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Thermal imaging as outcome measure

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This issue of Thermology international contains a number of papers, which report the medical use of therma imaging as an outcome measure in dermatology, surgery, neurology and sports medicine. In principle, thermal imaging can be applied in medince either as a diagnostic test or as outcome measure in clinical trials (1). Although the technique started as diagnostic procedure for breast cancer (2), both applications have a long history in medical thermography,.A recent review on the topics of presentations at the European congresses of Thermology found that roughly 10 percent of all presentations were related to thermal imaging as outcome measure (3). A similar percentage was reported in the annual review of publications related to thermal imaging and temperature measurements in medicine and biology (4).

When treatment modalities add or remove heat from the human body, the resulting change of temperature may be utilised as outcome measure of such a therapy. Thermal imaging has already been applied for recording changes induced by thermotherapy (5), but publications of cryotherapy in dermatology are scarce. A group of Polish dermatologists report in this issue (6), that patients with akne rosacea react different to cooling with carbondioxid snow than healthy subjects. A faster recovery of the skin temperature after cold exposure in akne patients may also be indicative for skin inflammation in this disease.

Thermal imaging was used to evaluate the effects of anti-inflammatory drugs or compounds for the treatment of Raynaud´s phenomenon (1). Few papers reported the use of thermography as outcome measure in clinical trials of headache paper (7). Dr. Govindan describes in this issue (8) the temperature ratio of the forehead to the nose as new outcome measure in drug treatments for migraine patients.

Sufficient perfusion of skin flaps is a critical issue in plastic surgery. Several methods for preconditioning of tissue has been developed to increase tissue viability (9). A group from Norway investigated transcutaneous electrical nerve stimulation as means to increase the perfusion of the skin and the subcutaneous tissue. They used thermal imaging in this study as outcome, but could not detect significant changes in infrared thermal and Doppler flow images, which could have been indicative for tissue preconditioning (10)

Finally, muscle contraction will affect skin temperature (11). Also massage can lead to temperature changes on the body´s surface (12). The influence of massage on a graded exercise test is reported in this issue and thermal imaging was applied as outcome measure (13).

A main feature of outcome measures is the reliability of the measurement. There is sufficient evidence that thermal imaging is a reliable outcome measure (14)which may be used in a variety of medical applications.

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Dynamic thermography for the monitoring of flushing in patients with rosacea

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SUMMARY

The aim of the study was to introduce thermography in the evaluation of thermal reaction in the facial skin exposed to superficial cooling with application of snow paste in patients with rosacea and in healthy controls.

MATERIAL AND METHODS: The study enrolled 40 individuals including 20 rosacea patients and 20 healthy volunteers without any clinical, mycological and parasitic lesions in facial skin. Superficial cooling was applied using snow paste i.e. mixture of solid carbon dioxide and ether. Both, the areas of the face with rosacea lesions in patients and the corresponding skin areas in healthy volunteers were exposed to carbon dioxide snow . The skin was stimulated with massage using snow paste with light pressure lasting from 5 to 8 s (including each cheek area for ca 0.5 s). The distribution of temperature changes in the treated skin areas was monitored with a ThermaCAM™ SC 500 thermovision camera. Thermal images were analyzed using the computer software ThermaCAM Reporter 2000 Professional and the following temperature parameters: Tmax- maximal temperature, Tmin- minimal temperature; Tavg- average temperature were displayed

RESULTS: The baseline mean temperature of the cheek skin in patients with rosacea was 1.8 °C higher than the mean skin temperature of the cheek in healthy volunteers.

Following the application of carbon dioxide snow to the facial skin, the skin temperature returned faster to baseline readings (after 3 minutes on the average) in rosacea patients than in the control group which showed a slower temperature recovery (baseline values were established after 6 minutes on the average).

10 minutes after cooling the final average temperature (Tavg) was by 1.4 °C higher than the baseline readings in rosacea patients, and by 0.4 °C in healthy volunteers.

CONCLUSION: The period of thermal recovery of the same areas of facial skin in response to superficial cooling is shorter in rosacea patients than in healthy volunteers.

KEY WORDS: Thermography, cooling, rosacea, flushing

DYNAMISCHE THERMOGRAPHIE FÜR DAS MONITORING DER GESICHTSRÖTE BEI AKNE ROSACEA

Das Ziel der Studie war es die Infrarotthermographie zur Evaluierung der thermischen Reaktionen der Gesichtshaut einzusetzen, nachdem bei Patienten mit Rosazea und bei gesunden Personen das Gesicht mittels "Schnee-Paste" oberflächlich gekühlt worden war.

PATIENTENGUT UND METHODE: Insgesamt wurden 40 Personen untersucht und zwar 20 Rosazea-Patienten und 20 gesunde Freiwillige, die keinerlei klinische, mykologische oder parasitäre Zeichen an de Gesichtshaut boten. Eine oberflächliche Kühlung wurde mit "Schnee-Paste" einem Gemisch aus fester Kohlensäure mit Äther durchgeführt. Sowohl die Gesichtshaut mit Rosazea-Veränderungen der Patienten als auch die entsprechende Gesichthaut bei den Gesunden wurden mit Kohlensäureschnee behandelt. Dabei wurde der Kohlensäureschnee unter geringem Druck 5 bis 8 Sekunden lang einmassiert. (die Behandlung beider Wangen dauerte dabei jeweils 0,5 Sekunden) Die Verteilung der Temperaturveränderungen im Bereich der behandelten Haut wurde mit einer ThermaCAM™ SC 500 Thermographie-Kamera erfasst. Die Wärmebilder wurden mit dem Software-Paket ThermaCAM Reporter 2000 Professional analysiert und die Temperaturwerte: Tmax- Maximaltemperatur, Tmin- Minimaltemperatur und Tavg- Durchschnitttemperatur dargestellt

ERGEBNISSE: Die Ausgangsswerte der durchschnittlichen Hauttemperatur der Wangen war bei Rosazea-Patienten um 1.8 °C höher als bei gesunden Freiwilligen.

Nach der Anwendung von Kohlensäureschnee an der Gesichtshaut erreichte die Hauttemperatur von Rosazea- Patienten rascher den Ausgangswert (im Durchschnitt nach 3 Minuten) als bei Gesunden (im Durchschnitt nach 6 Minuten).

10 Minuten nach der Kühlung fand sich bei Rodazea-Patienten eine finale Durchschnitttemperatur (Tavg), die um 1.4 °C über dem Ausgangswert lag. Gesunde boten eine Temperaturerhöhung von 0.4 °C im Vergleich zum Zeitpunkt vor der Kühlung.

SCHLUSSEFOLGERUNG: Im Anschluss an eine oberflächliche Kühlung erreicht ein vergleichbares Areal des Gesichthaut bei Patienten mit Rosazea rascher die Ausgangswerte als bei gesunden Kontrollpersonen.

SCHLÜSSELWÖRTER: Thermographie, Kühlen, Rosazea, Erröten

Thermology international 2006; 16: 126-128

Introduction

Rosacea is a common, chronic dermatological disease with pathologic eruptions presenting mainly within the facial skin. Manifestation of symptoms occurs usually at the age of 30 and the peak exacerbation of the disease is seen between 40th and 60th year of life. Rosacea occurs in four clinical forms with characteristic features including: transient or persistent erythema, telangiectasiae, papules, pustules, nodules and plaques (1). The cause of rosacea remains unclear. The factors predisposing to rosacea include vasomotor abnormalities associated with the autonomous nervous system, and gastrointestinal disturbances, most frequently hypo-chlorhydria and Helicobacter pylori infections. Other factors include endocrine disorders, sunlight and arterial hypertension. Also statistically significant higher rates of infection with mites demodex folliculorum and yeast-like fungi (mainly Pityrosporum species) have been found (2).

Moreover, the etiopathogenesis of rosacea is not consistent and we lack uniform diagnostic criteria for that disease. The presence of facial erythema for at least 3 months is currently believed to be the most important clinical symptom (1). The important diagnostic symptom is flushing and characteristic location of skin eruptions, mainly in the mid-facial area. Skin erythema may be caused by disturbances in vascular homeostasis associated with humoral or neural factors (3). Erythema may be also caused by factors such as hot food and spices or ultraviolet exposure (4). Professional exposure to heat is believed to be one of the most important causes of rosacea (5). Moreover, the facial skin contains an increased number of skin vessels, which diameter sare larger, and which site is more superficial when compared to skin vessels in other body areas.

In order to differentiate rosacea and other skin diseases including common acne, perioral dermatitis, systemic lupus erythematosus, dermatomyositis, carcinoid, diabetes mellitus, mastocytosis and other, the diagnostic criteria for rosacea are still sought (1). The etiology of rosacea remains unknown; however, it seems that abnormalities of facial skin vessels exposed to many environmental factors play an important role in the pathogenesis of rosacea.

The aim of the study was to introduce thermography in the evaluation of thermal reaction in the facial skin exposed to superficial freezing with application of snow paste (solid carbon dioxide with ether) in patients with rosacea and in healthy volunteers.

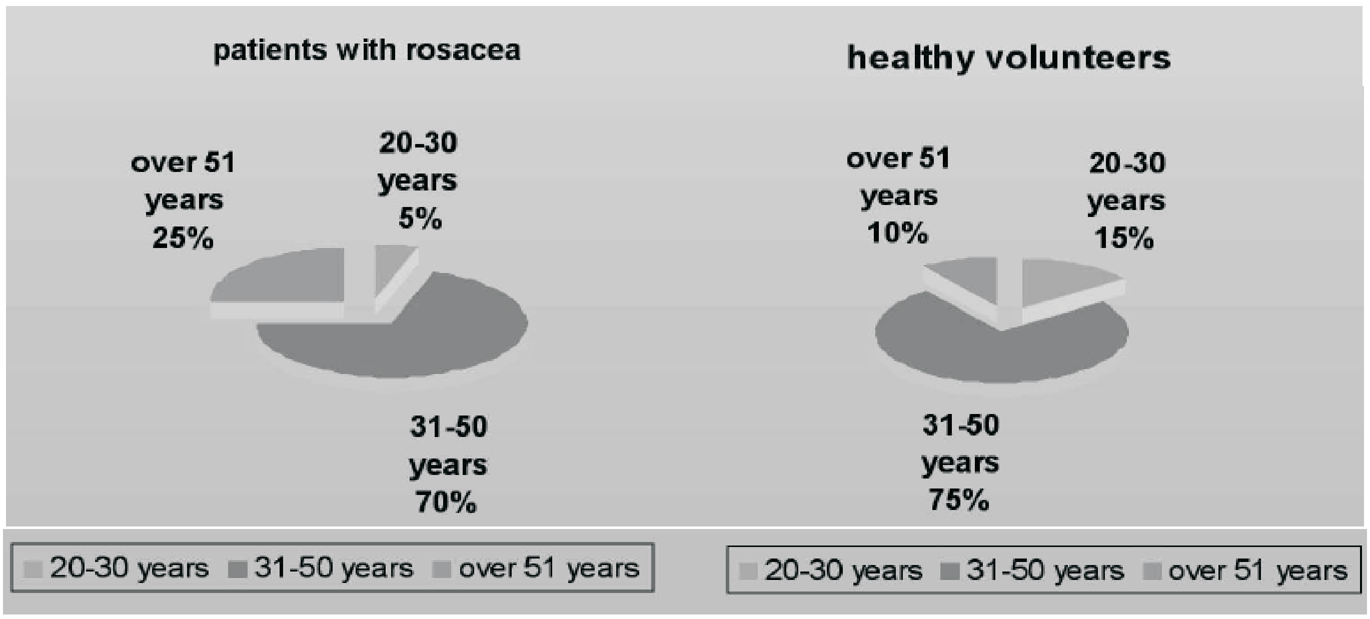
Material and methods

The study enrolled 40 individuals including 20 patients with rosacea diagnosed and classified according to National Rosacea Society Expert Committee criteria (1). The rosacea patients belonged either to the clinical subgroup erythemato-telangiectatic (65% of studied individuals) or papulo-pustular (35% of studied individuals). For rosacea patients the following criteria excluded from enrollment: coexistence of general diseases and current pharmacological therapy, the presence of Demodex folliculorum at rates higher than 5 parasites/1 cm² within the affected skin, positive mycological testing for Pityrosporum sp.; coexistence of allergic contact eczema confirmed by skin patch tests or irritation eczema; application of local corticosteroid therapy.

The control group enrolled 20 healthy volunteers without any clinical, mycological and parasitic lesions in facial skin. Healthy volunteers were not taking any medications, and have not received any cryotherapy procedures in the past 6 months. Twenty studied rosacea patients and 20 healthy volunteers were age-matched with the majority of individuals in the age group between 31 and 50 years (Figure 1).

Superficial cooling was applied using snow paste i.e. mixture of carbon dioxide snow and ether. The sublimation temperature of carbon dioxide is -78,9°C. The location of

Figure 1
Age distribution in rosacea patients and healthy volunteers



rosacea lesions on the face was determined in patients and the same skin areas were exposed to carbon dioxide both in patients and in healthy volunteers. The skin was stimulated with carbon dioxide snow and massage with light pressure was apllied for 0,5 s on the cheeks, while total massage time ranged from 5 to 8 s. Facial skin massage was performed always by the same person. The distribution of temperature changes in the areas of facial skin exposed to carbon dioxide snow was monitored with a ThermaCAM™ SC 500 thermovision camera. The study was performed according to approved guidelines for thermovision measurements (6). During the study the following conditions were maintained: all procedures were performed in the same indoor facility, with bright walls, constant room temperature (22-23 °C) and humidity (50%). The adaptation period in the room temperature was ca 15 minutes and the distance between the studied person and the camera was 1 m. The thermovision camera recorded skin temperatures before, during application of carbon dioxide snow and continuously for 10 minutes after cessation of cooling.

The results of the study were analyzed with the computer software ThermaCAM Reporter 2000 Professional and temperature values were displayed in centigrades (°C). According to experts' guidelines the regions of interest for measuring thermal changes with the option to repeat the measurement in the region were recorded in the study protocol (7). The same triangle- shaped area of left cheek and corresponding area of the right cheek were evaluated. The thermograms recorded were stored on a computer hard disk. The final evaluation included temperature measurements in all 40 studied subjects, which were extracted from triangle-shaped areas of cheek skin prior and up to 10 minutes after cooling in 1-minute intervals.

The following parameters were analyzed Tmax- maximal temperature, Tmin- minimal temperature and Tavg- average temperature- according to the previously described protocol (8). The statistical analysis was performed with Statistica software.

Results

In rosacea patients the average temperature was 35, 1 °C and in healthy volunteers - 33, 1 °C. The difference was statistically significant as shown in the figure 2. Figure 3a shows thermogram obtained from the female diagnosed as rosacea patient with increased facial skin temperature, figure 3b shows the same female patient during snow paste applied to rhe cheek. Figure 3c shows rosacea patient 3 minutes after cessation of the cooling procedure with corbon dioxide snow. In comparison, figures 4a, b, c show

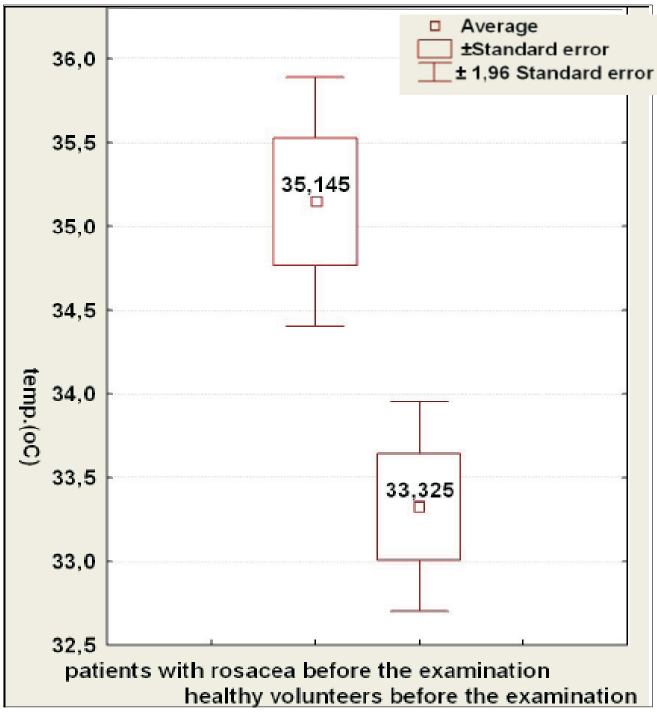


Figure 2
The comparison of average temperatures of examined cheek skin before cryostimulation in patients with rosacea and healthy volunteers.

successive thermograms before, during and after cooling of the cheek obtained in female from the control group. Application of carbon dioxide snow to the cheeks resulted in lower temperatures in healthy volunteers (29, 8 °C on the average) than in rosacea patients (31,1°C on the average).

The recovery time to baseline temperatures was shorter in rosacea patients (3,7 minutes on the average) than in control subjects (6,4 minutes on the average) after cessation of application of carbon dioxide snow (Figure 5). In both groups- rosacea patients and controls- the final buccal skin temperatures obtained 10 minutes after cooling were higher than baseline temperature. However, the temperature increase of the buccal skin was greater (1,5°C on the average) in the rosacea group than in healthy controls (the mean temperature rise from baseline was 0,9°C). This difference was statistically significant at $p<0,001$.

Figure 6 shows the comparison of the mean of median temperature changes at the left cheek in successive minutes after cooling with snow paste between patients with rosacea and the healthy volunteers. As shown in table 1, statistically significant differences were found between rosacea pa-

Table 1
The comparison of differences of mean of median temperature changes at the left cheek in successive minutes after cooling between patients with rosacea and the control group.

Time (min	Patients with rosacea (n=20)	Healthy volunteers (n=20)	p-value
0-1	2.7	1.6	p>0.01
1-2	1.5	0.8	p>0.02
2-3	0.4	0.5	p>0.7

tients and control group in the course of mean temperatures during first 2 minutes following the skin cooling .

Discussion

The use of infrared thermographic camera allows precise monitoring of influence of temperature on skin as previously described by Ammer (9). The measurements of infrared radiation provides means for the evaluation of different modalities of cryotherapy (10, 11,12). Different durations of decreased skin temperature have been reported after applications of cold gel and ice packs (10). The application of the cold gel with or without skin rubbing can

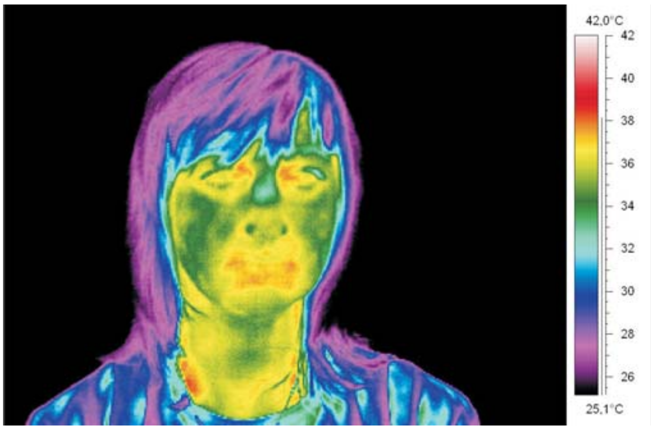


Figure 3a

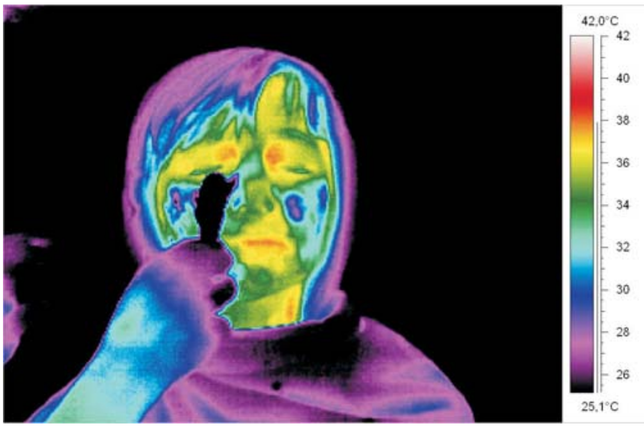


Figure 3b

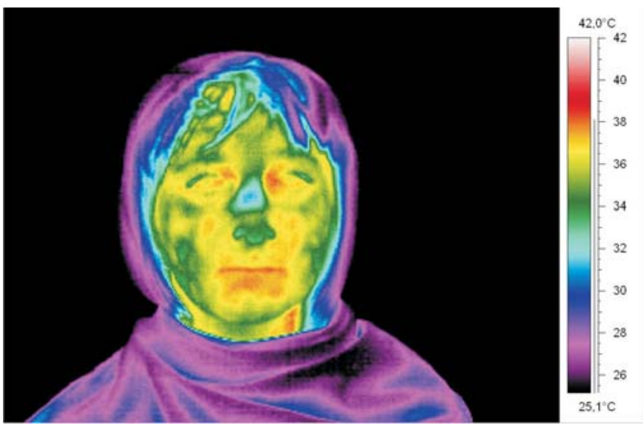


Figure 3c

Figure 3a, b, c
Thermal images of the face of the female patient with rosacea:
a.) before cooling,
b.) the superficial cooling with application of snow paste (solid carbon dioxide with ether),
c.) the same female patient three minutes after cooling

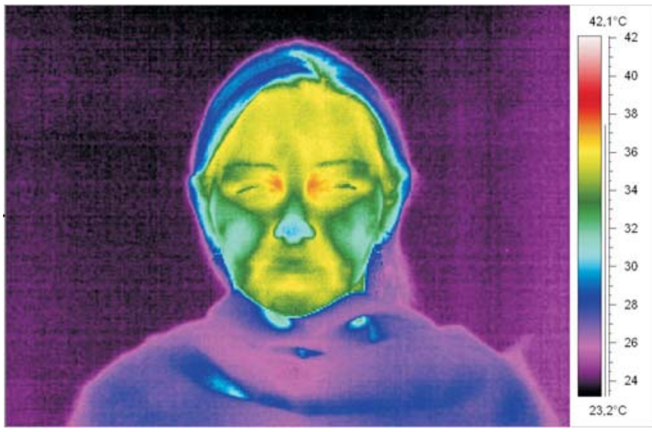


Figure 4a

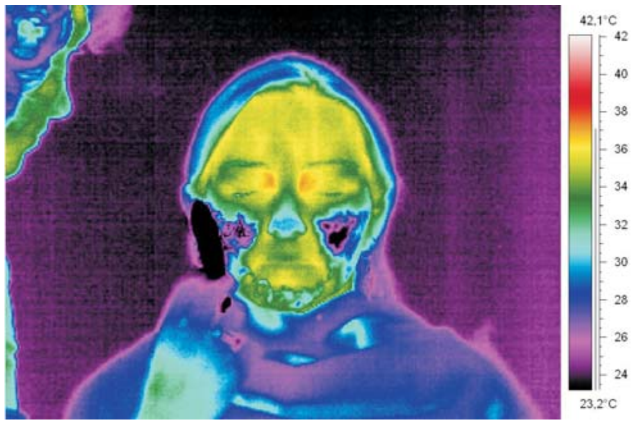


Figure 4b

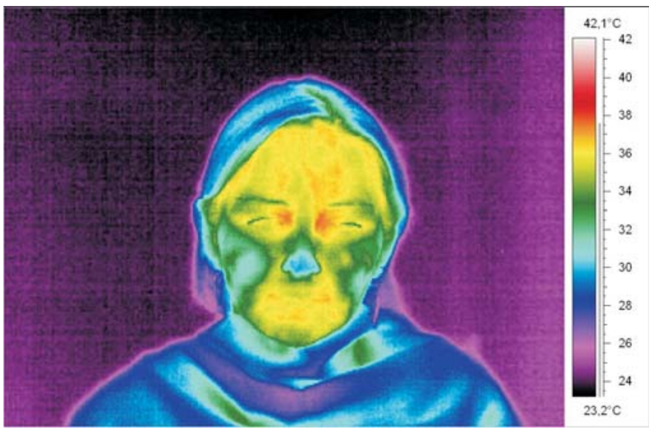


Figure 4c

Figure 4 a, b, c
Thermal images of the face of the healthy female volunteer :
a.) before freezing,
b.) the superficial freezing with application of snow paste (solid carbon dioxide with ether),
c.) the same female patient three minutes after freezing

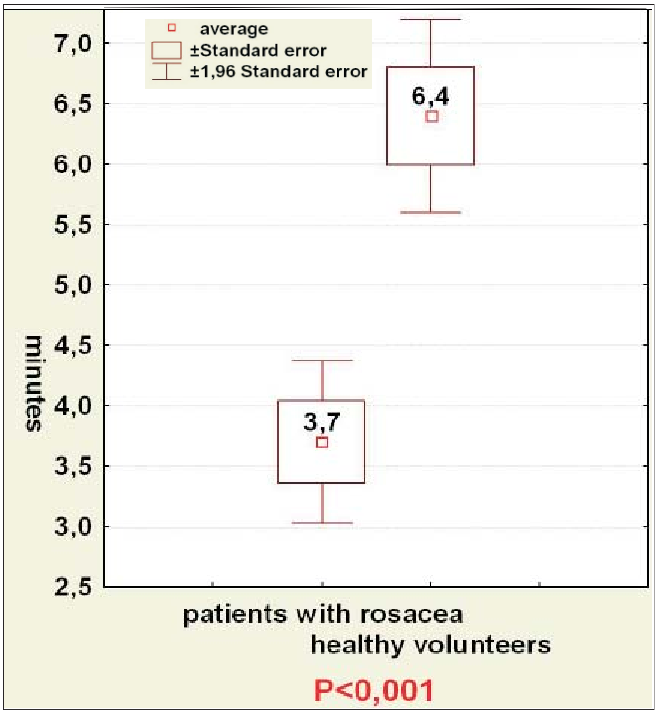


Figure 5
Recovery to baseline temperatures: rosacea patients versus healthy volunteers.

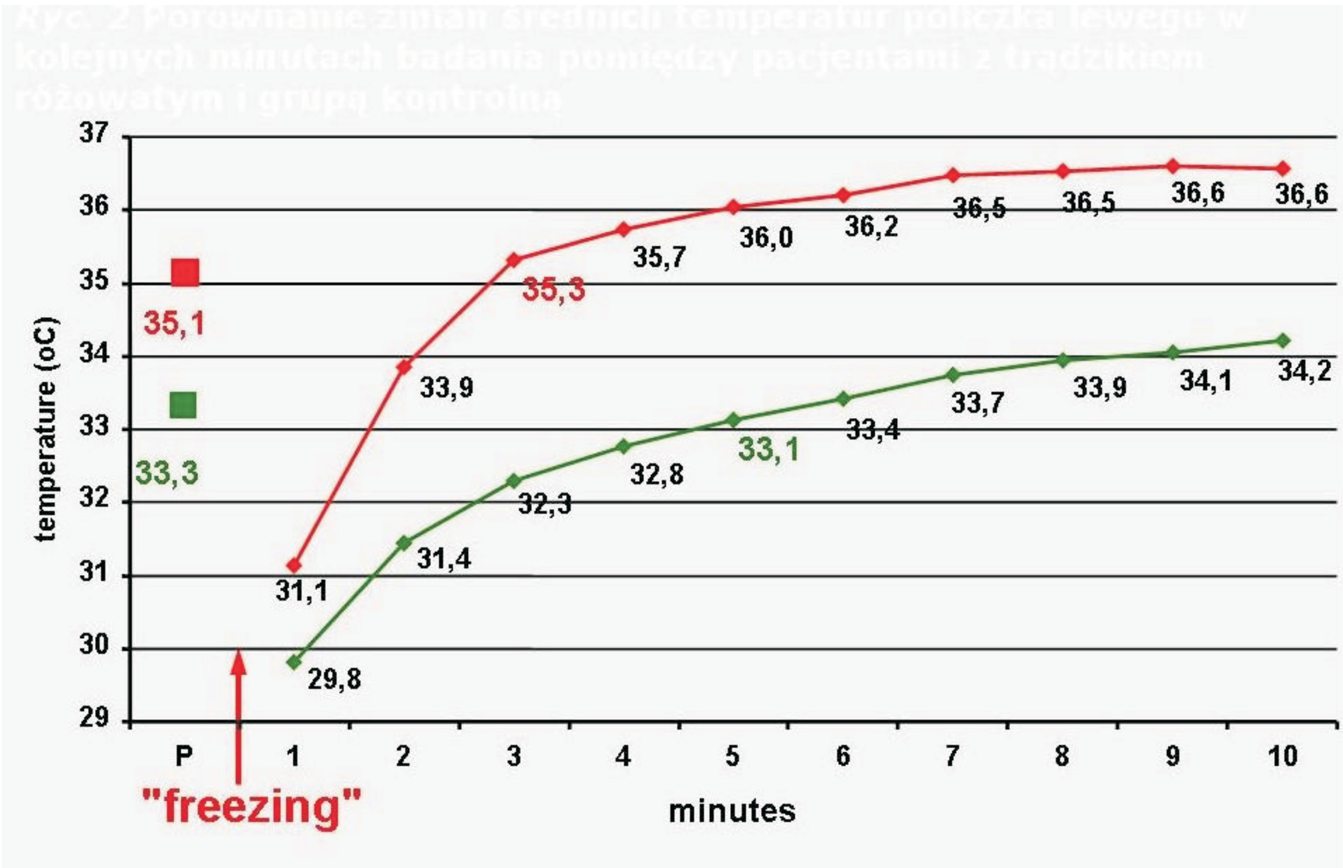
also affect the time course of skin temperature (11). Skin temperature reactions after cryotherapy may vary in healty and diseased subjects (12).

Thermal imaging is an complementary diagnostic method in rheumatology and in diagnosis of other inflammatory processes (13). The cold water challenge is applied for the diagnostic evaluation of Raynaud's phenomenon (14, 15).

The thermographic monitoring of temperature changes following cooling of the cheeks with dry ice revealed that the facial skin reacted differently in rosacea patients and in healthy subjects. During the first 2 minutes following the superficial cooling, the temperature of the skin rises rapidly leading to statistically significant differences in the course of mean temperatures between rosacea patients and healthy controls. That dynamic phenomenon may correspond clinically with the "flushing" reaction found and characteristic for rosacea patients (16). The clinical picture includes facial erythema, especially distinct in midfacial area, presenting after exposure to some factors like hot drinks or spices, chocolate or alcohol.

The research on flushing phenomenon in rosacea is aimed to find therapeutic methods that could inhibit that reaction in patients (17). Moreover, the diagnostic criteria for rosacea are still under research (1,2). This is an important issue since it may facilitate the differentiation between rosacea, especially in early erythemato-telangiectatic stage, and other

Figure 6
The comparison of mean changes of median temperatures of the left cheeks in successive minutes of cooling with snow paste between patients with rosacea and the control group.
P – before freezing, upper line – patients with rosacea, lower line - healthy volunteers.



diseases such as lupus erythematosus. This is important for further diagnostics and treatment in rosacea patients (18).

Conclusions:

1. The period of thermal recovery of the same areas of facial skin in response to superficial cooling is shorter in rosacea patients than in healthy volunteers.

2. Infrared thermal imaging may be a complementary diagnostic method in the evaluation of facial skin vessel homeostasis in rosacea patients.

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Zolmitriptan Nasal Spray in the Treatment of Migraine

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SUMMARY:

Migraine patients have both intra and extra cranial vasomotor abnormalities. In migraine there are associated changes in neuropeptides eg., CGRP and it´s effects on the trigeminovascular system.

Infrared Imaging of Extracranial/Facial bloodflow and vasomotor response with induced hyperoxia before and after treatment with Zomig« (Zolmitriptan) Nasal Spray, a drug approved in the treatment of acute migraine was done in this case. In migraine vasomotor abnormalities are imaged as asymmetrical perfusion/facial temperature pattern by thermography. Subjecting the patient to vasomotor and pharmacological challenges during migraine can help us to understand the pathophysiology.

KEY WORDS: Zomig (Zolmitriptan) Nasal Spray ,Hyperoxia, Migraine, Forehead-Nose Thermal Ratio.

ZOLMITRIPTAN-NASENSPRAY FÜR DIE MIGRÄNEBEHANDLUNG

Migränepatienten zeigen intra-und extrakraniale vasomotorische Fehlfunktionen. Bei Migräne kommt es zu assoziierten Veränderungen der Sekretion von Neuropeptiden wie z. B. des CGRP und ihren Einflüssen auf das trigeminovaskuläre System.

Mittels Infrarot Thermographie wurde bei einem Patienten die extrakraniale Gesichtsdurchblutung und die durch Sauerstoff induzierte vasomotorische Reaktion vor und nach Behandlung mit Zomig« (Zolmitriptan) Nasal Spray, einem für die Behandlung von Migräneattacken zugelassenen Medikament, untersucht. Bei Migräne stellen sich die vasomoto- rischen Störungen thermographisch als asymmetrische Verteilung der Gesichtstemperatur als Ausdruck der veränderten Durchblutung dar. Die pharmakologische Provokation von vasomotorischen Reaktionen im Migräneanfall kann zu einem besseren Verständnis der Pathophysiologie der Erkrankung beitragen..

Schlüsselwörter: Zomig (Zolmitriptan) Nasen-Spray, Hyperoxia, Migräne, thermisches Stirn-Nasen-Verhältnis.

Thermoogy intetrnational 2006, 16 (4): 132-137

Introduction

Thermography images perfusion and can monitor dynamic changes in vasomotion related to pathophysiology. The clinical history can help to correlate vascular pathology with symptoms.. In migraine the apparent paradox of distended cranial arteries and decreased tissue perfusion led Heyck to postulate excessive opening of arteriovenous anastomoses at the onset of migraine headache [1]. To evaluate Heyck's hypothesis Spierings and Saxena [2] studied the effects of three anti-migraine drugs (ergotamine, dihydroergotamine, and methy sergide) on the arteriovenous anastomotic bloodflow in the cephalic circulation of the cat. They demonstrated that the two most effective drugs in the management of the migraine attack- ergotamine and dihydroergotamine- effectively closed the arteriovenous anastomoses and called for further clinical assessment of Heyck's shunt hypothesis. Testing the migraine patients before after treatment with vasomotor challenge can help in imaging microcirculatory changes due to shunting/arteriovenous anastomoses involved in migraine pathophysiology.

Zomig® (Zolmitriptan) Nasal Spray

In this case report a migraine patient underwent non thermal stimuli with induced hyperoxia before and after treatment for acute migraine headache with Zomig® (Zolmitriptan) Nasal Spray. Zolmitriptan is a selective 5-hydroxytryptamine $_{1B/1D}$ (5-HT $_{1B/1D}$) receptor agonist. The therapeutic activity of zolmitriptan for the treatment of migraine headache has been attributed to the agonist effects at the 5-HT $_{1B/1D}$ receptors on intracranial blood vessels (including the arterio-venous anatomoses) and sensory nerves of the trigeminal system which result in cranial vessel constriction and inhibition of pro-inflammatory neuropeptide release. Zomig® (Zolmitriptan) Nasal Spray is indicated for the acute treatment of migraine with and without aura in adults. The recommended dosage of Zomig® Nasal Spray is 5 mg for the treatment of acute migraine and two hours after the first dose if the headache improves but persists or it recurs within twenty four hours a second dosage of 5 mg nasal spray.

Innervation

Intra- and extracranial vasculature are innervated by trigeminovascular system. In humans or cats, vasoactive peptides are released in the extra cerebral circulation during activation of the trigeminovascular system [3]. Differences in sensitivity of cerebral and extracranial arteries to adrenergic stimuli may relate to different embryonic origin of the vessels. Intracranial and extracranial arteries arise from different primordial cells, and the site of fusion of the arteries corresponds to the abrupt change in responsiveness to nor- epinehrine [4]. The blood flow in the internal and external carotids and also pharmacological comparison of histamine receptors have been studied in the animal models [5, 6].

Central sensitization

The pathophysiology of migraine can involve the trigeminal ganglia, the brainstem and the thalamus [7, 8]. The clinical presentation can depend on the extent of the involved brain structures. The vasomotor testing with hyperoxia allows us to evaluate the status of the vasomotor function/capacitance under the control of cerebrovascular regulatory region at the brainstem [9].

Vasomotor response

The alteration in extracranial blood flow depends on pre--existing vasomotor tone and the vasomotor capacitance of the individual [10]. Induced hyperoxia allows us to test the vasomotor status before and after Zolmitriptan treatment. The vasomotor tone before treatment may have an influence on the clinical benefit from the drug given for migraine. Imaging the change in vasomotor reactivity due to the drug allows us to document the clinical response and correlate it with the type and duration of benefit following the administration of the drug and the tendency/frequency of recurrence.

Case Report

The patient a 51 year old, right handed white female, height 173cm, weight 63,5 kg was symptomatic with migraine with aura [11]. She had no history of diabetes, head injury, thyroid disease or malignancy. During migraine diplopia or paresthesias were absent, but photophobia, phonophobia and visual aura present. She had tried Relpax® (eletriptan HBr), Maxalt® (rizatriptan benzoate), Imitrex® (sumatriptan succinate) and Migranal® (dihydroergotamine mesylate,USP) for acute attacks and for prevention, she tried also Lexaparo® (escitalopram oxalate) and Cymbalta® Delayed Release Capsules (duloxetine HCL) without benefit. For headache prevention she has started taking Neurontin® (gabapentin) 300 mg daily three months before the study with some improvement in the frequency and severity of headaches. General medical and neurological examination revealed normal findings. The brain MRI without and with contrast was also normal.

Thermographic examination

Committee for the protection of human subjects approved methodology [12] was used in a temperature and humidity controlled draft free thermography laboratory.

The patient was instructed on the day of the testing to abstain from applications of skin lotion or smoking. 48 hours prior to the investigation physical therapy or sun tan was not allowed. No vasoactive drugs must be taken in the 24 hours period before thermal imaging, also no coffee or meals for 4 hours before testing.

A mouth piece (no mask) was used to inhale oxygen. A nose clip was not applied. Thermal images were recorded during headache free period (figure 1) and during migraine.. The study during migraine was done in the following 4 steps. There were no waiting periods between steps 1, 2, 3 and 4.

Step 1: During headache, the baseline facial thermogram was recorded in the frontal view, (figure 2), prior to vasomotor (induced hyperoxia) or pharmacological (Zomig® Nasal Spray) challenges.

Step 2: During headache., before the pharmacological challenge with Zomig® Nasal Spray, a vasomotor challenge i. e.. induced hyperoxia was applied. 100% oxygen was administered at 15 liters per minute for five minutes. Post hyperoxia, facial thermograms were recorded up to 20 minutes after 100% oxygen inhalation.

Figure 3 was recorded 5 minutes post hyperoxia, figure 4 shows the patients face 20 minutes post hyperoxia.

Step 3: During headache after induced hyperoxia, a pharmacological challenge with the drug Zolmitriptan was applied as a nasal spray. The thermograms were recorded at

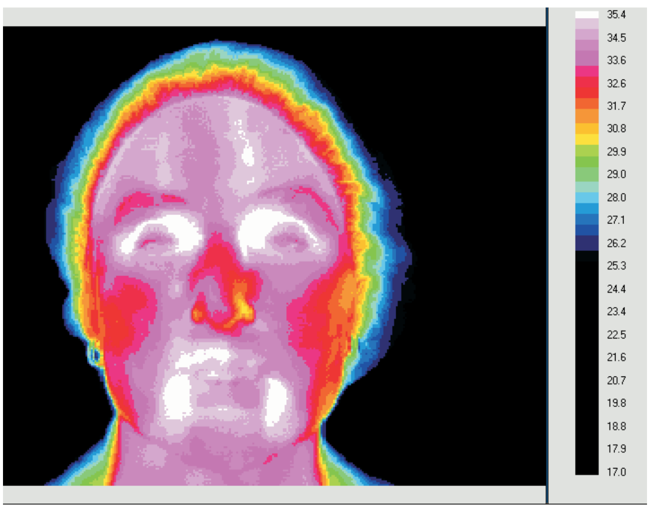

Figure 1
Thermogram done during headache free period. The nose is colder than the forehead. There is temperature asymmetry in the upper lip.

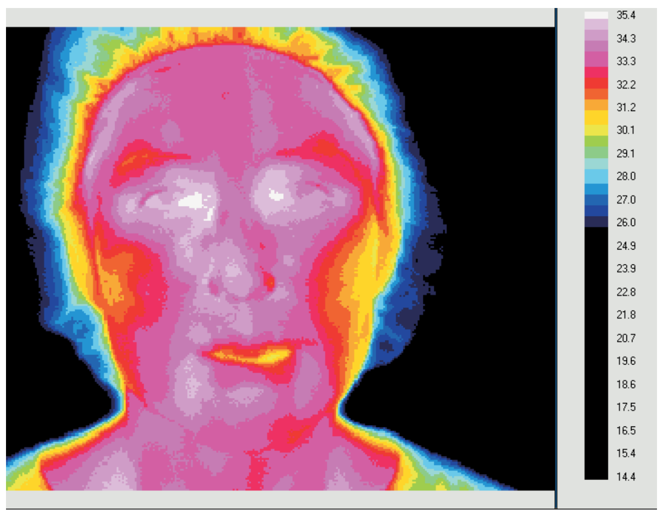

Figure 2
Step 1: Baseline thermogram, done when patient was symptomatic with migraine and before vasomotor or pharmacological stress.Nose is warmer than forehead and there is facial temperature asymmetry.

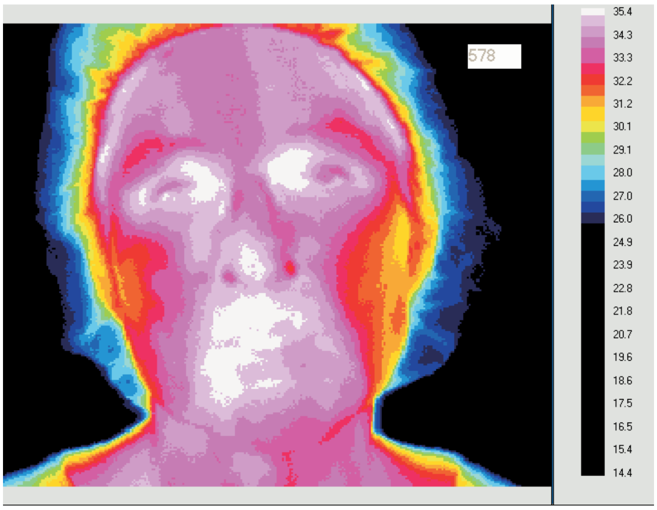

Figure 3
Step 2: Pre Zomig® (Zolmitriptan) Nasal Spray, post hyperoxia thermograms. Recorded when the patient had migraine symptoms, before treatment, imaged 5 minutes post hyperoxia.

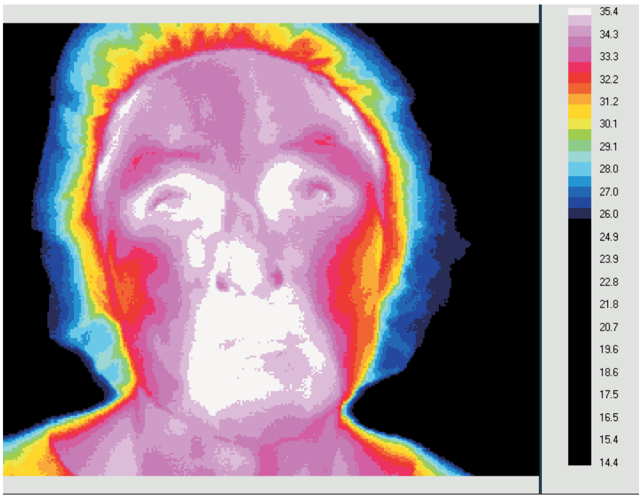

Figure 4
Step 2: Pre Zomig® post hyperoxia thermograms. Recorded when the patient had migraine symptoms, imaged before treatment, 20 minutes post hyperoxia.There is increased temperature due to vasodilatation, opening of the arteriovenous anastomoses respectively (paradoxical response to hyperoxia). Note changes in temperature between images taken at five and twenty minutes post hyperoxia.

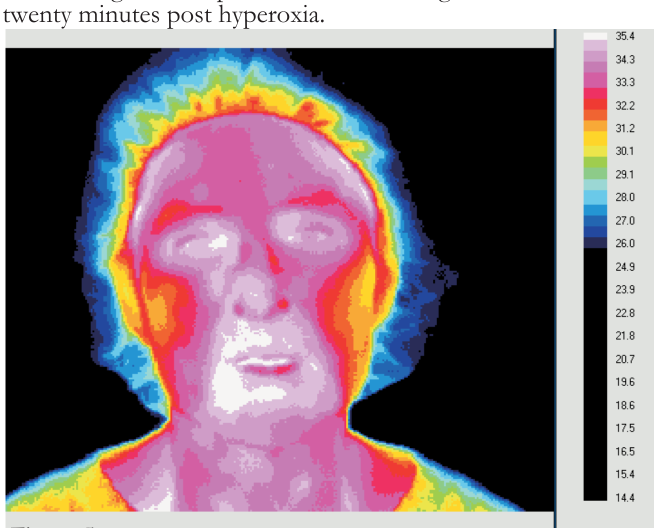

Figure 5
Step 3: Thermogram recorded 15 minutes after Zomig® Nasal Spray.

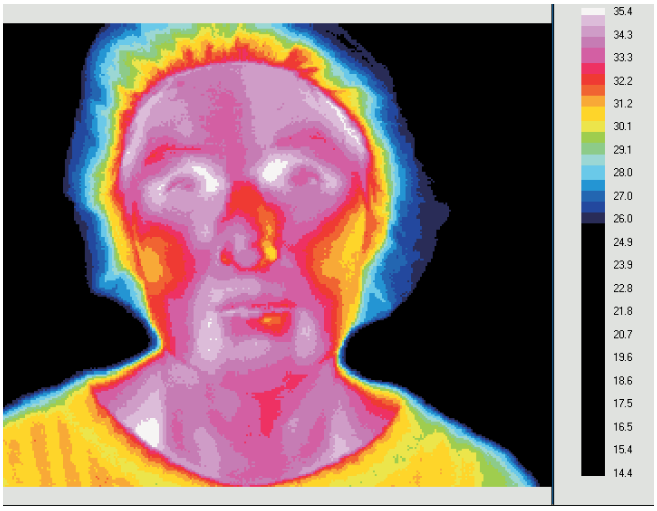

Figure 6
Step 3: Thermogram recorded 60 minutes after Zomig® Nasal Spray.

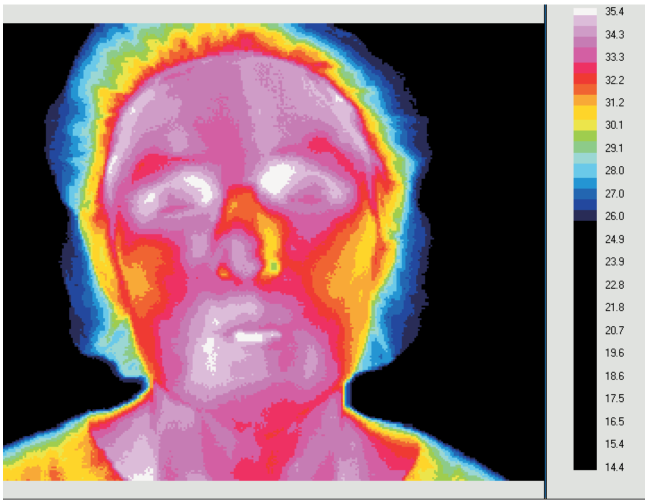

Figure 7
Step 4: Recorded 60 minutes after Nasal Spray treatment and 5 minutes post hyperoxia.

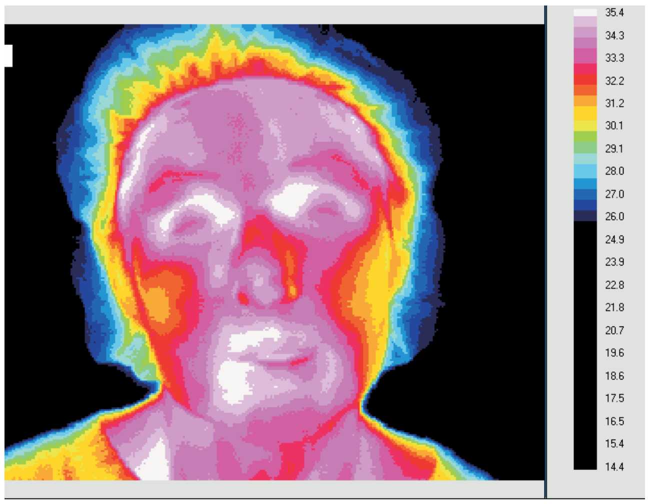

Figure 8
Step 4: Recorded 60 minutes after Nasal Spray treatment. and. 20 minutes post hyperoxia.
Note a less paradoxical temperature response to hyperoxia.

15 (figure 5)and 60 minutes (figure 6) after the drug application.

Step 4: After the application of Zomig® Nasal Spray, another vasomotor challenge was administered using 100% oxygen inhalation at 15 liters per minute for five minutes. Post hyperoxia facial ther mograms were recorded up to 20 minutes after 100% oxygen inhalation.

Fig ure 7 shows the thermogram post Zomig and 5 minutes post hyperoxia, figure 8 was recorded post Zomig. and 20 minutes post hyperoxia.

Comparing the thermal images in figures 1 and 8, the thermogram recorded in the period free of headache appears to resemble the thermogram taken post Zomig® and after vasomotor challenge as it shows a high similarity.

Normal facial temperature,Forehead-Nose Thermal Ratio and vasomotor response:

In normal non headache children there is facial temperature symmetry and the nose is colder compared to forehead [13]. During migraine, there is opening of the microvascular shunting and the nose becomes warmer. In headache free subjects, hyperoxia causes a decrease of the facial temperature due to vasoconstriction or changes in the microvascular shunting.

Criteria used for Interpretation of Infrared Imaging done before and after hyperoxia

The hyperoxia induced changes of microcirculation imaged by thermography were interpreted as normal (temperature decrease due to vasoconstriction), paradoxical (temperature increase due to vasodilatation), or no response (vasomotor paralysis).

Temperature measurements. Forehead-Nose Thermal Ratio

For temperature measurements of the forehead, the forehead was divided in to four quadrants and the highest temperature of the middle half of the forehead was registered. For the temperature determination of the nose, the highest temperature of the nose was taken.In migraine patients during headache free period, the temperature of the forehead is higher than that of the nose and during migraine headache the nose temperature is higher than that of the forehead. Decrease in temperature indicates closing and increase in temperature indicates opening of the shunts in the microvasculature.

Results

The effect of hyperoxia and Zomig® (Zolmitriptan) Nasal Spray on headache

The patient had moderate to severe migraine (intensity 8/10) at the beginning of thermography testing. Oxygen inhalation did not affect her headache before or after Zomig® Nasal Spray. The patient was free of headache, photophobia and phonophobia two hours after nasal spray and a second dose was not administered. 24 hours after the nasal spray she was still headache free.

Table 1shows the temperature values of the forehead and the nose after all the challenges.

Thermograms, interpretations

Thermogram done during headache free period (figure 1)

The nose is colder than the forehead. There is a slight temperature asymmetry in the upper lip.

Thermogram done during migraine: Steps 1-4.

Step 1: Baseline thermogram figure 2, recorded when the patient was symptomatic with migraine and before vasomotor or pharmacological stress. The nose is warmer than forehead and there is facial temperature asymmetry.

Step 2: Pre Zomig®, post hyperoxia thermograms.

The images were recorded 5 minutes post hyperoxia (figure 3) and 20 minutes post hyperoxia (figure 4).

There is increased facial temperature due to vasodilatation or to opening of the arteriovenous anastomoses, respectively (paradoxical response to hyperoxia). There is progression in temperature increase between images taken at five and twenty minutes post hyperoxia.

Step 3: Post Zomig® Nasal Spray Thermograms.

Figure 4 shows the baseline image for step 3. Note the forehead cooling by 0.8⁰C in figure 5, recorded 15 minutes after Zomig® Nasal Spray. 60 minutes after Zolmitriptan, a temperature decrease by 0.5⁰C was observed at the forehead, and by 0.9⁰C at the nose (figure 6).

Step 4: Post Zomig® Nasal Spray and post hyperoxia thermograms.

Figure 6 shows the baseline image 60 minutes after Zolmitriptan and prior to hyperoxia..

Note the only moderate increase of temperature indicating

Table
1temperature valuies at the forehead and at the nos

Fig #	Clinical	Forehead ^{0}C	Nose ^{0}C	Comment
1	No HA	35.1	34.0	Forehead warm
2	HA	33.6	34.7	Nose warm
3	HA Post Hyperoxia 5min	34.3	35.2	
4	HA Post Hyperoxia 20min	34.6	35.2	
5	HA Post Zomig 15 min	33.8	34.9	
6	HA Post Zomig 60 min	34.1	34.3	
7	HA Post Zomig Post Hyperoxia 5min	34.3	34.4	
8	HA Post Zomig Post Hyperoxia20min	34.6	34.6	

a less paradoxical response to hyperoxia in figure 7 (5 minutes after hyperoxia) and figure 8 (20 minutes after hyperoxia).

The tendency to normalize the vasomotor response to hyperoxia by Zolmitriptan was interpreted as improvement in vasomotor reactivity due to the drug administration.

Discussion

Role of microcirculation

De Castro [14] observed by binocular microscopy that when arteriovenous anatomoses were opened there was a rapid blood flow through the veins, while closing of arteriovenous anatomoses led to sluggish venous flow. He also observed variation in the lumen of arteriovenous anastomoses under stimulation with oxygen, carbon dioxide and epinephrine. Rapid flow of blood occurs when arterio-v enous anastomoses are open. Pale and red appearance may relate to size and neurochemical control of vascular system of the skin involved in particular clinical state.

Hyperoxia

Hyperoxia has been used to evaluate intra and extra cranial vasomotor abnormalities in migraine. Hyperoxia is well tolerated during migraine attack. Testing vasomotor responses with hyperoxia is safe, clinically helpful and demonstrates impaired or altered vasomotor reactivity [15]. Following hyperoxia in normal controls the facial skin blood flow changes and there is decrease in skin temperature imaged by thermography due to vasoconstriction or changes or shunting in the microcirculation. Swerdlow was able to reproduce the role of hyperoxia in normal controls and migraine patients [16].

Although ground state oxygen (dioxygen) is a powerful oxidizing agent, the molecule is stable and with an indefinite half-life. However, the oxygen molecule can be transformed in to a range of free radicals and other highly toxic substances, most of which are far more reactive than oxygen itself [17]. The production of oxygen-derived free radicals is increased at high levels of PO_2 by the law of mass action (18, 19).

In this case report the vasomotor response was tested with hyperoxia before and after Zomig® Nasal Spray treatment. Induced hyperoxia allows us to image vasomotor reactivity or capacitance i.e. vasoconstriction (normal response), vasomotor paralysis (absence of response) and vaso-di latation (paradoxical response). Thermography can image extracranial vasomotion by imaging dynamic changes in facial skin temperature distribution. Changes in vasomotion towards normality i.e. vasoconstriction to vasoconstrictor stimuli would be considered as normalization or stabilization of vasomotion and can be correlated with the effect of the migraine drug on vasomotion and the clinical response.

AVA's (Arteriovenous anatomoses)

Thermography images changes in cutaneous perfusion affecting vessel size of 300um or smaller in response to non thermal stimuli [20]. Because the AVA's and capillary bed may be regarded as flow resistors in parallel, vasomotor changes occurring predominantly at the AVA during central and at the pre-capillary sphincter during peripheral temperature changes, might be accompanied by parallel, though weaker changes in the parallel section of the vascular bed [21].

Forehead to Nose Thermal ratio

Variations in the temperature of the forehead resulting from an abrupt change in ambient temperature are very little [22]. Forehead temperature has been used as a reliable index in calculating ratio's for temperature aymmetry in other neurological disorders. Kusumi et al reported that the temperature of the forehead is nearly constant irrespective of a change in ambient temperature from 22C to 28.2 C [23]. Matsuda concluded that variation in skin temperature was the smallest in the forehead and forehead is the most stable site as a reference point [24]. Pre Zomig® Nasal Spray hyperoxia thermograms showed paradoxical vasomotor response probably due to oxygen radicals or dysfunction at the brainstem vasomotor control center. The Post Zomig® response to hyperoxia showed improvement in vasomotor reactivity. Drug testing with thermography allows us to image temperature changes in real time due to variations in microcirulation and AVA's shunting and visualizes vasomotion before and after treatment.

Conclusion

After the migraine treatment with Zomig® (Zolmitriptan) Nasal Spray, patient's headache improved from moderate to severe to mild or no headache in 60 minutes.Vasomotor reactivity improved and there was decrease in the paradoxical response to hyperoxia. The changes in microcirculation imaged during drug testing with vasomotor challenge reflects the effect of the drug on the 5-HT $_{1B/1D}$ receptors on the blood vessels and/or on the vasomotor centers in the brainstem. Thermography testing in migraine can help to understand pathophysiology. This has clinical and research implications.

The use of Forehead to Nose Thermal ratio in correlating thermographic changes in migraine, allows us to incorporate in the words of Michel Salmon [25] the Internal and External Carotid Artery Territory angiosomes (functional anatomy) with migraine related activation of perivascularly located mast cells and its neurosensitizing and vasoactive mast cell mediators (physiologic anatomy) [26, 27].

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Repeatability of temperature measurements at the forehead in thermal images from the standard view "face"

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SUMMARY

During a Training Course for Medical Thermal Imaging, two separate thermal images using the standard view "Face" were recorded from one subject by 8 participants. In all images the measurement areas were defined as "Right Forehead" to determine the mean temperature of this region of interest.

With respect to the applied method, the size of the imaged field of view varied from 0.2 to 3,7% of the number of pixels within the object imaged. Temperature readings from the right forehead showed small variations between the first and second evaluation. However, in two readers the temperature values were significantly different in repeated evaluation of thermal images. This must be considered as source of error, when thermal imaging is used as an outcome measure in clinical trials.

KEY WORDS: Repeatability, field of view, quality assurance, region of interest, temperature

WIEDERHOLBARKEIT VON TEMPERATURMESSUNGEN AN DER STIRN AUS WÄRMEBILDERN DER STANDARDANSICHT "GESICHT"

8 Teilnehmer an einem Trainingskurs für medizinische Thermographie nahmen von einer Person zwei Mal Wärmebilder in der Standardansicht "Gesicht" auf. Außerdem definierten die Teilnehmer in allen Bildern das Messareal "Rechte Stirn" definiert und bestimmten die mittlere Temperatur dieses Messareals.

In Abhängigkeit von der Methode, variierte die Größe des Bildabschnittes um 0, 2 bis 3,7% der Anzahl der Bildpunkte innerhalb des dargestellten Objekts. Die Temperaturbestimmun an der rechten Stirn zeigten nur geringe Abweichungen zwischen der ersten und einer zweiten Auswertung. Dennoch fand sich bei zwei Untersuchern statistisch signifikante Unterschiede in den Temperaturwerten bei wiederholter Bestimmung. Dieser Umstand muss als Fehlerquelle berücksichtigt werden, wenn Wärmebilder als Ergebnisparameter in klinischen Studien eingesetzt werden.

KEY WORDS: Wiederholbarkeit, Bildausschnitt, Qualitätssicherung, Messareal, Temperatur

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Introduction

Temperature readings extracted from thermal images must meet the challenge of high repeatability when they are used as outcome measures in clinical trials. Erroneous measurements due to the infrared camera such as start-up drift, long term drift, off-set variation, image non-uniformity and thermal flooding (1), variations in body positions during image recording and the position and size of the measurement area may all be sources of error (2).

The repeatability of the standard position "face" has been investigated previously (3) using the distance from defined anatomical landmarks to the upper and lower edge of the image as a measure of identical field of view. The reproducibility of the region of interest defined as " Half of the Face" (based on a centreline through the centre of the forehead and nose) was also reported (4). This study found that there was an influence of slight variations in body position on temperature readings measured from one half of the face.

Although temperature measurements from the region of interest "Half of the Face" showed a high repeatability, the reproducibility of temperature readings from the regions of interest "Forehead" has not yet been determined. Difficulties in the alignment of this measurement area to anatomical landmarks may result in a lower reproducibility than the determination of the temperature of half of the face.

Therefore, experiments were performed at the practical session in the 7th Course on Medical Thermal Imaging at the University of Glamorgan, where the 8 participants repeated the image recording of the standard view "Face" on two occasions and determined temperatures in the region of interest "Right Forehead" of all images obtained.

Method

The frontal face of a volunteer was imaged. All 8 participants were instructed to follow the instructions for standard views used in the protocol of the University of Glamorgan (figure 1). The subject imaged, was deliberately varying his head position in order to test for the highest level of control in recording identical images. Each participant recorded two separate thermal images of the face of the volunteer, which were then stored on the hard disk of a an image processing computer.

In the standard view "Face" the region of interest named "left" and "right forehead" were defined on two occasions based on the protocol of the University of Glamorgan and the mean temperature in these regions of interest were recorded by 7 participants. The repeated determination of temperature was performed in a blind manner as the readers were unable to use any information from the previous measurement.

Figure 1
Definition of the standard view "Face"

Title	Face
Code	FA
Number of ROIs	4
Description	roi 1: half of the face (red) **Shape:** polygon Outline of the face from the scalp to the chin, following the midline of the face. **roi 2:** half of the face (blue), **Shape:** polygon Outline of the face from the the scalp to the chin, following the midline of the face. **roi 3:** right forehead (yellow) **Shape:** rectangle Lower edge: adjacent to the right eyebrow. Right upper corner: adjacent to the hair line. Left upper corner: adjacent to the midline of the face. **roi 4:** left forehead (green), **Shape:** rectangleLower edge: adjacent to the left eyebrow. Right upper corner: adjacent to the midline of the face. Left uppercorner: adjacent to the left eyebrow.

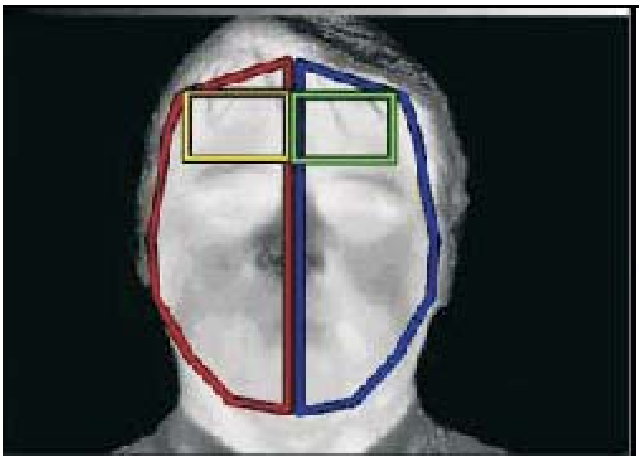

Figure
Definition of Regions Of Interest in the standard view "Face"

The size of the field of view was determined as described previously (5). The Ctherm Software was used and an isotherm was created which was as close as possible to the outline of the body region imaged. In the next step a polygonal measurement area was defined around the imaged object and the background temperature was increased to the level of the isotherm. This resulted in the number of pixels within the area of the defined isotherm.

Data were analysed with the spreadsheet Software Excel 2000 by calculation of mean and standard deviation values of all measurements. The same analysis was performed for the measurements of each individual participant. The mean value of all measurements was regarded as being closest to the true value. The individual measurement error was defined by the difference between the mean value of all measurements and the mean value of individual measurements.

In the comparison of the size of the object imaged, an alternative calculation of the individual error was performed. This was based on the variation of size compared to the image which was closest to the definition of the standard view "Face". The image in the 3rd row and 2nd column in figure 3 was chosen as reference image. The alternative individual measurement error was defined by the difference between the number of pixels in reference image and the number of pixels in individual image recordings.

Further statistical analysis was performed with the software package SPSS 10, where the reliability coefficient alpha and the average interclass correlation were determined. The recorded values from the regions of interest were compared by non-parametrical tests between first and second measurement. The level for significant differences was set for 2-tailed p=0.05.

Results

Size of the object

Figure 3 shows slight variations between first and second image recordings. Table 1 summarizes mean value, standard deviation and individual and alternative individual errors of the size of the imaged face.

The reliability coefficient alpha of the number of pixels in the first and the second image was low with a value of -0.27, the average measure interclass correlation showed a wide 95% confidence interval from -3.50 to 0.74.

However, comparison of the number of pixels based on the non-parametric Wilcoxon test did not obtain a significant difference (2-tailed p= 0,21). The mean individual error was equal to 2 percent of the mean number of pixels of all images.

In the first series of images, the alternative individual error was 0.2% of the number of pixels in the reference image, but 3.7% in the second series.In the first series of images, the alternative individual error was 0.2% of the number of pixels in the reference image, but 3.7% in the second series.

Region of interest "Right Forehead"

Table 2 shows the temperature values obtained in all measurements. Only small variations of temperature readings were obtained within and between investigators. Figure 4 shows the individual differences between first and second measurement. The individual error was slightly higher than the difference between first and second measurement (figure 5).

The reliability coefficient alpha of the first and second measurement series was poor with a value of -0.04 and the average measure interclass correlation showed a wide 95% confidence interval from -0.50 to 0.33. However, the reliability coefficients of individual investigators ranged from 0.84 to 0.86. 2-tailed p-values of the Wilcoxon test were in

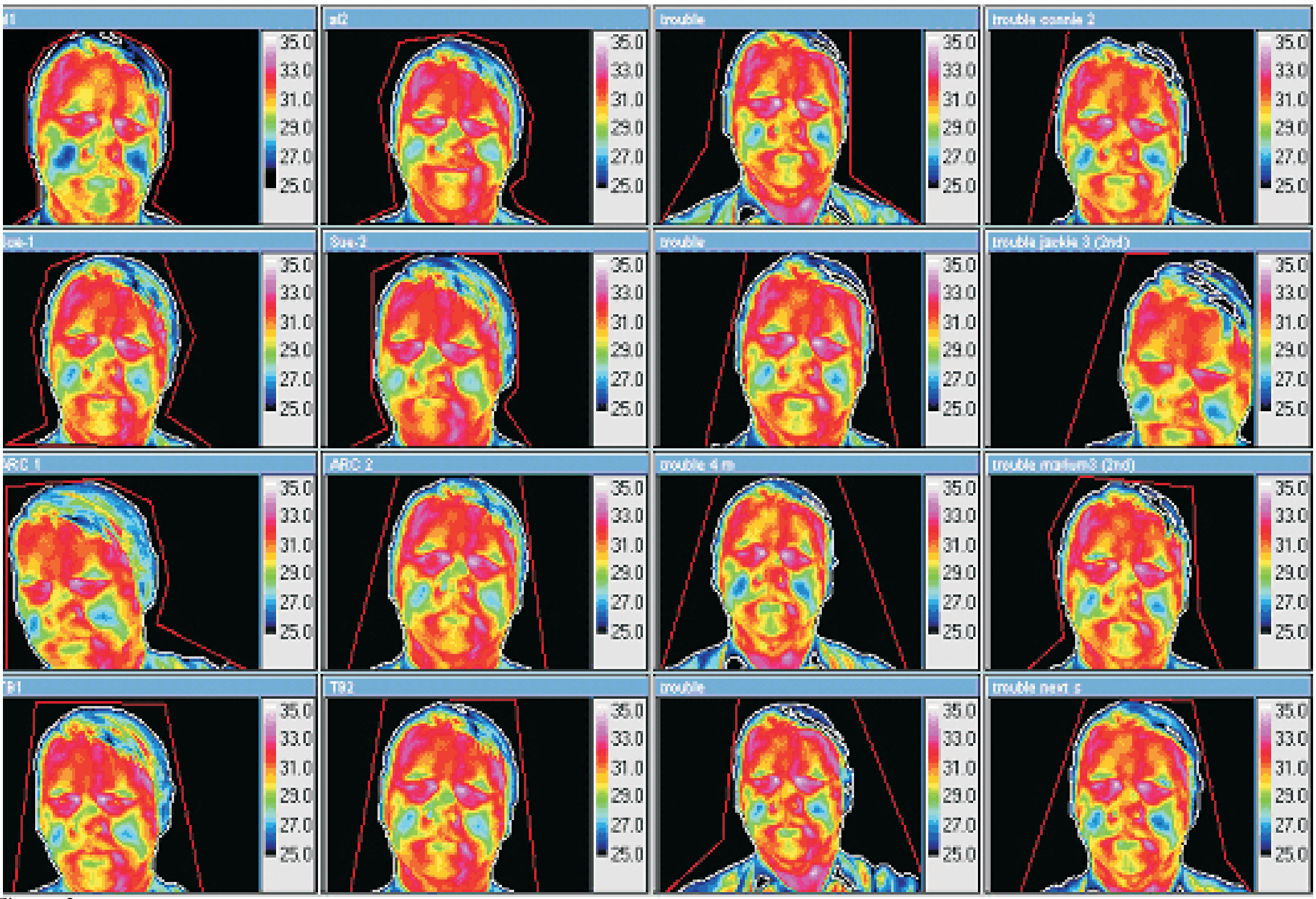

Figure 3
All images recorded: the first image recorded by participants is shown in columns 1 and 3, the repeated images are seen in columns 2 and 4. The image in the 3rd row and 2nd column was chosen as reference image being closest to the definition of the standard protocol

Table 1
Size of the imaged object, individual and alternative individual error

Investigator	First image	Second image	Individual error 1st image	Individual error 2nd image	Alternative individual error 1st image	Alternative individual error 2ns image
A	38397	33953	-1734,06	2709,94	-1084	3360
B	36430	38563	232,94	-1900,06	883	-1250
C	40438	**37313**	-3775,06	-650,06	-3125	0
D	36189	36121	473,94	541,94	1124	1192
E	35189	36535	1473,94	127,94	2124	778
F	40112	34423	-3449,06	2239,94	-2799	2890
G	37298	35988	-635,06	674,94	15	1325
H	35143	34515	1519,94	2147,94	2170	2798
mean	37399,5	35926,4	-736,56	736,56	-86,5	1386,63
SD	2069,5	1578,1	2069,47	1578,11	2069,47	1578,11

37313 = Reference value

Table 2
Temperature readings from the region of interest "Right forhead

Image	Investigations													
	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	F1	F2	G1	G2
1	31,55	31,46	31,1	31,22	31,15	31,25	31,25	31,23	31,34	31,31	31,44	31,42	31,26	31,33
2	31,49	31,5	31,17	31,04	31,16	31,19	31,24	31,41	31,41	31,45	31,13	31,62	31,29	31,37
3	31,51	31,48	31,02	30,97	30,98	31,33	31,61	31,42	31,38	31,4	31,46	31,54	31,31	31,24
4	31,22	31,55	30,58	30,59	30,59	30,76	31,07	30,92	30,83	30,77	31,07	31,02	30,66	30,76
5	31,25	31,25	31,04	30,88	30,93	31,04	31,76	31,39	31	31	31,14	31,26	31,13	31,1
6	31,13	31,17	30,89	30,87	30,86	31	31,11	31,09	31,13	31,1	31,25	31,34	30,83	30,93
7	31,26	31,28	31,02	30,9	30,98	30,94	31,2	31,19	31,31	31,22	31,45	31,4	31,24	31,19
8	31,52	31,46	31,24	31,19	31,16	31,09	31,39	31,44	31,33	31,43	31,56	31,51	31,36	31,17
9	31,47	31,52	31,13	31,1	31,32	31,25	31,34	31,52	31,52	31,4	31,75	31,65	31,36	31,23
10	31,04	31,17	30,93	30,82	30,87	30,98	31,02	31,1	31,04	31,05	31,06	31,27	31,11	31,08
11	31,46	31,42	31,11	31,12	31,17	31,16	31,36	31,31	31,51	31,52	31,57	31,52	31,51	31,47
12	31,36	31,31	31,23	31,06	31,19	31,26	31,5	31,48	31,46	31,46	31,55	31,57	31,29	31,32
13	31,61	31,65	31,23	31,33	31,5	31,55	31,47	31,6	31,13	31,71	31,83	31,79	31,43	31,47
14	31,55	31,54	31,28	31,18	31,27	31,44	31,56	31,4	31,54	31,57	31,65	31,71	31,47	31,4
15	31,52	31,52	31,23	31,1	31,28	31,48	31,59	31,47	31,59	31,48	31,69	31,7	31,52	31,33
16	31,5	31,51	31,28	31,22	31,22	31,36	31,45	31,51	31,53	31,57	31,61	31,67	31,39	31,46
mean	31,525	31,485	31,19	31,22	31,185	31,305	31,35	31,37	31,435	31,44	31,525	31,545	31,325	31,395
SD	0,035	0,035	0,13	0	0,05	0,08	0,14	0,20	0,13	0,18	0,12	0,18	0,09	0,09

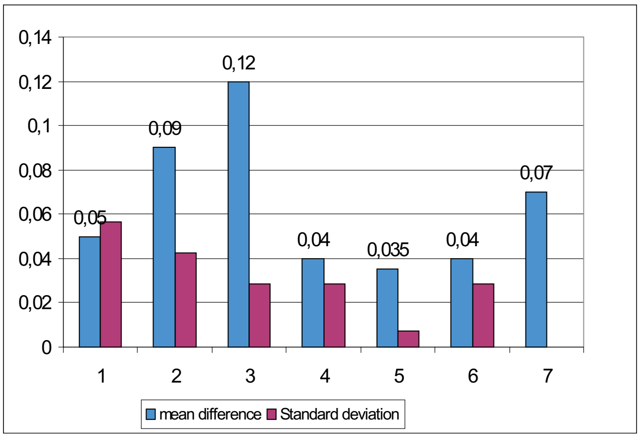

Figure 4
Mean temperature differences between first and second measurement

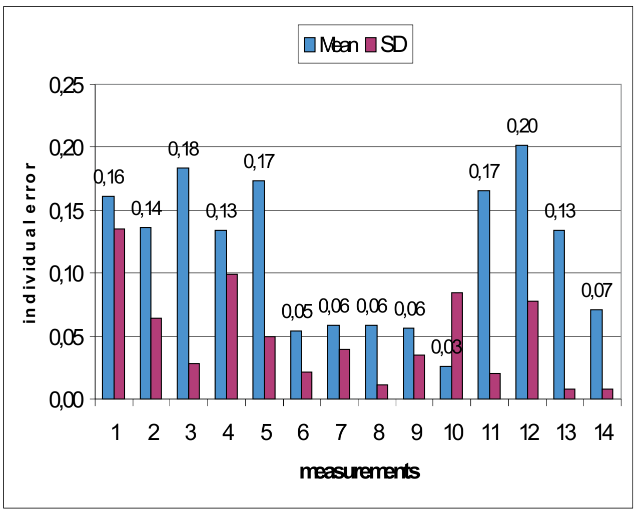

Figure 5
Mean individual errors of all measurement

thr range between 0.97 for the best and 0.02 for the least reproducible intra-rater comparison. Significant differences between first and second measurements were detected in two investigators (p-values =0.02 and 0.048). Analysis of temperature values in all first measurements compared to all second measurement using the Wilcoxon test or the Sign-test did not reveal significant differences (Wilcoxon 2-tailed p=0.86, Sign 2-tailed p=0.68)

Discussion

The repeatability of the standard view "Face" based on the
The repeatability of the standard view "Face" based on the
number of pixels in the field of view was lower than when derived from the distance of the upper or lower edge of the image. However, the difference of size between two images was not significant and the maximum mean variation of number of pixels was only 3.7%.

Comparing the temperature readings from thermal images at the right forehead, obtained in some raters significant differences of temperature values in repeated evaluation. Due to the small mean differences in repeated temperature readings these statistically significant differences may not confer clinical significance when infrared temperature measurements are used as an outcome measure.

However, appropriate training and tools such as masks for achieving identical contours of the object imaged and preformatted regions of interest for temperature measurements can reduce poor reproducibility of both field of view and temperature readings.

Conclusion

The number of pixels within the field of view of the standard position "Face" may vary at maximum by 3.7% of the total imaged body region. Although the reliability index of individual repeated temperature readings was high, the comparison of temperature values may detect statistically significant differences. This must be considered as source of error, when thermal imaging is used as an outcome measure in clinical trials.

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Some Preliminary Observations of the Effects of Sports Massage on Heat Distribution of Lower Limb Muscles During a Graded Exercise Test

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SUMMARY

There is a lack of scientific evidence to confirm the efficacy of massage for promoting both physiological and psychological preparation and recovery after exercise.

The purpose of the present study is to analyse the effect of pre event sports massage (effleurage) on sporting performance. Untrained subjects completed a sub maximal graded exercise test. Subjects were tested on three separate occasions, following a 10-minute massage, 30-minute massage or no massage at all (Control). Physiological and psychological parameters were recorded prior to and following massage and pre and post exercise testing. The results of the present study show Heart Rates (HR) decreased following massage ($P < 0.01$), whilst Skin Temperature (T_{sk}) increased compared to controls ($P < 0.0001$). During exercise Volume of Oxygen consumed (VO_2) increased, the increase was greater in the 10 and 30-minute massage groups compared to controls ($P < 0.05$ and $P < 0.001$). After exercise HR increased in all groups, there was no difference in HR between the groups following exercise. By the end of the exercise test T_{sk} for the massaged groups had returned to the pre massage baseline. As expected the lactate concentration increased for all groups following exercise no difference was detectable between the groups. The above findings provide some support for the benefit of pre-event massage in preparing an athlete for competition

KEYWORDS: sports massage, exercise, skin temperature, thermal imaging

VORLÄUFIGE BEFUNDE ÜBER DEN EINFLUSS VON SPORTMASSAGE AUF DIE WÄRMEVERTEILUNG AN DER UNTEREN EXTREMITÄT WÄHREND EINES BELASTUNGSSTESTS

Der wissenschaftliche Nachweis der Wirksamkeit von Massage zur physischen und psychologischen Vorbereitung und Erholung nach körperlichen Training fehlt weitgehend.

Der Zweck der vorliegenden Studie war es, den Effekt einer vorher durchgeführten Sport-(Streich)-Massage auf die körperliche Leistung zu untersuchen. Untrainierte Personen absolvierten einen submaximalen graduierten Belastungstest. Die Probanden wurden unabhängig unter drei unterschiedlichen Bedingungen untersucht: nach einer 10-minütigen Massage, nach 30 Minuten Massage oder ohne Massage (Kontrollle). Physiologische und psychologische Parameter wurden vor und nach Massage sowie vor und nach dem Belastungstest erhoben. Als Ergebnis der Studie zeigte sich, dass die Herzfrequenz im Vergleich zu Kontrollen nach der Massage ($P < 0.01$) veringert war, während sich die Hauttemperatur erhöht hatte ($P < 0.0001$). Während des Belastungstests fand sich eine höhere Sauerstoffaufnahme (VO_2) nach 10 und 30 Minuten Massage als ohne vorherige Massage ($P < 0.05$ and $P < 0.001$). Beim Belasten erhöhte sich die Herzfrequenz in allen Gruppen, nach dem Belastungstest zeigte sich kein Unterschied in der Herzfrequenz zwischen den Gruppen. Am Ende des Belastungstests erreichte die Hauttemperatur bei Probanden, die eine Massage erhalten hatten, wieder die Ausgangswerte vor dem Training. Erwartungsgemäß stiegen die Laktatspiegel nach dem Belastungstest bei allen Probanden unabhängig von der Vorbehandlung an. Die vorliegenden Ergebnisse weisen auf günstige Wirkungen der Massage in der Wettkampfsvorbereitung von Sportlern hin.

SCHLÜSSELWÖRTER Belastungstest, Sportmassage, Hauttemperatur, körperliches Training

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Introduction

There has been an explosive growth of interest in sports massage in the past two decades. Many questions have been raised over what are the physiological, psychological and metabolic responses and benefits from sports massage. For example Zelikovski *et al.* (1) found an overall improvement in subsequent exercise performances following a 20-minute massage. The overall aim of this study was to investigate how massage might influence performance during a controlled exercise. It has been suggested that massage will affect local surface temperature, the underlying subcutaneous vascular system and in turn could affect blood flow (2) with implications of changes in oxygen consumption and lactic acid dispersal. Lactic acid being the link molecule between glycolysis and aerobic metabolism and associated with the onset of muscle fatigue. Indeed Balke *et al.* (3); Ask et al. (4); and Rinder and Sutherland (5) have all demonstrated increases in muscle endurance and power output following massage..

In this study we have attempted to answer some of these questions by measuring a variety of physiological parameters including; Volume of Oxygen consumed (VO_2), Blood Lactate (BL), Heart Rates (HR), Tympanic Temperature (T_{tymp}) and Skin Temperature (T_{sk}) overlying the muscles of the lower limb. The skin temperature was measured using thermal imaging. This is a non-contact non-invasive method that allows the calculation of mean skin temperature over a large region of interest (6).

Subjects underwent a graded exercise test on three separate occasions, following a 10-minute massage, 30-minute massage or no massage at all (Control). Heart Rates, Tympanic Temperature and Skin Temperature of muscles of the lower limb were recorded immediately before and after massage and following exercise. Blood Lactate was recorded before and after exercise, Volume of Oxygen consumed and Rates of Perceived Exertion (RPE) were recorded before, during and after completion of the graded exercise test.A test.

Methods

Subjects

Seven female subjects aged 21 ± 1.25 years took part in the study voluntarily. Each subject took part on 3 separate occasions so that there were seven subjects in each of the three conditions (control, 10 minute and 30 minute). All subjects were students in Sport, P.E. and Recreational studies. Subjects completed a pre-health questionnaire before taking part in the study. Subjects had their anthropometric measurements of weight (Kg) and height (cm) recorded. All subjects were categorised as of low fitness levels none participated in regular exercise. The subjects were tested at the same time of day on three separate occasions over a period of three weeks. Subjects were divided up into three different categories, a control group, a 10-minute massage group and a 30-minute massage group. A different subject acted as a control each week (that is not receiving any massage). No food was taken for at least 4 hours before the tests, and no vigorous exercise was allowed before the experiments. The nature and risks of the study were explained, and the subjects were given time to familiarise themselves with the equipment and procedures before the test was carried out.

Measurements

Tympanic temperature (T_{tymp}) was recorded using the Radient TH809 (Radiant Innovation Inc. China.) Tympanic thermometer. Tympanic temperature is used as a measure of core temperature. According to Brinnel & Cabanac (7) the tympanic membrane is considered to be a temperature core site. However it should be pointed out that tympanic temperature is not necessarily the same as average ear canal temperature as defined by the ASTM E1965-98 (8).

T_{sk} of the anterior and posterior thigh was monitored using a Thermovision A40-M (FLIR) thermal imaging camera. Images were taken according to a standard protocol (6) in which the standard thigh posterior view was used where subjects stood with legs slightly abducted, feet parallel and the big toes point away from the camera and for the thigh anterior view, legs slightly abducted, feet parallel and the big toes point towards the camera. Ambient temperature (°C), ambient barometric pressure (mmHg) and relative humidity were recorded.

Regions of interest were defined for the left and right leg in the posterior and anterior views. Thighs posterior view: Two polygons following the outline of the left and right thigh. The upper edge of each polygon forms a horizontal line aligned with the gluteal fold. The l0ower edge forms a horizontal line aligned with the tip of the fibula (figure 1).

Thighs anterior view: Again two polygons following the outline of the left and right thigh. The upper edge of each polygon forms a horizontal line aligned with the lower end of the groin. The lower edge forms a horizontal line aligned with the rim of the patella (figure 2).

The mean temperature and standard deviation of the regions of interest for each image were found using the Ctherm thermal imaging software package.

Heart Rate was recorded using a Polar S610 Heart Rate monitor(Polar Electro, Finland.). In order to perform the graded exercise test it is necessary to estimate 85% HRmax for each subject, this was calculated using the age-predicted maximal heart rate equation (220 - age).

Blood lactate concentration was measured using a blood lactate test meter (Lactate Pro, KDK Corporation, Japan, supplied by Bodycare Products, Northfield Road, Southam, Warwickshire, England, UK.). Arterialised blood lactate samples were obtained immediately pre and post exercise.

VO_2 – Defined as the volume of oxygen consumed per minute was calculated in absolute values (L/min) for the non-weight bearing cycle ergometer test. During the last minute of each incremental exercise the subjects expired air was collected in a Douglas Bag (figure 3).

The volume of air in the Douglas Bag was measured using a Harvard Dry Gas meter and the percentages of oxygen and CO_2 analysed using the Servomex (UK) 1440C Gas analyser. VO2 values were calculated using the Expir Metabolic Gas Analysis Software programme. All values were STPD corrected.

RPE – To obtain ratings of perceived exertions subjects rated their perception of pain subjectively during exercise, at each level of exercise intensity. The rating was on the scale of 6 to 20 according to Borg G (9).

Graded Exercise Test

The YMCA Cycle Ergometry Test (10), for each individual, consists of a maximum of 4 consecutive, 3-minute workloads. The test is designed to raise the heart rate to between 110bpm and 85% of the age predicted HR_{max} for 2 consecutive workloads. The initial workload is was the same for all the subjects, working at a cadence of 50 revolutions per minute and with a load of 1 Kg (equivalent to 50 W) for 3 minutes. All subjects were given external verbal motivation. The HR during the last minute of the initial workload determines the subsequent workloads, see table 1. During the third and fourth workloads the HR is measured during the

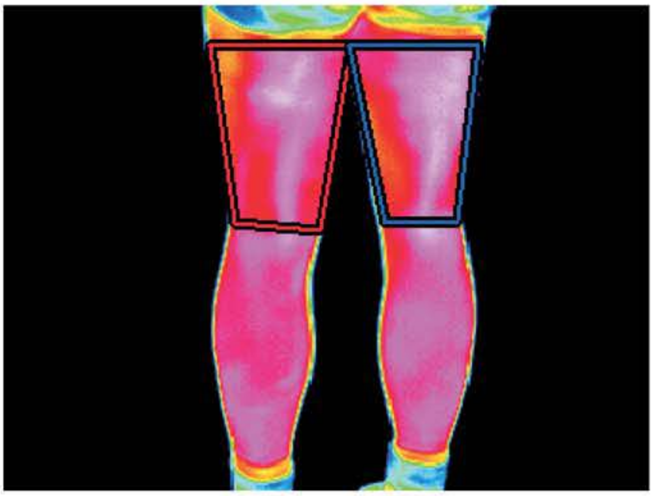

Figure 1. Regions of Interest defined for the posterior view.

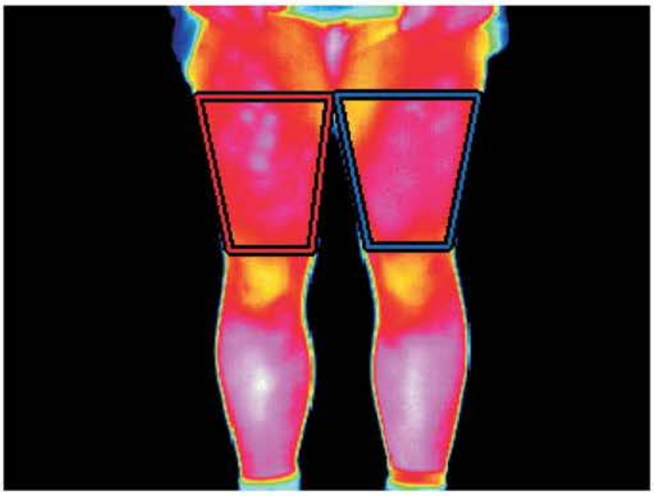

Figure 2. Regions of Interest defined for the anterior view

Table 1
Shows how HR during the initial workload determines subsequent workloads in the YMCA test.

First Work Load	50 W			
	HR<80	HR80-90	HR90-100	HR>100
Second Work Load	125W	100W	75W	50W
Third Work Load	150W	125W	100W	75W
Fourth Work Load	175W	150W	125W	100W

last 30 seconds of minutes 2 and 3, if the HRs differ by more than 5 or 6 bpm the workload is extended an additional minute until the HR stabilises. If the subjects steady state HR reaches or exceeds 85% of the age predicted HR_{max} during the third workload the test is terminated. This test was deemed appropriate, as it is suitable and safe for untrained subjects. VO_2 measurements were taken during the last minute of each incremental workload.

Figure 3
Cycle Ergometer Test

Massage

Sports massage using Effleurage hand techniques according to Lancey (11) were employed on the dorsal and ventral upper limb regions prior to exercise (figure 4). The massage starts with the pisiform technique and is followed by the 'V'-technique with an equal amount of time spent on each.

The Pisiform technique is one of the deeper techniques, as more pressure is applies using the hard bone at the base of the hand. The masseur stands in a lunge position with the body open to the subject with the bottom hand in a 'V' position acting as a template. The other hand (technique

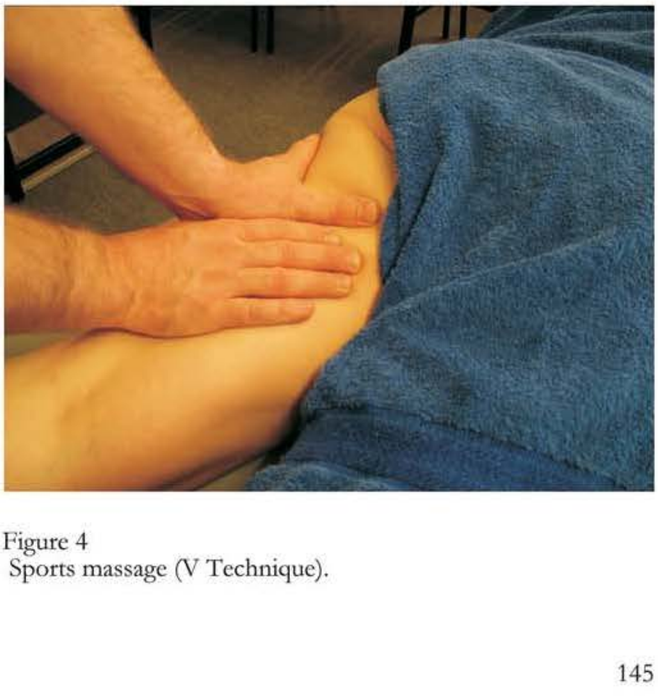

Figure 4
Sports massage (V Technique).

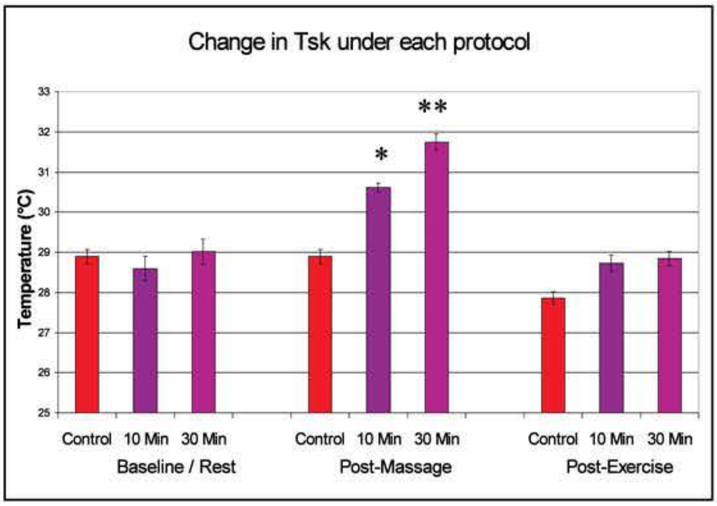

Figure 5.
Mean skin temperature under each protocol at rest after massage and post exercise.

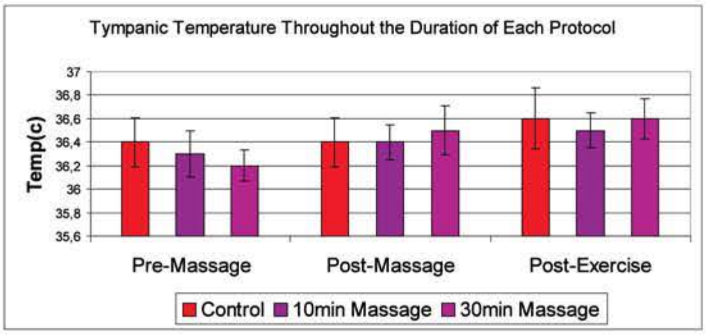

Figure 6.
Mean tympanic temperature throughout the duration of each protocol.

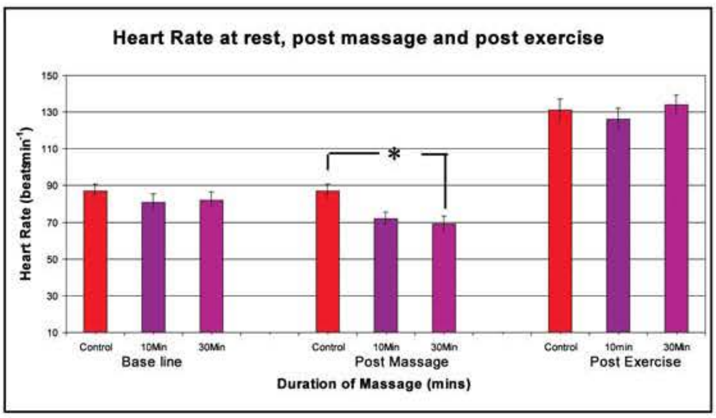

Figure 7.
Changes in Mean Heart Rate Under Each Protocol.

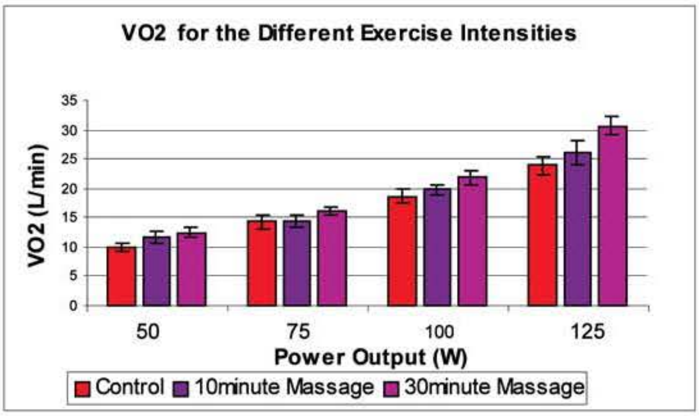

Figure 8.
Mean for VO_2 Under Each Protocol for the Different Intensities.

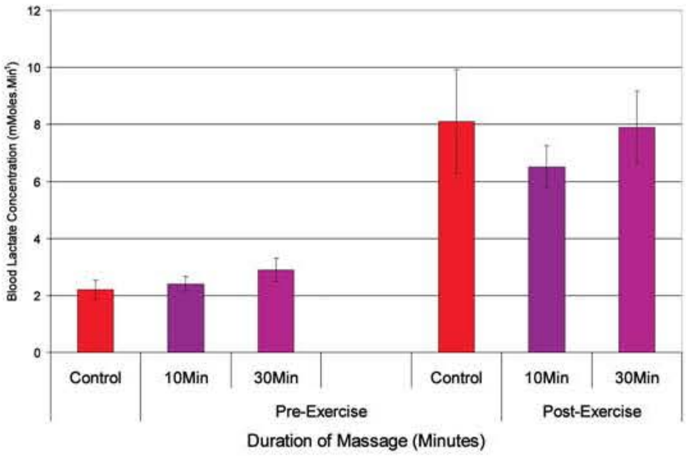

Figure 9.
Changes in Mean Blood Lactate Concentration Under Each Protocol.

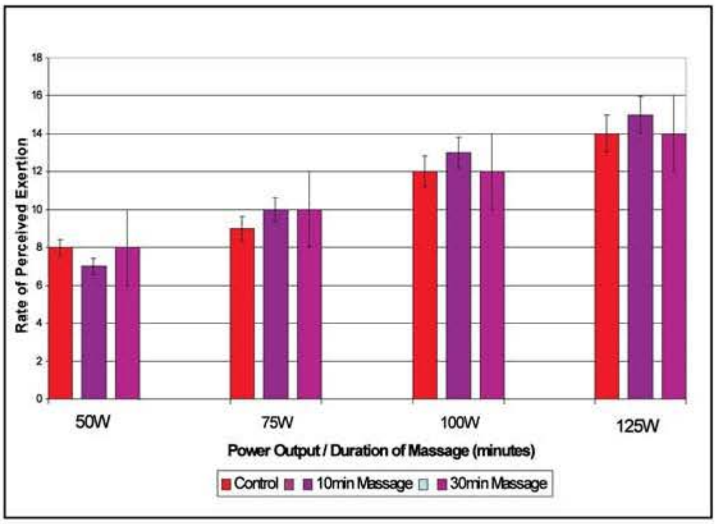

Figure 10.
Mean Rates of Perceived Exertion for Each Power Output.

Table 2: Shows the allocation of subjects (S) 1 to 7, to condition on the days of the study

Day1	Day2	Day3	Day4	Day5	Day6
S1 - Control	S1- Massage-10	S1-Massage-30	S5 - Control	S5- Massage-10	S5-Massage-30
S2-Massage-10	S2- Massage-30	S2 - Control	S6-Massage-10	S6- Massage-30	S6 - Control
S3-Massage-30	S3 - Control	S3- Massage-10	S7-Massage-30	S7 - Control	S7- Massage-10
S4 - Control	S4 -Massage-10	S4-Massage-30			

hand) cups over the template and is raised in a bridge shape to extenuate the pisiform bone. This technique is used to remove any waste substances from the area by applying a grater pressure and provides a mechanical movement of blood towards the heart.

The 'V'-technique is applied lightly following the deeper pisiform technique. The masseur stands in a lung stance for stability. A 'V' shape is made using the thumb and forefinger with both hands one in front of the other. The top hand is the technique hand and the lower hand is the template and acts as support. The masseur works in the direction of the heart along the muscle fibres. This aim is to generate heat in the skin and underlying tissues.

Procedure

All Procedures were performed in a draught free, temperature stable laboratory at 22^{o}C +/- 1^{o}C and relative humidity was 40%. All subjects were allowed to acclimatise to the laboratory temperature for 15 minutes. During each day of testing subjects acted as a control (no massage received) or were allocated massage times of either 10 minutes or 30 minutes (Table 2).

Baseline measurements of T_{tymp}, T_{sk} and HR were taken for all conditions.

Control subjects rested in a supine position whilst treated subjects underwent massage of the quadriceps and hamstring muscles for either 10 or 30 minutes.

Before exercise testing T_{tymp}, T_{sk} and HR were again recorded for all three conditions.

Lactate samples were taken before and after completion of the cycle ergometer test. Volumes of expired air, HR and RPE were recorded during the last minute of each exercise intensity.

Statistics

For comparison of control condition with massage conditions, the Wilcoxon signed-rank test was used. The P level used for comparisons was $P < 0.05$.

Results

Skin Temperature (Tsk)

Figure 5 shows T_{sk} increased post massage in the 10* and 30** minute massage groups compared to the control group. (Control - 10 minute $P < 0.0001$; and control - 30 minute $P < 0.0001$).

Post-exercise the massaged groups had returned to their baseline, there was no statistically significant difference in T_{sk} between baseline and post exercise.

Tympanic Temperature (Ttymp)

Figure 6 shows T_{tymp} for each protocol. No statistically significant changes in T_{tymp} were observed

Heart Rate (HR)

Figure 7 shows that HR decreased following both the 10 minute and the 30 minute massage protocols, although this difference was only statistically significantly different between the control and the 30 minute massage groups* ($P < 0.01$). There were no statistically significant changes between the 3 groups in the elevated post exercise heart rates.

Oxygen Consumption (VO_2)

Following the first workload (50W) all subjects' heart rates were between 90 and 100 bpm, according to the protocol subsequent workloads were set at 75, 100 and 125W respectively for all subjects. Figure 8 shows that as the VO_2 increases as the exercise intensity increase. The results show that massage has a direct impact upon VO_2; there is an increase in VO_2 for the 10-minute and 30 minute massage groups compared to the controls at each level of intensity of work. The differences in VO2 between the control and 10-minute massage groups, and the control and 30-minute massage groups, at each work level were statistically significant ($P < 0.05$ and $P < 0.001$ respectively)

Blood Lactate (BL)

The results in figure 9 show that there was a post-exercise increase in blood lactate concentration in all groups compared to the pre exercise values. There were no statistically significant differences between the three groups, either pre- or post-exercise.

Rate of Perceived Exertion (RPE)

The RPE increased as the intensity/power output increased, but no statistically significant differences were observed between the groups (Figure 10).

Discussion

Results from the present study showed that when comparing the control group to the 30-minute massage group, there was a significant decrease in HR in all subjects. This supports the findings of Hemmings *et al.* (12) and Hilbert *et al.* (13) who reported massage had therapeutic effects by relaxing athletes. Longworth (14) supports these findings, as massage had decreased arousal levels, resulting in decreased HR. This is a common response that occurs with massage as the body was in a supine position, circulation became reduced, and due to blood not pumping against gravity, HR decreased. In contrast Boone and Cooper (15) found a 30-minute massage had no impact upon HR at rest. Similar results were obtained by Callaghan (16).

Our results showed there was no significant difference in T_{tymp}. This is consistent with the findings of Shoemaker *et al.* (17) who found that low intensity exercise did not increase core temperature, as exercise needs to be substantially intense to initially strain the cardiovascular system. The subjects used with this graded test did not reach high workload intensity.

In the present study we observed a significant increase in T_{sk} following massage. As T_{sk} was measured immediately after massage we do not know if this is a transient increase or a longer-term effect. The increase in T_{sk} observed in the present study is consistent with previous work. Ebel and Wisham (18) noted a considerable increase in T_{sk} in all subjects when the calf muscle was massaged. Rowell (19) reported increases in muscle temperature as result of surface friction and Tiidus and Shoemaker (2) found muscle blood flow increased after Effleurage was applied and suggested that the increase in blood flow was a result of vasodilation, which increased the diameter of the blood vessel, increasing blood flow towards the surface of the skin, increasing T_{sk}. Studies from Ask *et al.* (3); Balke *et al.* (4) and Rinder and Sutherland (5) all showed increases in T_{sk} following massage. In some cases, as much as a 2-3°C increase in cutaneous temperature was obtained, which corresponds with the findings of this study. As of yet, evidence contradicting the fact that massage increases T_{sk} has not been found.

Present findings showed an increase in VO_2 following exercise in the massage groups. This contrasts with earlier studies by Tiidus and Shoemaker (2) and Boone et al (20) who found no significant difference in VO_2 however within the area of effleurage hand techniques differ widely and could account for these differences. The increase in $V0_2$ is unexpected as all subjects performed the same workloads suggesting that the massaged groups were less efficient and required more oxygen for the same workload. This appears to contrast with Balke *et al.* (3); Ask et al. (4); and Rinder and Sutherland (5) who demonstrated increases in muscle endurance and power output following massage. However the exercise test in the present study is a low intensity, It would be interesting to look for differences in VO2 following higher intensity exercises.

The statistical analysis showed there was not a significant difference, in lactate levels after applying massage. However Gupta et al. (21) found marginal benefits of lactate removal through massage compared to rest during recovery. Lactate removal is a complex process involving several transporters and metabolic pathways. Further studies are required to elucidate the suggested benefits of massage in enhancing such removal.

RPE increased with increasing work intensities but no statistically significant difference was observed between control and massage groups. Sports massage is a modality that has received little attention in terms of it psychological benefits to sports performance; therefore comparison of past research has been difficult. Much of the current research in sports massage has been directed upon how massage enhances positive mood states and psychological well-being (22). As to whether the emotional mood profile following massage would be related to performance enhancement, the results from the present study are negative.

In conclusion little change was observed in tympanic temperature, RPE and lactate levels between controls and massage conditions following exercise. In the case of lactate measurements the results showed large variability, measurement of specific enzyme activity such as LDH might shed more light on lactate production and removal following massage.

The increase in VO_2 in the massage treated subjects compared to control is somewhat surprising and bearing in mind the long standing importance of VO_2 for assessing aerobic performance necessitates a closer examination and standardisation of techniques currently employed in the field of sports massage.

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Intermittent isometric contractions of the rectus abdominis muscle by application of Transcutaneous Electrical Nerve Stimulation (TENS) and its effect on blood flow in the overlying skin

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SUMMARY

The less robust blood flow of the DIEP flap, in comparison to the free TRAM flap, limits the volume that safely can be harvested for breast reconstruction. Preconditioning the DIEP flap would augment the volume that can be used. This study investigates the effect of transcutaneous electrical nerve stimulation (TENS) in the burst mode of the rectus abdominis muscle on the blood flow in the overlying skin. In ten healthy female volunteers, skin temperature and skin blood flow were measured with respectively, infra-red thermography and laser-Doppler imaging before, during and after intermittent isometric contractions of the rectus abdominis muscle. No significant changes in skin temperature were found while minor changes in skin blood flow (SBF) (a decrease in SBF on the stimulated side) were registered. It is concluded that burst-mode TENS does not increase blood flow in the skin overlying the stimulated muscle and is unlikely to precondition the DIEP flap.

KEY WORDS: skin temperature, skin blood flow, transcutaneous electrical nerve stimulation

WIEDERHOLTE, DURCH TRANSKUTANE NERVENSTIMULATION (TENS) BEDINGTE ISOMETRISCHE MUSKELKONTRAKTIONEN DES M.RECTUS ABDOMINIS UND IHR EINFLUSS AUF DIE DURCHBLUTUNG DER DARÜBER LIEGENDEN HAUT

Die unregelmäßigere Durchblutung eines DIEP Lappens im Verglliech zu einem freien TRAM Lappen, beschränkt das Gewebsvolumen, das für Brusterkonstruktionen verwendet werden kann. Eine Präconditionierung des DIEP Lappens könnte das einsetzbare Gewebevolumen vergrößern. Die vorliegende Studie untersuchte den Einfluss transkutaner elektrische Nervenstimulation (TENS(im Burst-Mode of the Durchblutung der Haut über dem M.rectus abdominis.Bei zehn gesunden weilbliche Freiwilligen wurde die Hauttemperatur und die Durchblutung mittels Infrarot-Thermographie bzw Laser-Doppler-Imager vor, während und nach wiederholten elektrisch induzierten Kontraktionen des geraden Bauchmuskels gemessen. Es zeigten sich keinerelei signifikante Veränderungen der Hauttemperatur und lediglich geringe Veränderungen in der Hautdurchblutung (Verminderung der Hautdurchblutung an der stimulierten Seite) Es wird die Schlussfolgerung gezogen, dass die TENS-Therapie im Burst-Mode zu keiner Durchblutungssteigerung der Haut über den stimulierten Muskel führt und deswegen wahrscheinlich nicht für die Präkoditionierung eines DIEP Lappens geeignet ist.

SCHLÜSSELWÖRTER:Hauttemperatur, Hautdurchblutung, transkutane elektrische Nervenstimulation

Thermology international 2006, 16(4): 150-154

Introduction

Breast reconstruction has become an integrated part in the overall treatment for patients diagnosed with cancer of the breast. Patients with autologous breast reconstructions with a free transverse rectus abdominis musculocutaneous (TRAM) or deep inferior epigastric perforator (DIEP) flap are specifically pleased with the natural shape, soft consistency and permanency of the superior results. However, there is a recognised incidence of partial flap necrosis in both the TRAM flap and the DIEP flap: this is more likely in smokers and the obese [1]. Patients with an obese abdominal panniculus are poor candidates for this procedure since the myocutaneous perforators may be of an inadequate size for the size and thickness of the skin paddle.[2]. The main blood supply of the free TRAM as well as for the DIEP flap is the deep inferior epigastric artery. It is the dominant artery of the rectus abdominis muscle and only musculo- cutaneous perforators arising from this artery provide blood to the free TRAM and DIEP flap. Muscular blood flow can increase up to 25-fold during physical activity [3]. The increase in blood flow elicited by voluntary and electrically induced muscle contractions by transcutaneous electrical nerve stimulation (TENS) appears to be similar in magnitude [4]. TENS is widely used in clinical practise and a substantial amount of research has focused on the physiological effects of TENS. There are contradictory reports on the effect of TENS on skin temperature and cutaneous blood flow [5-9]. For example, Cramp et al [8]found no effect of high-frequency TENS upon cutaneous blood flow. On the other hand, there is evidence for an increased microcirculation in skin areas overlying stimulated muscle. Sherry et al.[10] showed that if the intensity is sufficient enough to cause a moderate muscle contraction, a transient, local increase in blood flow will occur. A similar finding was reported by Cramp et al.[11]. An increased blood flow in the contracting muscle could result in an augmented flow through the myocutaneous perforators to the skin. This could be a non-invasive method of preconditioning the TRAM or DIEP flap for autologous breast reconstruction. In this study, the effect of burst-mode TENS of the rectus abdominis muscle on the microcirculation in the skin is investigated. This pattern of external stimulation of the rectus abdominis muscle more closely mimics the intermittent muscle contractions during, for example, sit- ups.

Materials and methods

Subjects

Ten healthy female subjects voluntarily participated in this study. The study was approved by the Ethical Committee

Table 1
Subjects: vital statistics

ID	sex	Age (years	Height (cm	Weight (kg	BMI	smoker
1	♀	27	160	66	25.8	no
2	♀	38	167	64	22.9	yes
3	♀	47	169	63	22.1	no
4	♀	30	158	53	21.2	no
5	♀	34	170	64	22.1	no
6	♀	33	160	56	21.9	no
7	♀	52	167	59	21.2	no
8	♀	32	154	62	26.1	no
9	♀	35	165	59	21.7	no
10	♀	43	172	67	22.6	no
Mean		37.1	164.2	61.3	22.8	
SD		7.9	5 .9	4.5	1.8	

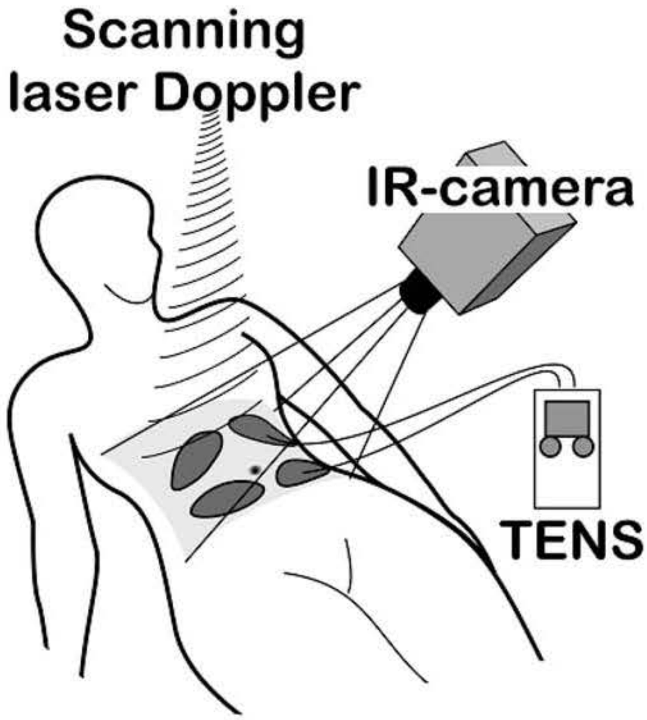

Figure 1.
Overview of experimental set-up

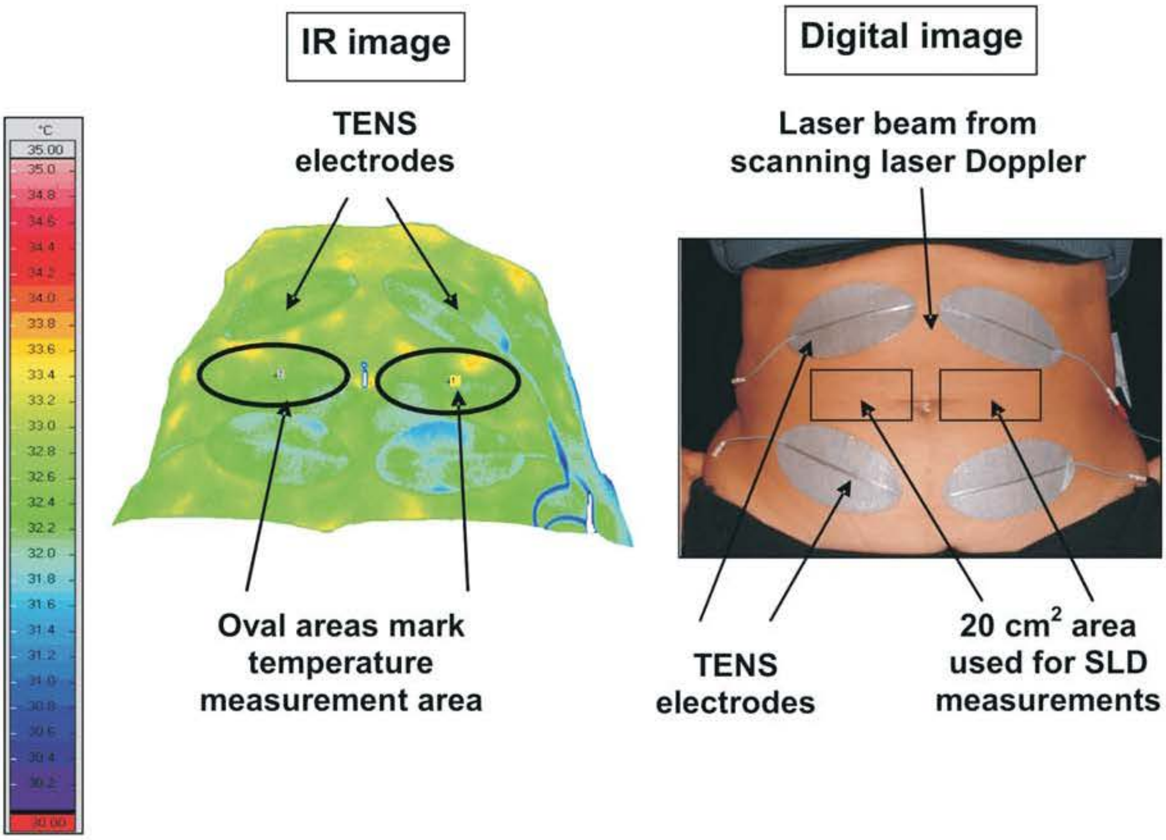

Figure 2.
Left panel: IR-image of abdominal area showing position of the selected oval areas used for the skin temperature measurements. Right panel: Digital photograph of abdominal area showing position of TENS electrodes. The black rectangles show the 20 cm² areas selected for blood flow measurements.

and all patients gave their informed consent. The average age was 37.1± 7.9 years and the average BMI was 22.8 ± 1.8. Other vital statistics are shown in Table1.

Muscle stimulation (TENS)

TENS was carried out with an ELPHA*II* – 3000 (Danmeter A/S, Odense, Danmark) stimulator in the burst mode. In this mode TENS causes intermittent isometric muscle contraction and this type of mode is often used in Physical Therapy. Two pairs of oval shaped surface electrodes (50mm x 100mm), each with a surface area of 39.3cm^2, were placed on the abdomen. One pair was situated on the right side and the other on the left. The position of the electrodes is shown in Figs. 1 & 2. During the experiments, only the left electrode pair was stimulated. By increasing the intensity (0-40 mA), visible intermittent muscle contractions were evoked. Each patient was subjected to a 20 minute period of stimulation. At the start of the stimulation period the intensity of the TENS stimulation was set to a low level. The stimulation intensity was gradually increased to a maximal level that could be tolerated without undue discomfort. At all stimulation intensities visible muscle contractions were observed.

Infra-red thermography

Throughout the experiments skin surface temperature of the entire abdominal area was monitored by infra-red (IR) thermal imagery using a Nikon Laird S270 (Tokyo, Japan) IR-camera. This camera produces high-definition digital infrared images. During each experiment digital IR images were taken at regular intervals, before, during and after TENS stimulation. The images were stored electronically. For processing of the IR digital images we used image analysis software PicWin-IRIS (EBS system technik GmbH, München, Germany), which could produce measurements of skin surface temperatures to an accuracy of 0.1ºC. Prior to each experiment a small piece of silver tape was placed over the naval. This acted as a visual reference point during the processing of the thermal images (see Fig 2). To examine the possible effect of TENS on skin surface temperature, either directly through increased skin blood flow or indirectly via heated conducted to the skin surface from the stimulated muscles, the average skin surface temperature of two identically oval shaped areas (ca. 26 cm^2) was calculated. The position of these areas lying between each ipsilateral pair of electrodes is shown in fig.2.

Laser Doppler Imaging

Skin blood flow of the entire abdominal area was monitored using a MoorLDI-2 laser Doppler imager (Moor Instruments ltd; England). The scanner was positioned on a shelf placed over the patient at a height that resulted in a total laser beam length (from skin surface to sensor opening) of approximately 90 cm (Fig.1). Through software, the entire scanned area was adjusted to cover an area of approximately 360 cm^2 although this varied slightly from patient to patient. However, in all cases it spanned an area which included all 4 TENS electrodes. Each scan took approximately 90 seconds to complete. In each experiment 6 scans were made. The first was made ca. 5 min prior to and the second immediately before the start of TENS stimulation, the 3rd was made immediately after the end of TENS, and the 4th, 5th and 6th scan were made at respectively 5, 10 and 15 min of the recovery period following TENS. It was not possible to perform LDI scans during TENS due to artefacts caused by abdominal contractions. The scanned LDI images were stored on a PC for later analysis. Analysis of the stored images was made using the MoorLDI-2 Software package. For each image two rectangular areas of skin lying between each lateral pair of electrodes were used (see right panel in Fig. 1). Each rectangle covered a skin area of 20 cm^2. The average skin flow in perfusion units (PU) was calculated for each rectangle.

Experimental protocol

The lightly clothed subjects lay in a supine position on a standard examination bench. The abdominal skin area was exposed and the electrodes placed in position (Fig. 1). After an equilibration period of approximately 20 minutes the first LDI scan was made. The 20 min TENS period commenced 5 min later. Room temperature was approximately 23°C.

Statistics

Statistical analysis was made using SPSS software. Values in Table 1 and figures 3-5 are means ± S.D. Comparison of means were made using paired sample statistics (T-test). P≤0.05 was considered significant.

Results

In Fig. 3 the intensity of TENS throughout the experiments is shown. As can be seen the intensity commenced at a low level (12 mA) and was gradually increased to an average level just below 40mA. At all stimulation intensities visible contractions were observed while no discomfort was registered.

The average skin surface temperature over the stimulated and non-stimulated abdominal muscle is shown in Fig. 4. On average, the skin temperatures on the non-stimulated side were 0.2 - 0.3 °C higher than on the stimulated side, although these differences were not statistically significant.

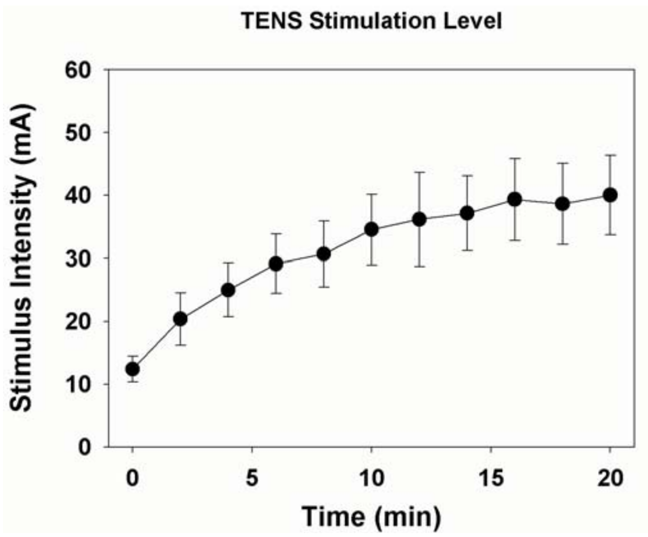

Figure 3
Time course of TENS intensity. Mean values ± S.D

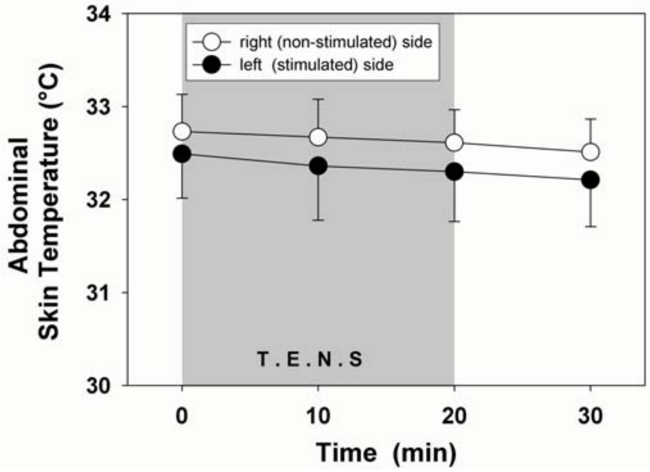

Figure 4.
Time course of changes in abdominal skin surface temperature during and after TENS. Mean values ± S.D.

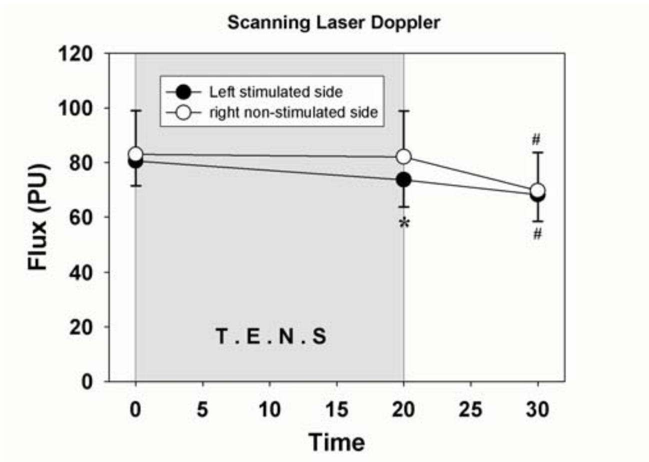

Figure 5.
Time course of changes in abdominal skin flow before and after TENS of the abdominal muscles. PU = perfusion units. Mean values ± S.D. * & # = Statistically significantly different from respective values at time zero.

Throughout the entire course of the experiment skin temperatures on both sides of the abdomen very slowly decreased by 0.2 - 0.3 °C. Apart from these minor changes in skin temperature no changes related to TENS could be discerned.

Changes in skin blood flow are shown in Fig. 5. There were no statistically significant changes between the left and right abdomen at any of the three time points shown. Interestingly there was a small but statistically significant decrease in blood flow between the start and end of the 20 min period of stimulation with TENS (i.e. the left side only). For both the stimulated and non-stimulated side of the abdomen the mean skin blood flow values 10 min after the end of TENS stimulation were both statistically significantly lower than their respective values at the start of TENS stimulation.

Discussion

The introduction of the pedicled TRAM flap by Hartrampf et al. (12) was a hallmark in the evolution of autologous breast reconstruction. The pedicled TRAM has proven to be a reliable method of reconstruction, but the rate of partial flap necrosis may approach 25% (13). Sheflan and Dinner (14) divided the pedicled flap into four zones according to its reliability of perfusion. To reduce the risk of partial necrosis, zone IV is often discarded. They advised those with a thick panniculus to reduce weight and to begin an exercise program involving sit-ups weeks before surgery. (15, 16). Application of microsurgical principles resulted in the use of the free TRAM, which reduces abdominal wall morbidity significantly compared to the pedicled TRAM. Although the free TRAM has a more robust blood supply, it is also divided into four zones.(17) The division is based on Taylor's angiosome concept: the progressive, step-wise perfusion of vascular territories and the tenet that one can only safely capture immediately adjacent angiosomes.(18). Nowadays, the deep inferior epigastric perforator (DIEP) flap is considered the state of the art in autologous breast reconstruction. By keeping the integrity of the rectus abdominis muscle intact, it further reduces donor-side morbidity. The blood supply to the DIEP flap is considered by some to be less robust as to the free TRAM flap. Nahabedian et al.(19) advise not to use a DIEP flap when the breast reconstruction exceeds 1000 gram, not even when the surgeon includes two perforators in the flap. Kroll (1) concluded in his study that there is a higher incidence of partial flap loss and fat necrosis is higher in DIEP flaps than in free TRAM flaps. In spite of the more complex nature of surgery, the DIEP flap has gained more popularity in Plastic Surgery, especially due to less donor morbidity, the reduced postoperative pain and the aesthetic results obtained.(20). Obesity is not considered a contraindication. By optimising the perfusion in the larger breast to be reconstructed, both deep inferior epigastric arteries and their venae commitantes are harvested and anastomosed to receptor vessels (21). Improvement of perfusion of a DIEP flap by a single pedicle might result in less fat necrosis and increase the volume to be harvested. The dominant artery of the rectus abdominis muscle is the deep inferior epigastric artery which, via musculocutaneous perforators, provides blood to the DIEP flap. Physiological studies have shown that muscle blood flow can increase up to 25-fold during intermittent isometric contraction. TENS is an often used treatment modality in Physical Therapy and can provide intermittent isometric muscle contractions (burst mode) causing an increase in blood flow to the muscle.

We postulated that an eventual increase in blood flow during muscle activity would lead to an increase in blood flow through the musculocutaneous perforators to the overlying skin. By using TENS in the burst mode on the rectus abdominis muscle, blood circulation in the overlying skin could become increased. However, as pointed out in the introduction, the previous published evidence regarding this point is contradictory. In our study, neither IR- Thermography nor Laser Doppler Imaging could register a significant increase in respectively skin temperature and skin blood circulation. In fact, the opposite occurred and there was a small, but statistically significant reduction in mean skin blood flow in the skin area overlying the stimulated abdominal muscles, which was not seen on the non- stimulated side of the abdomen. The recommendation to obese patients to participate in an exercise programme involving sit-ups weeks before a breast reconstruction with a pedicled TRAM, free TRAM or DIEP most likely improves her general health condition but does not guarantee a better flap perfusion. We conclude therefore, that intermittent isometric contractions of the rectus abdominis muscle by application of burst-mode TENS, does not result in a detectable alteration in skin temperature or blood circulation in the overlying skin. This mode of TENS is unlikely to precondition the TRAM and DIEP flap.

Acknowledgements

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General Assembly of the European Association of Thermology (EAT), held on September 15th, 2006 in Zakopane

Anna Jung, E. F. Ring, K.Ammer

European Association of Thermology, Vienna, Austria

The General Assembly was scheduled for September 15th, 2006, 14:30, at the Hotel Wersal in Zakopane, Poland. The president Prof Anna Jung opened the General Assembly in time at 14:30. Delegates from 5 of the 8 Member Societies were present,

As more than half of all members with voting rights have been present, the General Assembly was entitled to make decisions without delay. The Agenda included report of the president, report of the treasurer, statement of the auditors, election of a new board, any other business

Presidents Report EAT 2003-2006

The ninth European Congress of Thermology was held in Krakow Poland, and was successful in bringing together colleagues from many countries in a full programme of lectures. Since then we are pleased to record the formation of a new Society in Romania. Two meetings have already been held. Across Europe, annual meetings have continued in Poland, the United Kingdom, Austria and Germany. A major meeting in Italy took place in Rome in September 2005, organised at the University, with both medical and industrial applications of thermography.

An SPIE European meeting on infrared sensor technology was held in Jena Germany during 2005, and the industrial meetings QIRT, quantitative infrared thermography have continued their regular series. Prof. B.Wiecek having hosted one of these conferences in Lodz, Poland, is a member of the organising committee. The next of these conferences is scheduled for Krakow in Poland.

Prof. Benko and colleagues in Budapest have continued the long running series of meetings titles Thermogrammetry. These conferences are under the auspices of Thermal Engineering and Thermogrammetry organisation in Hungary, and include a technical exhibition. The next (15th) meeting for late June 2007 has been announced.

We have also been encouraged by the increasing interest in Norway, largely due to the activities of Prof.James Mercer at Tromsø University. It is good to welcome delegates from Norway over the last 2-3 years, for the first time since the formation of the EAT some 40 years ago.

Internationally, European members have attended meetings of the American Academy of Thermology, the Institute of Electrical and Electronic Engineers, medical and biological section in the USA, and their major international meeting held in Shanghai, China.

Our journal, produced regularly, Thermology international continues to publish papers from around the world, with a main contribution from Europe. Our thanks are due to Prof.Kurt Ammer for keeping this journal in print, which is a major resource for researchers in the field of thermal imaging.

The annual training course on the theory and practice of thermal imaging in medicine has continued at the University of Glamorgan. Normally held in the first week of July, this has drawn both new and experienced thermographers to the UK from a number of countries in Europe and North America. The emphasis of this course is on thermal physiology and issues relating to protocols for reliable thermal measurements from thermal imaging. These subjects are rarely included in any other forms of training at the present time.

A new world-wide interest in the use of thermal imaging as a screening tool in airports during fever threats has emerged. During the SARS epidemic in the Far East, thermography was used, especially in Singapore and China. Currently, a special committee of the International Standards organisation is meeting to draw up a standard for the correct use of this technology as a fever screening tool. The threat of Bird influenza from the H5N1 virus has prompted this initiative. Two of our committee members serve on this working group (Prof Mercer & Ring)

Throughout the history of our Association, the numbers of active participants in different countries has fluctuated. At one time, there were 600 members in France, the biggest group in Europe, although today, there are probably only a few isolated doctors working there with thermal imaging at the present time. The attendance at meetings has shown an encouraging increase in the UK recently. It is hoped that as the equipment continues to improve, and the costs reduce, that this trend will be seen in more countries across Europe.

It is important that those who are working in this unusual and exciting field should meet together. Experienced and newer workers with thermal imaging need to be able to exchange ideas and practical information with each other. We are pleased that this 10th European conference was hosted as was the 9th in here in Poland. The organising committee led by Prof. Jung expressed their wish that all delegates from Europe, Russia, Australia and the USA have had a pleasant and successful visit to Zakopane. The conference programme reflected the technological advances and increased efforts in standardisation of techniques as special issues at the present time.

Preliminary plans for both International and the 11th European congress over the next three years are in hand, the next being held at Auburn University USA next June. Announcements will be given to all these conferences in Thermology international, and on the Glamorgan group website

Treasurers Report

The treasurer Prof Ammer reported that the main expenses of the EAT are the costs for production of the journal Thermology international. Until 2005, the journal was financed half by the Ludwig Boltzmann Research Institute for Physical Diagnostics and the EAT in cooperation with the Austrian Society of Thermology (ÖGT) This year the full financial burden has to be taken by the EAT and the ÖGT. At the date of the General Assembly, all member societies had not paid yet there annual subscription, resulting in negative cash balance which was corrected meanwhile from the treasurers own money.

In order to increase the financial means of the society, the treasurer suggested to increase the annual membership fee for member societies from 3 Euro/per member in the member society to 4 Euro. The General Assembly accepted this proposal unanimously.

Statement of the Auditors

Dr Plassmann reported on behalf of both auditors, that both auditors had checked the accountancy of the EAT, and they did not found any irregularities. Dr Plassmann finally asked the General Assembly to accept the finance report and to relieve the board members from their responsibilities. The General Assembly agreed unanimously.

Election of a new board,

After that, the board members resigned and Prof Ammer conducted the elections for the new board. The following nominations has arrived in time at the EAT:

President: Prof Dr Anna Jung, Poland

Vice-President; Prof Dr Francis Ring, United Kingdom

General Secretary/Treasurer:Prof Dr Kurt Ammer, Austria.

The General Assembly the nominations with great majority. President, vice-president and general secretary/treasurer were elected with all votes and one single abstention. They newly elected Board accepted their duties and promised to support the EAT in the future with full engagement.

Any other business

The venue of the next, the 11th European Congress of Thermology was discussed. Three locations were proposed: Tromsoe in Norway, Bath in England and the Island Kos in Greece. A conference in Tromsoe would be organised by Prof Mercer, but has the dis-advantage that Norway is an expensive country and travelling to Tromsoe may be difficult and time consuming.

Prof Ring offered his help in organising the conference in Bath together with Dr Nigel Harris, who followed Prof Ring as the head of the Department for Clinical Measurement at the Royal Hospital of Rheumatic Diseases in Bath. High costs for hotel rooms and for hiring facilities are the main arguments against Bath.

Prof Jung proposed the Greek island Kos, where the conference could be organised in September at similar costs as in Zakopane. In the end of summer, flights to Kos are available from most of the capital cities in Europe.

It was agreed, that the venue for the next Euripean congress will be discussed further in the coming meeting of the EAT Board.

Finally, Prof Jung closed the General Assembly by 15:23.

Meetings

16-18 November 2006

VII Conference on Thermography and IR Thermometry
Ustron-Jaszowiec (near Wisla), Poland

Invited lectures:

Jean-Luc Tissot, ULIS, France
"*Uncooled Infrared Detector: State of the Art*"

Gilbert De Mey, Gent University, Belgium
"*How to design black body?*"

Andrzej Nowak, Andrzej Wawrzynek, Politechnika Slaska, Gliwice
"*Promieniowanie termiczne i jego rola w modelowaniu przepływu ciepła*"

Michal Strzelecki, Politechnika Lódzka
"*Podstawy przetwarzania obrazów - zastosowania w termografii*"

Jean-Luc Tissot, ULIS, France
"*Uncooled IRFPA with 25 µm pixel-pitch*"

Gilbert De Mey, Gent University, Belgium
"*Noise of thermal detectors, where does it come from?*"

Conference president:
Dr hab. Boguslaw Wiecek, prof. PL
(kier. Zakladu Ukladów Elektronicznych i Termografii Instytutu Elektroniki Politechniki Lódzkiej)

Conference Sekretariat:
Mgr Tomasz Wajman
Mgr inz. Mariusz Felczak
Mgr inz. Dariusz Rzeszotarski
Mgr inz. Tomasz Swiatczak
Mgr inz. Maciej Kulinski
Mgr inz. Krzysztof Tomalczyk
Mgr inz. Bartosz Ostrowski
Mgr inz. Marcin Lis

Information::
Sekretariat Konferencji TTP
Instytut Elektroniki, Politechnika Lódzka
ul. Wólczanska 211/215, 90-924 Lódz

Tel.: (042) 631 26 35, 631 26 56, 631 26 37
Fax: (042) 636 22 38 e-mail: ttp@p.lodz.pl
website: http://thermo.p.lodz.pl/ttp/

Thermal group portrait of the participants of the 10 European Congress of Thermology in Zakopane 2006

2007

March 22-23, 2007

6 INTERNATIONAL CONFERENCE QUALITY RELIABILITY and MAINTENANCE in Oxford

Information;
Dr R A Thomas, QRM Ltd, Tyn-y-Coed, Glynhir Road, Pontardulais, Swansea, SA4 8PX, UK.
Tel/Fax: +44 (0)1792 885089
Email: rod@qrmconference.co.uk

Web site: www.qrmconference.co.uk

April 9-13, 2007

Thermosense XXIX (DS37)

Part of the
SPIE International Defense and Security Symposium

Orlando World Center
Marriott Resort & Convention Center • Orlando, FL USA

Conference Chairs:
Kathryn M. Knettel, United Space Alliance, LLC;
Vladimir P. Vavilov, Tomsk Polytechnic Univ. (Russia);
Jonathan J.Miles, James Madison Univ.

Abstract Due Date: 25 September 2006

Abstracts, if accepted, will be printed and distributed at, or before the meeting.
On-Site Proceedings Manuscript Due Date: 15 January 2007

Up-to-date and Session Chair information is available at:
http://www.thermosense.org

May 26-30, 2007

OPTIMESS 2007

3rd Workshop on Optical Measurement Techniques for Structures and Systems

Faculty Club, Leuven - Belgium

CONFERENCE SECRETARIAT:
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Dept. of Mechanical Engineering, Vrije Universiteit Brussel
Belgium

Tel: ++32.(0)2.629.28.06, Fax: ++32.(0)2.629.28.65
E-mail: info@optimess.org
web site:www.optimess.org

June 8-10, 2007

33 AAT Congress and 7th International Congress of Thermology in Auburn, Alabama, USA

Information:

See pages 159-160

Prof Dr. David Pascoe
Auburn University

Email: pascodd@auburn.edu

June 27-29, 2007

15 International Conference on Thermal Engineering and Thermogrammetry (THERMO) in the House of Technology Budapest, V., Kossuth Lajos tér 6-8.

Information:
Application Forms and abstracts/papers should be sent to:
Dr. Imre BENKÖ,
MATE Secretariat,House of Technology,
III. 318.H 1372 Budapest,POB. 451., Hungary

Fax: +361-353-1406,
Phone: +361-332-9571., E-mail: mate@mtesz.hu
www.mate.mtesz.hu/eng/Pages/2007/Thermo2007/index.php

For any further information and personal inquiries please contact the following address:
Dr. Imre BENKO, H 1112 Budapest, Cirmos u. 1, 6/38, Hungary
Phone/fax: +361 310-0999.E-mail: ibenko@freestart.hu

July 2007

8th Course on the Theory and Practice of Infra Red Thermal Imaging in Medicine,
University of Glamorgan. Pontypridd CF37 1DL, UK

Information:
Prof Francis Ring
Medical Imaging Research Group,
Faculty of Advanced Technology,
University of Glamorgan, Pontypridd CF37 1DL, UK
Email: efring@glam.ac.uk

October 2007

20th Symposium of the Austrian Society of Thermology, SAS Hotel Vienna, Austria

Information
Prof Kurt Ammer MD, PhD
Austrian Society of Thermology
Hernalser Hauptstr 209/14
Email: KAmmer 1950@aol.com

33rd Annual Meeting

American Academy of Thermology

and the

International College of Medical Thermology

Seeking: Submission of abstracts for tutorials and scientific presentations (oral communication and posters). We are actively seeking conference participation from thermologists from all countries and disciplines. *Please see reverse for abstract submission form.*

Scientific Papers: Current research or clinical papers pertaining to infrared thermography. 20-minute oral presentations (15-minute talk/5-minute question period) or posters. Topic areas include: pain, worker's comp, international presenters track, veterinary medicine, student presentations, basic physiology and IR, neuromuscular, breast, musculoskeletal pathology, equipment, and other.

Tutorials: Critical reviews, analysis, or material relevant to the current state of knowledge or information that will promote scientific understanding of thermography (30-minute presentations). May include historical presentations, evaluation of current procedures/techniques, basic physiology as imaged by infrared thermography, tips for improving scientific/clinical presentations, preparation for journal publication, etc. Authors will be requested to send an abstract and a brief outline of the content area to be covered.

Special Interest Groups: Session time will be provided for special interest groups to get together and discuss important issues that will help to advance the understanding and use of thermography.

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David D. Pascoe, Ph.D., Chairman, Scientific Program at pascodd@auburn.edu

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Airport: Hartsfield International in Atlanta, Georgia, USA (90 minutes/105 miles/170 Km northeast of Auburn. Transportation from airport: rental car or Express 85, www.express85.com)

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June 7-9, 2007

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