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Temperature of the human knee

Breast thermography

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Organ of the UK Thermography Association (Thermology Group)

Contents (INHALTSVERZEICHNIS)

Past and future of Thermology international

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The Past

Preceded by proceedings of thermology symposia [1,2] organised by the Ludwig Boltzman Research Unit for Physical Diagnostics, the first issue of *Thermology international*, was published in May 1991. The journals name was at that time "*Thermologie Österreich*", cooperating publishers were the Austrian Society of Thermology and the Ludwig Boltzman Research Unit for Physical Diagnostics. 100 copies of the first issue have been printed, most of them have been distributed to the participants of the 4th Thermological Symposium of the Austrian Thermology Society. In the newly founded journal, this meeting was well documented by abstracts [3] and full versions of talks [4] presented at this and previous symposia [5].

Already in 1993, *Thermologie Österreich* became the official publication organ of the European Association of Thermology, changed its name in 1997 to "*European Journal of Thermology*" and finally in 1999 to *Thermology international* . The historical development of the journal was described at the 23rd Thermological Symposium of the Austrian Society od Thermology [6]. I want to update the citation history reported in 2010.

Meanwhile Thermology international (all former names included) received 176 citations in Thompsons database ISI. . Figure 1 shows the annual numbers of citations received. Most cited paper with 29 hits is a tutorial that describes conditions, equipment and indications for infra red thermal imaging in medicine [7]. In my own archive, paper was cited in total 109 times including journals, books and theses.

2010	19	10.795 %
2001	17	9.659 %
2004	16	9.091 %
2005	16	9.091 %
2012	15	8.523 %
2011	14	7.955 %
2006	13	7.386 %
2007	11	6.250 %
2009	11	6.250 %
1998	9	5.114 %

Figure 1
Annual citations for Thermology international

In my own archive, 204 cited papers (65 for *Thermologie Österreich*, 17 for the *European Journal of Thermology*, 121 for *Thermology international*) received in total 867 citations. The second rank in most cited papers is by James Mercer & Louis d Weerd on the effect of Infrared-A irradiation on skin temperature and skin blood flow [8].

The Future

As the production of one printed issue of the journal costs about 2200.- Euro, the current issue, number 4 of volume 22, 2012, is the last one which appears in print. From 2013 on, Thermology international will be published as an electronic internet based journal. This will reduce cost of production and allows to publish colour images or videos without extra costs.

This change of production will not affect the journal´s function as publication organ of the American Academy of Thermology, the Brazilian Society of Thermology, the Polish Society of Thermology and the UK Thermography Association (Thermology Group). As the Austrian Society of Thermology will stop all activities by the end of 2012, the European Association of Thermology will remain the only responsible publisher.

Authors interested to publish their work may submitt their papers to the editors email address **KAmmer1950@aol.com**. Decision on acceptance with or without amendments will be available within 4 weeks after submission

From 2013 the journal will only be available from the website of the journal at **http//www.uhlen.at/ thermology-international.** Access to the journal will only be possible after the EAT membership fee or the subscription rate have been paid. A pay-per-view service for current and back issues of the journal, also a facility for online subscription, both based on PayPal will become available.

Finally, the long announced DVD containing all issues of Thermologie Österreich, European Journal of Thermology and Thermology international plus the proceedings of the 1st and 2nd Thermological Symposum of the Austrian Society of Thermology, the proceedings the Bath conference 1994 [8] and all 3 volumes of the computed list of papers on thermology and temperature measurement [9,10,11] will become available by December 2012. This archive of thermology papers can be purchased for 100.-Euro. Please use the order form on page 164 of this issue.

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Temperature of the human knee – a review

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SUMMARY

BACKGROUND: Temperature measurement of the knee joint has a long tradition in medical thermometry. However, neither a standard for recording knee temperature nor agreed values of knees in healthy subjects or in articular disease are available.

AIM OF THE STUDY: To compute available data on knee temperature from the literature including the conditions of temperature recording, measurement sites and temperature values.

METHOD: A literature search was performed in the databases Medline and Embase using the search terms "skin temperature" or "intra-articular temperature" and "knee". Only papers written in English or German related to humans were considered for inclusion. The following data were extracted from included papers: Surface (skin) temperature, intra-articular temperature, site of measurement for skin or intra-articular temperature, measurement device, number of investigated knees, diagnosis of investigated subjects, biographic data of investigated subjects, room temperature, time of acclimatisation. If possible, temperature values were pooled if they have been recorded under similar conditions.

RESULTS: In total, the database included temperature measurements from 3463 knee joints, comprising data from 876 healthy subjects, 629 patients with osteoarthritis (OA), 512 patients with rheumatoid arthritis (RA), 67 patients with non rheumatoid and other non specified inflammatory arthritis have been investigated. 86 patients suffered from joint inflammation caused by trauma, and 96 patients had various injuries of ligaments and other fibro-cartilagenous tissues of the knee. 131 temperature measurements were performed during surgery and 285 after surgery. 33 patients suffered from algodystrophy, 200 patients were investigated during or after various methods of cryotherapy and 50 subjects during heat treatment. Only pattern description without temperature values was reported in 5700 other subjects with various knee disorders.

Based on contact temperature measurements, the mean temperature of the anterior knee in healthy subjects was 30.5 ± 1.1°C. Determined with radiometers, the corresponding mean temperature was 28.7 ± 0.6°C (95% confidence interval: 27.9 to 29.5). In thermal images from healthy subjects, the mean temperature of the anterior knee was 29.5 ± 1.6°C (95% confidence interval: 28.5 to 30.5°C) and 33,1 ± 0.0 °C of the posterior knee. The side difference of temperature was 0.2 ±1°C for both the anterior and the posterior knee.

Mean intra-articular temperature varied between measurements recorded during knee surgery (29.9 ± 4.4 °C; 95% confidence interval: 23.0 to 36.8), in patients with rheumatoid arthritis (35,1 ± 0.7 °C; 95% confidence interval: 34.2 to 36.0°C) or osteoarthritis (33,5 2,7°C; 95% confidence interval: 30.1 to 36.9) and healthy subjects (32.6 ± 0.9°C; 95% confidence interval: 31.5 to 33.7).

Measurements with contact thermometers revealed in patients with rheumatoid arthritis a mean temperature of 32.5 ± 0.9°C (95% confidence interval: 31.4 to 33.9°C) for the anterior knee, while the corresponding temperature recorded with infrared thermal images was 30.5 ± 0.8°C (95% confidence interval: 27.8 to 33.1°C). In osteoarthritis patients, contact thermometers obtained a mean anterior knee temperature of 31.3 ± 1,3°C and temperature measurements from infrared thermograms revealed a mean temperature of 30.7 ± 1.3°C (95% confidence interval: 29.4 to 32.0 °C).

CONCLUSION: Knee temperatures vary with respect to the method of temperature determination and between different health conditions of the knee joint. Moreover, mean knee temperature describes the condition of the knee incompletely and should be supplemented with a description of the temperature distribution.

KEY WORDS: knee, temperature, rheumatoid arthritis, osteoarthritis, healthy subjects

DIE KNIETEMPERATUR DES MENSCHEN - EIN ÜBERBLICK

HINTERGRUND: Die Temperatumessung am Kniegelenk besitzt eine lange Tradition in der medizinischen Thermometrie.. Trotzdem findet sich weder eine standardisiertes Vorgehen zur Temperaturmessung am (oder im) Kniegelenk noch existieren allgemein akzeptierte Temperturwerte der Knie von gesunden Personen oder von Patienten mit definierten Gelenkerkrankungen.

ZIEL DER STUDIE war es, die vorhandenen Daten über die Knietemperatur einschließlich der Messbedingungen, der Messstellungen und der Temperaturwertee aus der Literatur zusammen zu tragen.

METHODE: Es wurde eine Literatursuche in den Datenbanken Medline und Embase unter Verwendung der Suchbegriffe "skin temperature (Hauttemperatur)" oder "intra-articular temperature (intraartikuläre Temperatur") und "knee (Knie) " durchgeführt. Es wurden nur Untersuchungen am Menschen berücksichtigt, die in englischer oder deutscher Sprache veröffentlicht wurden. Folgende Daten wurde aus den Publikationen extrahiert: Oberflächen - (Haut) Temperatur, intra-artikuläre Temperature, Messstelle für die Bestimmung der Hauttemperatur oder der intraartikulären Messgerät, Anzahl der untersuchten Knie, Diagnose der untersuchten Personen, biographische Angaben der untersuchten Personen, Raumtemperatur, Akklimatisationszeit. Die Temperaturwerte wurden zusammengefasst und gemittelt, wenn sie unter ähnlichen Bedingungen erhoben worden waren.

ERGEBNISSE: Ingesamt enthält die Datenbank Temperaturmessungen von 3463 Kniegelenken, die Daten von 876 gesunden Personen, 629 Patienten mit Arthrose, 512 Patienten mit rheumatoider Arthritis, 67 Patienten mit nicht rheumatisch bedingter Arthritis wurden untersucht, 86 Patienten litten an traumatisch bedingter Gelenkentzündung. und 96 Patienten boten Verletzungen der fibro-kartilaginären Binnenstrukturen des Kniegelenks. 131 Temperaturmessungen wurden während und 285 nach gelenkchirurgischen Eingriffen durchgeführt. 33 Patients waren an Algodystrophie erkrankt. 200 Personen wurden während unterschiedlichen Verfahren der Kryotherapie, 50 Personen während einer Wärmetherapie untersucht. Bei weiteren 5700 Personen mit unterschiedlichen Kniegelenkserkrankungen wurden lediglich die Muster der Temperaturverteilung, jedoch keine Temperaturwerte berichtet.

Bei Messung mit Kontaktthermometern betrug bei Gesunden die mittlere Temperatur an der Vorderseite des Kniegelenks 30,5 ± 11°C. Bei Bestimmung mit einem Radiometers waren die entsprechende Durchschnittstemperatur 28,7 ± 0,6°C (95% Vertrauensbereich: 27,9 to 29,5). In Wärmebildern von gesunden Personen betrug die mittlere Temperatur an der Vorderseite des Kniegelenks 29,5 ± 1,6°C (95% Vertrauensbereich: 28,5 to 30,5°C) und 33,1 ± 0,0 °C an der Rückseite des Knies. Der Seitenunterschied war an der Vorder- und Rückseite des Knies 0,2 ±1°C.

Die durchschnittliche intra-artikuläre Temperatur unterschied sich in Abhängigkeit, ob die Messungen während eines chirurgischen Eingriffs (29,9 ± 4,4 °C; 95% Vertrauensbereich: 23,0 bis 36,8), bei Patienten mit rheumatoider Arthritis (35,1 ± 0,7 °C; 95%Vertrauensbereich: 34,2 bis 36,0°C), Arthrose (33,4± 2,7°C; 95% Vertrauensbereich: 30,1 bis 36,9) oder gesunden Personen (32,6 ± 0,9°C; 95% Vertrauensbereich: 1,5 bis 33,7) durchgeführt worden waren.

Messung mit Kontaktthermometern fanden bei Patienten mit rheumatoider Arthritis eine Durchschnittstemperatur von 32,5 ± 0,9°C (95% Vertrauensbereich: 31,4 bis 33,9°C) an der Vorderseite des Knies, während die entsprechenden Temperaturen in Infrarot-Wärmebildern 30,5 ± 0,8°C (95%Vertrauensbereich: 27,8 bis 33, 1°C) betrugen. Bei Arthrosepatienten, zeigte die Kontaktthermometrie an der Vorderseite des Kniegelenks eine mittler Temperatur von 31,3 ± 1,3°C, in Infrarotthermogrammen wurde die Durchschnittstemperatur mit 30.7 ± 1.3°C (95% Vertrauensbereich: 29.4 to 32.0 °C) bestimmt.

SCHLUSSFOLGERUNG: Die Knietemperatur variert in Abhängigkeit von der Methode der Temperaturbestimmung und bei unterschiedlichen Gesundheitszuständen. Darüberhinaus beschreibt die mittlere Knietemperatur den Zustand des Kniegelenks unvoll ständig und sollte mit einer Beschreibung der Temperaturverteilung ergänzt werden.

SCHLÜSSELWÖRTER: Knie, Temperatur, rheumatoide Arthritis, Arthrose, gesunde Personen

Thermology international 2012, 22(4) 137-151

Introduction

Temperature measurement of the knee joint has a long tradition in medical thermometry. Intra-articular temperature measurements of the were reported 1949 by Horvath & Hollander [37], case reports on thermal infrared imaging of the knee joint appeared in 3 articles [2,9,13] of the proceedings of symposium on medical thermography organised by the New York Academy of Sciences in 1963. Despite numerous papers reporting skin or intra-articular temperature of the human knee joint, neither a standard for recording knee temperature nor agreed values of knees of healthy subjects or in articular disease are available.

The aim of this review is to compute available data on knee temperature from the literature including the conditions of temperature recording, measurement sites and temperature values.

Method

A literature serach was performed in the database Medline and Embase using the search terms “skin temperature“ or ”intra-articular temperature” and “knee”. The findings were completed with a hand search in the literature archive of the author. Only papers written in English or German related to humans were considered for inclusion. Case reports of single patients were excluded as the minimum sample size of case series for inclusion was 3 subjects .

Titles and abstracts of the identified papers were read and if sufficient information was available from the abstract, the full version of the publication was retrieved. The following data were extracted from included papers:

- Surface (skin) temperature
- intra-articular temperature
- site of measurement for skin or intra-articular temperature
- measurement device
- number of investigated knees
- diagnosis of investigated subjects
- biographic data of investigated subjects
- room temperature
- time of acclimatisation

If possible, temperature values were pooled if they have been recorded under similar conditions.

The Thermal index (TI) as described by Collins & Ring, was converted to mean temperature values by adding 26° to the TI. In case of TI percentage and the given reference of 28°C for 50%, the reported TI% were converted accordingly (100% equal to 33°C).

Results

The search in Medline and Embase obtained 131 hits. After removing papers related to “peripheral occlusive artery disease”, leg ischemia”,”edema”, “erythema”, “skin ulcer”, wound healing”, “diabetes mellitus”, “postoperative complication”, ”chronic disease”, “shivering”, and “hyperhermia”, 52 papers remained. The abstracts of these papers were read and papers not reporting temperatures of the knee joint region were excluded. Full text versions of the remaining papers were retrieved, but in case that the full text version was not available, these papers were added to the excluded material. Reasons for exclusion are listed in table 1. In one non retrieved paper some data could be extracted from the abstract . From the original search remained 32 papers in the database. Hand search in the literature archive of the author obtained another 50 publications.

Investigated Subjects

In total, the database included temperature measurements from 3463 knee joints, comprising data from 876 healthy subjects, 629 patients with osteoarthritis (OA), 512 patients with rheumatoid arthritis (RA), 11 patients with non rheumatoid inflammatory arthritis such a peripheral involvement of ankylosing spondylitis (SpA), M Behcet and gout and 65 other non specified inflammatory arthritis were investigated. 86 patients suffered from joint inflammation caused by trauma, and 96 patients had various injuries of ligaments and other fibro-cartilagenous tissues of the knee. 131temperature measurements were performed during surgery and 285 after surgery. 33 patients suffered from algodystrophy, 200 patients were investigated during or after various methods of cr yotherapy and 50 subjects during heat treatment. All tables with the suffix "a" 2 show reference number, author, year of publication, sample size, gender and age of participants, diagnosis and objective of studies. Tables labelled "b" list the name of the measurement device, measurement site, acclimatisation time, room temperature and temperature values. Table 2 is dedicated to healthy subjects, table 3 lists the respective data for patients with osteoarthritis, table 4 shows findings for rheumatoid arthritis and other inflammatory joint diseases and table 5

Table 1
Excludes Studies

Reference	Author,	Year of publication	Reason for exclusion
1	Adam	1985	Not retrieved
3	Albrecht	1997	Baseline knee temperatures not reported
5	Arnold et al	1989	Mixed sample of healthy subjects and patients, knee joint temperatures have been reported, but could not related tohealth conditions
7	BenEliyahu	1992	Knee joint temperature not reported
10	Calvisi et al	2008	Knee joint temperature not reported
17	Darsow	1988	Not retrieved
18	Davidson	1979	Plausible knee joint temperature not reported
23	Farage	2010	Knee joint temperature not reported
24	Felhendler	1996	Knee joint temperature not reported
25	Fries	1990	Knee joint temperature not reported
27	Guadagni	1974	Not retrieved
31	Hayden	2003	Insufficent reporting of temperature
32	He et al	2008	Knee joint temperature not reported
39	Janik et al	2007	Knee joint temperature not reported; case report
43	Kladny	2005	Knee joint temperature not reported;
48	Marsh	1996	Knee joint temperature not reported;
50	Martin M	2002	Case report
52	Martin S	2002	Absolute knee joint temperature not reported
57	Mora	1999	Knee joint temperature not reported; case report
61	Parrini	2002	Knee joint temperature not reported; case report
63	Pelletier	1987	Case report
66	Rice	1989	Knee joint temperature not reported
80	Smith	1997	Not retrieved
81	Tanaka	1976	Not retrieved
82	Tanavalee	2111	Knee joint temperature not reported
88	Vardasca et al	2012	Knee joint temperature not reported
93	Yi et al	2011	Knee joint temperature not reported

Table 2a
Healthy subjects

Ref.	Author	Sample size	males	females	Age (mean±SD, range)	Diagnosis	objective
86	Uematsu 1985	32	?	?	?	Healthy subjects	Investigation in symmety of temperature distribution
87	Uematsu 1988	14	?	?	?	Healthy subjects	Investigation in symmety of temperature distribution
28	Goodman 1986	31	17	14	20-50	Healthy subjects	Investigation in symmety of temperature distribution
33	Hendiani 2003	27	6	21	47.96± 1.49 31-73	Healthy subject	Evaluation of pain threshold in chronic arthropathies
34	Herry 2004	14	?	?	?	Healthy subjects	Evaluation of automated computerised assessment of thermal images
96	Zhu 1999	223	138	35	42.5 ± 8.8	Healthy subjects	Investigation in symmety of temperature distribution
85	Uchio 2003	20	10	10	21-28	Healthy subjects	Evaluation of cryotherapy
37	Horvath 1949	4	4		32-44	Healthy subjects	Investigation in joint temperature
37	Horvath 1949	4	4		32-44	Healthy subjects	Investigation in joint temperatur
59	Oosterveld 1992	42	16	26	20 ± 2	Healthy subjects	Evaluation of cryotherapy and thermotherapy
6	Becher 2008	6	6		29.3	Healthy subjects	Investigation in knee joint temperature during sports
30	Haimovici 1982	140	?	?	?	Healthy subjects	Investigation in joint temperature
91	Warren 2004	12	5	7	26	Healthy subjects	Evaluation of cryotherapy
42	Kim 2002	20	15	5	33,8±12,7 23-68	Healthy subjects	Evaluation of cryotherapy
42	Kim 2002	20	15	5	33,8±12,7 (23-68)	Healthy subjects	Evaluation of cryotherapy
40	Janssen 1988	15			?	Healthy subjects	Evaluation of cryotherapy
75	Schmidt 1979	15	?	?	?	Healthy subjects	Evaluation of cryotherapy and thermotherapy
56	Menard 1980	50	?	?	?	Healthy subjects	Investigation in knee joint temperature
38	Ibrahim 2005	18	10	8	26 20-38	Healthy subjects	Evaluation of cryotherapy
14	Coughlin 1987	16		16	?	Healthy subjects	Diagnosis of algodystrophy
4	Ammer 1998	10		10	33.1 ±10.3	Healthy subject	Correlation WOMAC and knee temperature
22	Engel 1978	246	?	??	?	Healthy subjects	Investigation in knee joint temperature
11	Collins 1976		?	?	?	Healthy subjects	Investigation in joint temperature
12	Collins 1976	32	?	?	?	Healthy subjects	Investigation in joint temperature
67	Ring 1976	60	?	?	?	Healthy subjects	Investigation in joint temperature
68	Ring 1980	200	?	?	?	Healthy subjects	Investigation in joint temperature
15	Dachs 1991	5				Healthy subjects	Evaluation of cryotherapy
65	Rajapakse 1981	8	?	?	?	Healthy subjects	investigation in joint temperature
20	Denoble 2010	15		15	61.9±8.8 48-76	Healthy subjects	Correlation between thermo-graphy and radiography

Table 2b
Healthy subjects

Ref.	Measurement device	Measurement site	Acclimatisation time	Room temperature	temperature value
86	Thermography system	Anterior knee (patella)	?	?	Side-to-side diff. patella: 0.23 ± 0.17 °C
87	InfraEye 160 Thermography system (Fujitsu)	Anterior and Posterior knee	20 min	23-26°C	Side-to-side diff. ant. knee: 0.23 ± 0.17°C Side-to-side diff.post. knee: 0.12 ± 0.1°C
28	Dorex® thermograph	Right and left lateral lower extremity.	20 -25 min	20.5±0.5°C	Side-to-side diff. lat. knee 0.28 ±0.12°C
33	Infrared thermometer Entest, Inc., Carrollton, TX	lateral inferior aspect of knee	?	?	Side-to-side diff.: 0.3 ± 0.1°C
34	AGA Thermovision 680	Anterior and posterior knee	15 min	23°C	Side-to-side diff. ant. knee: 0.12 ± 0.13°C Side-to-side diff.post. knee: 0.15 ± 0.12°C
96	Thermovision® 470 Pro AGEMA	Anterior and Posterior knee	30 min	25°C	Right anterior knee: 30.4 ± 0.89°C Right posterior knee: 33.1 ± 0.58°C Left anterior knee 30.4± 0.88°C Left posterior knee:33.1 ± 0.58°C Side-to-side difference: 0.0 ± 0.8°C
85	Skin thermometer	Anteromedial aspect of the knee	?	17.6°–20.4°C	Male: 26.7 ± 1.3°C Female:25.8 ± 1,9°C
37	Thermocouple or thermistor	Intra-articular under the patella	30 min	24°C	Male 32.4 ± 0.6°C
37	Thermocouple or thermistor	Skin temperature of patella	30 min	24°C	Male: 30.6 ± 1,2°C
59	Exacon C-F04.30 catheter temperature probe	intra-articular lateral joint cavity	30 min	21.2 ± 0.7°C	32.5 ± 0.4 °C
6	Thermocouple probe; Model IT-18, Physitemp	Intra-articular medial aspect ofthe knee	?	19°C	Right knee: 31.4 ±
30	Digital thermometer Bailey BAT 8 C	Intraarticular suprapatellar pouch	60 min (?)	22 ± 1° C	32.8 ± 1.1°C
91	Model IT-18, Physitemp, Clifton, New Jersey	Intraarticular suprapatellar pouch	?	?	Median 33.5°C
42	k-wire thermostat, Barnant 90,Barrington, IL	Intra-articular lateroanterior aspect	?	26-28°C	33,9 ±1.3
42	Thermovision 900, Agema	Anterior knee, flexed 90	?	26-28°C	31.8 ±1.0
40	Infrared radiometer Thermopil Ultrakust	medial joint cleft lateral joint cleft lower border of patella	?	22°C	Mean of all 3 measurements:28.0 ± 1.1°C
75	Heimann radiometer KT 41	mid of patella above patella lateral of patella medial of patella lateral poplitea	13 min	18-22	Mean right knee: 29.0± 0.4 Mean left knee 29.07±0.24
56	Thermometer, type TE3 (Ellab Instruments, Copenhagen), thermocouple skin applicator, type H2,	mid of patella	5 min	21-25°C	30.3 ±0.9°C
38	Mon-a-therm adhesive skin probes (Mallinckrodt)	Gerdy´s tubercle	?	?	32.0 ±0.9°C
14	AGA 680M thermovision	Anterior and posterior knee	15 min	20°C	Side-to-side diff. ant. knee: 0.26 ± 0.05°C Side-to-side diff.post. knee: 0.25 ± 0.04°
4	Agema 870 Scanner	Total knee Suprapatellar Infrapatellar patella	15 min	20°C	Total knee: 31.4 ±0.8 Suprapatellar: 31.8±0.7 Infrapatellar:31.5 ±0.9 Patella: 31.5±0.9
22	Zeiss Ikotherm	Anterior knee	10 min	20-23°C	Mean knee: 29.36:±1.09
11	Bofors Scanner	Anterior knee		20°C	Mean knee:27.5 ± 0.4
12	Bofors Scanner	Anterior knee	20min	20°C	Mean knee:27.5
67	Bofors Scanner	Anterior knee		20°C	Meanknee 27.65 ±1.13
68	Bofors Scanner	Anterior knee		20°C	Mean knee: 27.8 ± 0.4
15	Hughes Probeye 4000	Patella, medial and lateral joint line	15min	24°C	Before cooling: Patella. 30.4 °C
65	AGA Thermovision 680	Lateral knee	30 min	20°C	Lateral knee, mean: 29.8 ± 1.8
20	Meditherm Med2000™	Anterior knee	10 min	23.1°C	30.6 ±0.8°C

Table 3a
Osteoarthritis

Ref.	Author	Sample size	males	females	Age (mean±SD, range)	Diagnosis	objective
30	Haimovici 1982	52	?	?	?	Latent osteoarthritis	Investigation in joint temperature
30	Haimovici 1982	78	?	?	?	Active osteoarthritis	Investigation in joint temperature
37	Horvath 1949	6		6	48-67	Osteoarthritis	Investigation in joint temperature
37	Horvath 1949	6		6	48-67	Osteoarthritis	Investigation in joint temperatur
64	Qiu 2011	56	19	37	59,8 55-70	50 OA, 5 RA 1 TA	Investigation in occurrence of deep venous thrombosis after arthroplasty
76	Schneider 1997	18	8	10	66±10	Osteoarthritis	Trial with hyalronic acid
71	Romano	40	28	12	63.5 53-78	Osteoarthritis	Postoperative management
55	Mehra 2005	19	12	7	73 44-85	osteoarthritis	Postoperative management of arthroscopy
33	Hendiani 2003	27	4	23	53.2 ± 2.1	Osteoarthritis	Evaluation of pain threshold in chronic arthropathies
44	Kraeff 1995	13	?	?	?	Osteoarthritis	Evaluation of cryotherapy
54	Mayr 1995	4				Osteoarthritis	Postoperative management of arthroplasty
4	Ammer 1998	29	7	22	54.0 ±11.4	osteoarthritis	Correlation WOMAC and knee temperature
68	Ring 1980	200				Osteoarthritis	Investigation in joint temperature
20	Denoble 2010	15		15	61.9±9.2 46-76	osteoarthritis	Correlation between thermography and radiography
29	Haidar 2006	32	10	22	70 59-85	osteoarthritis	Postoperative management of arthroplasty

the results from measurements during and after arthrotomy or arthroscopy.

Table 6 shows 5 studies that did not report mean temperatures, but employed pattern description instead. The largest of these studies reported examples from a database of approximately 5000 thermal images of various disorders of the knee recorded over 25 years [97].

Site of temperature measurement

Intra-articular

13 studies performed intra-articular temperature measurements of the knee joint [6, 16, 26, 30,37,42, 51,60,64,73, 76,91, 95]. The suprapatellar pouch[16, 26,30,73,91] and the lateral gutter [26,51] were the preferred localisation of intra- articular thermometers. 2 studies measured the temperature inside of the tibial bone during bone surgery, 2 and 3mm away from the cutting surface [46,47].

Figure 1 shows the mean intra-articular temperatures ± 95% confidence interval of 224 healthy subjects, 156 patients with rheumatoid arthritis, 210 patients with osteo- arthritis and 101 subjects during arthroscopy.

Subcutaneous temperature

1 study measured the subcutaneus temperature above the patella during postoperative cryotherapy and compared it to then non operated knee [16].

Skin temperature

Skin temperature was determined in 15 studies with contact thermometers [6,29,30,35,36,37,38,42,49,56,59,60, 62, 85,91]. 5 Publications reported skin temperature measurements with radiometers [33,40,44,55,75] and the remaining 19 studies applied infrared cameras [4,11,12,14, 15,20,21,

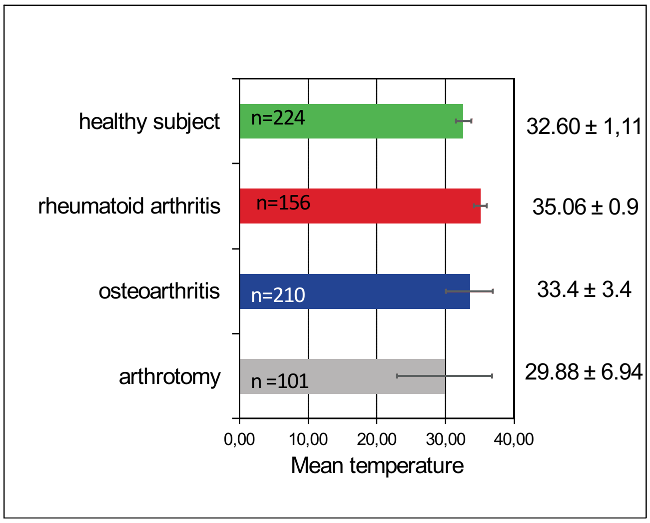

Figure 1
Mean intra-articular knee temperatures ±95% confidence interval of healthy subjects, patients with rheumatoid arthritis or ostearthritis and during arthrotomy

Table 3b
Osteoarthritis

Ref.	Measurement device	Measurement site	Acclimatisation time	Room temperature	temperature value
30	Digital thermometer Bailey BAT 8 C	Intra-articular suprapatellar pouch	60 min (?)	22 ± 1° C	32.9 ± 0.9°C
3	Digital thermometer Bailey BAT 8 C	Intra-articular suprapatellar pouch	60 min (?)	22 ± 1° C	36.1± 1.2°C
37	Thermocouple or thermistor	Intra-articular under the patella	30 min	24°C	Female 34.5 ± 0.6°C
37	Thermocouple or thermistor	Skin temperature of patella	30 min	24°C	Female: 32.2 ± 1.2°C
64	Thermocouples, Tse Company, Nanjing, China	Intra-articular: suprapatellar bursa Intra-articular: popliteal fossa		22-24	suprapatellar bursa: 29.0 ± 0.9 popliteal fossa:29.4 ± 0.8
76	Licox temperature probe (GMS)	Intra-articular, site not reported	?	?	Intra-articular: 34.8 ± 2.0
71	NEC-AVIO ThermoShot F30S digital telethermocamera.	Anterior knee (supine position)	?	?	Prior to surgery: 32.2 ±1
55	Genius First Temp Monitor	2 points upper border of the patella,	?	?	Prior to surgery:30.8
33	Infrared thermometer Entest, Inc., Carrollton, TX	lateral inferior aspect of knee	?	?	Side-to-side diff.: 0.5 ±0.1°C
44	Surface Temperature Scanner Omega Medical Corp	?	?	?	28°C
54	NEC Thermotracer	Patella suprapatellar infrapatellar	15 min	20°C	Before surgery Patella 29.6 ± 1.6°C suprapatellar:: 29.0 ±1.1 infrapatellar: 29.7 ±1.5
4	Agema 870 Scanner	Total knee Suprapatellar Infrapatellar patella	15 min	20°C	Total knee: 31.8 ±1.1 Suprapatellar: 31.8 ±1.1 Infrapatellar:32.0 ±0.8 Patella: 31.5±1.2
68	Bofors Scanner	Anterior knee	15 min	20°C	29.4 ± 1.0°C
20	Meditherm Med2000™	Anterior knee	10 min	23.1°C	30.6 ±0.9°C
29	digital pocket surface thermometers (PT-100C, Sealed Unit Parts Co. Inc,)	Superomedial to the patella	?	?	Before surgery:30.4°C

22, 28,34,42,62,65,67, 68, 54, 71,86,87,96]. The anterior knee was imaged in 15 of 19 thermal imaging studies, 1 study imaged only the lateral knee [65], and in another paper the lateral aspect of both lower extremities was imaged. 1 publication reported addiditonal images of the medial and the lateral joint line [15], and in 3 studies images in the posterior view of the knee were also recorded [14, 34, 87]. Thermal images for pattern description were recorded in the lateral view with the kne 90° flexed [19; 20, 74, 97]. 2 papers reported also anterior views, 1 with the knee 90° flexed [20] and the other with the knees fully extended [97].

Contact temperature measurements were performed at the superomedial, superolateral, inferomedial, and inferolateral border of the patella [36], (somewhere) over the patella [37], at the mid of patella [49, 56], above the patella [29, 62], , lateral and medial of the patella [62], at the medial joint cleft [60], at Gerdy´s tubercle [38] and at the anteriomedial aspect of the knee [85].

The localisation of spot measurements by radiometers was the lateral inferior aspect of the knee [33], the medial [40] and the lateral joint cleft [40], the lower border of the patella [40], the mid of patella [75], above the patella [55, 75], medial and lateral of the patella [75], and the lateral poplitea [75] .

Regions of interest, different in shape and size, were used for determination of knee temperature from thermal images One paper derived the mean temperature of the knee from multiple spot temperature measurements [15,] another one from line scans [22].

Pattern description of heat distribution

Salisbury defined the normal heat pattern of a joint *"as one in which there is a negative gradient from the centre to the periphery of the joint without localised areas of increased temperature. In general this gradient is in the order of 2-3°C*" [74]. The author used the relative frequency of 64 gray levels representing a temperature range of 10°C inside of a defined region of interest as measure for heat distribution. The heat distribution index (HDI)was defined as mean relative frequency ± standard de- viation. The normal pattern shows a mean of 19 ± 3.0 gray levels equal to 3.0 ± 1.0°C. Inflamed joints present with a mean of 39 ± 9 gray levels which is equivalent to 7.9 ± 2°C. However, absolute values for the HDI of normal and inflamed knees have not been reported by the author.

Devereaux et al. mentioned that in normal knees the patella acts as a heat shield visible on the anterior view, whilst on the medial view a gradual cooling from thigh and calf muscle towards the patella can be observed (21).Vujic based the "normal pattern of knees" on (a) thermal symmetry over the knees; (b) the knees were colder than the adjacent areas; (c) a narrow temperature isotherm produced a well shaped oval central prepatellar zone or, in adipose subjects a well shaped line tending from the superolateral towards the inferomedial part of the knee (89).Gabrhel (97,98) did not provide an explicit description of the temperature distribution over the knee of healthy subjects, but based his definition of "normal pattern" on a study, which he has published together with H.Tauchmannova (99) in which the temperature distribution of knees of healthy subjects have been described "as hypothermic region over the patella on the anterior view.".

Patients with patellofemoral arthralgia presented on the anterior view with an increase of heat medially beside the patella, and an increase in heat arising from the patella and radiating into the vastus medialis muscle on the medial view. (21). High temperature around the patella was also reported by Gabrhel in patients with patellofemoral osteoarthritis (97). Vuijic based the thermographic diagnosis of chondromalacia patellae on (a) themal asymmetry; (b) narrowing, irregular form or diminishing of the prepatellar zone of more than 50%; (c) isotherms spreading from the adjacent areas (except that of varicose veins) over the prepatellar zone (89).

Gabrhel described 1995 different thermal patterns in young athletes with knee pain. Local hyperthermia was related to painful tendon and ligament insertions, mostly caused by overuse. Four other patterns such as diffuse heat, warm patella, hot spots over the condyli and horseshoe-shaped hyperthemia either above or below the patella have been described, but not related to clinical symptoms (97). In recent review based on 5700 investigations, patterns of

Table 4a
Rheumatoid arthritis

Ref.	Author	Sample size	males	females	Age (mean±SD, range)	Diagnosis	objective
30	Haimovici 1982	104	?	?	?	Rheumatoid arthritis	Investigation in joint temperature
37	Horvath 1949	13	7	6	18-71	Rheumatoid arthritis	Investigation in joint temperature
37	Horvath 1949	13	7	6	18-71	Rheumatoid arthritis	Investigation in joint temperatur
60	Oosterveld 1994	39	22	19	61.9 ± 11.5	Inflammatory arthritis (33RA, 4 OA, 2 SpA)	Evaluation of cryotherapy and thermotherapy
60	Oosterveld 1994	39	22	19	61.9 ± 11.5	Inflammatory arthritis (33RA, 4 OA, 2 SpA)	Evaluation of cryotherapy and thermotherapy
56	Menard 1980	13	?	?	?	Rheumatoid arthritis	Investigation in knee joint temperature
11	Collins 1976	6	?	?	?	Rheumatoid arthritis	Evalution of NSAR therapy
12	Collins 1974	8	?	?	?	Rheumatoid arthritis	Evalution of intra-articular corticosteroids
35	Hoeft 1988	56	39	17	50 18-81	Inflammatory arthritis	Evaluation of cryotherapy
33	Hendiani 2003	28	4	24	46.9 ± 2.3	Rheumatoid arthritis	Evaluation of pain threshold in chronic arthropathies
62	Paterson 1978	9				Rheumatoid arthritis	Evalution of intra-articular corticosteroid
62	Paterson 1978	9				Rheumatoid arthritis	Evalution of intra-articular corticosteroid
68	Ring 1980	200				Osteoarthritis	Investigation in joint temperature
4	Ammer 1998	8	3	5	53.1± 17.9	Undifferentiated arthritis	Correlation WOMAC and knee temperature
14	Coughlin 1987	33	7	26	31.5 9-73	algodystrophy	Diagnosis of algodystrophy
30	Haimovici 1982	85	?	?	?	Traumatic arthritis	Investigation in joint temperature

temperature distribution have been related to the underlying diagnosis in patients with knee pain (98). **Juvenile rheumatoid arthritis** shows diffuse heat with maximum over the joint cleft. "**Growth pain**" is characterised by a cold patella and high temperature over the medial and lateral l condyli of femor or tibia, respecvtively. *Tumour growt*h :shows hot spots over the growing tumour. In patients with **hydrops or haemarthros**: high temperature over recessi, decreasing over time, may be observed. **In -flammatory arthritis** is presenting with diffuse heat with maximum over the joint cleft, hot patella, **osteoarthritis** shows also diffuse heat with maximum over the joint cleft, but the over the patella is less intensive than in inflammatory arthritis. **Sympathetically maintained pain** is characterised by low temperature over the total knee.

Mean knee temperature

Healthy subjects

The mean temperatures varied with respect to the applied measurement technique and the site of measurement. Mean intra-articular knee temperature was 32.6 ± 0.9°C (95% confidence interval: 31.5 to 33.7°C). Based on contact temperature measurements, the mean temperature of the anterior knee in healthy subjects was 30.5 ± 1.1°C. Determined with radiometers, the corresponding mean temperature was 28.7 ± 0.6°C (95% confidence interval: 27.9 to 29.5). In thermal images from healthy subjects, the mean temperature of the anterior knee was 29.5 ± 1.6°C (95% confidence interval: 28.5 to 30.5°C) and 33,1 ± 0.0 °C of the posterior knee. The side difference of temperature was 0.2 ±1°C for both the anterior and the posterior knee.

Osteoarthritis

Intra-articular temperature was 33.4 ± 2.7°C with lower values in patients with latent osteo arthritis 32.9 ±0.9°C than in patients with inflamed osteoarthritis 35.8 ± 1,5.[30]. In 38 osteoarthritis patients, contact thermometers obtained a mean anterior knee temperature of 31.3 ± 1.3°C. Measurements with an infrared radiometer found a mean temperature of 30.8°C in a small sample of 19 patients. Temperature measurements from infrared thermograms revealed a mean temperature of 30.7 ± 1.3°C (95% confidence interval: 29.4 to 32.0 °C).

Table 4b
Rheumatoid arthritis

Ref.	Measurement device	Measurement site	Acclimatisation time	Room temperature	temperature value
30	Digital thermometer Bailey BAT 8 C	Intra-articular suprapatellar pouch	60 min (?)	22 ± 1°C	35.8 ± 1.5°C
37	Thermocouple or thermistor	Intra-articular under the patella	30 min	24°C	Female 34.7 ± 0.7°C Male: 34.0 ± 0.9°C
37	Thermocouple or thermistor	Skin temperature of patella	30 min	24°C	Female: 33.4 ± 1.8°C Male: 32.8 ± 0.7 °C
60	Exacon C-F04.30 catheter temperature probe	Intra-articular lateral joint cavity	30 min	21.5 ± 0.7°C	35.6 ± 0.4°C
60	Exacon C-F04.30 catheter temperature probe	skin medial joint line	30 min	21.5 ± 0.7°C	32.3 ± 0.5°C
56	Thermometer, type TE3 (Ellab Instruments, Copenhagen), thermocouple skin applicator, type H2,	mid of patella	5 min	21-25°C	32.2 ±1.8°C
11	Bofors Scanner	Anterior knee		20°C	29.3 ± 0.8°C
12	Bofors Scanner	Anterior knee	20 min	20°C	29.8°C
35	Thermocouples	upper border of patella	?	?	31.4°C
33	Infrared thermometer Entest, Inc., Carrollton, TX	lateral inferior aspect of knee	?	?	Side-to-side diff.: 1.3 ± 0.3°C
62	Bofors	Anterior knee	15 min	20 ± 1°C	Prior to injection Side-to-side diff.: 1.2 ± 1.3°C
62	Ellab DU-3 Thermistor	Medial, lateral and superior of patella	15 min	20 ± 1°C	Prior to injection Side-to-side diff.: 2.3 ± 2.5°
68	Bofors Scanner	Anterior knee	15 min	20°C	30.2 ± 1.2°C
4	Agema 870 Scanner	Total knee Suprapatellar Infrapatellar patella	15 min	20°C	Total knee: 321.8 ±1.3 Suprapatellar: 32.5 ±1.2 Infrapatellar:32.8 ±1.3 Patella: 32.7±1.4
14	AGA 680M thermovision	Anterior and posterior knee	15 min	20°C	Side-to-side diff. ant. knee: 0.65 ± 0.1°C SEM Side-to-side diff.post. knee: 0.61 ± 0.09°SEM
30	Digital thermometer Bailey BAT 8 C	Intra-articular suprapatellar pouch	60 min (?)	22 ± 1°C	35.2 ± 1.4°C

Table 5a Arthroscopy and arthrotomy

Ref.	Author	Sample size	males	females	Age (mean±SD, range)	Diagnosis	objective
51	Martin 2001	17	13	4	39.4±16.4 18-76	meniscal tear, osteoarthritis, loose body plica, chondromalacia	Evaluation of cryotherapy after arthroscopy
95	Zaffagnini 1998	30					Evaluation of cryotherapy
26	Glenn 2004	16	8	8	27 14-49	ACL reconstruction	Evaluation of cryotherapy
73	Sánchez-Inchausti 2005	30	19	11	46.9 18-72	meniscal tear, osteoarthritis, loose body	Evaluation of cryotherapy
16	Dahlstedt 1996	8	5	3	25 (17-41)	ACL reconstruction	Evaluation of cryotherapy
49	Martin 2008	38	n.r.	n..r	n.r.	Knee arthroplasty	Postoperative pain management
71	Romano 2011	40	28	12	63.5 53-78	Knee arthroplasty	Postoperative management
55	Mehra 2005	20	13	7	73 44-85	Knee arthroplasty	Postoperative management
36	Honsawek 2011	49	40	9	67.8 ± 1.1	Knee arthroplasty	Postoperative management
54	Mayr 1995	16	2	14	72.3 ±5.1	Knee arthroplasty	Postoperative management
29	Haidar 2006	32	10	22	70 59-85	osteoarthritis	Postoperative management of arthroplasty

Table 5b Arthroscopy

Ref.	Measurement device	Measurement site	Acclimatisation time	Room temperature	temperature value
51	thermocouple probe (Model IT-18,Physitemp)	intra-articular lateral gutter of the knee.	53 to 117 min of surgery	?	At start of cooling: 25.5 ±1.4°C
95	digital thermometer Fischer Scientific	Intraarticular: intercondylar notch	?	?	At start of cooling:34.8 ± 1.0 °C
26	thermocouple probe (Model IT-18,Physitemp	Intra-articular suprapatellar pouch intra-articular lateral gutter of the knee	85to155 min of surgery	?	At start of cooling: 27.0°C
73	PT 100 (Intersa)	Intra-articular suprapatellar pouch	?	23,7±0,21 °C	32.2 ± 0.3°C
16	Thermosensors (NiCr-Ni(K)	Intra-articular suprapatellar pouch subcutaneous: above suprapatellar pouch Skin: above patella ligament	After operation (60-70 min)	?	6 hours after surgery(cooled knee) Median skin temperature: 24(20-28)°C Median subcutaneus temp.32(27-34)°C Median intra-artic..temp: 35(32-36)°C
49	Thermopoint device (Protechnique, Quebec).	Mid of patella	?	22°C	31.5 ± 0.3 (SEM)°C
71	NEC-AVIO ThermoShot F30S digital telethermocamera	Anterior knee (supine position)	?	?	1st day after surgery: 35.3±1.2°C 3rd day after surgery36.7±1.5°C 7thday after surgery 35.2±1.8°C 13th day after surgery:33.7±0.8°C
55	Genius First Temp Monitor	2 points upper border of the patella,	?	?	1 week after surgery: 35.3±1.2°C 6 weeksy after surgery36.7±1.5°C 18 weeksafter surgery 35.2±1.8°C
36	digital pocket surface thermometers	superomedial, superolateral, inferomedial, inferolateral border of the patella	?	?	Operated knee after 2 weeks: 36.3 ± 0.3 after 6 weeks: 36.0 ± 0.8 after 14 weeks_35.8 ± 1,2 after 26 weeks: 34.3 ± 1.7
54	NEC Thermotracer	Patella suprapatellar infrapatellar	15 min	20	Operated knee, patella After 2 weeks: 31.8 ± 1.1°C after 8 weeks: 30.3 ±1,5 after 16 weeks: 29.6 ±1.3
29	digital pocket surface thermometers (PT-100C, Sealed Unit Parts Co. Inc,)	Superomedial to the patella			Prior to surgery: 30.4°C 7 days after surgery:34.0°C 6 weks after surgery: 32.0°C

Table 6a
Pattern description

Ref.	Author	Sample size	males	females	Age (mean±SD, range)	Diagnosis	objective
74	Salisbury 1983	368	30	30	41.5 13-79	Healthy subjects	Investigation in joint temperature
74	Salisbury 1983	322	35	50	46.65 15-75	Inflammatory arthriis (82RA, 2 SpA, 1 Behcet)	Investigation in joint temperature
19	De Silva 1986	20	7	13	55.6 26-79	Rheumatoid arthritis	Assessment of inflammation
20	Deveraux 1986	30	18	12	23.3 11.61	patellofemoral pain	Thermography of patellofemoral pain
89	Vujcic 1891	157	62	95	15-59	Chondromalacia patellae	Thermography of patellofemoral pain
97	Gabrhel 1995	137	96	41	14.4 12-17	Young athletes with knee pain; healthy controls	Thermography of knee pain
98	Gabrhel 2012	~5000	?	?	6(?)-80(?)	Growth pain knee injuries osteoarthritis, rheumatoid arthritis tumour, bursitis Sympathetically maintained pain	Assisting diagnosis in combination with ultrasound imaging

Table 6b
Pattern description

Ref.	Measurement device	Measurement site	Acclimatisation time	Room temperature	temperature value
74	AGA Thermovision 680 medical system	Lateral knee, 90° flexed	15 min	20 ± 0.5° C	Heat distribution index (HDI) Values not reported
74	AGA Thermovision 680 medical system	Lateral knee, 90° flexed	15 min	20 ± 0.5° C	Heat distribution index (HDI) Values not reported
19	AGA Thermovision 680 medical system	Lateral knee, 90° flexed	15 min	20 ± 0.5° C	Heat distribution index (HDI) mean: 1.254 ±0.361
21	AGA Thermovision 680 medical system	Anterior and lateral knee, 90°flexed	15 min	20°C	Diffuse heat in osteoarthritis and rheumatoid arthrits: Patelofemoral pain: Increased heat medially beside the patella (anterior view) Heat arising from the patella and radiatingi nto the vastus medialis muscle (medial view)
89	AGA thermovision 780 medical system	Anterior and posterior view	15 min	18-20°C	Chondomalacia patella: narrowing, irregular form or diminishing of the prepatellar zone of more than 50%; and isotherms spreading from the adjacent areas over the prepatellar zone
97	AGA thermovision 780 medical system	Anterior and posterior knee in full extension	15 min	23±1°C	Painful tendon insertions: local hyperthermia Inflammation: diffuse heat, warm patella Other patterns: hot spots over the condyli Horseshoe-shaped hyperthemia above or below the patella
98	AGA 780, Raytek Ti30 Fluke Ti32 Fluke Ti32	Anterior and posterior knee in full extension Medial and lateral knee 90° flexed	15 min	23±1°C	Juvenile rheumatoid arthritis: diffuse heat with maximum over the joint cleft "Growth pain". Cold patella, high temperature over the medial and lateral l condyli of femor or tibia respecvtively Tumour growth: hot spots over the growing tumour Hydrops or haemarthros: high temperature over recessi, decreasing over time Inflammatory arthritis:diffuse heat with maximum over the joint cleft, hot patella Osteoarthritis: diffuse heat with maximum over the joint cleft, warm patella Sympathetically maintained pain: low temperature over the total knee

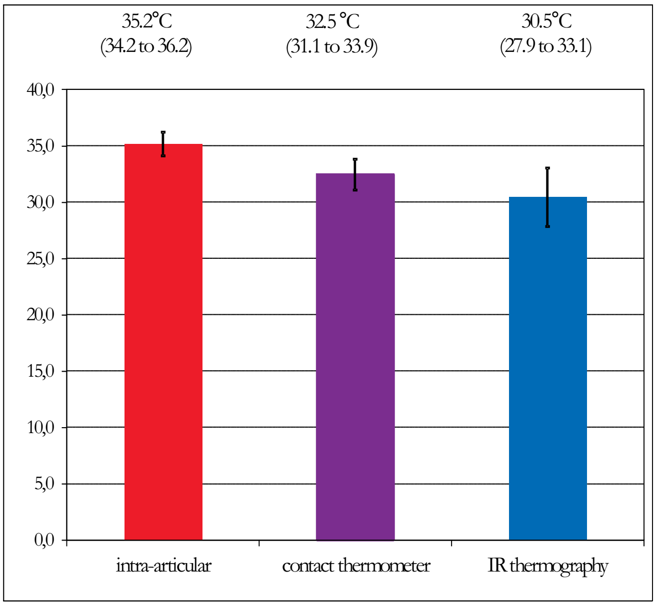

Figure 2
Inflammatory arthritis: mean anterior and intra-articular knee temperatures ± 95% confidence interval
Intra-articular measurements: n=293 (including 85 traumatic arthritis plus 78 inflamed osteoarthritis,
contact thermometry: n=95
Infrared thermography: n=222

Inflammatory arthritis

Measurements from 110 patients with rheumatoid arthritis, 85 patients with traumatic arthritis and 78 subjects suffering from inflamed osteoarthritis were cumulated for the mean intra-articular temperature of inflammatory arthritis (figure 2). Contact thermometry obtained 2 degrees higher surface temperatures than infrared thermography.

Knee temperatures during and after knee surgery

Intra-articular temperature measured during knee surgery showed a wide range of variation: 29.9 ± 4.4 (mean ± standard deviation) 95% confidence interval: 22.0 to 36.8). After surgery, the side difference between the operated and the non operated knee was less than 0.5 degrees after 9 weeks [45], 90 days [71], 18 weeks [55], 10 months [54] or 12 months [29]. A normal side temperature difference was not achieved 26 weeks after surgery in one study [36].

Discussion

This is the first attempt to cumulate temperature measurements from the human knee performed at different sites, with different equipment, in healthy subjects and in patients with various knee disorders.

Highest intra-articular temperatures were observed in rheumatoid inflammation of the knee, while the mean temperature of healthy knees differed from osteoarthritic knees only by 0.8°C. The lowest temperature values were reported during arthrotomy, which might be caused by the environtmental temperature in the operation room and due to cleansing procedures during surgery.

Irrespectivly whether healthy or diseased subjects have been investigated, higher surface temperatures were recorded with contact measurements than by single spot measurements with a radiometer or an infrared thermographic camera. The difference between intra-articular temperature and the surface temperature obtained by contact is approximately 2 degrees in healthy subjects and patients with osteoarthritis, but 2.7 degrees in inflammatory arthritis. In the latter disease, the difference between intra-articular and thermographiocally obtained surface temperature may be as much as 5 degrees.

This paper has also some limitations. Firstly, the data search might have been incomplete. Not accessed papers and papers in published in other languages than English and German might have provided important temperature data. Secondly, pooling of temperatures was performed with disregard to the environmental conditions and acclimatisation times. However due to small samples, data cumulation without neglecting these conditions would not have been possible. The same argument must be used for pooling mean temperature values from differently shaped and sized measurement areas. Finally, comparison of surface temperatures, obtained by contact or radiometric thermometry, with intra-articular temperatures across different samples of patients, provide only a rough estimation of the relationship between intra-articular and surface temperatures or between contact and radiometric temperature measurements, respectively. An accurate assessment of the relationship of temperatures in different layers of knee tissue can only performed when the various measurement methods are applied in parallel within one sample of investigated knee joints.

In conclusion, knee temperatures vary with respect to the method of temperature determination and between different health conditions of the knee joint. A temperature gradient from the joint cavity to the knee surface in the magnitude of 2 to 3(5)°C is supported by this analysis. The mean surface temperature of the knee describes the condition of the knee incompletely and should be supplemented with a description of the temperature distribution

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Cold provocation improves breast cancer detection with IR thermography- A pilot study

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SUMMARY

BACKGROUND: Previous studies applying infrared thermography for breast cancer detection have shown promising results.We assumed that the reaction for cold provocation differs in healthy and cancerous tissue. In this study we used cold provocation and movement correction in order to enhance the result.

MATERIALS AND METHODS: The cancer patients for the study are from a preliminary investigation made in Tampere University hospital. Three out of nine patients examined were suitable for this study. We used a microbolometric uncooled camera IRvox384 thermal camera developed at Technical University of Lodz for medical applications. We cooled the breasts for 15 seconds and then a sequence of 300 images was recorded with the frame rate of 2 frames per second. The total recording time was 150 s.

RESULTS: We found higher time constant over cancerous areas than over healthy tissues. It means that the reaction of affected tissuefis slower after thermal excitation . The temperature recovery to baseline readings takes a longer time over cancerous tissue than in normal, unaffected tissue.

CONCLUSIONS: These unexpected findings of high time constants must be confirmed in a larger sample of breast cancer patients. We also need to establish standard procedures for the imaging sessions so that the results could be repeated as precisely as possible.

KEY WORDS: breast cancer detection, thermal excitation, cold provocation

KÄLTEPROVOKATION VERBESSERT DIE ENTDECKUNG VON BRUSTKREBS MITTELS INFRAROT-THERMOGRAPHIE- EINE PILOTSTUDIE

HINTERGRUND: Frühere Studien zur Brustkrebserkennung mittels Infrarotthermographie haben vielversprechende Ergebnisse geliefert. Wir postulieren, dass die Reaktion auf eine Kälteprovokation an gesunden und karzinomatösen Gewebe unterschiedlich ist. In dieser Studie wurden Kälteprovokation und eine Bewegungskorrektur eingesetzt, um die Ergebnisse zu verbessern.

MATERIALS AND METHODS: Die Krebspatienten stammen aus einer vorläufigen Untersuchung, die im Universitätsspital in Tampere durchgeführt worden war. Drei von neun Patienten waren für diese Pilotstudie geeignet, Wir verwendeten eine ungekühlte mikrobolometrische Infrarot-Kamera IRvox384 , die an der Technischen Universität Lodz für medizischen Anwendungen entwickelt worden waren. Nach 15 Sekunden langer Kühlung wurde eine Serie von 300 Bildern wurde bei Bildrate von 2 Bildern pro Sekunde aufgezeichnet. Die Aufzeichnungsdauer betrug 150 Sekunden.

RESULTS: Höhere Zeitkonstanten wurden über karzinomatösen Gewebe als über gesunden Gewebe gefunden. Das heißt, dass die Reaktion des erkrankten Gewebes auf thermische Reize verlangsamt ist und deshalb die Erreichung der Ausgangstemperatur länger braucht.

SCHLUSSFOLGERUNG: Diese unerwarteten Ergebnisse langer Zeitkonstanten bedarf einer Bestätigung in einer größeren Gruppe von Patientinnen mit Brustkrebs. Außerdem müssen Standards für die Aufzeichnung der Wärmebilder entwickelt und eingehalten werden, um die Ergebnisse mit bestmöglicher Präzision wiederholen zu können.

SCHLÜSSELWÖRTER: Brustkrebserkennung, thermische Reizung, Kälteprovokation

Thermology International 2012, 22(4) 152- 156

Introduction

Breast cancer is the most common cancer among women nowadays [1]. It's very important to diagnose the cancer in an early stage, as e the chance of being cured is 96.3% for tumours less than 2 cm diameter and absent affection of lymph nodes, but the 5 years survival rate decreases to 82,2% in tumours with 2 to 4.9 cm diameter and uninvolved lymph nodes.[2]. Very often early detection is not possible using traditional methods such as mammography, magnetic resonance imaging (MRI) or ultrasonography (USG) [3]. Some of these investigations require ionizing radiation or contrast media and must not be repeated frequently, figure 1.

Screening for breast cancer is primarily based on mammography and secondarily on magnetic resonance imaging (MRI) and medical ultrasonography (USG). The advantage of using mammography is its high specificity is (up to 99,5 %) and disadvantages are that it requires radiation, it is uncomfortable to the patient due to the compression of the breasts, and the fact that the density of the breast tissue affects the sensitivity. MRI has good sensitivity (up to

100 %) and specificity (up to 95 %), but it is expensive, it is time consuming, and requires the application of contrast medium. USG generates a lot of false positive results, but shows good specificity in dense breast tissue. [4]

Due to the non-invasive and, harmless nature of infrared thermography IRT, many trials have been performed to detect and evaluate breast cancer with infrared cameras.A recent study used an artificial intelligence programme to evaluate infrared images for the detection of breast cancer in small sample of 106 women who underwent biopsy with 65 malignant and 41 benign findings. IR resulted in an overall diagnostic sensitivity for breast cancer of 70% and a specificity of 48%., but in small subgroup 21 women under the age of 50 with 9 cancers in total the diagnostic sensitivity increased to 78% and specificity to 75 % [5].

The rationale to detect cancer with IR imaging is based on the fact that metabolic activities of healthy and cancerous tissue differ from each other. Cancer cells exhibit an increased capacity for lactate production as the result of aerobic glycolysis, whilst normal, healthy cells depend on oxidative phosphorylation to synthesize ATP [6]. Very simplified, this results in the fact that tumour cells need mor glucose but less oxygen than healthy subjects. One limiting factor of tumour growth is perfusion, therefore the tumour may stimulate vasculogenesis. The differences in distribution of perfusion are visible in thermography. [1]

Most of the previous studies are based on asymmetric distribution of thermal or texture features (signatures) obtained from infrared images [7-10]. Typically, healthy women have a symmetrical temperature distribution on both breasts, figure 2, [11, 12].

During thermographic measurements it is very important to keep the same environmental conditions. Duration of preparation of subjects being investigated, environmental conditions such as a defined and stable room temperature, body positions during image recording and the field of view of the body part of interest must be standardised. [13-16].

In most cases, the static distribution of temperatures on the breast surface is recorded, and typically cancerous tissue presents with spots of high temperature as shown in figure 3 [17]. Reliable measurements of absolute skin temperature are difficult to perform, because the skin temperature depends on many different factors.

This was the main argument to investigate dynamic changes of temperatures after cooling the skin instead of measuring the absolute tempertures .over cancerous and healthy breast tissue .

Materials And Methods

It is assumed that cancerous tissue has different thermal time constants than unaffected, healthy tissue. The breast cancer had been defined with mammography and/or ultrasound, and biopsy before IR-imaging. The breast cancer was localized from mammography images

The skin of the breast of the patients was cooled for about 15 seconds using a 5mm thick cooling gel pad., which has been stored in a refrigerator for an hour at 4°C. The cooling pad was set directly on the skin covering both breasts, and was removed before IR imaging. Both breasts were cooled to compare the recovery time after cooling.. Measurements were performed for the entire breasts, but motion correction was applied to the selected regions of interest (ROIs.) [18,19]

We measured over time the temperature difference to the baseline temperature recorded immediately after removing the gel, and we plotted recovery curves. Exemplary ima ges from a set of a few hundred recorded for each patient, are presented in figure. 4. A small square region of interest with 16 pixels was defined, fig.ure 3 [20, 21].A sequence of 300 images was recorded at a frame rate of 2 frames per second. The total recording time was 150 s.

The approximation using the exponential function was the next step of the data processing. An example of approximation is presented in figure. 5.

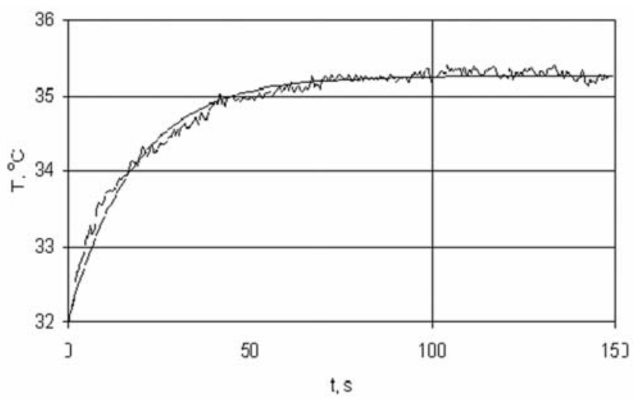

Figure 5.
Approximation of measured temperature recovery curve with exponential function

We assume the single thermal time constant model of the skin. It denotes that the temperature evolution is time can be expressed by the equation (1).

$$T = T_s\left(1 - e^{\frac{\tau}{x}}\right) \quad (1)$$

where Ts is the temperature after full recovery and is the thermal time constant describing the thermal inertia.

The preliminary investigations have been performed as the result of scientific cooperation of Finnish and Polish Technical Universities in Tampere and Lodz. Measurements have been made in Tampere University Hospital using microbolometric uncooled camera IRVox384 thermal camera developed at Technical University of Lodz for medical applications.

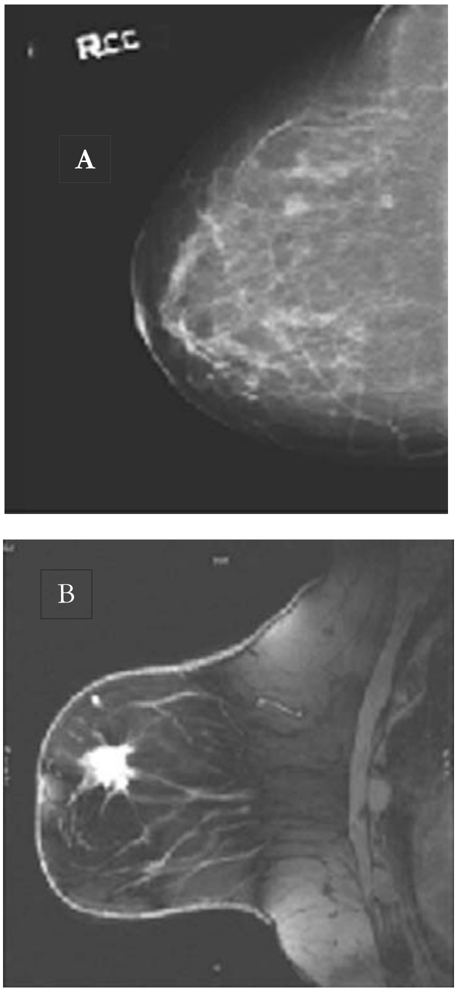

Figure 1
Imaging of breast cancers using mammography (A) and MRI (B)

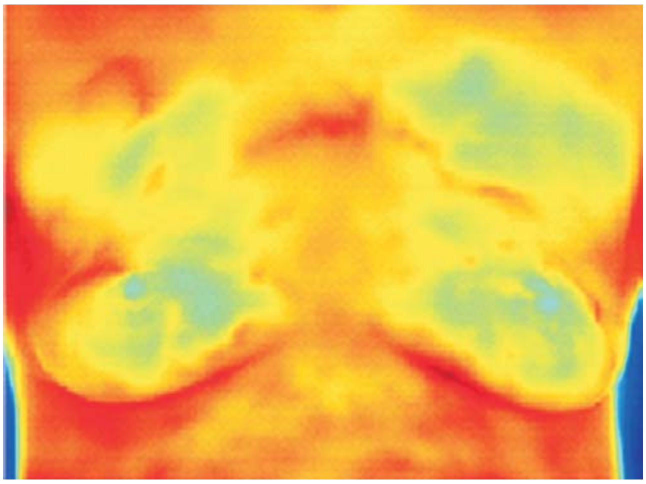

Figure 2
Breast Thermal Image of an healthy woman

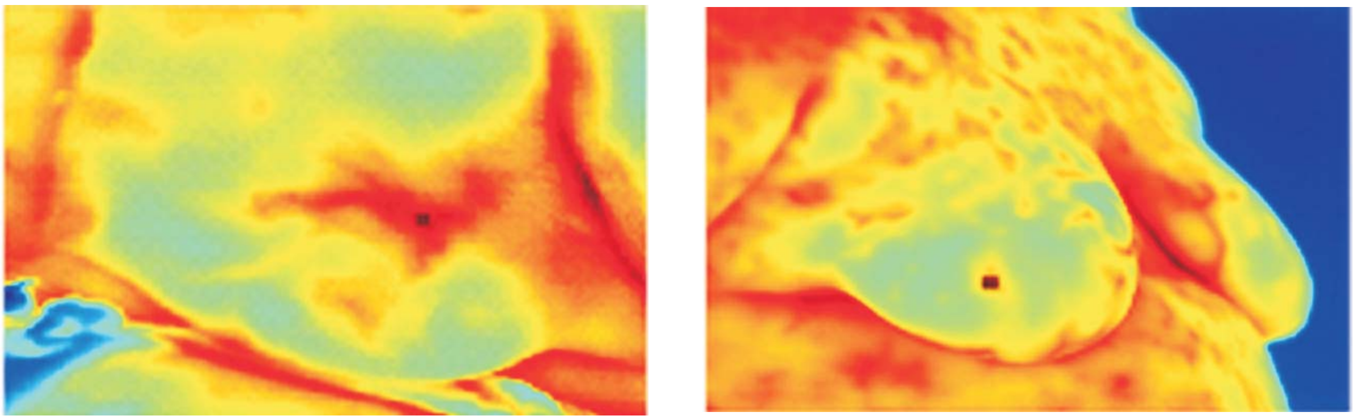

Figure 3.
Breast cancer thermal images, the cancer locatioon position is marked (■)

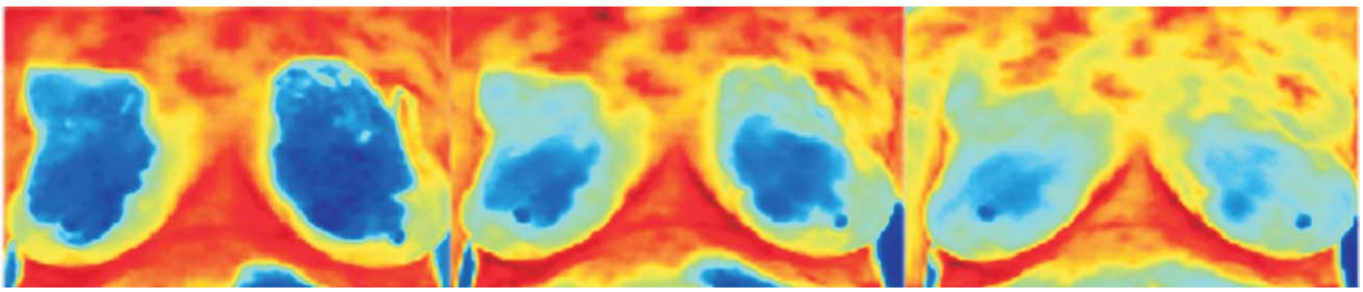

Figure 4.
Breast cancer thermal images, frames no. 1, 32 and 300, sampling rate 0.5 s, total recording time 150 s.

Table 1. Characteristics of the tumors

Patient	Tumor type	Tumor size (pathology)	Grade
B5	Ductal	8 mm	1
B6	Ductal	14 mm	2
B7	Lobular	20 + 10 mm	2

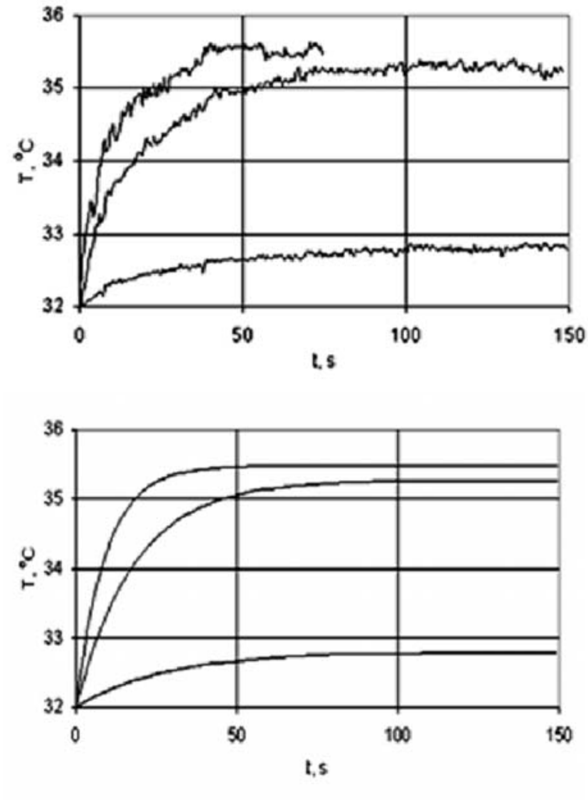

Figure 7.
Temperature evolution for breast cancer tissue after cold

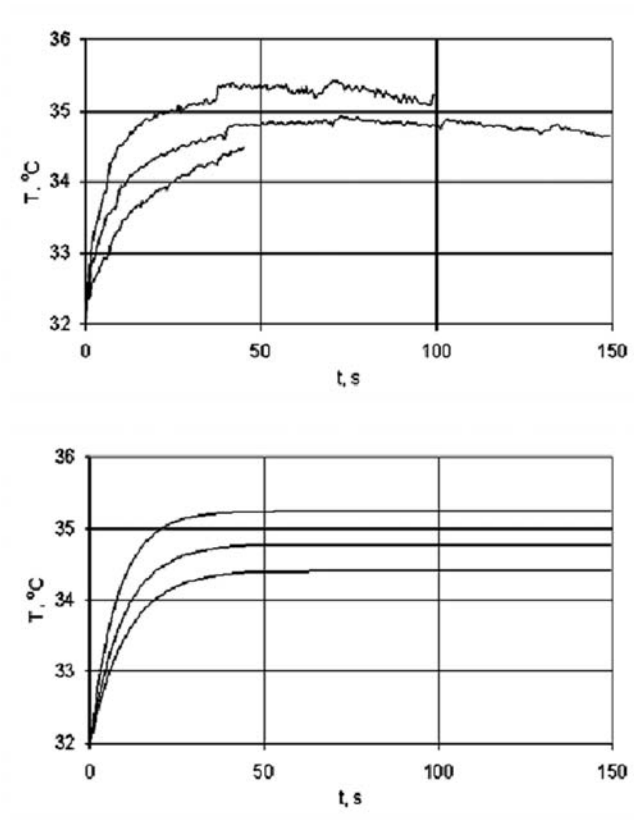

Figure 8.
Temperature evolution for healthy tissue after cold

Table 2.
Single thermal time constant model parameters for 3 cases of breast cancer

Case	Ts, °C	t, s
B5	35,5	9,2
B6	35,3	18,1
B7	32,8	27,5

Table 3.
Single thermal time constant model parameters for 3 cases of healthy tissue

Case	Ts, °C	τ, s
B5	35,2	7,9
B6	34,8	9,4
B7	34,4	10,5

Results

During the investigation 9 cases of breast cancer were examined. Only 3 of them are reported in this work. The main characteristics of the patients' tumours are summarized in table 1 .

The temperature evolution after cold provocation in breast cancer is shown in the diagrams of figure 7. Figure 8 presents the corresponding rewarming curves of healthy tissue. Table 2 lists the parameters of thermal time constants of breast cancer patients, table 3 those constants of healthy tissue.

Discussion

It is obvious, that the value of time constant is higher in cancerous cases. It means that the reaction of unhealthy tissue for thermal excitation is slower. and temperature recovery takes a longer period of time. Infrared radiation from the human skin is closely related to the width of superficial vessels. Dilatation of these vessels leads to higher blood flow, a bigger area for heat dissipation and therefore to higher temperature on the skin surface. However in the current study, the blood vessels induced by tumour growth react to a cold challenge similarly as patients suffering from Raynaud´s phenomenon who are thermographically characterised by prolonged temperature recovery after cold exposure [22]. This finding is in contrast to the behaviour of other tumours such as malignant melanoma after applying a cold challenge. Di Carlo [23] and recently Santa Cruz et al [24] and Herman & Pirtini Cetingu [25]reported quick recovery of the surface temperature of melanomas after a short period of cooling.

Our preliminary results of rewarming patterns of cancerous breast tissue must be confirmed in a greater sample of patients with diagnosed cancers. Temperature measurements should be done very precisely taking into account environmental condition and other standard procedures in order to repeat the measurement correctly.

Next step in our investigation is to extract parameters from the thermal model of human tissue which will suit to the experimental results. Then we will be able to do classification for healthy and unhealthy cases in automatic and quantified way.

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A Method For Whole-Body Skin Temperature Mapping In Humans

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SUMMARY

The described method provides a novel way to quantitatively and qualitatively report thermographic assessments of different humans. It combines a segmentation of defined body regions as well as a morphing technique in order to produce skin temperature body maps regardless of anthropometry and body position. This mapping method can be suitable for the creation of a skin temperature database of healthy individuals in various situations and environments.

KEY WORDS: Segmentation, temperature mapping, database

EINE METHODE ZUR AUFZEICHNUNG DER HAUTEMPERATUR DES GESAMTEN MENSCHLICHEN KÖRPERS

Die beschriebene Methode bietet eine neuartig quantitative und qualitative Bewertungt thermographischer Befunde von unterschiedlichen Personen. Es kombiniert eine Segmentierung der definierten Körperregionen mit einer Morphing-Technik zur Herstellung Hauttemperatur-Karten, die unabhängig der Anthropometrie und Körperposition sind. Diese Kartenerstellung eignet sich für die Schaffung einet Hauttemperatur-Datenbank gesunder Personen in verschiedenen Situationen und Umgebungen.

SCHLÜSSELWÖRTER: Segmentierung, Temperatur-Kartenerstellung, Datenbank

Introduction

Infrared thermography is a powerful tool with the great potential of mapping the skin over large areas of the human body. Large body views are beneficial for many fields of research. In the field of sport, thermographic studies often report their quantitative findings by regions of interest (ROI) arbitrarily obscuring the natural variation of skin temperature. Furthermore, they usually display a single thermogram only, questioning its representativeness for several participants. A processing technique enabling the joint analysis of several thermograms can take advantage of the thermographic mapping potential by providing population-average whole-body maps of skin temperature. The purpose of the described method is therefore to obtain human maps representing the average values of a large population.

Challenges

Inter-individual variability in body dimensions and intra-individual variability in body position during repeated infrared measurements correspond to the two main challenges when several thermograms must be aligned for mapping. The proposed method aims at overcoming the above issues using a specific image processing technique inspired by the work on human hands [1] and applied to the whole human body.

Procedure

The image processing method was entirely custom made under MATLAB. It combines a standardised segmentation with 51 ROI (based on superficial muscles) and a morphing procedure required to average several thermograms.

A) Participant is standing in an anatomical position following the body views 1 and 2 of the Glamorgan protocol [2] in a controlled environment.

B) Each thermogram is processed using image registration using 133 control points (CP) over the whole body. An automatic mask of CP from the reference image is positioned over the input image. CP are then manually adjusted to the defined anatomical landmarks.

C) CP coordinates are used for image morphing using a 3rd order polynomial algorithm transformation. This morphing is performed adequately to a reference body shape, defined *a priori* as the participant with the population median values (height, weight, body fat). Anthropometrical characteristics are standardised without losing the spatial information of the original thermogram. Selected morphed thermograms of a population can then be averaged to create various whole-body maps.

Outcomes and Application

Quantitative results (mean, min, max, median, standard deviation) are obtained for 51 ROI. Quantitative results (skin temperature distribution) can also be visually observed via the population-average *absolute* whole-body map of skin temperature (Figure 1A). Averaging pixels over the entire body gives a true estimation of the mean skin temperature

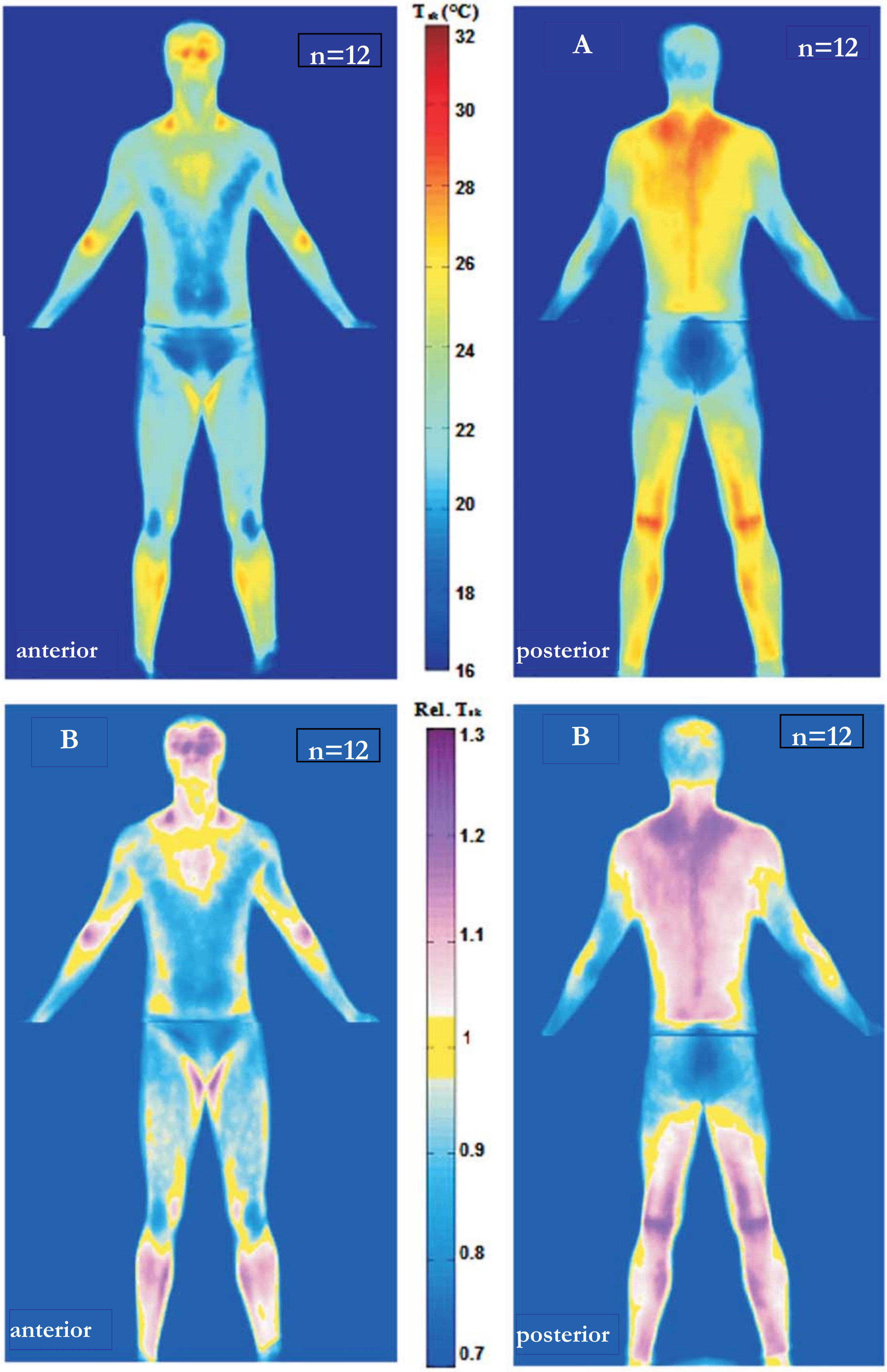

Figure 1
Population average absolute (A) and relative (B) whole-body maps of skin temperature after 40 minutes of running at 70% in a 10°C environment for a group of healthy males after morphing individual images of 12 participants onto a reference body shape. Relative body maps are obtained by dividing the absolute body map by the group mean skin temperature at this specific stage. A value of 1 corresponds to the group mean skin temperature.

for the group. This body mean skin temperature is then used to obtain a population-average *relative* whole-body map of skin temperature (Figure 1B). Our first results highlight the importance of exercise-specific active muscles (calves, hamstrings) as well as the exercise-induced vasomotor changes in a cold environment in line with therm ographic data during exercise [3]. A dynamic interplay between heat production, heat transport to the surface and heat loss to the environment necessarily contributes to the distribution of skin temperature.

Conclusions

The standardised method offers a unique approach with a limited number of body views [2] providing a whole-body representation of skin temperature, particularly applicable to exercising protocols. A normal database can be obtained in order to compare spatial and temporal variations of skin temperature between various exercise types, intensities and various populations (age, gender, body fat, fitness level). In thermal physiology, the detailed knowledge of regional skin temperature distribution may bring new insights in the autonomic and behavioural processes involved in human thermoregulation. This knowledge can be used for thermal manikin design and physiological modelling similarly to recent advances in body mapping of sweat production [4]. Improvements in the CP selection will be interesting in order to apply the method to a wider range of fields such as sports medicine, medical research or other applications.

Acknowledgments

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The paper received the "Kurt Ammer" prize at the XII European Association of Thermology Congress in Porto (2012).

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Report on the General Assembly of the European Association of Thermology on September 5, 2012 at the Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal from 17.00 to 19.00

James B. Mercer, Kevin Howell, Kurt Ammer

European Association of Thermology, Vienna, Austria

The president opened the General Assembly of the European Association of Thermology on 17.00 hours. As only 12 of 36 members with voting rights were present, the opening of the General Assembly was postponed to 17.30.

At the re-opening at 17.30 17 members with voting rights were present. Those were delegates from the Austrian Society of Thermology, the Polish Society of Thermology, the Romanian Society of Thermology, the Hungarian So- ciety of Thermology and the UK Thermography Association (Thermology Group). According to the number of members in these societies the Polish Society of Thermology held 4 voting rights, the Austrian Society of Thermology 2 voting rights, and the Romanian Society of Thermology, the Hungarian Society of Thermology and UK Thermography Association (Thermology Group) each had 1 voting right. A written proxy for transfering his voting right to Prof. Ammer was given by Dr Gabrhel .

The agenda included: Report of the president, statement of the auditors, change of statutes, honorary membership, setting membership fee, election of a new board and any other business.

President´s Report EAT 2009-2012

The president Professor James Mercer reported that several national conferences in Zakopane, Vienna, and Teddington and a short instructional course on medical thermography in Leiria, Portugal, had attracted new people who were interested in thermal imaging and other applications of heat energy in medicine and biology. A loose cooperation had been initiated with the Brazilian Association of Thermology to promote standards for thermal images which were discussed at two symposia in Brazil in 2010 and 2011. EAT board members were continuously involved in conduction and examination of PhD students based on thermology. This had resulted in new PhD awards in Norway, the United Kingdom and Portugal. The EAT webpage, which is maintained by Prof. Mercer, attracted ever higher numbers of visitors, although the numbers had plateaued recently. The president regretted that the German Society for Thermography and Regulation Medicine had cancelled their membership in the EAT in October 2011. Finally the president expressed his thanks to the EAT board members and to Dr. Vardasca and Prof Gabriel who had been responsible for organizing the 12th European Congress of Thermology in Porto.

Report of the General Secretary/Treasurer

Currently the EAT has 6 ordinary members with the status of a thermological association located in a European country These associations are active in Italy, Austria, Poland, Romania, Hungary and the United Kingdom. There are also 26 individual ordinary members from 13 European countries in the EAT and 3 extraordinary members.

The current balance of the EAT account was 573.35 Euro at the date of the General Assembly. Inclusion of not paid membership fees of 1480 Euro, would increase the balance of the EAT accounts to 2053.53 Euro. In the meantime 500 Euro of the missing fees have been paid.

The main expenses of the EAT are still the production costs of the journal Thermology International, which are covered to a proportion of 25% by the EAT. In order to reduce further costs, the journal will change from a print version to a fully internet-based electronic publication. Therefore this issue, number 4 of volume 2012, will be the last printed issue of Thermology International. From 2013 the journal will only be available from the website of the journal at .**http://www.uhlen.at/thermology-international/index.html**. Access to the journal will only be possible after the EAT membership fee or the subscription rate have been paid. A pay-per-view service for current and back issues of the journal, also a facility for online subscription, both based on PayPal will become available.

Change of statutes

The next point of the agenda was the discussion and decision on the proposed change of statutes, which was announced in full detail in the invitation letter to the General Assembly. The General Assembly agreed unanimously without abstentions to the proposed changes of the statutes. The new text is as follows:

§ 7 Right and Duties of Members

7.3. Honorary members pay no membership fees. Ordinary members with the status of an association of thermology pay one membership fee.

7.4. All ordinary members have an active voting right. Ordinary and extraordinary members with the status of an association of thermology located in a European country or country outside of Europe have also only one voting right which is administered by a designated delegate of the member association.

§ 9 The General Assembly

9.6 All members have the right to attend General Assemblies. Only ordinary and honorary members have voting rights. Every member has one vote. Legal persons are represented by a person with procura. Ordinary members with the status of a thermological association located in a European country have also only one vote. Voting rights may be transferred to another member by means of a written proxy. No member present may represent more than 5 of such proxy votes.

§ 11 The Board

11.1 The board is created from 6 members the President, Vice Presidents, Secretary, Treasurer and 2 other board member

13 Tasks of the Members of the Board

13.1 The President is the Association's representative. Written statements of the Association are only valid with the President's signature, in financial matters the signature of the treasurer. Legal relationships between members of the Board and the financial auditors have to be approved by the General Assembly.

13.2 Legal proxies to represent the Association in external affairs and signature rights may be given only by the officers mentioned in 13.1.

13.3 In emergency situations the president is entitled to act alone in matters usually confined to the General Assembly or the Board; these actions must be endorsed by the respective organ of the Association retrospectively.

13.4 The President presides over both the General Assembly and the Board.

13.5 The Secretary supports the president in leading the Association. The Secretary keeps the minutes of the meetings of the General Assembly and the Board.

13.6 The Treasurer is responsible for the financial matters of the Association.

§ 14 will be deleted

The following paragraphs will be renumbered

15 to 14 . The Financial Auditors

16 to15. The Arbitration Council

17 to 16. Termination of the Association

Honorary membership

Prof Mercer proposed to the General Assembly to award Prof Francis Ring and Prof Kurt Ammer with honorary membership in the EAT. The proposals were accepted by the General Assembly unanimously, with one abstention.

Setting membership fee

The membership fee was proposed to be 50 Euro. The General Assembly agreed unanimously to this proposal.

Statement of the auditors,

The auditors Dr. Zuber and Dr Vardasca, who were nominated instead of the absent Dr Plassmann due to a recently onset health problem, confirmed a careful and correct management of the finances. Dr Vardasca asked the General Assembly to accept the finance report and to relieve the board members from their responsibilities. The General Assembly agreed unanimously, with three abstentions..

Election of a new board

Prior to the General Assembly the following nominations had arrived within the time limit set by the EAT

President: Prof James B. Mercer PhD, Norway

Vice President: Prof Anna Jung MD, PhD, Poland

Secretary: Kevin Howell PhD, United Kingdom

Treasurer: Prof Kurt Ammer MD, PhD, Austria

Members: Prof Manuel Sillero Quintana PhD, Spain
Ricardo Vardasca PhD, Portugal

The majority of the General Assembly agreed with the nominations and the new board built of President, Vice President, Secretary, Treasurer and two members were elected unanimously by the General Assembly.

Prof Adriana Nica MD, PhD and Aderito Seixas MSc. were proposed for the function of auditors and the General Assembly agreed unanimously with this proposal. The newly elected board and the auditors graciously accepted their positions and promised to fulfill their duties to the best of their abilities.

Any other business

The frequency and time interval of the European Congress of Thermology were the topics of the closing discussion.

Prof Mercer closed the General Assembly at 19.00.

12th European Congress of Thermology in Porto 2012

The 12th European Congress of Thermology was remarkable event with respect to scientific merrit and in attracting new people interested in thermology. The pre-conference course on medical thermography assembled participants and lecturers from 7 countries (Spain, Portugal, Poland, Turkey, Norway, England, Austria).

The audience of the main conference was composed of attendents from 14 European countries (Denmark, Sweden, Norway, Poland, Hungary, Romania,Turkey, Austria, Italy, Portugal, Spain, United Kingdom, France, Ireland). Three former presidents of the American Academy of Thermology and the previous president of the Japanese Association of Thermology participated in the congress. Authors originating from Japan, Brazil , Canada and USA presented. papers.

The topics of the conference covered a wide range of applications. Thermal physiology, surgery, rehabiliation medicine, dermatology, urology, occupational medicine, sports medicine and psychology were discussed. Standards for image recording and archiving and application of thermal imaging in veterianry medicine and in viticulture were topics outside of human medicine

Prizes

Three prizes, one for the best overall oral presentation:, one best student oral presentation and best poster presentation were established. The winners received their prize during the congress dinner on Friday.

Best Overall Oral Presentation

"Mother and Child inSynchrony: Thermal Facial Imprints of Autonomic Contagion",
Professor Arcangelo Merla (U. Chieti-Pescara, ITALY)

Best Student Oral Presentation (Francis Ring prize)

"The Highly Focalized Thermotherapy in the Treatment of Solid Tumours: Temperature Monitoring Using Thermography",
Ana Portela (U. Porto, PORTUGAL)

Best Poster Presentation (Kurt Ammer prize)

“A Method for Whole-Body Human Skin Temperature Mapping",
Damien Fournet (U. Lougborough, UK)

Professor Gabriel and Dr. Ricardo Vardasca (Portugal) present a prize to Professor Merla (Italy) at the Congress Dinner

Meetings

October 27, 2012,
American Academy of Thermology Meeting in Greenville, South Carolina

Pre Meeting Certification Course:
Friday, October 26th, 2012

Take the next step toward AAT Membership status elevation! Take an AAT Certification Course

1:30pm - 7:30pm
Neuromusculoskeletal Emphasis On CRPS/RSD & Fibromyalgia

General Sessions:
Saturday, October 27, 2012

8am: Registration

8:30: Welcoming Remarks

8:45-10:30 Session 1:
Basic Science,
Clinical Conditions,
Skin Temperature Regulation,
AAT Guidelines & Indications

10:30-10:45 Break

10:45-12:00pm Session 2: Medical Thermal Imaging: Its Role in Objective Measurement and Treatment Planning

12:00pm-1:30pm Lunch (on your own, around town)

1:30pm-3:30pm Session 3: Vasomotor Monitoring, Neurovascular Considerations, Pitfalls and Look Alikes

3:30- 3:45 Break

3:45-5:00pm Session 4: Infrared Thermal Imaging Case Presentations and Paper Presentations

5:00-5:30pm Honor Ceremony for Past Presidents

6:30-7:30pm Meet and Mingle with the Leadership

AAT Committte Meetings:
Sunday, Ocotber 28th, 2012

8:30-10:00am AAT Board Meeting (Board Members only)

10:00-12:00pm AAT Committee Meetings:

Breast Guidelines

Complementary Alternative Medicine (CAM) and Allied Health

Devices and Equipment

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Membership

Past Presidents (Past Presidents only)

Website: aathermology.org

2013

March15th-17th,2013
17thNationalCongress of the PolishAssociation of Thermology in Zakopane

Abstract deadline: February 15th, 2013

Deadline for hotel reservation:March1st,2013

Registrationfee: 200.-Euro

Local organizing committee

Prof. Anna Jung (Chair)
Dr Janusz Zuber (DeputyChair)
Dr BoleslawKalicki
Mgr Ing.Piotr Murawski

Further information

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18th International Conference on Thermal Engineering and Thermogrammetry (THERMO)
Budapest University of Technology and Economics

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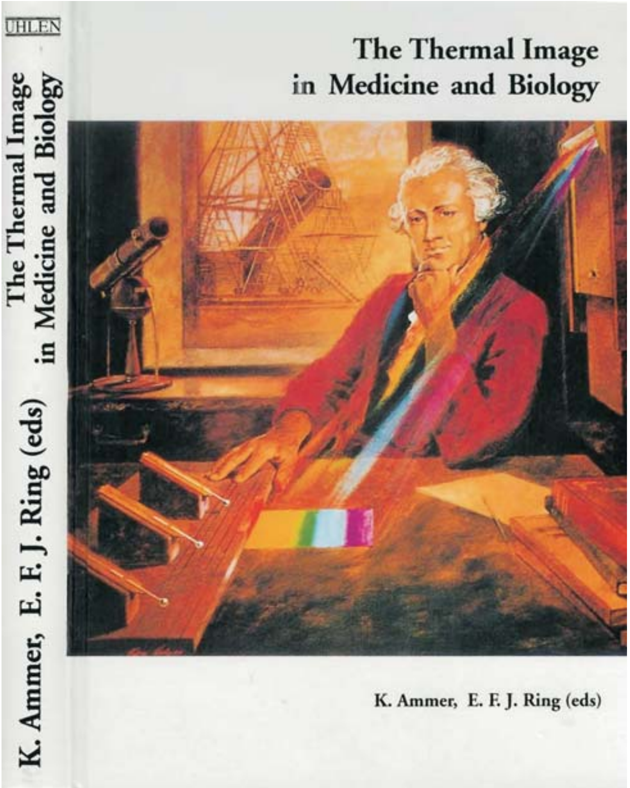

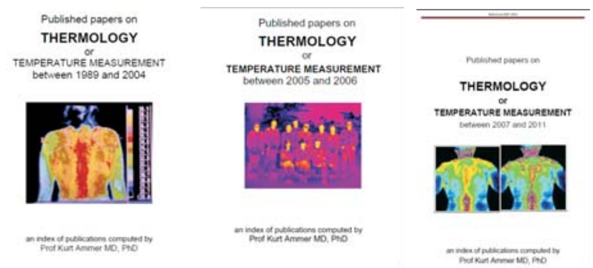

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