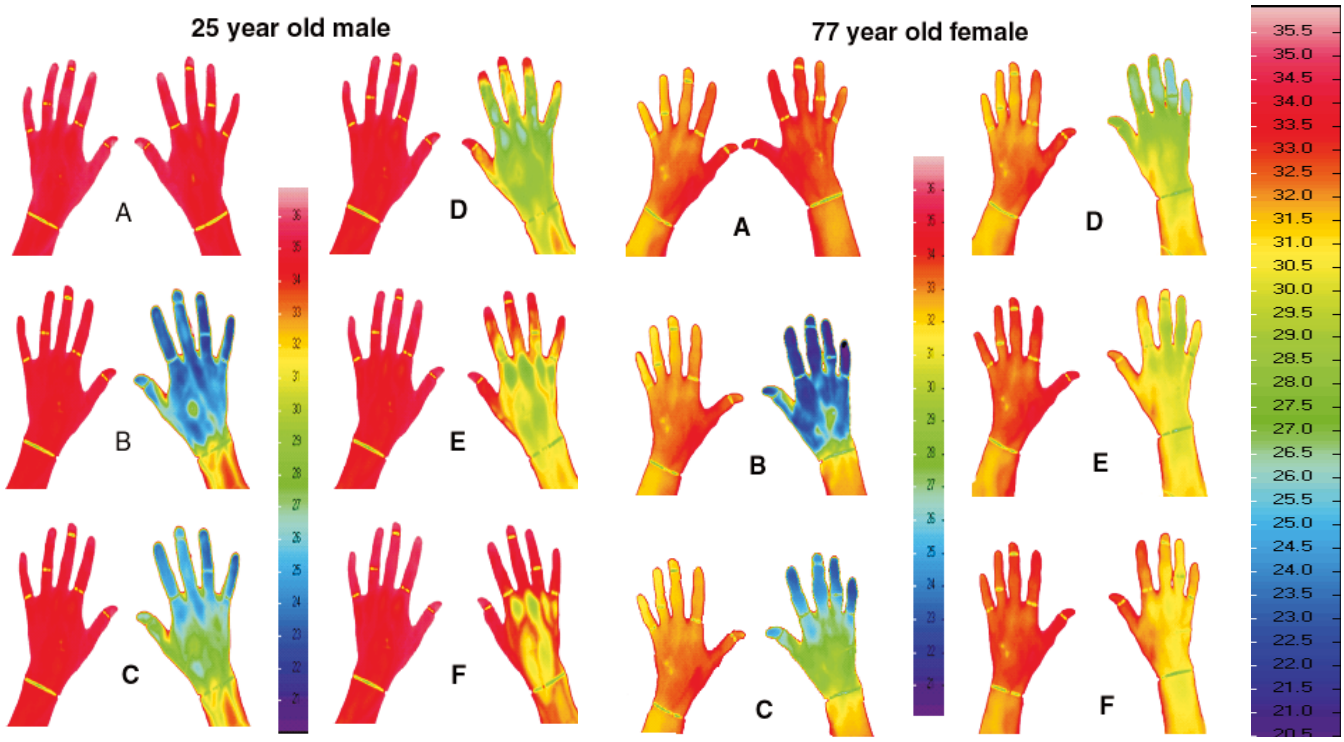



Figure 3
Sequence of thermal images of the dorsal surface of the hands in a young (25 years old) male and an elderly (77 years old) female. Image A for both subjects was taken immediately before a 2 minute long immersion of the right hand in cold (10ºC) water; image B for both subjects was taken 20 seconds after the end of the cold immersion . For the young subject images B,C, D and E were taken respectively at 1min 20 sec, 3 min 20 sec, 5 min 20 sec & 8 min 20 sec after end of cold immersion. For the elderly subject images B,C, D and E were taken respectively at 2min 50 sec, 9 min 20 sec, 17 min 50 sec & 20 min 20 sec after end of cold immersion.

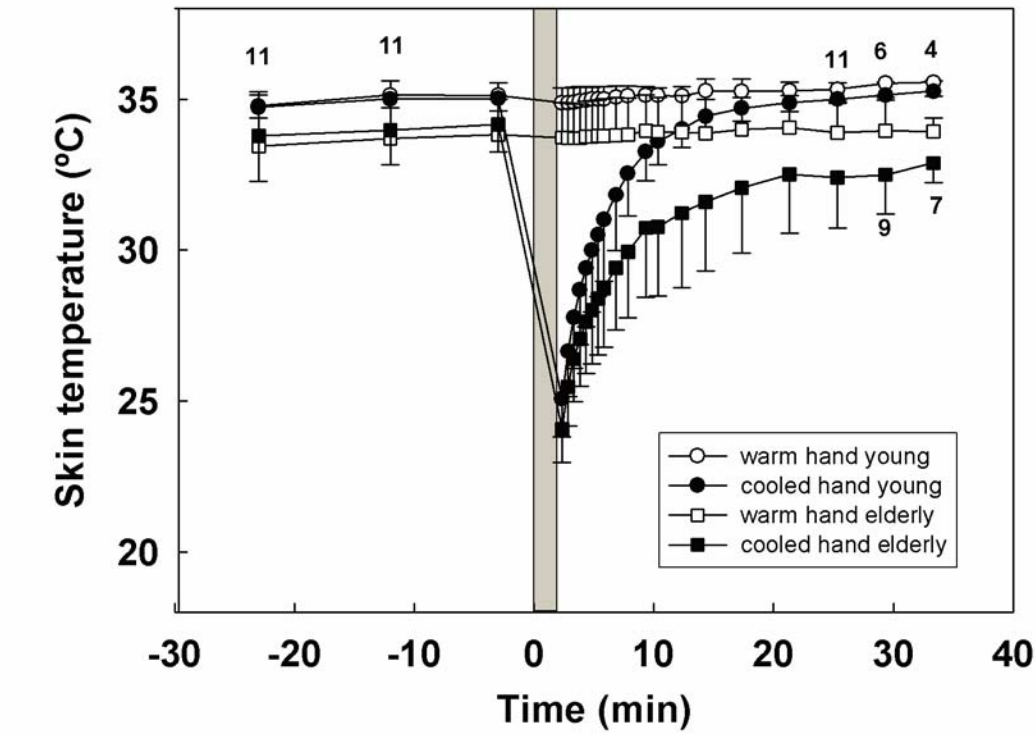



Figure 4.
Time course of changes in the average skin temperature of the dorsal surface of the hands of young (closed and open circles) and the elderly (open and closed squares), before, during and after immersion of the right hand in 10ºC water for a period of 2 minutes.

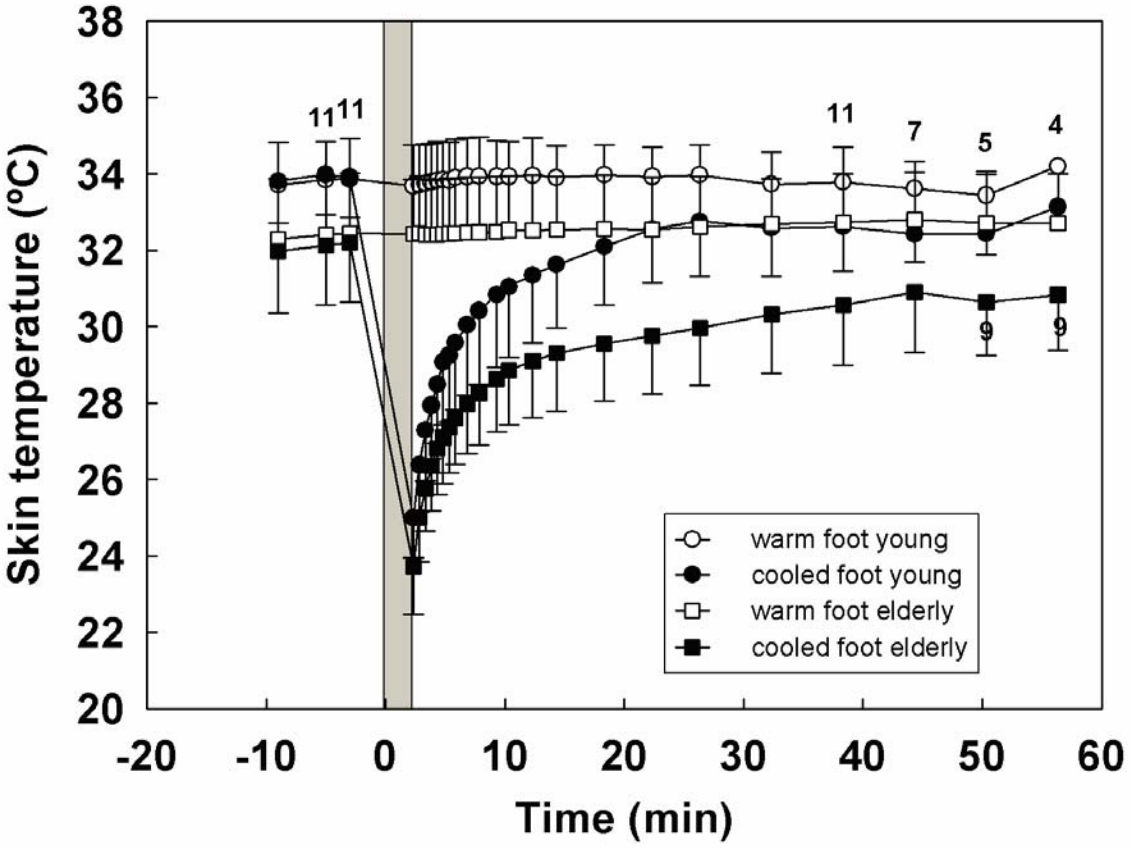



Figure 5
Time course of changes in the average skin temperature of the dorsal surface of the feet of young (closed and open circles) and the elderly (open and closed squares), before, during and after immersion of the right foot in 10ºC water for a period of 2 minutes. The cooling period, indicated by the grey bar, commenced at time 0. Means ± SD.

processing of the thermal images (Fig 2). Based on these reference points two empirical formulas we used to calculate the average surface temperature of the entire dorsal surface of the hands and feet (Fig. 2) In the results section skin temperatures are presented as the average temperature of the entire dorsal surface of each hand or foot (Figs 4 & 5) as well as for other sites, e.g. a specific finger or toe (Table 2).

To compare the responses to local cooling between the hands and feet calculations were made from the temperature data of the time taken for skin temperatures in the 'cooled' hand or foot to regain 80% of the cold induced drop in temperature, which is referred to as the recovery time. Skin temperatures were also measured at selected sites with thin thermocouples on the palmar side of the hand and the plantar side of the feet. Systolic and diastolic blood pressure (standard cuff) were measured at ca. 10 minute intervals and heart rate was continuously measured telemetrically (Polar Advantage).

Data are presented as mean values ± SD. Statistical comparisons were made using a nonparametric test (Mann-Whitney). The significance level was set at $P< 0.05$.

Permission to carry out the experiments was granted by the Norwegian Regional Committee for Research Ethics (Region V). All subject freely volunteered to participate.

## Results

Figure 2 shows sample IR-images in both a young (25 year old) and an elderly (77 year old) subject taken at various time intervals immediately before and during the recovery period following the 2 minute period of cold immersion of the right hand. The images show three main interesting points. First, the skin surface temperature prior to cold immersion is warmer in the younger subjects. Secondly, the hands of the young subject re-warm much more rapidly that in the elderly subject. Thirdly, in images B, which which was taken 20 seconds after the end of the cooling period there is a much clearer demarcation between cold and warm tissue at the wrist in the elderly subjects.

The curves in Fig. 3 show the time course of the average skin temperature of the entire dorsal surface of the hand, before and after the 2 minute period of cold immersion. A difference between T in the young and elderly on the hands in the control period prior to cooling was evident, T being slightly greater on the hands of the young subjects (right hand 35.0 ± 0.1ºC vs 34.2 ± 0.3ºC, P = 0.007; left hand 35.1 ± 0.1 ºC vs 33.8 ± 0.3 ºC, P = 0.001). The induced fall in T, which could be determined from point measurements with the thermocouples, for example at the tip of the finger and toe, were very similar in both groups ( 3 finger, 11.9 ± 2.9 ºC & 11.4 ± 2.3 ºC respectively and 1 toe 11.4 ± 0.7 ºC & 10.0 ± 0.8ºC). Although not clearly visible in Figs 2 and 3, a consensual vasoconstrictor response was observed in the non-cooled hand or foot. The consensual response was more clearly evident in the spot temperature measurements made with the thermocouples, for example at the tips of the digits.

From the shape of the curves following the drop in hand and foot temperature as a result of the cooling, it can be seen that recovery time is clearly always more rapid for the the young subjects as compared to the elderly subject (Figs. 3 & 4). These differences were highly significant (Table 2). In addition, for both groups recovery times from cooling were always more rapid for the hands than for the feet, although this may be partly due to hydrostatic effects (the patients were sitting during the experiments)..

Qualitatively similar results were found when temperature comparisons of selected skin areas were made such as a comparison between the average temperature of the dorsal surface of the 3 finger or third toe as measured by IR-thermal imagery or between the temperature of the ventral tip of the index finger or ventral tip of the 2nd. toe as measured with thermocouples (Table 2).

Although we observed small transient decreases in heart rate associated with the start and end of the cooling period, neither these nor heart rate or mean arterial blood pressure at any other stage of the experiments were statistically significant from the values measured during the pre-cooling period.

## Discussion

In this study we describe a non-invasive method involving the use of IR-thermal image analysis for examining peripheral circulation in the hand and feet of both young and elderly subjects. In this model it is assumed that changes in T reflect underlying changes in skin blood flow, although it must be emphasised that this may not necessarily always be true. The approach used was to monitor the time it took for

Table 2
Time required for 80% rewarming of the cooled hands (top panel) and feet (bottom panel) in young and elderly subjects.
Avg. hand = for total dorsal surface of hand including digits; back hand = dorsal surface of hand excluding digits. 3rd finger (t/c) = skin temperature measured with a thermocouple placed on tip of finger (palmar side); Avg. foot = total surface of foot including toes; back foot = dorsal surface of foot excluding toes. 1st Toe (t/c) = skin temperature measured with a thermocouple placed on tip of 1st toes (plantar side).

| | Avg. hand | 1st finger | Back of hand | 3rd finger | 3rd finger (t/c) |
|---|---|---|---|---|---|
| Young Subjects | 8.5 ± 0.6 | 4.2 ± 0.3 | 8.9 ± 0.7 | 4.2 ± 0.4 | 6.0 ± 1.0 |
| Elderly Subjects | 17.4 ± 2.4 | 10.2 ± 1.8 | 14.9 ± 1.6 | 10.6 ± 1.9 | 13.2 ± 2.4 |
| p-value | p=0.001 | p=0.004 | p=0.003 | p=0.003 | p=0.01 |

| | Avg. foot | 3rd toe | back of foot | 1st toe | 1st toe (t/c) |
|---|---|---|---|---|---|
| Young Subjects | 20.9 ± 2.7 | 19.8 ± 3.1 | 21.9 ± 2.8 | 15.1 ± 2.5 | 15.9 ± 3.0 |
| Elderly Subjects | 37.4 ± 3.7 | 35.1 ± 3.7 | 38.0 ± 3.7 | 36.1 ± 3.9 | |
| p-value | p=0.002 | p=0.005 | p=0.002 | p=0.003 | p=0.01 |

the skin temperature in a hand or foot to return to normal values following a short period of local cooling.

The method required that the subjects at the outset of the experiment be sitting quietly under thermoneutral ambient conditions and to be peripherally vasodilated. A combination of light clothing and a T of between 26 -28 °C seemed to satisfy our requirements and none of the subject complained of being too warm and no overt sweating was observed. While the main emphasis was to use IR-thermal imaging to record T, supplemental point measurements with thin thermocouples was found to be useful for two reasons. First, the thermocouple measurements could be made during the cooling and secondly, the thermocouple measurements provided thermal information for those aspects of skin not visible to the camera. While it is also possible to make single point temperature measurements with the IR-camera, its greatest use comes from the possibility of measuring the average temperature of large areas of skin. Further, the visual information provided by the IR-camera, either from time series image analysis or by video playback presents the observer with additional information concerning the pattern of rewarming of the cooled skin areas.

In our experiments, blood circulation and rewarming showed a fairly typical pattern (Fig. 2). Rewarming of skin tissue occurred most rapidly at the tips of the digits, and was followed by a gradual centrally directed rewarming of the digits and then the rest of the hand or foot. Thus, one gets the impression of an active increase in skin blood flow and rewarming starting at the apex of the digits followed by a wave of rewarming spreading centrally towards the wrist or ankle. In addition, from the IR-images one could clearly see a flushing out of cooled blood towards the more centrally located superficial veins on the back of the hand/foot and lower arm/lower leg. This always occurred more rapidly in the younger subjects (Fig. 2). The skin areas which were slowest to rewarm were those located over the less insulated structures such as the knuckles of the hand, where the rewarming procedure seemed to have a more passive nature.

In terms of subject comfort none of the experimental subjects found the protocol and experimental set up to be in anyway discomforting. However, it should be noted that in this study, we used healthy young subjects with no known chronic diseases. We have more recently made similar measurements in a variety of subjects with specific patho-physiological related illnesses which effect peripheral blood circulation, for example, patients with Raynauds phenomenon and patients with diabetes mellitus. None of these subjects had difficulties completing the examination protocol.

Despite the relatively small number of test subjects examined and despite individual variations, the results of the test experiments clearly indicate several two differences between the young and elderly subjects. First, during the pre-cooling control period T of the hands was higher in both age groups for both the hands and the feet. It is felt that these observations represent a genuine age related deterioration in the control of peripheral circulation. This finding is supported by others (1,2,3,4) as well as age related changes in both warm and cold peripheral thermal sensitivity (9).

The induced fall in T, which could be determined from point measurements with the thermocouples, for example at the tip of the finger and toe, was very similar in both groups (11.9 ± 2.9 ºC and 11.4 ± 2.3 ºC respectively). Whether this would have been the case with a longer and/or a more severe level of cooling is not known. Nevertheless, the second main finding in our test experiments in these young subjects was the slower recovery of T in feet. However, here caution must be applied as the experiments were carried out in subjects sitting in an upright position and it is more than likely that hydrostatic effects may largely explain these differences.

In summary, an experimental model involving the use of IR-thermal imagery for examining skin circulation in the hands and feet has been presented. Test results indicate that the model may be well suited for investigations concerned with the early detection of blood flow disturbances associated with pheripheral arterial disease.

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## Abstracts

### THERMOGRAPHIC STUDY OF TOPICAL COOLING AGENTS FOR THE SKIN

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Simple treatments based on the application of cold for localised minor injuries or pain, have been in use for many years. The commonly used technique is the application of crushed ice packs. This is more usually applied under supervision in a hospital clinic or physiotherapy department. Ice packs rapidly apply low temperatures to the skin, and cooling is accelerated if the ice is contained in a wet towel. One disadvantage is that for self-treatment it is less convenient to apply to some areas of the trunk than the extremities.

In recent years chemical products have been introduced for home or outpatient use. They are safe, inexpensive, and suitable for self-application. They may take the form of encapsulated gels, which are refrigerated before use, or a chemical reaction may be started by breaking a seal. In addition a gel can be applied to the skin, or an aerosol pack of coolants can be used.

In this study we report a comparison of ice packs applied to the lumbar spine of normal subjects for 10 minutes compared to a cold gel ( Deep Freeze) applied to the same area on another day for 60 minutes.

The subjects were examined in the prone position, lying on a couch in a temperature controlled room at 22C. After 15 mins stabilisation thermograms were recorded until no further temperature changes were evident. The 10x10cm Ice pack or gel was applied to the skin at the L4 level. The Thermographic Camera Flir SC500 was stand mounted above the patient in a vertical position. Automatic software CTHERM) was used for image capture at 3 minute intervals for a further 60 minutes. Subjective assessments were also recorded from each volunteer through the examination. Results showed that although a lower skin temperature was reached with ice ( mean fall of 7C) the temperature recovered quickly within 20 minutes. The gel applied to a 10x10 cm area of the lumbar region showed a more gradual fall in temperature mean approx 3.5C but this persisted for most of the 60minute application. After 50 minutes there was a slow rise in temperature towards baseline.

In a second in-vitro experiment three commercial aerosol coolants for topical skin use were sprayed onto 3 equal sized aluminium plates of 20x20cms. One surface was painted with matt black paint to achieve an emissivity of 0.95. This surface was imaged by automatic software at 1 minute intervals for 20 minutes. The unpainted surfaces were simultaneously sprayed with an equal does of the aerosol coolants. The cooling and rewarming of the plates was assessed by plotting the mean and standard deviation of temperature from each plate. The experiment was repeated and the order changed to obtain a mean of five such experiments for each product. The results showed that in this simple physical test the cooling effect of the three compounds on metal were not equal. However two of the products also contain other agents for pain relief. These finding will be compared to an in-vivo comparison using normal subjects.

This study demonstrates that quantitative thermal imaging is a simple and objective tool for the evaluation of such topical cooling treatments. It is however important to assess the emissivity of any applied substance which could have a significant effect on temperature measurement by remote sensing.

### HOT AND COLD

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A documentary scientific film on thermal physiology of the human body recorded at Bath and in The French Alps for British Television. (1980). This film traces the human body changes through a day in the life of two young skiers on holiday. There are many animated sequences to explain body temperature regulation, and the effects of a warm and cold environment on the body. Thermal images were recorded with an early real time thermal camera. The resolution by modern standards is poor but the film maker has effectively mixed from visible to infra red to demonstrate the skin temperature responses to the temperature changes from exposure in the snow to a sauna bath at the end of the day.

### STANDARDISATION OF THE TECHNIQUE OF THERMAL IMAGING IN MEDICINE: ISSUES FOR THE CREATION OF A REFERENCE ATLAS OF NORMAL THERMOGRAMS.

Report of the Anglo-Polish Research Group 2004.

Prof. A.Jung, Prof. B Wiecek, Prof. E.F.J.Ring, Prof. K Ammer, Dr. P Plassmann, Dr C Jones, P Murawski, T. Buczkowska-Murawska, S. Zwolenik, Prof.B.F.Jones.

This group has been preparing for the creation of a digital thermal image atlas of the human body. The aim is to establish a series of standardised thermograms recorded from normal subjects under identical conditions. During the past three years eight areas of the clinical procedure have been identified where variation and unreliable results can occur. Each of these areas has been investigated and solutions and recommended protocols have been developed.

1. Securing the full cooperation of the patient and referring physician. This is largely a question of supplying the correct information, to ensure that full cooperation during the examination, including the preparation time will be achieved.

2. The thermal imaging system, its reliability, calibration and stability.

3. Image capture. The use of standard positions and views of each area of the patient fitted to electronic masks provided by the software is a major step in standardisation.

4. Image analysis, the placing of shape and size of regions of interest. These have been defined to anatomical landmarks and may be incorporated into the software.

5. The storage and retrieval of thermograms, maintaining all data relating to the patient and the images that are essential for accurate repeat investigations.

6. The ability to transfer images electronically on and off line with full quantitative parameters intact.

7. Image presentation, ability to compare new images with reference data on screen, and to be clinically unambiguous.

8. To address the lack of knowledge and training issues relating to the clinical performance of the technique. The availability of archive and teaching materials, courses and education has been addressed.

## STATISTICAL ANALYSIS OF THE THERMOGRAMS IN MEDICAL DIAGNOSIS

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The medical thermograms are very often analyzed as a beautiful pseudo-colour picture.
It means any one or only some easier statistical analysis is made. Those statistical parameters like a mean, the standard deviation and the median value of a temperature is computed and used for comparison. This method helps us to "see" difference between regions but could not help us to correlate it with a correct medical diagnosis. This situation could be dramatically changed when we use more advanced method for thermal signal analysis.

In our work we present the other possibilities of thermograms comparison, which can be used in medical applications. It is suggested thats new parameters connected with a neural networks application help us to allocate correctly to the classification groups (diseased and healthy).

## INFRARED THERMOGRAPHIC ANALYSIS OF TEMPERATURE DISTRIBUTION ON THE SURFACE OF HUMAN TEETH DURING ND:YAG LASER IRRADIATION IN DEPENDENCE ON THE POWER AND REPETITION RATE OF THE LASER - IN VITRO STUDY

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*Aim*: This study was designed to use thermovisive method of temperature measurement to analyze the in vitro tooth surface temperature changes during Nd:YAG laser irradiation of human teeth with different power and repetition rate settings.

*Methodology:* A model was designed to allow temperature measurement with an

Infrared thermal imaging system. Upper extracted incisor was cut along its axis and placed in the dish with saline, in such a way that only a root was dipped. The external surface of incisor was coronally irradiated with the Nd:YAG laser for 30 s. The energy were varies from 1W to 5Wwith a repetition rate of 20 pps to 30 pps. Thermal change at the time of laser irradiation was measured coronally by thermovision. Measurements were repeated without saline in the dish.

*Results*: Our results revealed, that irradiation with Nd:YAG laser at 1 - 5 W applied on the external surface of human teeth elicited much higher temperature (even at above 200 degrees C at a power of 5W) when the tooth wasn't embedded in saline.

*Conclusions*: The Nd:YAG laser irradiation, applied on the external surface of human teeth may result in high temperatures in the root canal wall. Infrared thermography is a useful device for mapping patterns of temperature change over a large area.

## HYPOTHERMIC CHANGES OF SKIN TEMPERATURE

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Thermal imaging is a technique capable to map the temperature distribution on the human skin. In healthy subjects skin temperature is highly symmetrically distributed related to a symmetry axis situated in the median plane of the human body. In the extremities, higher temperatures are normally seen at the proximal end of the limb than on the tips of fingers or toes. Any disturbance of these normal temperature pattern may be detected either as hyperthermic or hypothermic area.

This paper will give examples of hypothermic skin changes, which may be caused by decreased blood flow, loss of muscle contraction, sympathetic hyperactivity induced by partial nerve lesion, lymphedema or artefacts due to the environment. Typical findings from patients with obstructive angiopathy . Raynaud`s phenomenon, motor deficit due plexus paresis, poliomyelitis, herpes zoster, radiculopathy, peroneal palsy and decreased range of motion induced by arthritis or arthodesis will be presented . The thermographic changes of common nerve entrapment syndromes such as carpal tunnel syndrome, thoracic outlet syndrome and ulnar nerve entrapment will be discussed. Cases of reflex dystrophy, thermal images from patients suffering from lymphedema and some artefacts causing hyperthermic changes of the skin temperature will close this lecture.

## TEMPERATURE EFFECTS OF THERMOTHERAPY DETERMINED BY INFRARED MEASUREMENTS

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This paper reviews the results of studies, in which the effects of heat or cold treatment were evaluated by infrared technology for temperature measurements. The advantages of infrared based temperature determination is measurement without contact and the ability to measure the surface temperature of an area simultaneously using either a scanning mechanism or a focal plane array. The limitation of this technique is the dependence of the results on both spectral and directional emissivity and the possible filtering effect of water on the surface of the object to be measured. Applying infrared measurements on living beings with a working temperature regulation system, generate further problems when temperature measurements need to be interpreted.

Infrared temperature measurements was used after application of various forms of cryotherapy such as cold air, nitrogen-air mixture, ice cubes or cold packs in both animals and humans. The effects of balneotherapy on skin temperature was investigated after thermo-neutral, hypo- and hyperthermic baths. The temperature course of hot packs used for medical treatment was studied and the influence of heat packs on the skin temperature of the human back has been shown. The depth of warming after application of ultrasound of different frequencies was clearly demonstrated by thermal imaging in a recent study. Older studies have used radiometers for measuring skin temperature after short wave application.

The change of skin temperature after application of various forms of heat and cold therapy is dependent on the duration of the treatment, the physical properties of the therapeutic agent, the body region treated and the thermal balance of the treated subject. Infrared technologies can reliable determine the temperature course of the treated surface.

## PROVOCATION TESTS WITH THERMAL IMAGING

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The majority of applications of thermal imaging In mediclne, depend on recording images of skin temperature after a period of preparation at a controlled temperature. If the subject is sufering from an inflammatory disease, lower room temperatures e.g.20°C are used. Other applications, which may be dependent on vasomotor activity, are recorded at 22-24°C. This is to maintain the vascular system in equilibrium, and avoid undue vasoconstriction.

However, there are situations where more information can be gained by the application of a physiological challenge. Thermal imaging can then be used to objectively record the response to challenge, which can be affected by some clinical conditions.

A challenge to the skin may take the form of a chemical, either topical or oral, a thermal (application of hot or cold) or mechanical.

An example of a chemical challenge may be the use of a skin test for allergy. Some agents such as nicotinic acid can be applied to the skin to assess the acute inftammatory response.

Thermal tests are more widely used for the evaluation of Raynaud‘s phenomenon.

The most widely accepted method is to record thermograms of the dorsal hand, before and at intervals after short immersion in water. Different authors have published their method where the water temperature is around 20°C or wider for 1 minute. In all cases the hands are kept dry by the use of plastic gloves. Imaging is then performed to assess recovery over 10-15 minutes.

In vibration injury to the hands, vasoconstriction by cold water immersion may be found, but the application of vibrating equipment to the fingers can be a sensitive method for detecting this form of neuro-vasacular injury.

A method, which proves to be reliable, is to use a water bath at 20°C, immerse the hands to the wrists for 1 minute, then after removal of the gloves, record thermograms at 10 and 15 minutes. By measuring the mean temperature of the fingers and the dorsal hand (MCP‘s to wrist area) before and after stress a good indicator of recovery can be calculated. Some normal subjects produce reactive hyperaemia, others fall to recover baseline temperatures, especially in Raynaud‘s phenomenon.

## DERMATOLOGICAL APPLICATIONS OF THERMOGRAPHY

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Generally, pathological processes based on microcirculation changes or inflammation development can be evaluated using thermographic protocols. As thermography is a noninvasive, non-contact, virtually devoid of side-effects method, it gains more and more applications in the clinical settings.

5km is the most easily accessible of all the Organs, thus is seems perfectly justifiable that thermography could be wider and wider used just also in dermatology. As many dermatological conditions either present systemic features or their liirther therapy requires different specific procedures, thus many specialists are generally involved in the management of a single patient. So, dermatological applications of thermography could overlap with oncology, rheumatology, surgery, alergology and others.

Thermography gains its clinical applications in diagnosis andlor differential diagnosis of many pathological conditions, evaluation of disease severity, management planning, monitoring of therapeutic effects including recurrence ofthe disease and metastases demonstration.

Thermography has been implemented in diagnosis ofboth vascular and pigmented skin lesions including angiomas, melanocytic naevi and malignant melanomas. This method is used in extensiveness evaluation ofchilblains, burns, ulcers ofvarious origins and their healing. Thermographic procedures are applied for the evaluation of psoriatic plaques severity, psoriatic arthritis, morphea - including plaque and linear forms, venous insufficiency, Raynaud‘s phenomenon in the development towards systemic sclerosis or even efficacy of hair regrowth in alopecia patients. They are also employed in monitoring of antiinflammatory treatment, cryotherapy, chemotherapy, engraftment or rejection of skin transplants and skin prick tests or patch tests evaluation.

Despite, quite an extensive literature data on the different dermatological applications of thermography, one has to bear in mmd that proper standardization protocols are absolutely prerequisite for this technique to become a screening and reliable one in dermatological practlce.

## THERMOGRAPHIC DATA ANALYSIS OF PSORIATIC SKIN LESIONS

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Psoriasis is a chronic, non-infectious inflammatory disorder affecting up to 2% ofthe population all over the word. lt is characterized by well-demarcated erythematous plaques covered by silvery scales. Inherited polygenic factors predispose to the development ofthis disease. Changes of dermal microvasculature, inflammation and epidermal hyperproliferation are well-recognized features of psoriatic plaques.

The purpose of our study was to perform thermographic analysis of psoriatic plaques presenting different degree of hyperkeratosis. Series of psoriatic lesions of different duration and localization were evaluated as for their induration, erythema and desquamation and were subsequently correlated with temperature measurements. The thermocamera INFRAMETRICS 760 was used in our investigation. Temperature resolution was 0. 1°C. The examined patients were prepared undressed for 20 min in a specially designed room before each thermographic examination.

Some correlation between thickness ofpsoriatic plaques and temperature measurements was observed.

However, despite widely accepted knowledge that thermography has quite a few invaluable advantages such as non-invasiveness and lack of side-effects, many properly designed, based on large number of cases studies are required in order to implement this technique as a prognostic tool ofpsoriatic plaque severity evaluation.

## INFRARED IN NEWBORN TEMPERATURE CONTFORT EVALUATION

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The specific solicitude to assure thermal comfort for a newborn is one of issues in neonatal health care. This highly important problem is based on:

1.The literature has shown increased mortality in cooled newborns

2.the influence ofhypothermia on the lenght of hospital stay - hypothermia prolongs hospital stay and increases treatment costs

3.the direct influence on medical treatment — hypothermia makes the effective care impossible int modern NICU's .

The thermal comfort is connected with the idea of neutral environment temperature — that is the temperature, at which a newborn does not lose ort gain heat and at which oxygen consumption is minimal.

Some doubts still exist, what is the optimal temperature of extremely bw birth weight newborn. Tables for optimal environment temperature warmth are at least 11 years old.

Abdominal skin and toe temperatures were measured, representing of central and peripheral temperatures. Temperature comfort is characterized by the level of three recorded temperatures: Core temperature >36°C, peripheral temperature >35°C, periphcral minus core tempcrature < 2°C. Abnormal temperature event is defined as the occasion where one or more than one of these variables is outside the normal range.

The aim of a study is the evaluation of infrared thermal imaging for the assessment of temperature comfort in newborns. 84 newborns with gestation age 25 —40 Hbd were examined. Body weight was between 750 and 3350g, 40 of them were boys, 44 girls. Babies were allocated into groups depending on gestation age and body weight.

The examination was performcd using ThermaCam PM5 95. The temperatures of forehead, abdominal skin and toe temperatures, differences between forehead and toe temperature and abdominal skin and toe temperature were analyzed.

Differences between temperature measured by the infrared camera and standard temperature measurements (axillary, rectal and skin temperature measured by thermocouple) were analysed..

Temperature obtained from standard procedures were different from temperatures measured by infrared. Optimal environmental temperatures taken from tables and controlled by infrared permitted the correction of the incubator temperature in almost half of the babies.

Conclusions: Temperature comfort evaluation at babies using infrared is simple, quick and usefiul method of monitoring.

## NEURAL NETWORK IN CLASSIFICATION OF BREAST THERMAL IMAGES

T.Jakubowska, B. Wiecek, M. Wysocki, C. Peszynski-Drews

Institute ofElectronics, Computer Thermography Group, Technical University of Lodz, Poland

An attempt was made to develop an automatic technique for the classification of healthy and malignant breast thermograms. 8 cases of healthy and 8 malignant cases were examined. Two infrared images were recorded of each breast: lateral and anterior views, resulting in a total 32 images for the database of this classification.

For each image 284 numerical features were defined.

First order histogram based features;

Gradient matrix based features;

Run length matrix based features;

Co-occurrence matrix based features calculated for matrices constructed for five distances between images pixels, and for fourth direction;

Wavelet transfomi based features.

From these features ten with highest discriminative power were selected. The selection of features-was tested, based on value of Fisher coefficient F and combined probability of classification error and average correlation between features (POE+ACC). The chosen features were used to classify healthy and malignant cases with two classifiers: the nearest neighbour classification test (l-NN) and artificial neural network (ANN).

When features were selected with POE+ACC methods neural network, all images were correctly classified..

| | | | Healthy | | Malignant | |
|---|---|---|---|---|---|---|
| View | | | Anterior | Lateral | Anterior | Lateral |
| Images | | | 8 | 8 | 8 | 8 |
| Classification of Errors | F | 1-NN | 2 | 0 | 3 | 0 |
| | | ANN | 0 | 0 | 1 | 0 |
| | POE+ACC | 1-NN | 3 | 0 | 2 | 0 |
| | | ANN | 0 | 1 | 1 | 0 |

## APPLICATION OF THERMOGRAPHY IN THE DIAGNOSIS OF EYELID MELANOMA INFILTRATING THE CHIN SKIN - A CASE REPORT

Mikulska D[1], Zejmo M[2], Czepita D[2], Maleszka R[1], Parafiniuk M[3]

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[2] Depart. Ophtalmology, Pomeranian Medical University, Szczecin

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Hyperthermic foci of malignant skin melanoma were described for the very first time by Brasfield in 1964. Further numerous studies on thermographic diagnosis oft that skin malignancy were performed. The results oft the studies report the applicability of thermovision in diagnoses of malignantskin melanoma. We present a case of melanoma of the upper right eyelid in patient, aged 52. Since the seventh year of life the patient had a dark-brown, pigmented lesion within the upper eyelid of the right eye. Three months before the referral, the lesion started to change pigmentation and dimensions. Physical examination revealed a tumor that obstructed the right orbital entrance. Laboratory findings, chest X-ray and abdominal ultrasound were normal. Computed tomography revealed the presence of a hyperdense tumor, 39 X 44 mm in diameter, infiltrating both the surface ofthe eyeball, the eyeball itself, and the orbital muscles. Also a pathological infiltration of the optic nerve has been noted. MRI studies revealed also infiltration of the soft tissues of the upper-right area of the nose. The histopathologieal studies confirmed the diagnosis of malignant melanoma in the tumor specimens. The thermographic examination using ThermaCAMTM SC500 camera revealed thermal asymmetry of the face with a focal hyperthermia located in the right cheek and chin. The histopathological examination of the patient's chin skin specimen, sectioned from the affected hyperthermic area seen in the thermographic studies, confirmed the presence of disseminated malignant melanoma cells. Due to the advanced stage of the cancer surgery was not applied. The case is presented due to the rare localization of the melanoma within the eyelid and the confirmation of local hyperthermia as malignant metastatic lesions to the skin ofthe patient's chin.

## COMPARISON OF THE LAND FTI MV AND THE FLIR SC 500 THERMAL IMAGING CAMERA

Plassmann P, Jones C, Ring F

Medical Imaging Researeh Group, University ofGlamorgan, Pontypridd, UK

Two thermal imaging systems one radiometric and one low cost focal plane array (FPA) camera have been compared under labo-

ratory conditions. The FPA of the Land has half the resolution of the Flir camera (320 x 240).

Both systems were connected to dedicated PC's. The Flir system was connected to a workstation running CTHERM software, the Land System was connected to a PC running Land software.

The Flir SC 500 relies on internal calibration and calibration data contained in the Ienses to provide accurate temperature measurement. In contrast the Land FTI Mv uses two external heat sources for regular recalibration,

A number of image attributes were tested including; noise and uniformity, spatial resolution, and stabiiity. The cheaper Land camera performed well in comparison to the Flir eamera in all tests apart fiom the Spatial Resolution test. Using a heated bar chart the Flir eamera resolved to better than l mm whereas the Land eamera under the same conditions resolved to 3mm. Due to its poor performance in the stability test the Flir camera was returned to the manufacturer where a fault was diagnosed. The Flir camera showed significant improvement in stability following repair and recalibration.

These results show that the low cost Land FTI Mv camera with external calibration can produce stable images suitable for medical applieations. The results also highlight the need for regular monitoring of camera performance.

## THERMOGRAPHIC DIAGNOSIS OF PERIODONTAL AREA IN 16-17 YEARS OLD HEALTHY ADOLESCENTS

Dorota Burchardt*, Szczesny G6rski **

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** Radiophysical Laboratory, J.Strus Municipal Hospital ,61-833 Poznan, Szkolna 8/12 Street, Poland

Thermographic methods have been used in dentistry for diagnostics and for assessment of the effects of treatment of soft tissues (periodontum), for assessment of the effects of endodontic treatment, in implantology, for assessment of the effect of laser treatment on dental pulp and in assessment of reactivity of periodontum vessels in IDDM sufferers.

The aim of the study was to propose a thermographical model (reference standard) and compare the results of the clinical and thermographical assessment of the periodontal tissues in healthy adolescents.

The subjects ware 18 healthy adolescents, 16-17 years old, whose family members were free from periodontal diseases, did not experience bleeding on teeth brushing and were in generatly good health. The level of the oral cavity hygiene was described with the help of plaque index PI-I after Silness & Löe. The periodontal status was described with the help of Gl after Silness & Löe and SBI after Mühlemann & Son.

The thermographic study was performed with an AGA Thermovision System 680 under standard conditions for thermo graphical analysis.

The thermographical analysis revealed that the periodontal tissues of all subjects were free from periodontal diseases.

The clinical and thermographical analysis was performed for the periodontum in the neighbourhood of the upper jaw incisors. The reactivity of the blood vessels was determined on cooling. The thermographic measurements ware made prior to the cooling (T0) and 1 (T1 ),2 (T2),3 (T3), and 4 (T4) minutes after cooling with cold water of a constant temperature (1°C). The minimum, maximum and mean weighted temperatures ware calculated separately for the left and right hand side of the periodontum.

The mean weighted temperatures of periodontal tissues in healthy adolescents were: T0 = 32.7°C, T1 = 27.6 °C, T2 = 27.9°C, T3= 28.5°C, T4 = 28.9°C

The model values of the temperatures and the corresponding thermographic images obtained from these people can be used in further studies as reference standards.

# Generalversammlung der Österreichischen Gesellschaft für Thermologie am 24.2.2004

**T. Schartelmüller, K. Ammer**

Österreichische Gesellschaft für Thermologie, Wien

Die Eröffnung durch den Präsidenten erfolgt um 19:30 Uhr. Da die Zahl der anwesenden Mitglieder nicht zur Beschlussfähigkeit ausreicht, wird der Beginn auf 20:00 Uhr verschoben.

## Bericht des Präsidenten

Die Österreichische Gesellschaft für Thermologie hat derzeit 28 Mitglieder (26 ordentliche Mitglieder, 1 außerordentliches und 1 Ehrenmitglied). Es wurde angeregt, über Strategien zur Werbung neuer Mitglieder nachzudenken.

Die Zeitschrift Thermology international wird seit 2002 in der Datenbank Embase gelistet. Zur Zeit sind aus diesem thermologischen Journal insgesamt 25 Artikel in dieser zweit wichtigsten medizinischen Datenbank zu finden. Der Verlag Elsevier, der Embase betreibt, hat sein Interesse bekundet, Artikel,die vor 2002 in Thermology international publiziert wurden, ebenfalls in die Datenbank aufzunehmen.

Das 15.Thermologische Symposium hatte die Qualitätssicherung sowie Neuentwicklungen in der Infrarotthermographie zum Thema. Referenten aus Großbritannien, Polen und Österreich berichteten über den derzeitigen Stand in der Entwicklung von Standards zur Aufnahmetechnik von Infrarotbildern. Die medizinische Anwendung von Verfahren, die vermehrt in der Technik zur zerstörungsfreien Überprüfung eingesetzt werden, wurde ebenso diskutiert wie der Einsatz der Infrarotthermographie in der Angiologie, Augenheilkunde und als Outcome Measure nach Trainingstherapie.

Das 16.Thermologische Symposium war Teil des 9. Europäischen Thermologiekongresses, der 2003 in Krakow statt fand. Diese Veranstaltung zog 80 Teilnehmer aus Europa, Amerika und Asien an. Die Österreichische Gesellschaft für Thermologie war mit insgesamt 8 Vorträgen vertreten.

Das 17. Thermologische Symposium ist wegen der Häufung von thermologischen Kongressen im Frühjahr 2004 (Zakopane, Auburn, Seoul, München) für den Herbst mit dem Generalthema "Infrarotthermographie als Outcome Measure" geplant.

## Bericht des Kassiers

In den Jahren 2002 und 2003 konnten dank der Mitgliedsbeiträge und Spenden leichte Zuwächse des Vereinsvermögens erzielt werden.

Die Überprüfung der Buchhaltungsunterlagen ergab keine Unregelmäßigkeiten, daher konnte nach Antrag des Rechnungsprüfers der Kassier und somit auch der Vorstand entlastet werden.

## Mitgliedsbeitrag 2004/2005

Der Antrag des Präsidenten auf eine Reduktion des Mitgliedsbeitragesfür Mitglieder im Ruhestand findet keine Mehrheit. Damit bleibt der Beitrag für alle weiterhin 40 Euro.

## Neuwahl des Vorstandes

| | |
|---|---|
| *Präsident:* | Prof. DDr .Kurt Ammer |
| *1.Vizepräsident:* | Prof. Dr. Otto Rathkolb |
| *2.Vizepräsident:* | Prim. Dr. Thomas Maca |
| *Kassier:* | Prim. Dr. Johann Mayr |
| *Sekretär:* | Prim. Dr. Thomas Schartelmüller |
| *Rechnungsprüfer:* | Dr. Peter Melnizky,<br>Dr. Brigitte Engelbert |

Die Wahl des neuen Vorstandes erfolgt ohne Gegenstimmen.

Schluss der Generalversammlung: 20:30 Uhr.

# Veranstaltungen (Meetings)

### June 5-6, 2004

The **6th International Congress of Thermolog**y combined withl3th Annual Meeting of the Korean Academy of Medical Thermology

*Venue:* Konkuk university, New Millennium Hall
#l Hwayang-dong Gwangjin-gu, Seoul 143-701, Korea

Tel +82-2-455-1896-7, Fax +82-2-455-4084
http://www.konkuk.ac.kr

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Tel : +82-2-3497-3390, Fax +82-2-3461-9229
E-mail: ydnscho@yumc.yonsei.ac.kr

### June 25.-27 .2004

**Jubiläumskongress** der Deutschen Gesellschaft für Thermographie und Regulationsmedizin in München Deutschland

*Information:* Deutsche Gesellschaft für Thermographie und Regulationsmedizin e.V.,

An der Steig 6, D-88483 Burgrieden-Rot,
Tel. +49 7392 704945 oder +49 160 96712989
Email: reinhold.berz@inframedic.de
WebSite: http://www.thermomed.org

### June 30 -July 2, 2004

**Short Course**
**on InfraRed Thermal Imaging in Medicin**e at the University of Glamorgan, School of Computing, Medical Imaging Research Group,
Pontypridd CF37 1DL, Wales, United Kingdom

**Topics:** Thermal Physiology and skin temperature,

Standardised techniques for clinical examination,

Clinical applications of IR imaging;
Peripheral vascular diseases, pain syndromes etc.

IR camera Systems, Image capture, Image processing,

Setting up a thermal imagiong facility

Methods of quantitation, Future developments

This is a course recognized by the University, leading to a certificate for IR imaging techniques in medicine.

**FEE:** £ 300.- includes a CF of archived publications and hardback book "The Thermal Image in Medicine Biology"

Prior reservation is essential !

**Faculty** will include
Prof K Ammer MD, PhD (Vienna)
Prof FJ Ring Dsc FIPEM (Glamorgan)
Dipl Ing (FH) P Plassmann PhD (Glamorgan)
Dr R Thomas (Swansea)

**Accomodation available.**

**Application forms** from Prof Ring, Medical Imaging Research Group; School of Computing, University of Glamorgan, Pontypridd CF37 1DL, UK, efring@glam.ac.uk

### July 5-8, 2004

**7th International Conference on Quantitative Infrared Thermography** - QIRT 2004

von Karman Institute for Fluid Dynamics,
Rhode-St-Genèse, Belgium

*Information:* QIRT2004 secretary

von Karman Institute for Fluid Dynamics
Chaussée de Waterloo, 72
B-1640 Rhode-St-Genèse, Belgium

Phone : +32 359 96 11Fax : +32 359 96 00
Additional information available on the QIRT'2004 web site:www.vki.ac.be/qirt2004

### September/October 2004

**17th Thermological Symposium** of the Austrian Society of Thermology and the Ludwig Boltzmann Research Institute for Physical Diagnostics

*Venue*: Hanuschkrankenhaus, Sitzungszimmer
Heinrich Collinstr. 30, 1140 Wien
*Main Theme:* Outcome measure thermal image

*Information:* Prof Dr Kurt Ammer PhD

Ludwig Boltzmann Research Institute for Physical Diagnostics, Heinrich Collinstr. 30, A-1140 Wien

Tel: + 43 1 914 97 01 Fax: +43 1 914 92 64
Email: lbfphys@a1.net or KAmmer1950@aol.com

return to TOC

# Thermology international

Dr. Kurt Ammer
Österreichische Gesellschaft für Thermologie

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Österreich

This journal is a combined publication of the Ludwig Boltzmann Research Institute for Physical Diagnostics and the Austrian Society of Thermology. It serves as the official publication organ of the European Association of Thermology (EAT), the American Academy of Thermology, the German Society of Thermology, the UK Thermography Association (Thermology Group) and the Austrian Society of Thermology. An advisory board is drawn from a panel of international experts in the field. The publications are peer-reviewed.

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Österreichische Gesellschaft für Thermologie

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Österreich

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