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Thermology 2009- literature search

Thermographic findings in the lower back

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Volume 20 (2010)

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Thermology 2009 – a computer- assisted literature survey

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SUMMARY

The literature survey 2009 is based on 743 papers found in the databases MEDLINE and EMBASE with the keywords “thermography” or “thermometry” or “thermotherapy” or ‘skin temperature’ or ‘core temperature’ and restricted to “humans” and “included in the databases between 01-01 and 31-12 2009”. 43 percent of papers of this review are originated from Europe and 91.5 percent of all papers are written in English. 266 controlled studies using some kind of temperature measurement were reported. Physiology, surgery, dermatology, neurology, clinical and experimental pharmacology were the predominant fields of applications of temperature measurement in medicine. Therapeutic hyperthermia and hypothermia treatment was the topic of many papers. Fever attracted also a high publication interest. Only some papers were related to intravascular temperature measurement, Raynaud’s phenomenon or breast thermography.

KEY WORDS: Thermography, literature search, temperature measurement

THERMOLOGIE 2007 – EINE COMPUTER-GESTÜTZTE LITERATURSUCHE

Die Literatursuche für 2009 basiert auf 743 Arbeiten, die unter den Schlüsselwörtern “Thermographie” oder “Thermometrie” oder “Thermotherapie” oder ‘Hauttemperatur’ oder ‘Kerntemperatur’ und den Einschränkungen “Mensch” und “zwischen 1. Jänner und 31. Dezember 2009 erfasst” in den Datenbanken MEDLINE und EMBASE gefunden wurden. Die Autoren thermologischer Publikationen kommen in 43,3 Prozent aus Europa, und 91,5 Prozent aller Arbeiten wurden in Englisch publiziert. 226 kontrollierte Studien setzten irgendeine Form von Temperaturmessung ein. In der Medizin waren Physiologie, Chirurgie, Dermatologie, Neurologie sowie klinische und experimentelle Pharmakologie die vorherrschenden Anwendungsgebiete für Temperaturmessung. Therapeutische Hyperthermie und die Behandlung mit Hypothermie war das Thema vieler Veröffentlichungen. Auch Fieber erzielte ein hohe publizistisches Interesse. Über die intravaskuläre Temperaturmessung, das Raynaud-Phänomen oder die Brustthermographie wurden nur wenige Publikationen gefunden.

SCHLÜSSELWÖRTER: Thermographie, Literatursuche, Temperaturmessung

Thermology international 2010, 20(1) 5-27

Introduction

The tradition of annual surveys of thermology literature goes back to the year 1989 (1). Last year this survey was combined with an update of thermological information available from the internet (2). The search for thermology papers published in 2009 returns to the databases EMBASE and MEDLINE, which have been the pool for the very first literature in 1989.

Methods

Due to the expectation of a high number of hits when using the same combination of key words as in previous searches, various combinations of search terms were applied. A search in EMBASE and MEDLINE with the terms “thermography”, or, “thermometry” or “temperature measurement or “thermotherapy” or, “skin temperature” or “core temperature” and “year 2009” yielded 1905 hits. Exchanging “year 2009” with “included between 01-01-2009 and 31-12-2009” reduced the number of hits to 1350. Further restriction with the term “human” yielded a further reduction of hits.

The papers were analysed to show the origin of authors, the language, the journal and issue number of publication. For further classification, the Citation Report Database at

Thompson Institute for Scientific Information (ISI) was searched to obtain the most recent Impact Factor for journals publishing papers related to the search profile in 2009. For the journals not yet recognised by ISI, such as “Thermology international”, the SCImago Journal Rank: Citations per article (2years) was used instead.

Papers were allocated with respect to the topic of the publication into medical and non medical publications. Non medical papers were further classified into basic sciences, applied sciences and biology.

Results

772 publications were obtained with the search profile described, which yielded 669 hits in EMBASE and 103 in MEDLINE, after removal of doubles 743 papers remained.

All but 62 papers of this database were published in English. 19 publications appeared in German (69,88,158, 164, 228, 255, 260, 347, 423, 372, 430, 525, 536, 658, 673, 725, 728,740,741), 13 papers in Chinese (14, 391, 592, 625,686, 712, 713, 714, 719, 731, 735, 732, 739), 6 publications in French (56, 108, 184, 356, 415, 568) and 6 in Japanese (341,342, 478, 602, 630, 715), 4 publications in Russian (171, 234, 334, 348) and 4 in Portuguese (180, 181, 479,

727), 3 papers in Polish (434, 537, 649) and 3 in Danish (27, 314, 347). Spanish (30), Romanian (120), Italian (580), Czech (503), Croatian (742) and Hungarian (179) was the language of the other 6 papers. All but 2 publications (372, 602) showed a summary of the article in English.

In total 2971 authors were found in 743 journal papers. Craig Crandall from the Institute for Exercise and Environmental Medicine, Presbyterian Hospital, Dallas, Texas published the highest number of journal papers in 2009 (80,125,322,393,596,597,702,703).

707 research institutes in 55 countries were named. 30.6.% of these were located in North America, the majority, i. e. 191, in the United States, 25 in Canada and 4 in Mexico. 43,3% of temperature related research facilities were active in Europe, 67 of these were situated in the United Kingdom. About 20% of all research institutions are located in Asia, two thirds of these in the Far East.

In total, 488 journals published papers related to the search profile. Two journals "European Journal of Applied Physiology" and "Journal of Applied Physiology" published 13 papers each on these topics. Next in rank was "Medicine and Science in Sports and Exercise" with 10 papers. 30 journals published between 4 and 13 papers related to this years search profile. Table 1 lists the journal name, the number of papers of interest and the Impact factor 2008. A mean impact factors of 2,915 was calculated

for 30 journals listed. The mean impact for publications on thermography was derived from the cumulated impact factors of all papers. The cumulated impact factor was 510,67 and the mean impact of a single publication was 2.986.

7 papers reported animal experiments (130, 490, 590, 653, 656,663,734).266 publications reported controlled studies . 9 papers were classified as short survey (42, 82, 108, 184,206,298,356,658,700) and 111 as reviews. 14 of these were performed as systematic review (4, 5, 25, 37, 75, 79, 109, 174,246,268,302,609,632,655). 19 practice guidelines mentioned temperature measurements (32, 43, 58, 67, 97, 122, 132, 188, 294, 295, 327, 350, 402, 431, 499, 529, 540,587,679). 66 case reports, 13 editorials, 51 letters and 8 comments were also related to the search profile. 10 conference papers (551, 191, 522, 525, 602, 624, 689, 690, 710,742) were published.

Medical publications

The citations in MEDLINE and EMBASE are allocated to distinct fields of medicine. Usually , allocations to more than just one field are made. However, in table 2 the citation were allocated to one field only and multiple allocations have been avoided. Some papers were related to defined diagnoses such as fever, therapeutic interventions such as therapeutic hypothermia or diagnostic techniques.

Table 1
Journals publishing between 4 and 13 papers related to the search profile
SJR=SCImago Journal Rank: Citations per article (2years)

Journal	Impact factor	Temperature related papers published
Acta Paediatrica, International Journal of Paediatrics	1,517	4
American Journal of Emergency Medicine	1,188	4
Anaesthesia and analgesia	2,590	4
CardioVascular and Interventional Radiology	1,721	4
International Journal of Cardiology	3,121	4
Journal of Anaesthesia	0,82 (SJR)	4
Journal of Clinical Microbiology	3,991	4
Medical Hypotheses	1,416	4
Medical Physics	3,871	4
Physics in medicine and biology	2,748	4
Skin Research and Technology	1,348	4
Anaesthesia	2,148	5
Anaesthesiology	5,124	5
Annals of Thoracic Surgery	2,689	5
Biological Rhythm Research	0,627	5
BMJ	10,665	5
Burns	1,605	5
Cochrane Database of Systematic Reviews	5,182	5
Intensive Care Medicine	5,055	5
Journal of Medical Engineering and Technology	0,6 (SJR)	5
Journal of Neurotrauma	3,528	5
Resuscitation	2,513	5
Journal of Clinical Rehabilitative Tissue Engineering Research	0,10 (SJR)	6
International Journal of Hyperthermia	2,239	7
Journal of Physiology	4,663	7
Critical Care Medicine	6,594	8
Thermology International	0,87 (SJR)	8
Medicine and Science in Sports and Exercise	3,398	10
European Journal of Applied Physiology	1,931	13

Table 2 shows the allocations to fields of medicine. Physiology was the most frequent allocated speciality of medicine. Physiology publications were broken down into three subgroups, Exercise Physiology, Thermoregulation and other Physiology, with the highest number of papers in

Thermoregulation. Surgery, Therapeutic Hyperthermia & Hypothermia, Cardiovascular Diseases, Clinical & Experimental Pharmacology, Drug Treatment, Toxicology, Dermatology, Neurology, Fever and Urology & Nephrology. were the next in frequency of allocation. Only some papers

Table 2
Papers allocated to medical fields

Physiology	3,8,28,80,84,100,139,155,196,213,265,267,333,407,435,515,526,550,640,694,714
Physiology: Exercise	20,51,59,77,102,125,149,151,153,154,156,195,198,264,274,298,299,309,326,359,375,383,398,422,448,464,475,523,529,534,535,597,716
Physiology: Thermoregulation	92,101,107,125,116,129,186,195,197,222,229,234,266,288,300,316,322,323,360,362,365,379,376,393,397,400,426,433,441,474,495,500,513,566,567,588,606,645,697,702,703,704,717
Anesthesiology	43,99,103,179,188,228,279,353,371,384,424,436,462,536,546,547,557,619,699
Acupuncture & Complementary Medicine	270,271,284,355,388,394,607,715
Breast disease	58,230,258,325,492,658,665
Physical Medicine & Rehabilitation	23,79,161,180,182,255,296,336,583,621,664,667,698,711,739
Cardiovascular Diseases,	11,12,13,17,18,47,75,81,97,144,235,241,272,302,351,352,354,356,367,373,378,405,408,483,487,490,545,577,613,633,654,645,654,705,740,741
Atherosclerotic plaque	127,145,421,470,511,650,651
Raynaud's Phenomenon	24,34,357,444
Dentistry	31
Dermatology	29,61,93,131,169,181,200,201,204,218,273,290,308,324,404,409,425,434,452,471,477,580,604,605,614,651,661,672,727,728,729
Clinical & Experimental Pharmacology, Drug Treatment, Toxicology	72,122,141,165,184,214,243,250,256,269,275,306,361,389,406,469,447,469,502,506,521,593,594,653,678,679,684,689,690,726,730,734
Imaging	60,221,227,231,236,304,338,430,467,563,578
Psychiatry	56,330,482,556,600,601,682
Nuclear Medicine	688,742
Neurology	38,42,74,132,138,159,173,189,215,216,239,268,291,301,313,340,414,445,454,458,525,546,575,576,582,628,674,724
Complex Regional Pain Syndrome	111,163,232,242,648
Sleep Medicine	7,67,98,108,118,135,197,344,347,358,423,507,659
Endocrinology	36,41,177,187,191,277,289,427,432,480,497,541,549,624,657
Forensic Science	142
Obstetrics & Gynecology	53,109,499,620,707,708,709,721
Occupational & Industrial Medicine	94,219,225,310,334,364,570,616,701
Ophthalmology	28,63,123,217,320,321,392,439,478,484,516,537,592,598,599,608,636,66,735
Otorhinolaryngology	5,248,341,342,423,569,584,673
Pediatrics	22,59,68,93,157,183,233,254,257,262,280,293,294,346,348,349,368,403,473,501,509,554,602,649,720
Physical Medicine & Rehabilitation	23,79,161,180,182,255,296,336,583,621,664,677,698,711,739
Sports Medicine	166,176,259,327,525
General Surgery	4,78,114,124,136,137,168,172,317,382,479,518,558,587,609,611,732
Orthopedic Surgery	33,190,223,238,246,283,331,420,562,693,722,743
Vascular Surgery	372,374,460,574,629,623,731,736
Urology & Nephrology	6,10,20,32,37,85,106,339,461,568,630,133,170,174,185,211,240,251,450,451,481,530,572,603,613,617,655
Nursing	71,281
Thermal injury	158,286,292,442,695
Medical Thermography	2,9,23,83,110,171,209,261,278,315,318,386,417,418,429,446,453,468,472,512,532,533,560,561
Therapeutic Hyperthermia	14,27,40,65,92,178,337,339,449,494,527,618,637,680,733
Therapeutic Hypothermia	17,44,146,148,175,244,247,253,261,287,295,311,314,328,343,345,350,366,377,390,401,402,413,491,504,517,542,555,571,581,586,622,625,626,632,635,643,643,667,696,706
Fever	45,50,66,73,93,120,121,128,134,147,152,162,164,192,220,226,262,319,428,431,455,465,486,639,641,642,649,668

were found for Breast Disease, Complex Regional Pain Syndrome, Raynaud's Phenomenon and Atherosclerotic plaque.

Medical thermography

2 reviews were allocated to Medical thermography. One paper reviewed the recent literature on thermology, available on the internet (2). The other publication provided a short survey on intraoperative thermal imaging and combined that with a case report on detection of a brain tumour with thermography (318).

A group of engineers from Italy developed a new method for reduction of motion induced artefacts in dynamic breast thermography (9). Another Italian group designed a wearable system for contact thermography and proposed this device for monitoring of a skin region at the point of affixation (209). In Japan, a non-contact screening system for rapid medical inspection was developed, that consisted of a Doppler blood-flow meter for measuring the peripheral pulse (=heart rate), a 10-GHz microwave radar for determination of respiration rate and an infrared imager for measuring facial temperature (417,418). Infrared thermography was also used to determine the effectiveness of two waste anaesthetic gas-scavenging systems (512).

The local temperature changes associated with mouth opening/closing were recorded with an infrared camera and investigated as an access pathway for individuals with severe motor impairments (429). The recorded temperature information seemed feasible to be used as a highly sensitive and specific binary switch.

The repeatability of the identification of thermal patterns was the topic of 2 papers. One publication reported a good intra-rater reproducibility of temperature readings performed on two consecutive days from knees of healthy subjects and subjects with previous knee injuries (261). Hot spots were proposed to be related with tenderness in fibromyalgia or/and myofascial pain syndrome. The inter- and intra-observer reproducibility of visually identified hot spots on thermal images recorded from fibromyalgia patients was investigated (23). A fair intra-rater repeatability of the hot spot count was reported, but the intra-observer repeatability was poor.

4 papers reported the diagnostic use of thermography. A study from the United States investigated the ability of long wave infrared imaging to assist the diagnosis of inattention-deficit/hyperactivity disorders (ADHD). They found a moderate sensitivity of 65.71% in identifying patients with ADHD and a high level of specificity (94%) in discriminating those with ADHD from those with other diagnoses (110). Russian gastroenterologists combined measurements of the electrodermal resistance with skin temperature for diagnosing biliary dysfunctions (171). A publication from Brazil re-invented thermography as a method for early diagnosis of varicocele (472). Another paper investigated the correlation between skin temperature and the level of lesion in paraplegics (533).

German physicians applied infrared imaging for mapping the nasal surface temperature within the nasal vestibules

during several breathing cycles (315). During inspiration, the vestibular surface cooled down and during expiration the inner nasal surface was warmed again. The temperature distribution was non-homogenous in both conditions, ranging from 24.7 to 30.2 during inspiration and from 33.1 to 36.2°C during expiration. In a second publications the same authors investigated the intranasal heat exchange in 3 patients with nasal septal perforations in comparison with healthy subjects (386). A reduced and irregular inspiratory cooling of the entire surface within the nasal vestibules was detected in patients with septal perforations. Infrared imaging was investigated as a non-contact method to monitor airflow during polysomnography (453). The authors reported an excellent agreement between infrared thermography and an intranasal thermistor in the detection of apnea and hypopnea. Good agreement was noted between infrared imaging and nasal pressure and between infrared imaging and expired CO₂.

Morphoea or localised scleroderma was investigated in three papers (83, 278,446, all applied infrared imaging and laser Doppler imaging. The studies confirmed increased microcirculation around morphoea lesions which occur in both large, thermoregulatory vessels and more superficial in the skin situated nutritive capillaries (446). The group at the Royal Free Hospital in London, UK, established the normal range for skin temperature and Laser Doppler blood flow at six standardised sites: forehead, cheek, abdomen, back, arm and leg (278). Two studies from Argentina reported monitoring of boron neutron capture therapy for cutaneous malignant melanoma (560, 561). The skin temperature from melanomas and from irradiation induced erythema recovered faster after mild cooling than in healthy skin.

2 studies confirmed the well known fact, that the temperature of feet in diabetics is elevated (468, 532). Both papers speculated about the predictive value of these temperature increase for diabetic ulcers, but did not provide evidence for temperature changes as risk factor for skin lesions.

Fever

A number of papers were related to fever. The range from typical cases in which fever is a prominent feature (134, 192, 262, 455, 639), over fever control in intensive care units (45, 147, 220, 226) to critical reviews on fever management (50, 120) and the antipyretic effect of drugs such as ketoprofen (93).

The application of acetaminophen plus ibuprofen or ibuprofen alone (152, 164) or alternating use of acetaminophen and ibuprofen (486) in children with fever was discussed in 3 papers. A study from India compared the effectiveness of tepid sponging and antipyretic drug versus antipyretic drug only in the management of fever among children (641). Apart from an initial rapid temperature reduction, the addition of tepid sponging to antipyretic medication did not offer any advantage in ultimate reduction of temperature; but may result in additional mild discomfort.

A paper from France reviewed existing studies on fever screening by non-contact infrared thermometers to estimate their efficacy under the hypothesis of pandemic influenza (66). In these studies, sensitivity varied from 4.0% to 89.6%, specificity from 75.4% to 99.6%, positive predictive value (PPV) from 0.9% to 76.0% and negative predictive value (NPV) from 86.1% to 99.7%. When fever prevalence was fixed at 1% in all studies to allow comparisons, the derived PPV varied from 3.5% to 65.4% and NPV was $\geq 99\%$. The authors express their opinion that the low PPV suggests limited efficacy of non-contact infrared thermometer to detect symptomatic passengers at the early stages of a pandemic influenza, when fever prevalence among passengers would be equal or less than 1%. Board members of the European Association of Thermology expressed their concerns on the use of infrared thermal imagers in mass screening for fever (431). Remote mass screening for fever with infrared thermography was also discussed in a paper from Singapore (465).

2 reviews were dedicated to the management of neutropenic fever syndromes in adult cancer patients (73) and in children with cancer (428). Another paper focussed on the diagnostic significance of daily morning temperature spikes, which are highly suspicious for miliary tuberculosis (128).

Authors from Belgium made an attempt to separated signs and symptoms in patients with fever of unknown origin (FUO), defined by prolonged and perplexing fever $>38.3^{\circ}\text{C}$, from patients with inflammation of unknown origin (IUO, defined as prolonged and perplexing inflammation with temperatures $< 38.3^{\circ}\text{C}$ (668). After careful analysis of 57 pairs of matched patients with either disease, it was concluded that the temperature cut-off of 83.3° may be arbitrary. The diagnostic approaches used in FUO can also be applied to IUO.

3 publications were related to fever management in children by their parents. A study from Baltimore investigated the knowledge about fever of Spanish-speaking-only parents bringing their child to a hospital-based urban pediatric clinic (121). Another paper from Poland investigated parents' knowledge about antipyretic medications (649). 87% of interrogated parents gave a correct definition of fever. The most frequent site of body temperature measurement was under the axilla (53%). More than half of the parents chose paracetamol or ibuprofen for treatment. A paper from New York, reported the accuracy of parental palpation for fever in young infants (319). As compared with the "gold standard" of rectal thermometry, parental palpation for fever had a sensitivity of 81%, specificity of 82%, positive predictive value of 59% and negative predictive value of 93%.

A study from England derived temperature and age appropriate heart rate centiles for children with acute infections (642). Based on data from 1589 children aged 3 months to 10 years, heart rate increased by 9.9-14.1 bpm with each 1°C increment in temperature.

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Biophysics, Bioengineering, Medical Instrumentation (30, 49, 55, 62, 105, 140, 194, 205, 208, 312, 379, 380, 415, 458, 493, 520, 564, 638, 644, 671, 700, 713, 719) had the highest number

of hits in the allocation applied sciences. The use of various methods for body temperature measurement was published (35, 119, 160, 224, 238, 282, 332, 335, 363, 395, 410, 456, 463, 467, 485, 498, 505, 510, 526, 548, 591, 610, 627, 647, 662, 669, 683, 691, 692) including reliability of thermometers (103, 198, 224, 335, 510, 610). The influence of measurement sites on temperature findings was topic of some papers (395, 448, 485). Thermal modelling (85, 263, 627) was the topic 3 papers.

Various applications of lasers were discussed in 38 papers (69, 86, 112, 209, 249, 303, 411, 508, 538, 539, 579, 595, 615, 623) including Laser Doppler flowmetry (4, 61, 72, 107, 202, 269, 278, 279, 333, 361, 382, 388, 394, 417, 418, 427, 446, 452, 456, 497, 580, 597, 707, 727,) and Laser Doppler imaging (83, 107, 338, 446, 452). Application of microwave technology was the topic of 19 papers (10, 14, 27, 32, 37, 65, 133, 170, 251, 312, 339, 417, 418, 451, 481, 572, 617, 630, 655, 733). Focussed ultrasound for hyperthermia generation was addressed in 10 papers (74, 85, 106, 217, 231, 304, 337, 339, 450, 498, 577, 719, 733), 11 papers reported ultrasound as imaging technique (4, 88, 325, 421, 470, 545, 560, 561, 576, 578, 665).

A high number of papers was allocated to clinical and experimental biochemistry (64, 70, 89, 95, 104, 115, 130, 143, 150, 199, 202, 203, 206, 245, 285, 297, 305, 329, 381, 399, 438, 443, 519, 544, 551, 559, 589, 590, 596, 656, 676, 681, 685, 687, 712, 718, 723, 737).

Microbiology (46, 87, 90, 91, 210, 387, 440, 476, 543, 553, 573, 631, 666, 670, 675, 725, 744) agriculture (17, 96) and environmental health (35, 252, 489, 503) were the topics of the remaining papers.

Discussion

The search profile of this year's survey is similar to that of the literature review for the year 2006 (745) with similar results related to fields of application.

Thermoregulation and exercise physiology were the topics with a high number of hits. Various aspects of therapeutic hypothermia were discussed. Localised hyperthermia generated with various heating modalities was a topic of complementary treatment for tumour disease.

Temperature measurements in cardiovascular disease were often related to radiofrequency ablation of atrial fibrillations. Other vascular disorders such as intravascular temperature measurements at atherosclerotic plaques or the thermographic assisted diagnosis of Raynaud's phenomenon achieved less publications as in previous surveys. None of the few articles related to breast cancer reported new research results for breast thermography.

English continues to be the predominant language for medical publication 8,5 percent of the papers reviewed in this article were not published in English, which is a bigger portion of non English publications than in previous surveys. An average impact factor of about 3.0 points. Was calculated for journals, which published in 2009 papers on temperature measurement in medicine.

43,3% of papers were published by authors from Europe, 30.6 % originated from North America and 20 % from

Asia. Papers from countries in Africa and South America are still rare.

In conclusion, this years' literature survey was focussed on temperature measurements in medicine. Physiology and thermotherapy including intended changes of the core temperature in either direction were the most frequently identified fields of temperature measurement in medicine.

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Thermographic Findings In The Lower Back: Can They Be Explained By A Reflex Mechanism?

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Summary

OBJECTIVE: Thermal images of the lumbar and gluteal area were analysed retrospectively in a group of 141 patients (77 male, 64 female, mean age:43.2 years) suffering from pain in the lumbar and sacral region. Patients with post-traumatic and rheumatic disorders were excluded. In all 141 patients, X-rays, CTs and MRIs were carried out. Ultrasound scans and laboratory examinations were performed in patients with urogenital ailments.

RESULTS: The majority of 28 patients with structural changes in the lower back area (discopathy, facet syndrome) showed in their thermal images various hyperthermal patterns over the lumbar spine and paravertebral areas.

In patients with urogenital findings, hypothermal areas over the lateral parts of the lumbosacral (LS) region and parasacral areas were found as a consequence of the visceroreflexive autonomic reaction. 89 patients, who presented with painful manifestations but without structural and urogenital disorders, showed active thermal findings in small sites in the gluteal area caused by local trigger points and over the crista iliaca due to enthesopathy. A small number of these patients with functional disorders showed hypothermal patterns over the spine and in the paravertebral region.

A high sensitivity of thermography was observed among patients with structural and urogenital findings. Low specificity of this method was revealed in patients with structural findings of the lower back. Due to different thermal changes caused by functional and structural disorders of the lower back and rare thermal findings after urogenital disease, these disorders can be differentiated with high sensitivity, but low specificity. High specificity was only observed in patients with a history of urogenital diseases and absence of hyperthermic changes.

CONCLUSION: The thermographic examination assists in identification of the affected region and for assessing whether the thermal changes originate from a functional disorder or an inflammation. In this respect, it offers a solid basis for further diagnostics and adequate treatment.

KEY WORDS: low back pain, urogenital disorders, infrared thermography, sensitivity, specificity, inflammation

THERMOGRAPHISCHE BEFUNDE BEI KREUZSCHMERZEN: KÖNNEN DIESE DURCH REFLEKTORISCHE MECHANISMEN ERKLÄRT WERDEN?

ZWECK DER STUDIE: In einer retrospektiven Studie analysierten die Autoren die Wärmebilder des lumbosakralen und glutealen Bereiches in 141 Patienten mit Schmerzen in dieser Körperregion. 77 Männer und 64 Frauen im Durchschnittsalter von 43,2 Jahren ohne traumatisch oder rheumatisch bedingte Schmerzen, wurden in die Studie eingeschlossen.

Alle Patienten wurden röntgenologisch, tomographisch und mittels MRI untersucht. Die Patienten, die an Hand der Krankengeschichte unter urogenitalen Beschwerden gelitten haben, wurden auch sonographisch untersucht.

ERGEBNISSE: Bei der Mehrheit von 28 Patienten mit strukturellen Befund im lumbosakralen Bereich (Diskopathie, Fazetsyndrom) zeigte die thermographische Untersuchung hypertherme Zonen über der Wirbelsäule und paravertebral.

Bei den Patienten mit urogenitalem Befund wurden laterale des lumbosakralen Übergangs und parasakral als Folge eines viszerovegetativen Reflexes hypotherme Wärmemuster gefunden. Bei 89 Patienten ohne strukturelle und urogenitale Befunde wurden im glutealen Bereich fokale Hyperthermie nachgewiesen, die als Triggerpunkte palpatorisch diagnostiziert wurden. Die hyperthermen Zonen über der Crista iliaca entsprachen einer lokalen Enthesopathie. Die Minderheit der Patienten mit Funktionsstörungen boten hypotherme Zonen über der Wirbelsäule und paravertebral.

Auf Grund der differenten Wärmebilder bei Funktionsstörungen und strukturellen Affektionen des Bewegungsapparates bzw. den seltenen Veränderungen der Oberflächentemperatur nach urogenitalen Erkrankungen ist es möglich, diese von einander mit hoher Sensitivität, aber mit erheblich niedrigerer Spezifität zu unterscheiden. Hohe Spezifität wurde nur bei Patienten mit urogenitaler Anamnese erzielt, bei denen keine hyperthermen Zonen gefunden wurden.

SCHLUSSFOLGERUNG: Die Bedeutung der thermographischen Untersuchung liegt in der Lokalisierung des Störungsgebietes und in Beurteilung der Wärmemuster (Funktionsstörung, Entzündung). Wärmebilder können als Ausgangsbasis für weitere gezielte Diagnostik und einer adäquaten Therapie dienen.

SCHLÜSSELWÖRTER: Kreuzschmerz, urogenitale Erkrankungen, Infrarot-Thermographie, Sensitivität, Spezifität, Entzündung

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Introduction

The etiology of lower back pain is multi-factorial. It can develop due to a series of organic, non-vertebrogenic diseases, degenerative changes in the spine and functional changes in the joint and musculoskeletal systems. Most of the patients are examined on X-ray, CT or MRI equipment. In spite of the marked progress in diagnostics, there is still a high number of patients for whom a definitive diagnosis cannot be made due to the inadequate correlation between the symptoms, pathological changes and results of the imaging methods. Morphological findings, even pronounced ones, have shown little relevance. In many patients who suffer from back pain, no morphological findings can be detected even through recent diagnostic methods. As a result, the pain is labelled as “non-specific or idiopathic”. (1,2,3,4).

For both rehabilitation and therapeutical procedures, it is important to establish the local anatomic finding and its biomechanical relation to other structures in the same area and the whole organism.

The shortcoming of active imaging methods and invasive examination procedures is that they only provide information about structural changes. They do not provide any information about inflammatory responses or autonomic nervous system reactions.

Information of this type can be only provided by the only passive, non-invasive imaging system - thermography.

Everything, the human body included, radiates some of its thermal energy in the form of infra-red radiation, i.e., electromagnetic oscillation with a wave length of $10^{-6} - 10^{-4}$ cm. Visualisation of the infra-red radiation from the surface of bodies represents the principle of thermography.

The locomotive system, with its structures positioned mostly at or near the surface, is a very suitable object for thermographic examination. The temperature on the surface of the human body depends, to a certain extent, on the individual physiological properties of the organism, but is ultimately determined by pathological changes occurring in the organism. Its measurement allows us to detect and specify pathological changes. The surface temperature of the human body is established by the local skin blood flow and the ambient temperature of the environment. The resting skin blood flow is represented by the homeostasis between vasodilation controlled by humoral regulation over a longer term and vasoconstriction controlled by neural regulation – through a sympathetic mechanism – in the short term. In addition to these neural and local, hormone-driven mechanisms, other factors play an important role. They include pH value, electrolyte concentration, mechanic factors and blood cells (5, 6, 7). However, in case of temperature regulation, all variations in the diameter of the vascular bed i. e. vasodilation and vasoconstriction are caused by the sympathetic nerve system. (8)

With accidents and any damage to soft structures, various biochemical processes induce inflammation in the damaged structure (2,9,10,11,12,13).

Pain from discopathy is traditionally explained by the mechanical irritation of the nerve root and its swelling. The extent of the root compression verified by imaging methods does not always correlate with the pain. The pain information is generated by several factors.

Discogenic pain is generated by the change in pH value and chemical composition of the intervertebral disc (IVD) even when no protrusion of the IVD is present. Released acid metabolites which are secreted from the disc area via increased hydrostatic pressure or fissures in the degenerated disc cause inflammatory reactions of adjacent nerve fibres.

Nerve root irritation can be induced in a biochemical way, when the tissue of the disc in the spinal canal causes the same reaction as any foreign body, acting also in a direct toxic way and inducing an inflammatory response in the nerve root (oedema-like charges and later atrophy).

In the nerve fibre, impaired by compression, spontaneous action potential is developing. Ischaemia, an arachnoid block caused by an IVD prolapse, and arachnoiditis, all result in a metabolism disorder and together with venous compression they lead to the swelling of the nerve root (1, 2,3,5,6,7). In addition to these local tissue changes, the damaged structures cause autonomic reactions due to blood circulation deviations (hyperaemia, haematoma, increased metabolic activity, swelling, transfer of biologically active substances, cells, water, ions), resulting in temperature changes above the impaired area of the locomotive apparatus. These are reflex nociceptive mechanisms, in which due to nociceptive impulses in a specific segment, the activity of the sympathetic nerve system increases and a temperature in a given segment change may occur.

Reflex mechanisms of nociperception have yet not to be explained in detail, but it seems that the signals coming through A delta fibres from the periphery not only connect to the opposite side's ascending pathways of the tractus spinotamicus in the rear of the spinal cord and the motor cells of the front of the same side, but also the sympathetic neurons of the side chain of the same side became activated. In this way, besides motor efference via alpha fibres and gamma motoneurons, sympathetic efference at the same segment level, called nociceptive sympathetic efference takes place. As a result, a small monosegmental, circumscribed area of skin with low blood flow develops, resulting in a hypothermic zone. The range and intensity of the segmental reflex changes predominantly depends on the response of the autonomic system. R. dorsalis n. spinalis innervates the extensor muscles of the back and its irritation leads to immediate reflex muscle spasms (14,15,16).

There is also an indirect effect of neural pathophysiology influencing the surface temperature via a reflex-response of the muscles. This action, called nociceptive motor efference, results in increased tone of a muscle or muscle group with an aggregation of acid products of metabolism and shifts in electrolytic environment. The microcirculation of the area of skin above results in an increased rate of

skin blood flow, for the pH and electrolytes shifts act as vasodilation stimulus on one hand, and on the other in a regional redistribution of blood, whereas the muscles themselves contain less blood resulting in higher congestion and their adjacent areas, in contrast contain more blood resulting in less congestion, and this can lead to relative hyperthermia.

Sympathetic efference is induced not only via the receptors at the periphery, but also from sympathetic afferences of the viscera. The skin areas involved in this way are known as Head's zones. Because sympathetic afferences coming from internal organs pass through the truncus sympathicus to the neural structures of the rear of the spinal cord, right before they reach the spinal cord they intertwine in the truncus sympathicus cranially and caudally through several segments. That is why Head zones show polysegmental hypothermic patterns, unlike changes in noci-reactive sympathetic efferences from locomotive apparatus, which are mainly monosegmental reflexive-autonomic responses. Viscerogenic impulses to the skin result in vasoconstriction and a subsequent decrease in the blurred demarcated temperature area.

Viscero-sensitive and autonomic segmental innervation of urogenital organs comes from the Th8-L3, and S2-S4 segments (5,15,16).

Neurogenic inflammation (17) and sympathetic – mediated painful syndrome will result in changes in the thermal pattern. Such pain is mysterious from a clinical point of view, as it often appears suddenly, without any evident pathology or signs in either laboratory or diagnostic imaging methods. This discrepancy can result in a misdiagnoses or unsuitable treatment. Thermography (TMG) appears to be as useful as these examination methods. If the results of standard examinations are ambiguous, TMG can provide yet additional information and make it possible to monitor changes during the back pain treatment.

Method

In our retrospective study, we analysed 141 patients who were examined for low back pain of non-rheumatic and non-traumatic origin in the period from January 2007 to June 2008.

A Thermographic examination using the AGA 782 and Fluke Ti30 thermographic systems was carried out in all patients, following the standard procedures given by the Glamorgan Protocol of the European Association for Thermology and the American Association for Thermology (18,19,20). In each patient, the lower back and gluteal region were examined. In these areas, thermal patterns and absolute temperature parameters were analysed according to the criteria elaborated by Uematsu (21), when temperature differences $0,24 \pm 0,073$ °C in the back area are considered normal. The assessment was carried out in these regions of interest (ROI) :

- over the spine and paravertebrally
- over the lateral part of the paravertebral back muscles
- above the crista iliaca
- in the gluteal area

In these ROI, site findings were recorded in either increased or decreased temperature activity and changes in the pattern.

Statistical evaluation

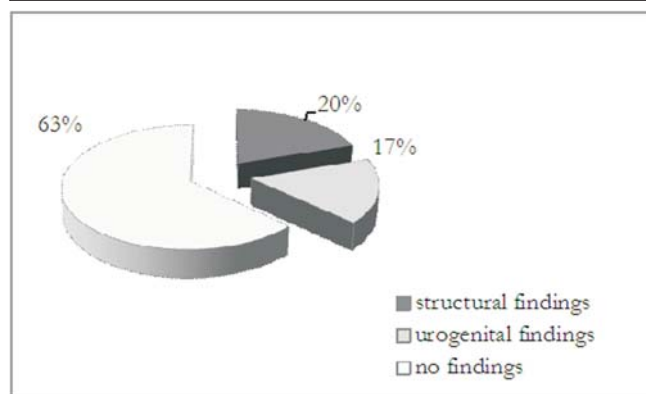
We calculated simple descriptive statistics. Diagnostic sensitivity and specificity was related to structural changes of the lumbar-sacral region, to functional findings of the lower back or to reported urogenital symptoms.

Results

Biographic data of the patient sample is shown in table 1. Thermographic results are summarised in table 2.

Table 1
Patients characteristics

	number
Examined patients	141
Male	77
Female	64
Mean age(range)	43,2 yrs(15-75)
Patients with structural findings in the lumbar-sacral region	28
Patients with urogenital findings	24
Patients without structural or laboratory findings	89



Most patients with low back pain present with sites of increased thermal activity, localised either directly over the spine and above SI joints, or in the soft tissue – in muscle trigger points, or ligament enthesopathies in the crista iliaca region. They constitute 78% of the total of thermal findings.

Hypothermic findings over the spine and those located paravertebrally are due to nocireactive sympathetic efference in discogenic, facet, muscular and other disorders. They represent 14% of the total of thermal findings.

Table 2
Thermal findings on the lower back in 141 patients

LOCATION	INCREASED THERMAL ACTIVITY				DECREASED THERMAL ACTIVITY				Thermal findings in total
	In total	Bilaterally	Unilaterally	On the painful side	In total	Bilaterally	Unilaterally	On the lesion side	
Spine, paravertebrally	90				28				118
SI joints	62	24	38	15		2	11	10	75
Crista iliaca	49	19	30	17	138	4	4	4	57
Gluteal region	74	29	45	23	14	2	12	7	88
Lumbar area, laterally					14	12	2	1	14
Total	275	72	113	55	77	20	29	22	352

Table 3:
Characteristics of the group with structural findings.

Structural findings	28
Thermal patterns	25
Hyperthermic patterns	21
Hypothermic patterns	4

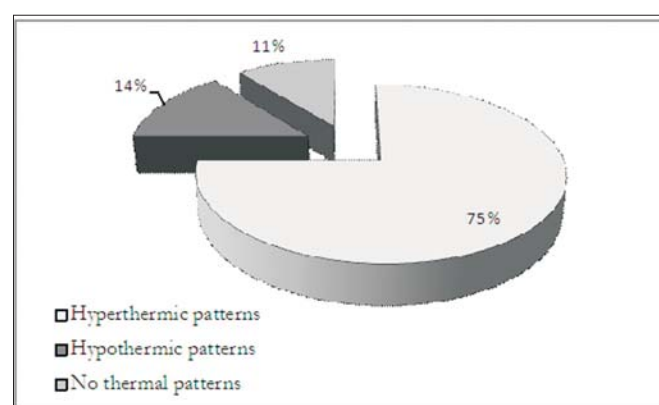
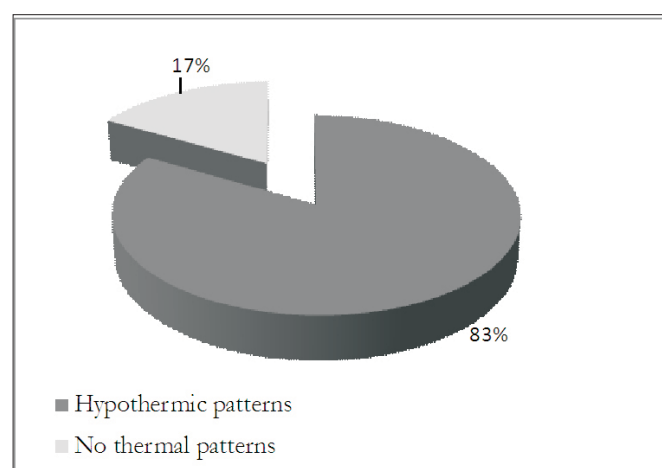


Table 4:
Characteristics of patients with urogenital disorders

Urogenital findings	24
Hyperthermic patterns	0
Hypothermic patterns	20
No thermal pattern	4



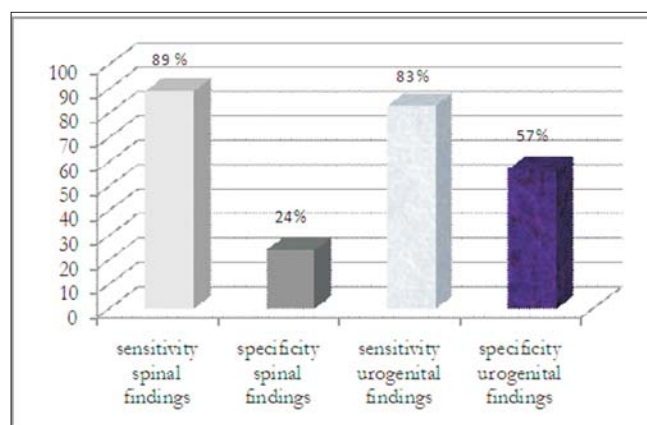
Hypothermic findings in the lateral part of the back and the gluteal area located parasacrally are of a viscerogenic origin. In our group, they comprised 8% of the total of thermal findings.

A detailed analysis of the thermal images of the patients with structural changes in the lower back (i.e., positive X-ray, CT, MRI findings) revealed thermal findings of increased temperature activity over the spine and located paravertebrally in 75% of the patients. The above mentioned thermal finding can be considered specific for this group of patients.

The analysis of the thermal images of patients with urogenital findings showed that in 83% of these patients, thermal patterns with hypothermic patterns in the lateral part of the lumbar area as well as paramedian findings in the sacral area were observed. These thermal patterns can be considered specific for the abovementioned group of patients.

In the group of examined patients, a high sensitivity of thermography was discovered in patients with structural findings for the lower back and in patients with urogenital findings. The specificity of thermography for these two groups of patients compared to the thermal images of all of the patients was significantly lower, especially in patients with structural lower back findings.

Figure 4:
Sensitivity and specificity of thermography in patients with spinal and urogenital findings



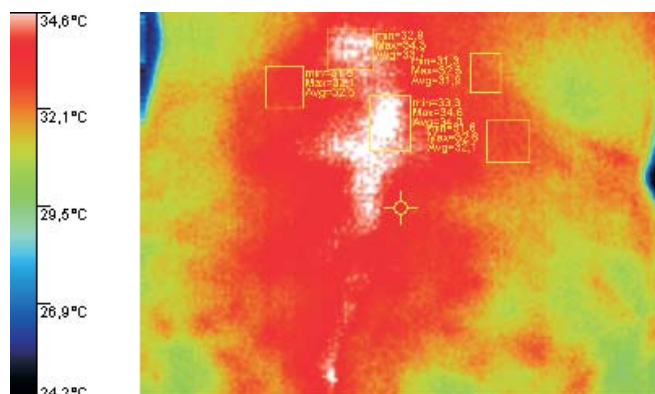


Figure 1:
Thermal findings over the spine and paravertebrally

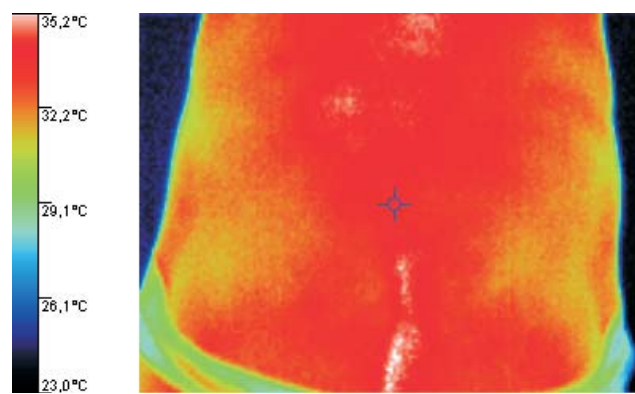


Figure 2
Increased thermal activity above the left sacroiliacal joint.

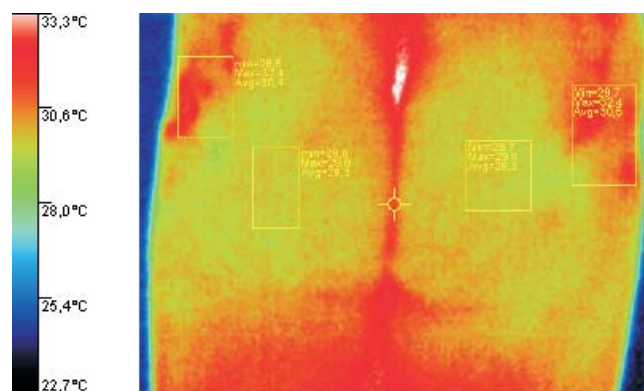


Figure 3
Increased thermal activity in the upper lateral quadrants of the gluteal area

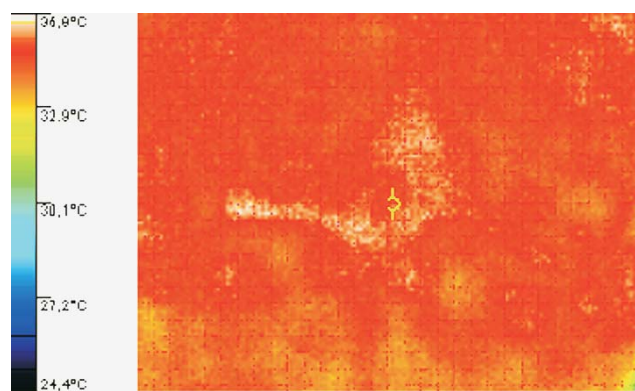


Figure 4:
Increased thermal activity over the medial part of the left crista iliaca

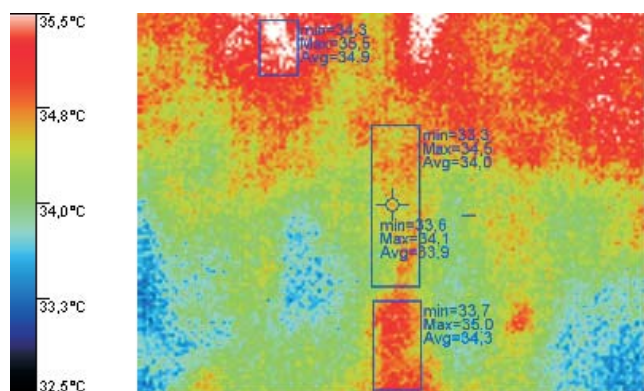


Figure 5.
Hypothermic findings over the spine and paravertebrally

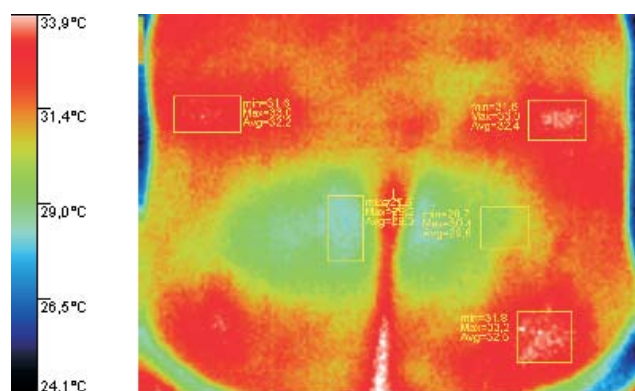


Figure 6:
Hypothermic parasacral finding, bilaterally

Discussion

In our previous studies, we assessed thermal findings in the spine area in rheumatic patients and compared them with healthy controls (22,23,24) and the thermal findings in non-rheumatic patients related to acute and chronic pain. The differences between findings in athletes and non-athletes were also evaluated (25). The occurrence of increased or decreased temperatures at specific sites has not yet been evaluated in structural changes of the spine and visceral disorders.

Fischer & Chang (26), and Weinstein (27) studied the visualisation of trigger points (TrP) and myofascial pathology. They described the trigger points as a demarcated site of pain, 5-10 mm on average, with a lower threshold of pain. Hakküder et al. discovered that after laser therapy was applied to these site findings, the pain significantly decreased (28). In other published papers, the site findings of increased thermal activity were mentioned as a possible cause of back pain. Mostly they were thermally active TrP

in the upper part of the back (29) and lower back area of the spine (30) occurring after accidents.

In our group of patients with no trauma and no rheumatic etiology, thermally active TrP were observed, especially in the gluteal area and the most frequent findings were in the upper lateral quadrant – i.e., in one of the locations examined in fibromyalgia (2,31). Activation of these TrP triggers pain that the patient localises either in the lumbar spine or it is propagated in the lower extremities, with an imitation of radicular pain. This knowledge applied in clinical practice calls for a standard examination of these locations in patients with lumbalgia.

In our previous papers, we looked at the occurrence of sites of increased thermal activity in the areas of the locomotive apparatus, in which overloading or micro traumas occur – such as elbows, and knees. We also looked at enthesopathies typical for individual sports (9, 10, 11, 12, 13, 32). The most important anatomical location of thermally active enthesopathies in our group of patients appears to be the crista iliaca area with its muscle and fascial ligaments close to the surface and deep layers of both the back and abdomen muscles (*M. obliquus abdominis externus*, *internus*, *M. transversus abdominis*) and *M. quadratus lumborum* (14). Because of this, painful signals from these thermally active enthesopathic findings can also negatively influence both the statics and dynamics of more distant areas of locomotive apparatus.

Hooshmand, Hashmi, and Philips, who based on their experience on the examination of more than 3000 patients, pointed out that thermal dysfunction of sensory nerves cannot be recorded in structural tests. This can lead to a misdiagnosis of “psychogenic” or “functional” disorders. TMG provides diagnostic and therapeutical information related to those diseases which include autonomic neurovascular and neuro-inflammatory changes. On the other hand, progress in nerve trauma diagnostics cannot be expected if the microvascular effect is not taken into consideration (33).

Chan proved that IR thermography can be a successful method of post-surgery follow up for patients with anterior cervical sequestrectomy for the cervical disc herniation in persisting cervicobrachial pain (34)

Kim and Cho studied the application of IR thermography in the monitoring of elderly patients with compression fractures of vertebra due to osteoporosis. They found that IR images detect painful osteoporotic compression fractures with high sensitivity - 94% - and can differentiate an acute symptomatic compression from an old asymptomatic lesion. Even during the post-surgical follow up, the clinical outcome showed high correlation with the thermal image (35). They also looked at the correlation of subjective pain and thermal differences in patients with lumbar disc herniation, the high correlation between the intensity of pain, the degree of disc protrusion, recently appearing symptoms and the increased difference between the temperatures of lower extremities. IR thermography is consid-

ered to be a useful method for post-surgical monitoring (36).

In his study, DallaVolta made an effort to establish the correlation between clinical, radiological and thermographic findings in patients with intervertebral disc hernia before and after ozonotherapy (37). His assumption based on current neuropathophysiological knowledge, was that radicular compression caused by the compression of a disc in the lumbosacral area irritates the orthosympathetic system, which is associated with motor and sensitive roots, and via vasoconstriction it regulates skin microcirculation (cold image) related to radicular microcirculation. On the other hand, the neurolytic block of autonomic fibres results in an image of increased temperature. The direct correlation between clinical outcomes of neuroradiological images and thermal asymmetry moderation detected by thermography was observed in 76% patients.

The studies by Albert (38), Weinstein (39), So (40), and others looking at thermography in low back pain confirmed its 81% sensitivity, but they were not successful in determining the right strata of lesions via thermography in radiculopathic conditions. Therefore, Hoffman did not recommend thermography for clinical use in lumbar radiculopathies (41).

In our group of patients, a low specificity of thermography was also confirmed. However, according to current neuropathophysiological knowledge described in the introduction of this paper, pain in discopathies can arise due to inflammatory mechanisms even without any intervertebral disc prolapse or nerve root compression. It develops due to pH alteration and the chemical composition of the intervertebral disc.

Released acid metabolites which are secreted from the disc area via increased hydrostatic pressure or fissures in the degenerated disc cause inflammatory reactions of adjacent nerve fibres.

Nerve root irritation can be induced in a biochemical way, when the tissue of the disc in the spinal canal causes the same reaction as any foreign body would, acting also in a direct toxic way, inducing inflammatory response in the nerve root (1,2,3, 5, 6,7). Described processes induce thermal changes in the pertinent thermosom (angiosom) that can be observed via thermography (17,42). In light of this knowledge, the high sensitivity of thermography is beneficial for this type of pain.

The outcome of our study shows that it is also necessary to differentiate within a group of patients with hypothermal site patterns in the back area. To date, these have been considered specific for patients with nerve root compression in which the irritation of sympathetic nerve fibres developed followed by the effect on microcirculation in the pertinent thermotom of the back area (37). They can however, be induced by the possible irritation of sympathetic nerve fibres in *r. dorsalis n. spinalis* in intervertebral functional disorders of facet joints in the back area and in *n. meningicus*

recurens (n. sinuvertebralis) in ligamentous lesions in the back (2,14,15,16). It is a type of nociceptive sympathetic efference. As a result, a slight blood flow in a monosegmental demarcated area of the skin occurs, with hypothermic zone development, which is localised either directly above the spine or paravertebrally. Hypothermic parasacral findings localised in the lateral part of the skin appeared in our group of patients, but mainly among patients with urogenital findings. Therefore we consider them to be reflex- autonomic responses to viscerogenic stimuli from urogenital organs, which cause vasoconstriction in the Th8-L3, and S2-S4 segments of the skin (7, 14,15,16) and later a decrease of temperature in a blurry demarcated spot.

Conclusion

Thermography appears to be a useful examination method and not only in cases for which other laboratory or imaging methods fail to provide an outcome.

Thermography is helpful in differentiating the inflammatory etiology of low back pain from painful syndromes of a reflex origin induced either through the mechanism of nociceptive sympathetic efference or autonomic reaction.

This method is characterised by high sensitivity for both vertebrogenic and viscer-vertebrogenic pain syndromes.

Due to its low specificity, especially in cases of structural lower back damage, it is not possible to make a final diagnosis solely based on this method.

Its significance lies in moving in the direction of accurate diagnostics and in assisting in the choice of proper treatment.

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Comparison of Measuring Sites for the Assessment of Body Temperature: Final amendment

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Dear editor

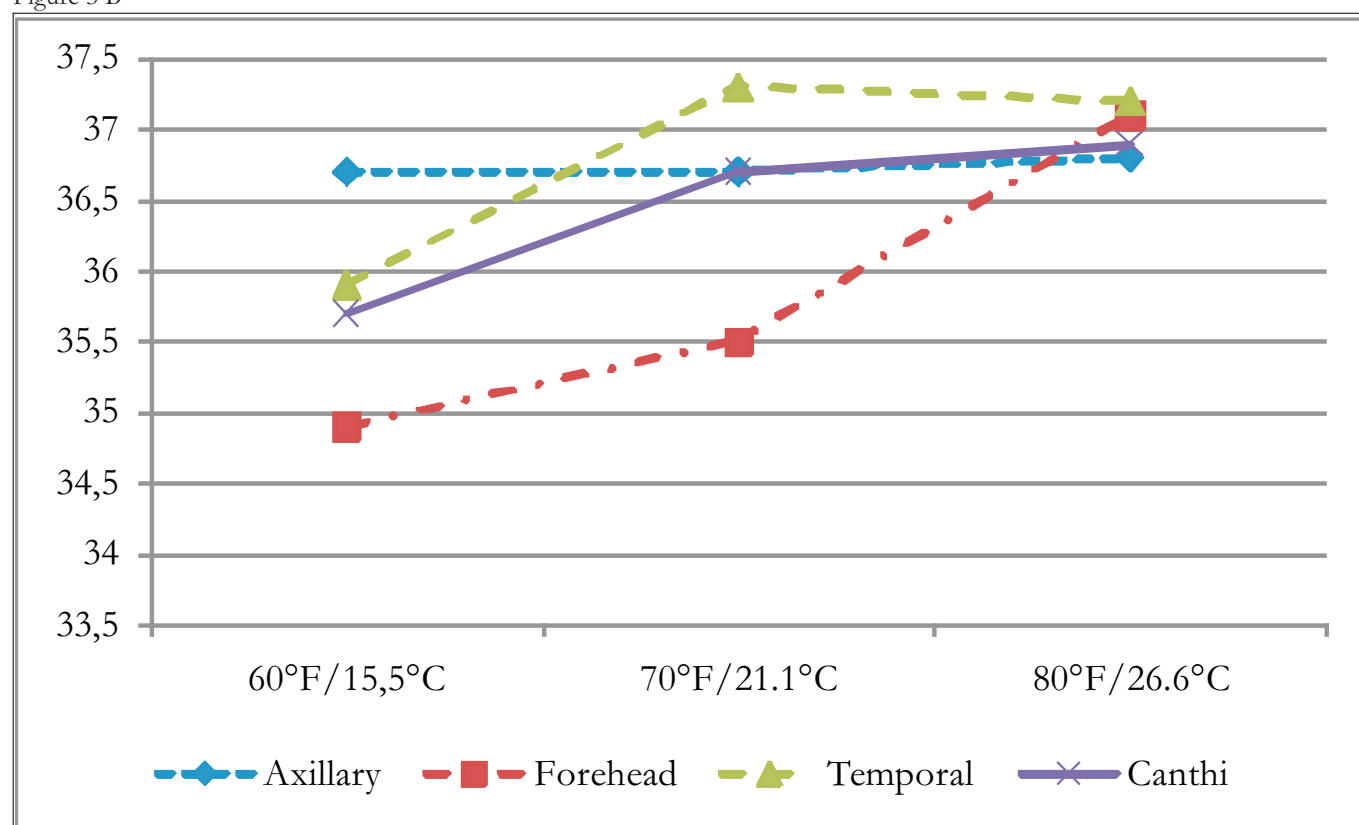
At the European Academy of Thermology (EAT) meeting we discussed printing a correction for the last journal article (Vol 19, 2009) in which graph 3B had the core data listed under the graph rather than the skin data chart from the manuscript.

However, since our EAT meeting I have been working on my data based on discussions from the meeting. Several of us were perplexed by the inner canthus measurement at 26.6°C/40°F that was higher than the core measurement. It was suggested that I determine the reflected source of radiation using an emissivity calculation as a possible cause for these findings. At the 26.6°C/80°F trial condition, the reflected source of radiation increases surface temperature

measurements by 0.1°C. As standard practice, I rechecked the calibration on my equipment to no avail. I have also reviewed the data on several occasions. but this time I noted that the left side inner canthus data for the 26.6 °C for statistical analysis was input from the high temperature image analysis of the inner canthus region rather than the average temperature. This changes the inner canthus reported number from 37.6 to 36.9 °C. This also changes the regression formula and a couple lines of the discussion.

I have sent a revised copy of the manuscript with changes. Therefore 3B and Discussion should read as follows, with changes appearing in Bold letters..

Figure 3 B



Ambient Temp (°F/°C)	Axillary	Forehead	Temporal	Canthi
60/15.5	36.7 ± 0.9	34.9 ± 2.3	35.9 ± 1.1	35.7 ± 1.0
70/21.1	36.7 ± 0.8	35.5 ± 1.4	37.3 ± 0.7	36.7 ± 0.6
80/26.6	36.8 ± 0.7	37.1 ± 0.9	37.2 ± 0.7	36.9 ± 0.6

Non-significant differences between site measurements are noted, all other measurements are significantly different from each other at the indicated ambient temperature.

Discussion

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

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

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

screening procedure the axillary temperature may be difficult to access, slow to obtain, and impractical.

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

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

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

Recent research from Ring and colleagues (17) has suggested that the inner canthi may be a good surface location to obtain a reliable febrile temperature measure. The inner canthi regions have a profuse blood supply that comes from the Lacrimal branch of the Ophthalmic Artery. Their research support a threshold temperature for febrile detection set at 37.5 °C to account for the ± 0.5 °C tolerance associated with the thermal measuring systems and to retain screening sensitivity necessary to identify those with elevated temperatures. This recommendation comes from research from 191 Children (173 normal, 18 febrile) in which

core was measured by axilla thermometry and ear tympanic radiometry and surface temperature (inner canthi) by infrared thermography. This recommendation is lower than the 38°C previously used for the SARS outbreak in China (18, 19).

In our investigation, the inner canthi temperature increased with increasing environmental temperatures. The regression formula ($R^2 = 0.93$) for the relationship between the inner canthus and environmental temperature for this study was:

$$\text{inner canthi temperature Celsius} = 0.1597 (\text{environmental temperature Celsius}) + 32.999$$

Under these climatic experimental conditions (15.5 °C – 26.6 °C), the temperature measurements from the inner canthi surface increased from 35.7 °C to 36.9 °C. **This 1.2°C increase in temperature demonstrates the strong influence of environmental temperature and humidity on skin temperature sites. This is important to note because the inner canthus temperature of 36.9°C at the extreme temperature condition (26.6 °C) with the potential tolerance (± 0.5 °C) associated with the thermal measuring systems, brings this measurement near the threshold of 37.5 °C proposed by Ring and colleagues during research on non-febrile and febrile children in a clinical setting (17).** Our study reinforces the concept that the room environment for imaging must be controlled. In the clinical setting, the room temperature standard for imaging procedures is specified as 18-25 °C (20), under these climatic conditions the inner canthi would not be expected to exceed the threshold. Infrared thermal scanning procedures suggested for potential pandemic screening also adhere to room controls that limit temperature to less than 24 °C, assuring that the threshold

temperature would not be exceeded due to environment. If the environment for the scanning procedure cannot be maintained within clinical standards 18-25 °C, the above regression formula allows the practitioner to make a correction for the influence of ambient temperature and humidity on the inner canthi measurement under conditions of 15.5- 26.6 °C (60-80 °F) and 35% to 70% relative humidity.

In conclusion, as environmental temperature increased, the variance associated with the measurement of each temperature measurement site investigated decreased irrespective of the humidity. The rectal temperature was the highest but most consistent measurement of all core measures regardless of changes in environmental temperature and humidity. The axillary site provided the most consistent values of the surface sites. The inner canthus provided the best predictive ($R^2=0.93$) non-contact measurement of skin surface temperature across all trial conditions. Thus, the inner canthi may be useful in detecting individuals with high temperatures as a potential screening method for fever related pandemic diseases. Outside of the clinical setting, the inner canthi may need to be corrected for the influence of ambient temperature and humidity.

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Meetings

2010

23rd February 2010

Seminar on Research in Medical Imaging

Organised by the Medical Imaging Research Unit, Faculty of Advanced Technology, University of Glamorgan

Programme

2.30-5pm H144 (first floor of Hirwen Bldg.)

Welcome

Dean of The Faculty: Prof.V. Konstantinou

The new imaging standards on fever detection for pandemic influenza infection

Prof. Francis Ring (Glamorgan Univ)

Applications of infrared imaging in Connective Tissue Diseases

(Dr)Kevin Howell (Royal Free Hospital)

Thermal imaging assessments of repetitive strain and vibration injury to the hands

Ricardo Vardasca (Portugal)

Break 15 mins

Cold stress tests for the hands in objective measures for Raynaud's phenomenon

Prof. Kurt Ammer (Vienna)

Infrared Camera technology advances

Prod Rod Thomas (Swansea)

Reference Temperature Sources for calibration of thermal Imagig cameras

Dr Rob.Simpson (NPL, Londoin)

Three dimensional measurement camera system for medicine

Dr Peter Plassmann (Glamorgan Univ)
Dr Carl Jones (Glamorgan Univ))

5.15pm Transfer to the Conference Centre (5.30 refreshments)

Inaugural Lecture by Professor Graham Machin at 6pm

(Head of Thermal Metrology Standards, National Physical Laboratory, Teddington UK)

Is Temperature Measurement Necessary or Important?

26th-28thFebruary , 2010

University of FloridaThermal Imaging Seminar
UF College of Veterinary Medicine
Gainesville, FL, USA,

Who Should Attend?

Anyone can register, but the focus is on Veterinary Professionals. Medical and industrial thermographers, saddle fitters, and horse enthusiasts are welcome to register and attend as well

Registration

TheThermal Imaging Seminar registration fee includes 18 Continuing Education hours in both a lecture and Hands on Wet Lab environment. Participants will receive lectures on imaging techniques, management of artifacts, and clinical case studies. Additionally a "Knobology" section is included for training in the operation of the thermal cameras. Participants will give a four hour session to practice ac-

quisition of clinical images on live patients. Lunch is also included on both days.

ADVANCE REGISTRATION IS REQUIRED by February 19, 2010.

NOTE: The Seminar is limited to 30 registrants.

Registration Fee

Early Registration (by February 8, 2010)	\$850
Regular Registration (after February 8, 2010)	\$950

Refund Policy

Requests for registration refunds will be honored if written notice of cancellation is received by the Office of Conferencens and Institutes on or before February 1, 2010. A 25 percent processing fee will be deducted. No refunds will be honored for cancellations after February 1, 2010

 Friday, February 26, 2010 – The Cabot Lodge

7:45AM – 8:00AM	Welcome		
8:00AM – 10:00AM	Thermal Imaging in Veterinary Medicine Today -	<i>Waldsmith,</i>	2.0 hr
10:00AM – 10:15AM	Break		
10:15AM – 11:00AM	How to Obtain Thermal Images for Studies on Equine Patients	<i>Waldsmith</i>	0.75 hr
11:00AM – 12:00AM	Utilizing thermal imaging in Canine Sports Medicine	<i>Henneman</i>	1.0 hr
12:00PM – 1:00PM	LUNCH		
1:15PM – 2:00PM	Dynamic Examinations using the High Speed Treadmill	<i>Waldsmith</i>	0.75 hr
2:00PM – 3:00PM	Utilizing Thermal Imaging as Part of an Athletic Wellness Program in Thoroughbred Racehorses	<i>Waldsmith</i>	1.0 hr
3:00PM– 4:15PM	Saddle Fit	<i>Corcoran</i>	1.25 hr
4:15PM – 4:30PM	Break		
4:30PM – 5:30PM	Knobology - Hands on session with participants in using their cameras and software. Participants to bring their cameras to this session. Software and computer lab. Demonstration of Flir cameras. Participants to bring their laptop Computers for hands on session. Presenters to assist with individual participants in utilizing their cameras and in report generation.	<i>Waldsmith</i>	1.0 hr
5:30 PM	Dinner on your own		

 Saturday, February 27, 2010 – UF College of Veterinary Medicine

8:30AM-10:30AM	Thermal Imaging in Wildlife and Marine Mammal Species	<i>Walsh</i>	2.0 hr
10:30AM – 10:45AM	Break		
10:45AM-11:45AM	Normal Mature Equine Thermographic Examination	<i>Turner</i>	1.0 hr
11:45AM-12:45PM	Artifacts in the Thermographic Exam	<i>Turner</i>	1.0 hr
12:45PM – 1:30PM	LUNCH		
1:30PM-2:30PM	The Foot	<i>Turner</i>	1.0 hr
2:30PM- 2:45PM	Break		
2:45PM-4:00PM	Tendons and Ligaments	<i>Turner</i>	1.25 hr
4:00PM -5:00PM	Joint Disease	<i>Turner</i>	1.0 hr
5:00PM	Dinner on your own		

 Sunday, February 28, 2010 – Location to be determined

8:00AM - 12:00 PM	Informal Wet Lab Session: This is a session for individuals to get one-on-one assistance in thermal imaging technique, camera function, software issues, and report generation. The session will begin with a demonstration of how to perform the basic equine thermal examination and a brief review of artifacts. The UFL Veterinary staff will be available to work with participants individually with specific issues to further their educational experience.	<i>Turner</i>	4.0 hr
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Speakers

Mike Corcoran, Master Saddle Fitter
Master Saddlery, Argyle, TX

Kimberly Henneman, DVM, CVA, CVC, FAAVA
Animal Health Options, Park City, UT

Tracy Turner, DVM, MS, DACVS
Board Certified in Thermal Imaging
Anoka Equine Veterinary Services, Ltd. Elk River, MN

James K. Waldsmith, DVM
Board Certified in Thermal Imaging
Staff Veterinarian - The Equine Center
San Luis Obispo, CA

Mike Walsh, DVM
University of Florida – Gainesville, FL
College of Veterinary Medicine

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College of Veterinary Medicine

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Registration Information

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Office of Conferences & Institutes (OCI)

PO Box 110750 Building 639, Mowry Road

Gainesville, FL 32611-0750

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Email: spb@ufl.edu

26th-28th March 2010

XIV National Congress of the Polish Association
of Thermology in Zakopane

Abstract deadline: January 15th, 2010

Deadline for hotel reservation; March 1st, 2010

Registration fee: 200 €

Further information

Prof Dr. Anna Jung

ajung@wim.mil.pl or a.jung@spencer.com.pl

5th -9th April 2010

Thermosense XXXII- Part of program track on
IR Sensors and Systems at SPIE DSS

Venue: Orlando World Center Marriott Resort and Con-
vention Center – Orlando, FL United States

Conference Chairs: Ralph B. Dinwiddie, Oak Ridge Na-
tional Lab.; Morteza Safai, The Boeing Co.

Program Committee

Andrea Acosta, Colbert Infrared Services; Nicolas P. Avdelidis, National Technical Univ. of Athens (Greece); Pierre G. Bremond, Cedip Infrared Systems (France); Jeff R. Brown, Hope College; Douglas Burleigh, La Jolla Cove Consulting; Antonio Colantonio, Public Works and Government Services Canada (Canada); Fred P. Colbert, Colbert Infrared Services; K. Elliott Cramer, NASA Langley Research Ctr.; Ermanno G. Grinzato, Consiglio Nazionale delle Ricerche (Italy); Sheng-Jen Hsieh, Texas A&M Univ.; Herbert Kaplan, Honeyhill Technical Co.; Timo T. Kauppinen, VTT (Finland); Kathryn M. Lee, United Space Alliance, LLC; Dennis H. LeMieux, Siemens Power Generation, Inc.; Robert P. Madding, FLIR Systems, Inc.; Xavier P. Maldague, Univ. Laval (Canada); Jonathan J. Miles, James Madison Univ.;

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Steering Committee Emeritus Members:

Sven-Åke Ljingsberg, Univ. of Gäyle (Sweden);

John R. Snell, Snell Infrared

Information: <http://thermosense.org>

19th – 21th July 2010

7th International Conference on Heat Transfer,
Fluid Mechanics and Thermodynamics-HEFAT2010
Antalya, Turkey

Important dates

Final paper acceptance feedback: 1 March 2010

Early bird registration deadline: 10 March 2010

Final registration deadline: 10 May 2010

Further Information:

Prof Josua P Meyer

Chair: School of Engineering

Head: Department of Mechanical and

Aeronautical Engineering, University of Pretoria, Pretoria

Tel: (012) 420 3104, Fax: (012) 362 5124

E-mail: josua.meyer@up.ac.za

Conference website: <http://www.hefat.net>

27-30th July 2010

QIRT 2010 The 10th Quantitative Infrared
Thermography Conference at Université Laval,
Québec City, Canada

Important dates

February 20th, 2010 - Acceptance Notification

May 20th, 2010 - Full-paper submission

May 20th, 2010 - Advance registration

Topics:

- State of the art and evolution in the field of infrared scanners and imaging systems allowing quantitative measurements and related data acquisition and processing.
- Integration of thermographic systems and multispectral analysis. Related problems like calibration and characterization of infrared cameras (mono and multidetector systems), emissivity determination, absorption in media, spurious radiations, three dimensionality of observed objects, certification and standardization.
- Thermal effects induced e.g. by electromagnetic fields, elastic waves or mechanical stresses.
- Application of infrared thermography to radiometry, thermometry and physical parameters identification in all fields such as (and not limited to): industrial processes, material sciences, structure and material non destructive eval-

uations, medicine, and biomedical science, fluid mechanics, cultural heritage, environment, food production.

Further information

QIRT 2010 Secretariat

Electrical and Computer Engineering Dept.
Université Laval, Québec (Québec)
CANADA G1V 0A6

<http://qirt2010.gel.ulaval.ca>

Infrared 100 Events

RPS Exhibition (Bath, October 2010)

Science Museum Lecture (London, October 2010)

Medical and Industrial Infrared conference
(London, October 8th 2010)

Astronomical Infrared conference
(London, October 9th 2010)

13th November 2010

23rd Thermological Symposium of the Austrian
Society of Thermology

Venue: SAS Hotel Vienna, Austria

Deadline for Abstracts: 10th October 2010

Electronic submission is preferred and strongly suggested
(Email: KAmmmer1950@aol.com)

Information

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Hernalser Hauptstr 209/14
Email: KAmmmer1950@aol.com

2011

6-8 July, 2011

17th International Conference on Thermal Engineering and Thermogrammetry (THERMO)

at the Budapest University of Technology and Economics (BME), Budapest, XI .Műgyetem rkpt.3., Hungary

THE CONFERENCE ORGANIZER:

Branch of Thermal Engineering and Thermogrammetry (TE and TGM),

Hungarian Society of Thermology (HST) at MATE,
European Association of Thermology (EAT),

CALL FOR PAPERS

The photocopy-ready papers(for CD-ROM presentation) of max. ten A4 format pages to be presented on the conference are to be submitted before 15 February, 2011. To assist the work of the Scientific Committee the authors are kindly requested to point out the aim, method and results of their

work in the summary to be provided according to the typing instructions.

Notification of the acceptance of abstracts will be forwarded to the authors until 30 November, 2010. The full text of all accepted papers will be included the CD-ROM Proceedings to be presented to the participants at the Conference

Information

Prof. Dr. Imre BENKÖ,

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H-1521 Budapest, Muegyetem rkp. 7 / D.301. Hungary

Phone/fax: +361-310-0999.E-mail: ibenko@freestart.hu

Dr. Kurt Ammer

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-
- Hernalser Hauptstr.209/14
- A-1170 Wien
- Österreich

- This journal is a combined publication of the Austrian Society of Thermology and the European Association of Thermology (EAT)
- It serves as the official publication organ of the the American Academy of Thermology, the Brazilian Society of Thermology the UK Thermography Association (Thermology Group) and the Austrian Society of Thermology.
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