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# International

Thermology 2014 a computer asissted literature survey

Infrared Thermography Can Discriminate the Cause  
of Skin Discolourations

This journal is indexed in  
EMBASE/Scopus

Published by the  
European Association of Thermology

# **THERMOLOGY INTERNATIONAL**

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# Thermology 2014 - a computer-assisted literature survey

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## SUMMARY

The literature survey 2014 is based on 1620 papers found in Scopus or Science Direct or the journal "Thermology international, Vol.24" with the keywords "thermography" or "thermometry" "temperature measurement" or 'skin temperature' or 'core temperature' and restricted to "human" and "published in 2014". 38 percent of papers of this review are originated from Europe and 93.7 percent of all papers are written in English. The open access journal Plos One published 81 articles related to thermometry. 550 controlled studies using some kind of temperature measurement were included in this survey. Physiology and Endocrinology, Surgery, Pharmacology and Radiology (including Nuclear Medicine and Thermography) were the predominant fields of applications of temperature measurement in medicine. Hypothermia and hyperthermia, both as physiologic condition and as treatment option was the topic of many papers. Fever attracted also a high number of publications. The majority of papers related to breast thermography originated from Asia. Temperature measurements were an important outcome in trials of patients with complex regional pain syndrome or Raynaud's phenomenon.

**KEY WORDS:** Thermography, literature search, temperature measurement

## THERMOLOGIE 2014 – EINE COMPUTER-GESTÜTZTE LITERATURSUCHE

Die Literatursuche für 2014 basiert auf 1620 Arbeiten, die unter den Schlüsselwörtern "Thermographie" oder "Thermometrie" oder "Temperaturmessung" oder 'Hauttemperatur' oder 'Kerntemperatur' und der Einschränkung "Mensch" und "2014publiziert" in der Datenbank Scopus bzw. ScienceDirect und im 24. Jahrgang der Zeitschrift "Thermology international" gefunden wurden. 38 Prozent der Autoren thermologischer Publikationen kamen aus Europa, und 93,7 Prozent aller Arbeiten wurden in Englisch publiziert. 355 kontrollierte Studien, die irgendeine Form von Temperaturmessung einsetzen, wurden in diese Übersicht aufgenommen. Physiologie & Endokrinologie, Pharmakologie und Radiologie (einschließlich, Nuklearmedizin & Thermographie) waren die vorherrschenden Anwendungsgebiete für Temperaturmessung in der Medizin. Hypothermie und Hypothermie, sowohl als physiologischer Zustand als auch als therapeutische Option, war das Thema vieler Veröffentlichungen. Auch Fieber erzielte eine große Zahl von Publikationen. Die Mehrzahl der Publikationen zur Brustthermographie hatte ihren Ursprung in Asien. Temperaturmessungen waren wichtige Ergebnisparameter in Behandlungsstudien von Patienten mit komplexem regionalen Schmerzsyndrom (CRPS) oder Raynaud-Phänomen

**SCHLÜSSELWÖRTER:** Thermographie, Literatursuche, Temperaturmessung

Thermology international 2015, 25(4) 153-207

## Introduction

This year's annual survey is again based on a literature search in Scopus, a database that allows access EMBASE and MEDLINE. The aim of this regular annual publication is to survey the publications of 2014 related to thermography and temperature measurements in medicine.

## Methods

A search in Scopus with the terms "thermography" or "temperature measurement" or "thermometry" or "skin temperature" or "core temperature" and "year 2014" yielded 5675 hits. Table 1 shows the contribution of each search term to the results. Restriction with the term "medicine" yielded a reduction to 1580 hits. Hand search related to breast thermography identified 5 other papers in the database Science Direct. After removal of 3 doubles, all articles and abstracts from the journal "Thermology international", Vol.24 were added, resulting in total of 1620

Table 1  
 Search terms and results

Combination of search terms	Hits
thermography AND "year 2014"	1714
thermography OR "temperature measurement" AND "year 2014"	4199
thermography OR "temperature measurement" OR thermometry AND "year = 2014"	4618
thermography OR "temperature measurement" OR thermometry OR "skin temperature" AND "year = 2014"	5197
(thermography OR "temperature measurement" OR thermometry OR "skin temperature" OR "core temperature") AND "year = 2014"	5675
thermography OR "temperature measurement" OR thermometry OR "skin temperature" OR "core temperature" AND "year = 2014" AND (limit to "medicine")	1580

Figure 1a  
Origin of authors: countries

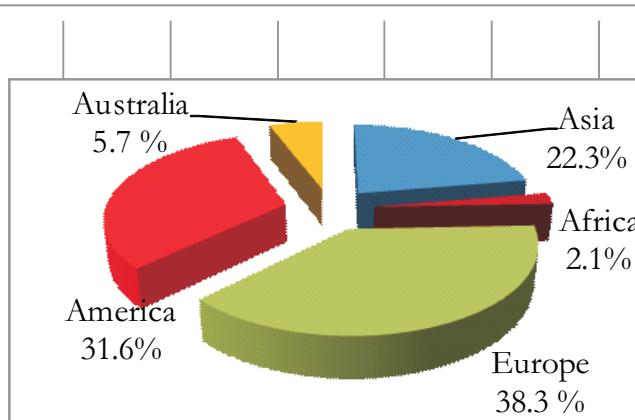
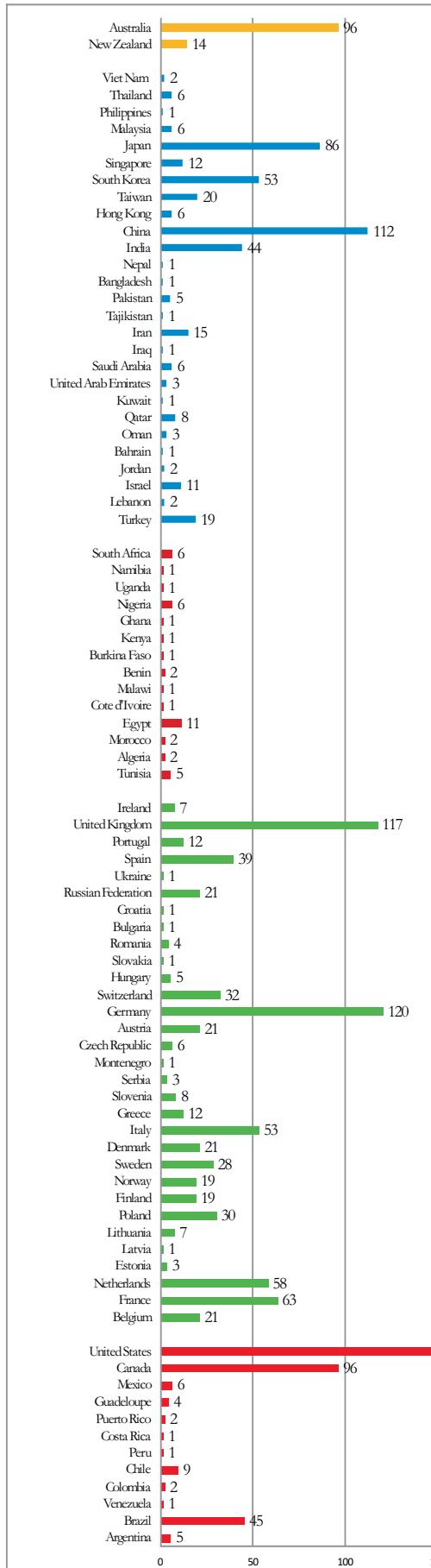


Figure 1b  
Origin of authors: continents

documents which appear in the section "References" of this survey. The total list of 1620 references will be included in the extended reference collection of "Published papers on Thermology or Temperature Measurement in 2014". This will become volume 5 of a collection of references related to thermology spanning the period from 1989 to 2014. They are available from the webpage of Thermology international at "www.uhlen.at/ Thermology international/ Publications on thermology and temperature measurement/ Volume 5". Volumes 1-5 of this reference collection can be accessed free of charge at "www.uhlen.at/ Thermology international/Archives".

The papers were analysed to show the origin of authors, the language, and 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 2014. If a journal was not listed in ISI, the two years citation index, published by SciImago, was used instead.

Papers were allocated with respect to the subject of the publication using the list of medical fields used in last year's literature survey [1].

## Results

5675 publications were obtained with the search profile. Restriction to "medicine" reduced the number of hits to 1577 publications. After adding 5 papers related to breast thermography and 38 papers from Thermology international, this survey is based on a total of 1620 publications.

### Language of publication

All but 76 papers of this database were published in English (93.7%). 27 publications appeared in Chinese (1.7%), 13 papers were published in German (0.8%) and 10 in Russian (0.6%). 6 papers were written in Japanese (0.4%), 4 pa-

pers in Polish (0.25%) and 3 papers in Spanish (0.19%). The language in 2 papers each was French (0.12%) or Turkish (0.12%), or Portuguese (0.12%). Croatian, Czech, Norwegian, Persian, Romanian and Ukrainian was the language of publication in 1 paper (0.01%) each.

### Authors

In total, 7452 authors appeared in 1615 publications. Prof Glen P. Kenny, who holds the Research Chair in Environmental Physiology at the School of Human Kinetics, Faculty of Health Sciences, University of Ottawa, was the author in 2 paper [2,3] and co-author in 14 other papers [4-16].

Mike Tipton, Professor of Human & Applied Physiology at the University of Portsmouth, co-authored 6 articles related to temperature measurement in human physiology [12,17-21], and Nigel Taylor, Associate Professor in the School of Medicine of the University of Wollongong, Australia, was co-author of 3 papers [22-24] and first author in 3 other publications [12,25,26]. Together with Glen Kenny and Mike Tipton, Nigel Taylor published a worth reading review on "Considerations for the measurement of core skin and mean body temperatures" [12]. Marcos Brioschi, an activist in promotion of thermal imaging in Brazil, was co-author in 1 article [27], first author in 2 extended abstracts [28,29] and co-author in 21 abstracts [30-50] published in Thermology international.

Research was performed in 1369 institutions located in 67 countries. 28% of these were situated in North America, the majority, i. e. 314 in the United States, 63 in Canada and 7 in Mexico. 41% of researchers came from European countries, 114 research institutions were located in the United Kingdom, 67 in Germany, 51 in France and 49 in the Netherlands. 21% of temperature related research was conducted in Asia, 66 research sites were situated in China, 55 in Japan, 36 in South Korea and 34 in India. 5.7% of

Table 2  
Journals which published 7 to 41 papers on thermography or thermometry

Journal	Number of papers	Impact factor
American Journal of Physiology Regulatory Integrative and Comparative Physiology	10	3.106
Journal of Biomedical Optics	10	2.859
Resuscitation	12	4.167
Ultrasound in Medicine and Biology	12	2.214
Journal of Applied Physiology	13	3.056
IScientific World Journal	14	0.99 *
Proceedings of SPIE-Progress in Biomedical Optics and Imaging	15	0.36 *
Magnetic Resonance in Medicine	16	3.571
Sensors Basel	16	2.245
International Journal of Biometeorology	18	3.246
International Journal of Hyperthermia	20	2.645
European Journal of Applied Physiology	22	2.187
Journal of Thermal Biology	28	1.505
Plos One	81	3.234
Thermology international	38	0.576°

\* based on ScImago ° based on Google Scholar

temperature research was performed in Australia or New Zealand, 3.6% in South America and 2.1% in Africa (figure 1).

## Journals

In total, 832 journals published papers related to the search profile. 15 journals published 10 to 81 papers related to topic of this survey. First in rank was "PLOS One" with 81 papers, followed by "Thermology international" with 38 publications (7 articles, 24 extended abstracts, 7 abstracts) and the "Journal of Thermal Biology" with 28 papers.

Table 2 lists the journal name, the number of papers of interest and their impact factor 2014. A mean impact factors of 2.836 was calculated for the 15 journals listed. The mean impact was derived from the cumulated impact factor of all 15 journals. The impact factor for "Thermology international" was calculated in the way that Thermology international published between 2012 and 2013 in 9 issues in total 66 cite-able papers which received together 38 citations resulting in an impact factor of  $38/66 = 0.576$ .

## Type of publication

1336 papers were classified as articles, 33 as article in press and 86 as review. 6 short papers, 2 short surveys, 31 conference abstracts and 38 full length conference papers have been published. The remaining papers were classified as 41 letters, 24 notes, 17 editorials, 2 book chapters and 1 erratum.

## Type of study

916 papers have been related to keyword "human". 102 reported findings in normal humans and 87 human experiments. 42 investigations conducted research on human tissue. 370 papers showed the keyword "nonhuman". 304 papers have been published with the keyword "animals" and 119 papers were related to "animal tissue". 550 controlled studies, 122 major clinical studies, 75 randomised controlled trials, 76 comparative studies, 35 controlled clinical trials and 76 case reports have been included in the list of references. 95 studies have been labelled a prospective and 104 as retrospective. 138 clinical articles were detected. 94 papers were found with the keyword "sensitivity and specificity" and 30 publications showed the keyword "prediction". "Reproducibility" was a keyword in 51 papers and "reproducibility of results" was addressed in 58 articles.

## Human Medical publications

As in last year's surveys, papers were allocated to a keyword that roughly describe a distinct field of medicine. Usually, allocations to more than just one field are made. . Table 3 shows the allocations to fields of medicine. Physiology and Endocrinology was the most frequent allocated speciality of medicine. Surgery, Pharmacology and Pharmacy and Radiology & Nuclear Medicine & Thermography, were the next in frequency of allocation, followed by Cancer, Bio-

Table 3a  
Medial papers related to temperature

Medical field	Reference	Total number of identified papers
Biochemistry	51-309	259
Cancer	309-527	282
Dermatology and Venerology	528-604	128
Genetics	605-622	93
Geriatrics and Gerontology	622-637	36
Immunology and Haematology	638-880	121
Internal Medicine	681-750	188
Medical instrumentation	751-771	38
Microbiology	772-814	119
Neurology and Psychiatry	815-901	217
Obstetrics and Gynecology	902-926	71
Otorhinolaryngology	927-934	12
Paediatrics	935-950	52
Pathology and Forensic Science	951-984	191
Pharmacology and Pharmacy	985-1002	289
Physiology and Endocrinology	2-26,1003-1245	803
Public Health and Occupational Medicine	1246-1266	113
Radiology, Nuclear Medicine and Thermography	1, 27-50,1267-1358	270
Rehabilitation and Complementary Medicine	1359-1372	169
Surgery (including injuries)	1373-1453	690
Toxicology and Drug Dependence	1454-1460	50
Papers not allocated to a field	1461-1615	154

chemistry, Neurology & Psychiatry, Pathology and Forensic Science, Internal Medicine, Rehabilitation, Dermatology and Venereology, Public Health. A high number of papers

was missed during the allocation process and therefore 153 articles were not automatically allocated to a field.

Table 3b  
Medial papers related to temperature

Medical field	Reference	Total number of allocated papers
Thermography	1, 12, 26-50, 60, 61, 67, 70, 74, 75, 83, 84, 87, 88, 91, 101, 109, 117, 139, 143, 148, 159, 161, 162, 163, 171, 175, 177, 178, 183, 184, 187, 191, 194, 200, 225, 231, 234, 238, 243, 244, 250, 252, 267, 270, 274, 283, 287, 289, 291, 293, 295, 299, 300, 308, 310, 314, 316, 320, 324, 325, 328, 330, 332, 334, 336, 340, 344, 347, 349, 350, 351, 355, 360, 364, 365, 367, 371, 372, 375, 378, 379, 381, 383, 384, 385, 388, 391, 407, 408, 410, 413, 420, 423, 425, 426, 430, 431, 432, 442, 446, 452, 453, 454, 461, 462, 478, 480, 484, 489, 490, 491, 493, 495, 499, 501, 504, 508, 512, 518, 523, 524, 525, 528, 532, 540, 543, 545, 546, 548, 550, 551, 553, 556, 561, 562, 563, 564, 568, 574, 575, 579, 584, 592, 595, 603, 617, 654, 666, 668, 670, 679, 680, 703, 709, 713, 717, 722, 733, 738, 739, 740, 755, 756, 757, 759, 760, 761, 762, 766, 773, 775, 785, 790, 793, 797, 839, 842, 849, 855, 860, 883, 886, 889, 909, 912, 918, 934, 938, 944, 950, 951, 952, 955, 958, 963, 966, 968, 969, 975, 978, 981, 985, 988, 990, 992, 994, 995, 1000, 1004, 1007, 1009, 1010, 1023, 1024, 1026, 1032, 1036, 1039, 1044, 1045, 1046, 1054, 1055, 1059, 1065, 1076, 1079, 1080, 1083, 1089, 1090, 1091, 1095, 1097, 1100, 1105, 1111, 1118, 1126, 1130, 1136, 1136, 1144, 1159, 1171, 1175, 1176, 1178, 1182, 1183, 1190, 1191, 1206, 1207, 1215, 1217, 1220, 1223, 1235, 1236, 1241, 1247, 1247, 1248, 1249, 1253, 1259, 1269, 1270, 1271, 1273, 1275, 1276, 1277, 1278, 1280, 1283, 1286, 1288, 1290, 1293, 1295, 1297, 1298, 1299, 1300, 1301, 1302, 1303, 1305, 1307, 1308, 1309, 1310, 1311, 1312, 1313, 1314, 1315, 1316, 1317, 1318, 1319, 1320, 1321, 1323, 1324, 1327, 1328, 1329, 1330, 1333, 1335, 1337, 1338, 1339, 1340, 1341, 1343, 1344, 1346, 1348, 1349, 1351, 1353, 1354, 1355, 1356, 1356, 1357, 1358, 1363, 1366, 1368, 1374, 1375, 1378, 1379, 1387, 1390, 1391, 1400, 1411, 1413, 1414, 1420, 1421, 1427, 1433, 1438, 1445, 1447, 1455, 1470, 1480, 1486, 1572, 1615	382
Fever	12, 14, 25, 26, 85, 99, 107, 120, 125, 140, 141, 142, 1469, 147, 1473, 150, 184, 196, 219, 250, 251, 271, 276, 286, 302, 305, 340, 343, 345, 351, 355, 358, 374, 395, 398, 421, 425, 430, 433, 440, 450, 466, 482, 519, 520, 524, 538, 543, 548, 575, 58, 587, 588, 589, 607, 611, 628, 630, 631, 636, 639, 640, 642, 644, 647, 652, 659, 660, 676, 683, 688, 689, 69, 692, 698, 701, 716, 723, 725, 730, 739, 765, 767, 768, 776, 778, 779, 782, 808, 809, 815, 816, 817, 827, 828, 832, 837, 853, 860, 880, 882, 883, 890, 908, 915, 922, 930, 934, 935, 940, 941, 943, 949, 973, 974, 1019, 1046, 1077, 1080, 1085, 1195, 1196, 1229, 1246, 1255, 1256, 1260, 1307, 1335, 1350, 1365, 1372, 1377, 1403, 1406, 1487, 1490, 1501, 1518, 1596, 1545, 1564, 1572	144
Hyperthermia, local & general	2, 7, 8, 11, 13, 15, 16, 22, 23, 24, 63, 64, 70, 88, 97, 100, 103, 105, 109, 110, 117, 118, 138, 156, 158, 162, 163, 170, 173, 174, 179, 181, 189, 190, 199, 201, 203, 207, 208, 209, 214, 218, 226, 232, 235, 241, 253, 256, 261, 263, 269, 278, 282, 299, 313, 314, 323, 324, 325, 331, 333, 334, 336, 337, 338, 339, 344, 346, 348, 350, 352, 354, 356, 357, 363, 369, 370, 376, 383, 384, 384, 390, 392, 399, 402, 404, 409, 410, 414, 415, 419, 420, 432, 436, 439, 441, 444, 445, 446, 451, 452, 454, 455, 456, 456, 458, 459, 459, 460, 468, 470, 471, 473, 474, 477, 479, 481, 483, 484, 485, 488, 492, 493, 494, 495, 497, 501, 502, 503, 505, 515, 522, 527, 534, 559, 560, 566, 570, 571, 576, 584, 591, 613, 623, 627, 663, 667, 670, 684, 690, 695, 697, 699, 706, 707, 711, 728, 729, 736, 742, 745, 749, 753, 757, 818, 831, 836, 854, 858, 861, 862, 875, 877, 881, 889, 896, 901, 913, 919, 923, 924, 939, 942, 945, 947, 961, 969, 976, 982, 1008, 1014, 1015, 1018, 1025, 1028, 1034, 1039, 1040, 1042, 1049, 1050, 1055, 1063, 1072, 1073, 1079, 1083, 1088, 1101, 1104, 1114, 1118, 1131, 1135, 1137, 1143, 1151, 1160, 1161, 1170, 1177, 1179, 1183, 1189, 1200, 1203, 1204, 1207, 1209, 1211, 1214, 1216, 1224, 1225, 1230, 1231, 1232, 1238, 1254, 1262, 1268, 1281, 1317, 1331, 1339, 1397, 1415, 1423, 1428, 1430, 1435, 1444, 1452, 1510, 1520, 1540, 1547, 1557, 1563, 1571, 1583, 1591, 1593	262
Hypothermia, local & general	19, 22, 24, 55, 59, 73, 80, 92, 96, 108, 113, 118, 122, 132, 137, 160, 167, 168, 170, 176, 206, 211, 223, 260, 269, 278, 279, 282, 285, 290, 321, 324, 328, 468, 476, 487, 493, 500, 511, 522, 528, 534, 537, 553, 555, 559, 576, 604, 622, 624, 626, 627, 629, 637, 641, 645, 662, 668, 679, 684, 694, 695, 697, 710, 711, 712, 718, 721, 724, 726, 728, 734, 741, 745, 746, 753, 757, 765, 766, 835, 836, 839, 844, 851, 852, 858, 865, 875, 876, 879, 884, 887, 889, 891, 893, 898, 903, 904, 911, 912, 914, 916, 917, 919, 920, 923, 933, 936, 939, 942, 945, 950, 953, 972, 976, 987, 1005, 1006, 1024, 1029, 1035, 1042, 1043, 1055, 1056, 1067, 1068, 1083, 1087, 1090, 1101, 1106, 1114, 1120, 1126, 1143, 1145, 1148, 1156, 1166, 1170, 1189, 1194, 1215, 1221, 1224, 1230, 1234, 1239, 1243, 1249, 1252, 1325, 1338, 1360, 1361, 1373, 1376, 1380, 1381, 1382, 1384, 1388, 1393, 1396, 1398, 1399, 1401, 1405, 1407, 1408, 1409, 1416, 1419, 1424, 1425, 1426, 1428, 1429, 1430, 1431, 1435, 1440, 1442, 1443, 1444, 1448, 1451, 1462, 1479, 1483, 1494, 1499, 1505, 1509, 1510, 1512, 1520, 1525, 1526, 1527, 1532, 1540, 1544, 1546, 1551, 1557, 1559, 1565, 1567, 1573, 1580, 1583, 1584, 1591, 1593	219
Breast or Breast Cancer	32, 60, 83, 87, 131, 132, 158, 163, 186, 194, 205, 233, 289, 310, 314, 320, 321, 322, 324, 328, 329, 331, 335, 336, 344, 347, 348, 350, 354, 359, 360, 364, 365, 372, 376, 379, 380, 381, 384, 385, 390, 392, 400, 401, 404, 409, 414, 419, 424, 427, 428, 442, 444, 445, 446, 452, 353, 454, 457, 458, 459, 461, 462, 464, 467, 468, 471, 473, 475, 477, 479, 484, 486, 487, 493, 494, 497, 501, 504, 515, 507, 508, 509, 513, 517, 518, 535, 526, 527, 1415, 1615-1620	97
Complex regional pain syndrome	89, 314, 396, 403, 425, 511, 549, 567, 581, 593, 717, 833, 842, 849, 854, 863, 866, 870, 878, 1009, 1059, 1127, 1316, 1346, 1376, 1420,	26
Raynaud's phenomenon	17, 25, 162, 242, 243, 313, 314, 396, 531, 556, 564, 605, 654, 691, 713, 717, 938, 1065, 1115, 1124, 1179, 1225, 1257, 1293, 1312,	24

97 papers were found for Breast or Breast Cancer, Disease, 26 publications for Complex Regional Pain Syndrome and Raynaud's Phenomenon was keyword of 24 papers. The search term "thermography" retrieved 382 papers, fever appeared in 144 publications, the term "hyperthermia" had 262 hits and "hypothermia" found 219 papers.

## CRPS

A search in the database with the keywords "complex regional pain syndrome" or "CRPS" identified 25 papers and 1 abstract [1316], but only 10 of these reported findings closely related to complex regional pain syndrome. 3 papers were single case reports of individual patients with CRPS [833,1316, 1420]. Two articles provided a general overview on this pain syndrome [549, 717]. Two studies discussed the mechanisms involved in the generation of CRPS [89, 503]. A small, uncontrolled case series investigated the effect of sympathetic blocks on the cortical representation of the affected hand in patients with CRPS type located on the hand [878]. Pain reduction after isolated sympathetic block of the stellate ganglion was accompanied by an increase in the blood oxygenation level dependent response of cortical representational maps only of the affected hand which had been reduced before the block. A paper from Japan claimed the development of CRPS in adolescents after vaccination against human papilloma virus [403]. However, neither the way to diagnose CRPS nor the relationship between vaccination and CRPS are conclusively provided.

A diffuse hyperthermia of the palm of the hand and an increase of fingertip temperature of more than 0.5°C compared to healthy subjects, both visible 3 to 15 days after the initiating trauma, was proposed as a predictive finding for CRPS [849].

Two studies employed temperature measurements as an outcome measure in clinical trials. Researchers from the Netherlands reported a controlled study in which they investigated the effect of botulinum toxin injections in patients suffering from CRPS with tonic dystonia in comparison to the unaffected limb and healthy controls, respectively [870]. Skin temperature was measured with "iButtons", fixed to the skin in the area of extensor digitorum brevis (EDB) muscle. Response to the botulinum therapy was assessed the percentile decrease of the amplitude of the compound muscle action potential (CMAP) of the EDB muscle. In addition, the authors investigated the relation of skin temperature with the responsiveness to botulinum. Their results obtained that botulinum toxin has a normal, although perhaps slightly lower efficacy in CRPS patients with dystonia. The decrease in CMAP amplitude was not related to skin temperature.

A study from South Korea reported a lack of correlation between pain intensity (measured by visual analogue scale=VAS) and temperature difference between the affected and the non-affected limb [842]. Temperature measurements were obtained from infrared thermal images with regions of interest in the most painful area of the affected limb and the corresponding site. The mean temperature difference was  $3.0 \pm 2.3^\circ\text{C}$ , the correlation coefficient

for temperature difference and VAS score was 0.066 ( $p = 0.677$ ).

## Raynaud's phenomenon (RP)

25 papers were found with the key word "Raynaud's phenomenon", but 15 [242, 243, 313, 396, 531, 556, 605, 717, 938, 1115, 1124, 1125, 1179, 1293, 1312] papers were not relevant for the topic including an article on the contribution of infrared thermography to the diagnosis of psoriatic arthritis [556], a case report on the effect of low level light therapy of elbow pain in a patient with limited scleroderma [531] and a study that investigated the change of facial thermograms recorded from subjects with mild post-traumatic stress disorder [605]. Other articles not-relevant for Raynaud's phenomenon reported hydration dependent thermoregulation during exercising in humid heat [1125], effects of propolis in a mouse model [243], surface temperature changes in an animal model for distal venous arterialis-ation [1179], or the diagnostic accuracy of Laser Doppler flow for obstructive arterial disease [1124]. 2 reviews discussed cutaneous vasodilation and vasoconstriction [162] and the role of hands and feet [25] in temperature regulation.

A topical review on techniques of microvascular imaging, reported some studies in which thermography was successfully used as outcome measure in drug trials for Raynaud's phenomenon and discussed the role of the hand cold challenge as an outcome measure in RP [314].

A study from South Korea investigated fingers and toes of 146 healthy volunteers and patients with primary ( $n=33$ ) or secondary Raynaud's phenomenon ( $n=24$ ) by infrared thermography [713]. The authors identified the coldest finger based on the temperature difference of the middle of the palm to the tip of the 2<sup>nd</sup> to 4<sup>th</sup> finger. On the feet, only the temperature difference between the dorsum of the foot and the big toe was determined. Diagnostic sensitivity and specificity was calculated for the temperature difference of the coolest finger a cut off value of  $2.2^\circ\text{C}$ . This calculation for the temperature difference to the first toe was based on a cut off value of  $3.11^\circ\text{C}$ . Combining the coldest finger with the toe temperature obtained a sensitivity 89% and a specificity of 45%.

Authors from Japan reported that various orally administered phosphodiesterase-type 5 inhibiting drugs increased the finger tip temperature for 120 minutes after administration in 6 patients with Raynaud's phenomenon secondary to mixed connective tissue disease or systemic sclerosis [654]. In three patients, the daily administration of vardenafil for 12 weeks resulted in an increase of the mean fingertip temperature between  $3.03$  and  $7.96^\circ\text{C}$  observed at the end of the study.

Systemic sclerosis patients suffering from severe Raynaud's phenomenon have been treated for 3 years with cyclic intravenous iloprost in combination with the endothelin receptor antagonist bosentan [691]. Fingertip blood perfusion was evaluated by laser Doppler flowmetry and microangiopathy was assessed by nailfold videocapillaroscopy. This combination therapy seemed to increase fingertip blood perfusion, and also capillary dilation capacity and number.

A double-blind, randomized, placebo-controlled crossover trial of the  $\alpha_{2c}$ -adrenoceptor antagonist ORM-12741 for prevention of cold-induced vasospasm in patients with systemic sclerosis was conducted in England [1065]. At each treatment visit, each of the 12 participants received a single oral dose of 30 mg or 100 mg of ORM-12741 or placebo. Thirty minutes later the subject underwent a cold challenge. Blood flow to the fingers was assessed by three methods i. e. temperature by probe, laser Doppler imaging and infrared thermography, performed before, during and after the cold challenge. The key finding from this study was that, contrary to expectation, ORM-12741 prolonged rather than attenuated cold-induced vasoconstriction.

### Breast cancer

Out of 97 hits labelled with the key words "breast" or "breast cancer" only 13 papers [360, 365, 427, 463, 484, 489, 518, 525, 1616-1620] and 1 abstract [32] were dedicated to imaging of the female breast and 2 articles to thermotherapy monitoring of breast disease [324, 384].

A group from Texas demonstrated that the use of forced current excitation (FCE) enabled effective breast imaging and proton-decoupled carbon-13 spectroscopy at 7T [427]. Magnetic resonance (MR) imaging can be used for temperature mapping during the thermal ablation procedure for guidance and safety [324]. A study from the Netherlands showed that MR thermometry is affected by magnetic susceptibility changes induced by heating of breast fatty tissue samples. The resultant errors could be reduced by the use of a model-based correction procedure.

Engineers in California developed a real-time microwave imaging system to image differential temperature with the goal of non-invasive temperature monitoring for thermal therapy systems [384]. Changes in scattering contrast due to temperature were successfully imaged in cluttered environments, including a simple breast phantom.

The majority of papers on infrared breast thermography have authors living in an Asian country. As screening modality, temperature differences  $>3.0^{\circ}\text{C}$  detected by infrared thermography show a diagnostic sensitivity of 97.6% for breast cancer, a specificity of 99.17%, positive predictive value 83.67% and negative predictive value 99.89% [463]. Although these figures look impressive, the method of recruitment, the study population, evaluation of thermal imaging and calculation of diagnostic accuracy must be questioned. 49 women presented with temperature difference  $>2.5^{\circ}\text{C}$ . 3 of them were lactating and all other had a palpable lump in their breast, but no clinical abnormality was found in 959 women with a temperature difference  $<2.5^{\circ}$ . In this sample, the calculation of diagnostic accuracy of a palpable lump for cancer reveals a sensitivity of 100% (41 true positives/41 true positives + 0 false negative) and a specificity of 99% (962 true negatives/962 true negatives + 5 false positives). This means that a temperature difference  $>3.0$  has a similar ability to detect breast cancer as clinical examination. Clinical breast examination as method for screening has sensitivity in the range of 40% to 69% and a specificity between 88 % and 99% [261]. A large study screened initially 11130 women with physical

examination and mammography, and after classification to fatty or dense breasts targeted or full screening ultrasonography was applied to decide on biopsy. In 4897 women with normal findings in mammography and physical examination 320 biopsies were performed and 33 cancers in 31 women were detected [1662]. As the study from India did not further investigate 959 women with normal findings in thermography and clinical, non palpable breast cancers expected in 6 women might have been missed.

A study from China found in a retrospective evaluation similar diagnostic accuracy of mammography, ultrasonography and far-infrared thermography for breast cancer [518]. However, analysis of infrared images was based on a model of heat distribution which considered mainly heat conduction, assumed large temperature differences between the lesion and the surrounding tissue and disregarded the contribution of blood perfusion to the temperature gradient from deep to more superficial tissue layers.

A paper from Brazil presented a survey on existing protocol for recording breast thermograms and proposed a own protocol for the acquisition of thermal images of the female breast [484]. This protocol was used for the generation of database of breast thermograms. Unfortunately, the reproducibility of body position used for image capture and of the field of view was not investigated.

A number of papers were dedicated to software for the automatic evaluation of breast thermograms [360, 365, 489, 1616-1620]. A review on the application of infrared thermography in computer aided diagnosis overestimated the predictive value of infrared imaging for the development of breast cancer [1620].

### Discussion

The search profile of this year's survey is identical to that of the literature review for the year 2013[1]. It must be mentioned that the application of search filters provided in Scopus resulted in a rather inaccurate allocation of papers to distinct fields of medicine. This became particularly obvious in publications on breast diseases where only 6 out of 11 papers related to thermography were correctly identified, but 85 other papers, non relevant for breast thermography, were found.

The focus of detailed description of papers is temperature measurement in the three clinical entities i.e. complex regional pain syndrome, Raynaud's phenomenon and Breast diseases.

There is a tendency to use infrared thermal imaging as an outcome measure in trials of patients with CRPS [842, 870] or Raynaud's phenomenon [654, 691, 1065]. In the latter, temperature measurements are often combined with laser Doppler flow imaging for assessing the efficacy of drugs investigated.

There was increased research activity in breast thermography in India and China. However, many of these studies suffer from high risk of bias and shortcomings in methodology and evaluation of results.

English continues to be the predominant language for medical publication. 6.3 percent of the papers reviewed in

this article were not published in English, which is a slightly greater portion of non English publications than in last years survey. Chinese achieved the second rank of publication languages.

An average impact factor of 2.836 points was calculated for the 15 journals, which published in 2014 ten to eighty- one papers on temperature measurement. This is an increase by 0.216 points compared to 2012, but a decrease by 0.438 compared to 2013. However, the total number of articles in journals that had the highest rate in publishing temperature related papers, increased from 221 in 2013 to 339 this year.

In 2014, there was a shift in publication productivity from Europe (minus 2.7%) to Asia (plus 1.3%), Australia (plus 0.7%) South America (plus 0.6%) and Africa (plus 0.1%). 26.2 of research institutions in Asia are located in China, 20.1% in Japan, 12.4 % in South Korea and 10.2% in India. Papers from countries in Africa and South America are slightly increasing in numbers and comprise together 5.7% of all articles included. The same percentage was observed for papers from Australia & New Zealand.

In conclusion, this years' literature survey was based on a literature search in Scopus and focussed on temperature measurements with impact on clinical medicine, particularly applications for complex regional pain syndrome, Raynaud's phenomenon and breast diseases. Physiology & Endocrinology, Surgery, Pharmacology and Radiology were frequently identified fields of temperature measurement in medicine. Thermography appeared as keyword more often as in 2013 (207-times in 2013 versus 382-times in 2014). However, only some papers reported diagnostic infrared thermal imaging..

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## Assessment of Fever

Review of the book "Assessment of Fever. Physiology, Immunology, Measurement in Clinical Practice" by Ewa Gordzinsky and Martha Sund-Levander (Gleerups, Malmö 2015). ISBN 978-91-40-68696-1"

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Humans are homeothermic creatures whose thermoregulatory mechanisms allow them to have a determined body temperature that is independent of the environment. Scientists, researchers, and medical physicians have long recognized the association and importance of body temperature and health. The appearance of fever was likewise observed, but remained more of a mystery until the advent of our understanding of the roles, functions, and thermal consequences of the inflammatory, immunological system activation to pathogenic attack. This book and our path to understanding human thermal responses evolve through the development of thermometry, basics of thermo-regulation as influenced by heat transfers and thermal gradients,

and the relevance and implications of thermal measures as a diagnostic tool in clinical practice. The authors clarify and bridge the information gap between thermal physiology, the biological immune responses, and clinical care.

Throughout the text, they have provided "thought clouds", reflections, and clinical scenarios that provoke the readers to further think about pertinent issues. For the clinical practitioner, this provides the etiology behind the observation of a fever. The reader will appreciate the author's development of the thermal literature evolving from basic temperature information through the complex interactions of the immunological responses.

# Infrared Thermography Can Discriminate the Cause of Skin Discolourations

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**BACKGROUND:** Increase of local skin temperature may indicate an underlying inflammatory process. Bruises are the result of blunt trauma, but other conditions such as insufficient compression after venepuncture may form bruise-like lesions. As inflammation is partly involved in the repair of tissue damage, injury- induced bruises should also present with features of inflammation.

**AIM OF THE STUDY:** To explore if bruises and bruise-like lesion can be the discriminated by means of infrared thermal imaging.

**METHOD:** Using infrared thermography, the temperature dynamics of the forearm skin was studied before, during and after initiation of 4 artificial bruises or 2 bruise-like lesions in 5 healthy adult volunteers. Bruises developed after the research assistant had squeezed skin folds with thumb, index and middle finger of both hands until the skinfold became red. Bruise-like lesions were created by intradermal injections of 0.5 ml of venous blood in two sites of the anterior surface of the forearm. It was also investigated whether injection of isotonic sodium chlorides solution into the region of bruises and bruise-like lesions can alter the bluish or reddish skin colour of these lesions.

**RESULTS:** True bruises appear in red colour that is permanent for approximately 120 minutes. The red spots are associated with a quickly established increase of temperature in the centre of the lesion, exceeding the temperature of the adjacent skin by 1 to 5°C. Bruise-like lesions present with blue colour and are not associated with temperature changes. In other words true bruises appear as red and hot, but pseudo-bruises are blue and cold. Infiltration with 0.9% sodium chloride solution bleached the bluish bruise like lesions, but the skin colour and temperature of true reddish bruises was not altered by the salt solution.

**CONCLUSION:** Infrared thermography may me a promising technique for the discrimination of bruises, which are defined as skin discolouration caused by blunt trauma from bruise-like lesions such as haematoma after venepuncture, or intra-dermal injection of venous blood. Further research is warranted.

**KEY WORDS:** temperature, bruise, bruise-like, forensic medicine, bruise bleaching.

## INFRAROT-THERMOGRAPHIE KANN DIE URSACHE VON HAUTVERFÄRBUNGEN UNTERSCHIEDEN.

**HINTERGRUND:** Erhöhung der lokalen Hauttemperatur kann auf einen darunterliegenden Entzündungsprozess hinweisen. Prellmarken entstehen durch ein stumpfes Trauma, aber auch andere Bedingungen wie eine unzureichende Kompression nach Venenpunktur können zu Prellmarken-ähnlichen Läsionen führen. Da Entzündung an der Reparatur von Gewebeschäden teilweise beteiligt ist, sollten verletzungsbedingte Prellungen auch Merkmale einer Entzündung zeigen.

**ZIEL DER STUDIE:** war es zu erkunden, ob mittels Infrarot-Thermographie Prellmarken von Prellmarken-ähnlichen Läsionen unterschieden werden können.

**METHODE:** Mit Infrarot-Thermographie wurde die Dynamik der Hauttemperatur vor, während und nach der Erzeugung von künstlichen Prellmarken bzw. Prellmarken-ähnliche Läsionen bei 5 gesunden erwachsenen Probanden untersucht. Die blauen Flecken entwickelten sich, nachdem die Studienassistentin Hautfalten solange mit Daumen, Zeigefinger und Mittelfinger beider Hände gequetscht hatte, bis die Hautfalte rot geworden war. Prellmarken-ähnliche Läsionen wurden durch Injektionen von 0,5 ml des venösen Blutes an zwei Stellen der Vorderseite des Unterarms erzeugt. Es wurde auch nachgeforscht, ob die Infiltration der Prellmarken bzw. der Pseudo-Prellmarken mit isotoner Natriumchloridlösung die bläuliche oder rötliche Hautfarbe der Läsionen ändern kann.

**ERGEBNISSE:** Echte Prellmarken zeigen eine rote Farbe, die ungefähr 120 Minuten lang bestehen bleibt. Diese roten Flecken entwickeln rasch im Zentrum der Läsion eine Erhöhung der Temperatur, die 1-5°C über der Temperatur der angrenzenden Haut liegt. Pseudo-Prellmarken stellen Sie sich in blauer Farbe dar und sind nicht von Temperatur-änderungen begleiten. Mit anderen Worten: echte Prellmarken erscheinen rot und heiß, Pseudo- Prellmarken sind jedoch blau und kalt. Infiltration mit 0.9% Natriumchloridlösung führte zum Ablassen von bläulichen Pseudo- Prellmarken, während die Hautfarbe und die Temperatur echter, rötlicher Prellmarken durch die Salzlösung nicht verändert wurde.

**ZUSAMMENFASSUNG:** Infrarotthermographie ist eine vielversprechende Technik, um echte Prellmarken, die als durch ein stumpfes Trauma ausgeloste Hautverfärbung definiert sind, von Pseudo-Prellmarken z.B Hämatome nach Venenpunktion oder nach Injektion von venösem Blut, zu unterscheiden. Weitere Untersuchungen sind gerechtfertigt.

**SCHLÜSSELWÖRTER:** Temperatur, Prellmarke, Prellmarken-ähnliche Läsion, Gerichtsmedizin, Ablassen von Prellmarken.

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## Introduction

A bruise can be defined as "an injury to the body by a blunt or heavy instrument causing discolouration, but no laceration of the skin" [1]. Two events must occur before a bruise can form: damage to a blood vessel (usually small-calibre blood vessels such as veins and arterioles) from which blood leaks, and the deposition of that blood into surrounding tissues [2]. Also skin squeezing or suction, venepuncture, intradermal or intramuscular injections may be followed by skin discolouration. Bruises may develop spontaneously without preceding exposure to external forces in diseases that lead to increased vulnerability of blood vessels and/or decreased ability of blood clotting.

The International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10 -2015) [3] lists in chapter XIX: "Injury, poisoning and certain other consequences of external causes" under T14.0 Superficial injury of unspecified body region bruises as "Unspecified or Not otherwise specified (NOS) Codes". In chapter XVIII." Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified" spontaneous ecchymoses are coded as R23.3. However, ecchymoses in fetus and newborn have the code P54.5 allocated, and most cases with "purpura and other haemorrhagic conditions" should be coded as D69.x. The ICD-10 catalogue clearly classifies bruises and spontaneous ecchymoses as non-specific signs [3] and does not regard them as markers of a defined disease [4, 5, 6]. However, in the official and scientific literature bruises continue to be regarded as unequivocal marks of injury and damage soft tissues [7, 8].

Inspection is still the standard method to diagnose bruises and photography is used for the documentation of clinical findings [2]. The determination of the age of bruises by colour assessment is still under debate, but agreement exist that bruises that appear in yellow colour have been inflicted at least 18 hours earlier [2,9]. However, colour photographs of bruises may not be sufficiently reliable for determining the age of a bruise [10]. Spectrography might be of use in age evaluation of bruised tissue[11].

Infrared photography working in the near infrared range that does not include heat rays, may have the ability to demonstrate the presence of a bruise after the injury is no longer visible to the human eye [12] or hidden bruises [13]. In Switzerland, Marty investigated thermal imaging for the detection of blunt trauma without skin damage [14]. However, artefacts such as touching the region of interest with the hands of the subject under investigation reduces the value of IR imaging for producing evidence in such cases [15]. Also, various forms of massage applied in the region of interest prior to thermal image capture can produce at least a transient increase in local skin temperature [16]. In equine medicine, infrared thermography was used to show extensive whip use in competition horses [17] or to indicate injuries due to ill-fitted saddles [18].

A number of methods for producing bruises in human *in vivo* experiments have been reported including a light

weight falling from a defined distance on the skin in the region of the anterior upper arm [10], a tennis ball shot on the anterior surface of the quadriceps muscle by using a tennis ball machine [19], a firm grip at the upper arm [14], a suction pump [20, 21] or a pulsed dye laser [22]. In *ex vivo* experiment, human skin explants have been injected subcutaneously with various small blood volumes (25, 150 or 500 µl) to imitate bruise formation [23].

In humans, to date there is no standard treatment of bruises and only few therapeutic interventions have been developed for the removal of skin discolouration caused by blunt trauma. These treatments include topical or homeopathically oral application of arnica preparations [22-26]. The effectiveness of topical vitamin K treatment of bruises remains unclear [21]. A study conducted in Houston, Texas, investigated the effectiveness of cold compresses, 3% hydrogen peroxide-soaked gauze, over-the-counter bruise serum, and pulsed dye laser in minimizing the time required for bruise resolution. Treatment did not result in significantly shorter bruise resolution time than in controls. Bruises treated with the laser, took a statistically significantly longer time to resolve than controls [22]. Finally, a study reported in a thesis submitted to the Brigham Young University, in Provo, Utah, compared the effects of 4 modalities on colour changes on experimental bruises induced by tennis ball shots [19]. None of the four interventions i.e. 1) cryotherapy with compression (applied 5 times separated by 2 hours, compression applied with and without the ice until return on Day 2); 2) compression alone (worn continuously until Day 2); 3) a tobacco poultice (worn for no less than 12 hours, then removed; compression re-applied until Day 2); and 4) the Sports Wrap (worn continuously until Day 2) did influence the colour development of bruises.

Recently, a programme of medical research has been undertaken in the Udmurt Republic of the Russian Federation, to clarify the mechanisms of induction of bruises [8,27,28] or bruise-like lesions [6,7], the related clinical picture [4,5] including determination of the age of bruises based on skin discolouration [31,32] and epidemiology of bruises [33]. Medicaments have been developed for the treatment of bruises [34,35] and they have been tested in a pilot clinical trial [36,37]. The value of infrared imaging for identification of bruises [8, 27,28] and bruise-like lesions [6, 36] was the focus of single case and case series reports.

In recent research, the objective of the study was to explore the relationship between tissue damage, local temperature and blood absorption by the skin in the area of skin discolouration caused by blunt trauma.

## Methods

A study was conducted in 5 adult healthy volunteers to investigate the dynamics of colour and local temperature in the region of bruises of the skin of the forearm. Prior to the study, the study protocol was approved by the Ethics

Committee of the Izhevsk State Medical Academy following the principles that are outlined in the Declaration of Helsinki of the World Medical Association [25]. All volunteers signed written informed consent to participate in the study.

Skin discolouration was generated in two ways: by squeezing of skin folds in one forearm or by injection of venous blood into the skin of the contra-lateral forearm. A 22 years old female assistant gripped simultaneously with both hands skin folds using her thumb, index and middle finger for squeezing. The skin was squeezed until the skin colour appeared in a bright red due to provoked haemorrhage. 4 bruises were produced at a distance of approximately 8 cm from each other on the anterior side of the forearm.

For intradermal injection, 1 ml blood was taken from the cubital vein of the participant using an insulin syringe with injection needle 23 G. Immediately after harvesting, 0.5 ml blood was injected with a needle 31 G into the skin of the palm and forearm, respectively. The dynamics of colour and skin temperature in the areas of the produced lesions was observed for 10 days.

In a second phase 5 months later, the same method was used for the generation of skin discolouration induced by skin fold squeezing or intra-dermal blood injections in the same group of volunteers. We investigated the effects of intra-dermal injections of 0.9% sodium chloride solution on the dynamics of the colour and skin temperature of skin of the forearm in the areas of bruises. 0.5 ml of isotonic sodium chloride solution at a temperature between 36 and 37°C was injected into the skin using an insulin syringe connected to the injection needle 31 G. Each area of the bruise was injected 4 times at a distance of approximately 1.0 - 1.5 cm. The purpose of this intervention is to dilute the deposited blood volume and thereby enhance the removal of blood.

In addition, we studied the dynamics of skin colour of the forearms in the area of intravenous injections in 10 in-door patients aged from 26 to 57 years. Unlike other patients, these 10 patients had only bruises in sites where medicaments have been applied intravenously.



Figure 1

Forearm of a volunteer 45 minutes after induction bruises by skin squeezing, a. photograph, b. thermogram

In a final self-experiment, the dynamics of skin colour and temperature of the back of a male healthy volunteer aged 24 was investigated after being beaten twice with a police baton applying moderate force by moving the bludgeon at low speed over a distance of 35cm towards the back. These baton blows resulted in local areas of hyperaemia, but did not cause bruises as blood vessel rupture and bleeding did not occur.

Skin changes were documented with photographs, skin temperature was recorded with thermal imager Thermo Tracer TH9100XX (NEC, USA). Ambient temperature of the examination room was  $24 \pm 0.5^\circ\text{C}$ , the temperature window of the thermal camera was set to the range of 25 to  $36^\circ\text{C}$  [11,14,15]. The data were processed using the software Thermography Explorer and Image Processor. A region of interest was defined over the entire hand and forearm using the outline of the arm to separate its temperature from the background. From this region of interest, we determined the mean temperature, standard deviation and the distribution of isotherms at the thresholds of 34, 32, 30, 29 and  $25^\circ\text{C}$ .

## Results

### Visual images

The injection of venous blood and also interstitial venous bleeding after venepuncture results to immediate formation of growing blue spots in the skin at the injection sites in which the local temperature is not different from the temperature of the surrounding skin. 10 minutes after venepuncture, a blue area in the shape of an ellipse appeared with its long axis being parallel to the axis of the forearm. These ecchymoses presented with maximum length of  $9.2 \pm 0.4$  cm and a width of  $8.3 \text{ cm} \pm 0.2$ . The skin discolouration which appeared 10 minutes after intradermal injection of 0.5 ml of blood in the forearm, were of similar elliptic shape, orientation and size (maximum length of  $10.7 \pm 0.5$  cm, width of  $9.7 \text{ cm} \pm 0.4$ ) as the blue areas observed after venepuncture (figure 1).

Skin squeezing and baton blows result at first in pale skin at the injury site associated with a transient decrease of local

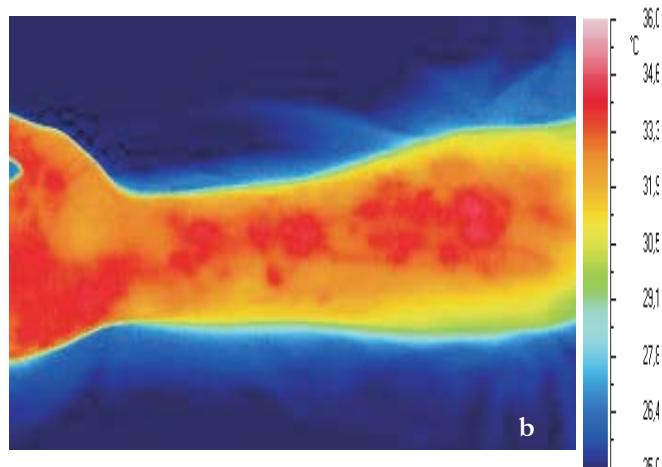




Figure 2  
Forearm of a volunteer 10 minutes after intra-dermal injection of 0.5 ml of its own venous blood, a. photograph, b. thermogram

skin temperature. But only few seconds later, non-expanding red spots are formed on the skin at the damaged site, in which the local temperature exceeds the temperature of the surrounding skin.

The results showed that the shape and dynamics of hyperaemic areas are different from the thermal changes developed in the region of each nip. The red colour of these areas remains without significant changes for 120 minutes after initiation. The zone of hyperaemia is circular in shape, the area of which exceeds the total area of the 6 finger pads that caused the lesion.

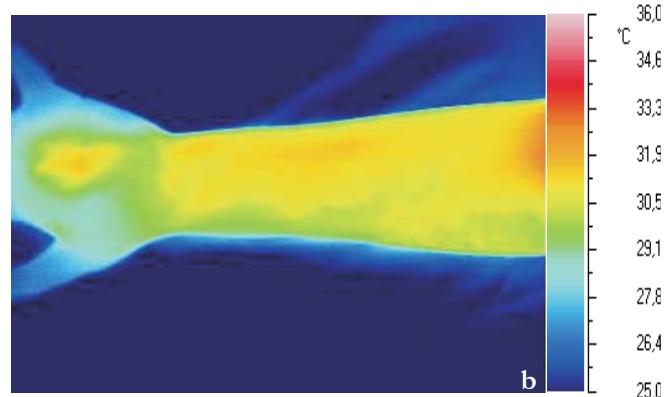
#### Thermal images

Before creation of artificial lesions, the skin temperature of the anterior side of the forearm in five healthy adult volunteers was in the range from 26 to 36°C (mean temperature  $\pm$  standard deviation:  $34.0 \pm 1.1^\circ\text{C}$ ). In patients selected from the hospital, the forearm temperature was in the range from 26 to 37°C (mean temperature  $\pm$  standard deviation:  $34.4 \pm 1.2^\circ\text{C}$ ). Before deliberate bruising, the total range of isotherms with thresholds at 34, 32, 30, 29 and 25°C were visible in the thermal images of forearms recorded in healthy volunteers and in patients.

Thermal imaging can differentiate skin discolouration caused by non-traumatic imbibition with venous blood from bruises that resulted from blunt trauma. Interstitial blood deposition due to intradermal injection or leakage after venepuncture is followed by the formation of blue "cold" bruises.

Both bruises that resulted from external forces applied to the skin presented after a transient phase of skin paling and decrease in local temperature, local hyperaemia and local hyperthermia, which remained on the skin for 2 hours at maximum (figure 2). Already 1 minute after the skin was squeezed, the temperature in the area of damage exceeds the temperature of the adjacent skin by 1.0 to  $1.2^\circ\text{C}$ . This temperature differences increased in the following 5 minutes to 1.5 to  $5.0^\circ\text{C}$  and remain at this level for 100 to 120 minutes.

A closer look in the area of local hyperthermia, revealed that the site of each pinch consists of 6 individual small zones of hyperthermia. Each of these small areas is circu-



Forearm of a volunteer 10 minutes after intra-dermal injection of 0.5 ml of its own venous blood, a. photograph, b. thermogram

lar in shape with a diameter of 3 to 10 mm. The temperature of the skin in small circles increased significantly less than in the large circles. In particular, temperature of circles with a diameter of 3 to 4 mm did not exceed  $34^\circ\text{C}$ , but temperature increased to  $36^\circ\text{C}$  in the circles with a diameter of 9 - 10 mm, but in the intact areas of the skin, temperature remained at  $30 - 33^\circ\text{C}$ . In addition, in one lesion these small round areas of hyperthermia remained isolated from each other, but in other lesions the small warm areas merged with each other and formed a large zone of hyperthermia. Each of the 6 areas of relative hyperthermia represents the grip-imprint of the 6 finger pads that have induced the artificial bruises and corresponded exactly to the sites of applied pressure force of each of the 6 fingers.

The shape and size of each of the small areas of local hyperthermia was preserved without significant changes for 30 minutes. 70 to 120 minutes after skin squeezing, they gradually disappeared completely. Most small foci of relative hyperthermia with the low temperature values disappeared first, the large warm areas with the highest temperature values stayed at longest.

In phase 2 of the study, intra-dermal injection of 0.9% sodium chloride solution in the area of bruises produced by skin fold squeezing, did not bleach skin colour in the area of bruises and did not eliminate the associated hyperthermia in these lesions (figure 3ab).



Figure 3a  
Right forearm of a volunteer. 3 hours after initiation of 4 artificial bruises by squeezing skin folds.



Figure 3b.  
Right forearm of a volunteer 15 min after intra-dermal injections of 0.5 ml of 0.9% sodium chloride solution in the area of local redness.



Figure 4  
Forearm of a healthy adult volunteer after 0.1 ml of venous blood have been injected at 2 sites and 2 hours later, 3 intra-dermal injections in the proximal lesion, each with 0.5 ml of 0.9% sodium chloride solution .

The distal blue discolouration served as control.

However, discolouration caused by intra-dermal injection of autologous venous blood behaved differently to treatment with 0.9% sodium chloride solution. A total volume of 1.5 ml 0.9% sodium chloride, applied in 3 portions for intra-dermal injection into the blue coloured lesion resulted in a change of the bruise colour, permanent for at least 5 days. (figure 4).

In the case of being beaten with a police baton, the colour and temperature of the skin developed in similar way as in bruises induced by firm skin squeezing. Immediately after being hit with a truncheon on the back, the skin in the region of contact became pale and cooler. But few seconds later the impacted skin started to get reddish and warm (figure 5).

In figure 5b two areas of local hypothermia can be detected corresponding to two regions of local hyperthermia visible in figure 5c. Localization and size of these areas correspond to the size and shape of the baton and indicate the amount of damage that has occurred. It should be noted that in this case of baton blows, bruises did not develop, but transient signs of inflammation were observed. 1 minute after application of moderate external force, the skin temperature in the area of baton contact exceeds the temperature of the adjacent skin areas by 1.0 - 1.5°C. 2-3 minutes later the temperature of this area was 3.5 - 4.5°C warmer than the adjacent areas and remained at this level for 60 minutes. 70 minutes after the injury the relative increased temperature and the reddish skin colour indicating hyperaemia disappeared completely. Therefore, thermal imagers may track the impact of a moderate blunt trauma for only 60 minutes after onset.

## Discussion

Our results showed that it is not possible to identify the cause of bruises by analysing only skin colour as blunt

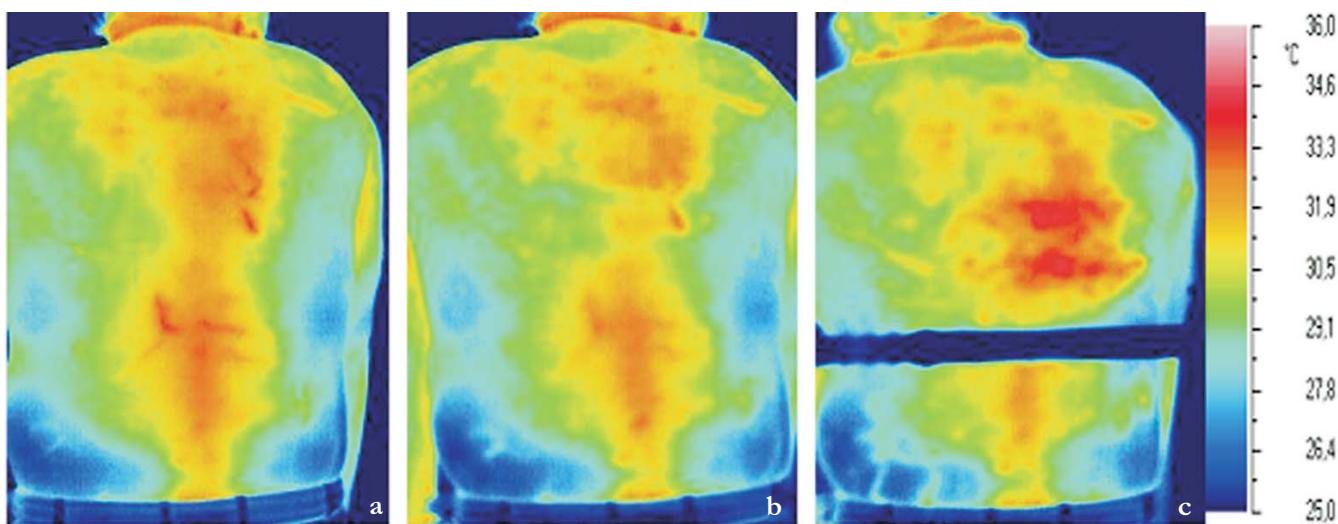


Figure 5. The thermograms of the back of a volunteer  
a. baseline image before the injury  
b. immediately after being beaten twice with moderate force by a police baton across the back at the lower edge of the shoulder blades  
c. and 10 minutes after 2 blows with a police baton, which lies across the back below the region of bumps

trauma, ingression of subcutaneous tissue with blood due to leakage after venepuncture, and injection of venous blood all produce areas of blue colour on the skin. But thermal imaging provides evidence that only bruises caused by blunt trauma are associated with an increase of local temperature. Blood deposition due to injection or after venepuncture is not followed by increased skin temperature. It seems, that small volumes of autologous blood do not stimulate vascular reactions of the inflammatory response that occur when small vessels have been damaged. Also the different temperature patterns observed in lesions produced by skin fold squeezing may be a hint that the applied force is rather related to skin temperature than to red skin colour indicating local hyperaemia.

A study published in 1995 reported thermographically recorded temperature changes after painful squeezing of inter-digital skin folds in patients with diabetic poly-neuropathy and healthy controls [39]. Noxious mechano-stimulation elicit an antedromic vasodilatation response resulting in wider vascular beds with an increased area for infrared heat emission. This mechanism contributes at least in part to the spatial extent of skin hyperaemia and skin hyperthermia in our study. However, blood flow in vessels responsible for skin colour may not be involved in heat exchange and thus may explain the difference in distribution of reddish skin colour and temperature. Research on the temperature course after a very superficial skin "scratch" showed also that a change in temperature is not necessarily associated with a change in skin colour [40].

Blood deposits in the skin can be removed by dilution with injected isotonic sodium chloride solution, but this intervention does not affect the grade of vasodilatation of skin vessels that are responsible for redness and increased temperature in the area of blunt trauma impact.

There are limitations of this study. The investigated sample of bruises and bruise-like lesions is too small for the results to be generalised. For the same reason, analytical tests statistics have not been performed. Use of a clamp for squeezing the skin fold, might have produced more uniform appearance of the bruises. A pain scale, completed by the study participants, would have provided a more comprehensive description of the investigated bruises.

Beside these limitations, infrared thermography may be a promising technique for the discrimination of bruises that are defined as skin discolouration caused by blunt trauma from bruise-like lesions such as haematoma after venepuncture, or intra-dermal injection of venous blood. Recently deposited blood can be removed by dilution with injected isotonic sodium chloride solution, providing in this way evidence that the mechanism of blood deposition did not provoke an inflammatory response. But thermography has the advantage of being non-invasive, a remote sensing technique that generates immediate information on temperature changes in the region of interest, which may indicate inflammation. Therefore, the use of an infrared thermal camera can improve the results of clinical examination in

forensic medicine, when used in living persons with bruises, and in patients with bruise-like lesions after intravenous medication. A series of thermal images in combination with photographs, recorded in standard views and body positions at a defined time interval, provide information on the dynamics of change in temperature and skin colour.

## Conclusions

1. Photographs and video film clearly document the visual appearance of bruises and an eventual visible redness, but infrared images recorded in the period from the initiation of the bruise to 60 - 70 minutes after the injury, reveals additional information on temperature distribution. A relative increase in temperature indicates an inflammatory response due to tissue damage that combined with bleeding are the cause of bruises. The shape and size of the area of local hyperthermia represents the area of local damage more accurately than the spatial extent of the local hyperaemia.
2. The absence of local hyperthermia in the area of the bruise indicates that the bruise was not caused by blunt trauma and as small volumes of autologous blood are inert and do not provoke inflammatory responses in soft tissues, normal skin temperature indicates the absence of inflammation.
3. Intradermal injections of isotonic 0.9% sodium chloride bleach the skin in areas of non-traumatic induced haemorrhage, but do not change redness of the skin, and therefore have no impact on the magnitude of hyperaemia.

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# General Assembly of the European Association of Thermology (EAT)

K. Howell<sup>1</sup>, R. Vardasca<sup>2</sup>, K. Ammer<sup>3</sup>

<sup>1</sup> President of the EAT, <sup>2</sup> General Secretary of the EAT, <sup>3</sup> Treasurer of the EAT

The 2015 General Assembly of the European Association of Thermology was held at Facultad de Ciencias de la Actividad Física y del Deporte - INEF, Ciudad Universitaria de Madrid, 3rd September 2015 at 19:40.

19 members were present (17 ordinary, 2 extraordinary). 2 proxy votes were brought to the meeting by members.

## 1. Report of the President

James Mercer welcomed members to the General Assembly. He noted that since the previous General Assembly in Porto, there had been a definite upswing in activity. The Association had attracted several new members in the last six months. 25 people registered for the pre-congress training course in Madrid, which demonstrated a growing interest in thermology. The general standard of papers at the EAT 2015 congress was good, and it was pleasing to see new people, with new ideas, presenting research.

2011 had seen the final thermological symposium in Vienna, but the Board had still been able to meet on several occasions over the last three years, including at the annual meetings of the Polish Association of Thermology in Zakopane. The Board had maintained the policy of a minimum standard of experience for membership of the Association, as it was felt that the EAT should be a flagship organisation which stood for doing good thermography.

The EAT website would be revised by Ricardo Vardasca over the coming months. This was an important resource, as it was the EAT's "window on the world" and continued to receive a large number of site visits.

Prof. Mercer explained that he had taken on the Presidency six years ago with the aim of growing the Association. The decision by the German Society to end its affiliation had been a disappointment, but since the Porto meeting the situation had been steadily improving. The Association was still a small but very active group, and he was pleased to be able to retire from the Presidency with the EAT in a strong position.

## 2. Report of the Treasurer

Kurt Ammer reported that the Association currently had 51 members, 36 of whom were ordinary members. There were three affiliated national associations and two honorary members.

The account summary was presented, showing that the Association currently had €1916.28 in the bank.

Marlous Kelderman enquired why the cost of managing the online journal was so high, and wondered if more extraordinary members could be admitted to the Association. Kurt Ammer explained that the journal costs partly covered a period when the journal was still a print edition, which was considerably more expensive to produce than the current online-only version. Any applications for extraordinary membership would be considered.

The Treasurer's report was accepted by the Assembly.

## 3. Statement of the Auditors

Adérito Seixas reported that the auditors had examined the EAT accounts for the period 5.9.12 - 19.3.15. All transactions had been checked, and no irregularities had been found.

The statement of the auditors was accepted by the Assembly, and the accounts adopted.

## 4. Honorary Membership

Kevin Howell explained that the EAT Board was proposing Honorary Membership be awarded to Prof. James Mercer.

James was retiring from the Board in 2015, and had contributed many hours to the running of the EAT, including as President for the last six years. He had guided the EAT with good humour, infectious enthusiasm and wise counsel. The EAT would not have developed into the strong organisation it is today without James' input.

Honorary membership for Prof. Mercer was approved by the Assembly.

James Mercer thanked the Board and the membership for bestowing upon him this honour. He had been fortunate to work over the past six years with a great team. Discussion amongst the Board members was always well-mannered and constructive, and the EAT would not be where it is today without their contribution.

## 5. Setting of Membership Fee

James Mercer explained that the annual membership fee was currently €50. Francis Ring felt it was important to retain the lowest fee possible to encourage new and student members. Manuel Sillero pointed out that the EAT 2015 Congress and course had been a great success, and this was likely to have created significant income which could be charitably donated back to the EAT account.

In the light of these views, the Assembly agreed to retain the annual membership fee at €50.

## 6. Election of a New Board

James Mercer explained that the following nominations for the new EAT Board had been received (proposed by Kurt Ammer and seconded by James Mercer).

President - Kevin Howell

Vice-President - Anna Jung

Treasurer - Kurt Ammer

Secretary - Ricardo Vardasca

General Board Members - Manuel Sillero and Adérito Seixas

Auditors - Adriana Nica and Peter Plassmann

There being no other nominations received, the Assembly approved the new Board and Auditors.

James Mercer said that Kevin had been an excellent secretary, and would do a great job for the Association as President. He left the Board with the EAT in safe hands.

Kevin Howell commented that it was a great honour to be elected President of the EAT, and thanked the membership for the trust they had invested in him. Prof. Mercer would be a very hard act to follow, but he was confident that he had a great team around him in the newly elected Board.

The Board would always do its best to develop the EAT for the benefit of its members and for the science of thermology.

## 7. Miscellaneous

Manuel Sillero said that he would submit a full report on the Madrid meeting finances to the EAT Board in due course. However, it was already clear that both the meeting, and the pre-congress course, had been a financial success. The course would have broken even with 12 participants, and actually attracted 25 students. This higher than expected attendance would allow him to increase the salary paid to the course tutors, effectively paying for their flights. Currently it looked as if around €7000 would be available to pay back into the EAT accounts as a donation to support the Association's charitable activities.

Marlous Kelderman enquired if the EAT could publish its membership list so that members knew about each other and their interests. Ricardo Vardasca felt there would be some difficulties with this regarding data protection, unless the Association gained permission from every member to publish their details. Kevin Howell agreed, but said the new Board would look at some options. He felt if the EAT could develop a better online forum (other than the established version on LinkedIn), those members who were happy to share their information could do so on there.

There being no other business, the meeting closed at 20:20.

# Congratulations to Francis Ring

K. Ammer<sup>1</sup>, J. Allen<sup>2</sup>, J. Gabrhel<sup>3</sup>, K. Howell<sup>4</sup>, A. Jung<sup>5</sup>, J. Mercer<sup>6</sup>, A. Nica<sup>7</sup>, D. Pascoe<sup>8</sup>  
R.C. Purohit<sup>8</sup>, M. Sillero<sup>9</sup>, A. Seixas<sup>10</sup>, H. Tauchmannova<sup>11</sup>, R. Vardasca<sup>10</sup>, J. Zuber<sup>5</sup>

<sup>1</sup> Vienna, Austria, <sup>2</sup> Newcastle, United Kingdom, <sup>3</sup> Trenčín, Slovakia, <sup>4</sup> London, United Kingdom, <sup>5</sup> Warsaw, Poland, Tromsø, Norway<sup>5,6</sup> Bucharest, Romania<sup>7</sup>, Auburn, Alabama, USA, <sup>8</sup> Madrid, Spain, <sup>9</sup> Porto, Portugal, <sup>10</sup> Bratislava, Slovakia

## From Vienna, Austria

It is my periodical pleasure to collect congratulations for Francis Ring's birthday. I will put my personal greetings to Francis on the end of the list of birthday wishes, which have been received from around the world.

## From Newcastle UK

Francis - the Newcastle thermal imaging team in Microvascular Diagnostics at Freeman Hospital want to wish you a really great and special birthday. I personally also want to say thank you for all your warm support over the years and encouraging me to contribute scientifically to this exciting area of medical imaging.

Best Regards,

John

John Allen, PhD  
Freeman Hospital, Newcastle, United Kingdom

## From London, United Kingdom

Dear Francis,

On the occasion of your 80th birthday, I send you my very best wishes from the Royal Free Hospital! Your wise counsel and support has been vital to me over nearly 25 years at the Free, and of course my achievements at Glamorgan would not have been possible without your guidance. I look forward to many more friendly and interesting discussions at thermography meetings to come.

Best wishes

Kevin

Kevin Howell, PhD  
University College London,  
Division of Medicine, London, UK  
President of the EAT

## From Auburn, Alabama, USA

Happy 80th Birthday Francis. I am happy to count you as a very good friend and an inspirational colleague.

We first met in the early 1990's after I had read many of your thermographic journal and text articles describing the role of infrared imaging for medical use. Infrared imaging has been a strong focus in my career and your research, science, and investigational insights have been a mainstay in this process. I commend you for a life of service to science, medicine, and the nurturing of those who have followed your

infrared path, a non-visible light path, but a beacon of light for all thermologists. I wish you the best and treasure our academic and social friendship.

David

Prof David Pascoe PhD  
Auburn University, Alabama, USA

## From Auburn, Alabama, USA

Dear Francis,

**This is a special greeting from your colleague and a friend on your 80th birthday.** When I started my thermography studies in early 1970's using 680 AGA, I searched for literature and found your publication "Skin Temperature Measurements by Radiometry in British Medical Journal 1968 and "Quantitative Thermography" in *Rheumatol. Phys. Med.* 1970. Your work inspired me and forms a guide line for my work in Thermology. You became my mentor and colleague for my feature studies in use of thermography in Veterinary Medicine, in early 1970's. Since then we have attended and presented papers in many international meetings. We had great time together on all those precious's occasions'. Ram and Cynthia Purohit wish you happy happy birth day and many more to come.

Love and kind regards from Auburn, Alabama, USA

Ram

Ram C Purohit, DVM, PhD, DACT  
Professor Emeritus  
Department of Clinical Sciences  
College of Veterinary Medicine  
Auburn University, Auburn, Alabama, USA

## From Bratislava, Slovakia

Dear Francis

all the best and lots of happiness, health and life enthusiasm to your jubilee.

Thanks to your work, I was introduced to the thermographic method that influenced my professional interests and on the basis of which I have gained my scientific gradus.

I remember how we met at the first Thermographic Congress in Amsterdam, the Van Gogh Museum, in 1974. I did not know anybody there and as I asked who is dr. Ring I got

to know you, a slim unassuming gentleman, who kindly and gladly answered questions about thermography to a unknown colleague. In the following years thanks to your interaction I was borrowed thermovision systems which allowed me to make a series of expert studies on the basis of which I gained my scientific title, and also thanks to your recommendations membership at the presidency of the European Association of thermography. Your support and invitation letters to the Ministry of Health allowed me to participate scientific at conferences and congresses held in the countries behind the Iron Curtain which during the Cold War was something unreal. You visited the former Czechoslovakia several times at our invitation, met with my husband with whom you immediately hit it off. It was and is a long-term friendship and cooperation, which has been going on for 35 years.

I am proud that I can call you my friend.

Vara

Univ Doc MUDr Helena Tauchmannová  
Bratislava, Slovakia

From Warsaw, Poland

Dear Francis,

On the occasion of the 80th anniversary of your birthday we are sending our sincere congratulations and best wishes for your continuing success .

We wish you good health and every happiness on this special day, have a enjoyable celebration, one that you'll always recall.

Many thanks for your friendship and a long term, fruitful cooperation for more than 20 years

Anna and Janusz

Anna Jung MD, PhD  
Paediatric, Nephrology & Allergology Clinic  
Military Institute of Medicine, Warsaw, Poland  
Vice-president of the EAT  
Janusz Zuber MD, PhD  
Military Institute of Medicine, Warsaw, Poland  
on behalf of the Polish Society of Thermology

From Trencin, Slovakia

Dear Francis.

Congratulations to your jubilee. I wish you health and strength in the following years of creative work.

I was introduced to Francis by my friends Vara and Miro Tauchmann's 25 years ago in one of the thermography congresses. I consider him the main character of medical thermography. Without him, this union would not have been what it is today. He is a very clever and gracious man who always finds time to talk to his colleagues even about private matters. At our last meeting at the Congress in Madrid, I was lucky that I could spend more time with him. Francis recalled his repeated visits to Slovakia, where he has

good friends and where he has always immensely enjoyed his stay. We had a lot of fun talking about some humorous experience that had happened to him.

I hope I will be able to meet him many times again and to enjoy his favour.

Jozef

MUDr Jozef Gabrel  
Trencin, Slovakia

From Tromsø, Norway

It is a great pleasure for me to have this opportunity to send greetings to Francis Ring on the occasion of his 80th birthday.

My first acquaintance with Francis was associated with the start of my interest in Medical Thermography. I first met Francis when I attended a combined meeting in 2001 in Vienna (the 5<sup>th</sup> International Congress of Medical Thermology, the 14<sup>th</sup> Thermological Symposium of the Austrian Society of Thermology and the Annual Meeting of the German Society of Thermology - how times have changed!). At this meeting I gave my first ever presentation on Medical Thermography. I remember feeling a little bit like Daniel entering the Lion's Den since I had no previous experience in using infrared thermography and was presenting our first results to an audience that included many of the well-known names in Medical Thermography at that time including, of course, Francis. I somehow survived! This was to mark the start of not only a long academic association but also the start of a personal friendship with Francis, which continues today. Throughout the last 15 years, Francis has helped to foster my interest in Medical Thermography and has helped to open many doors for me on the way, not least his gentle guidance that ultimately cumulated in me becoming President of the EAT for 6 years. An unconditional attitude to helping and guiding others is the sign of a true academic.

It is no secret that we all recognize Francis as the uncrowned king of Medical Thermography. His knowledge and insight in this area of science spans many decades. Not only has Francis a huge knowledge of the historical development of infrared thermography and thermometry in general and its use in medicine but Francis also has his finger well and truly on the pulse concerning modern developments in which he continues to play an active role and is still very much in the forefront. His knowledge and experience on the subject is like a bottomless pit. On more than a few occasions I have come up with what I thought was a new idea but when discussing it with Francis he would say - oh yes we did that 20 years ago! Frustrating and enlightening at the same time. My nickname for Francis for his knowledge of Medical Thermography is "Ringapaedia", which explains it all. I know that many others will echo this sentiment.

On a more personal note, I have come to know Francis as a kind and considerate person - a real gentleman. On a few

occasions, I have had the pleasure of guiding Francis when visiting Tromsø and have been witness to his keen eye as a nature photographer. He has been my personal courier for Glenettie teabags for many years and packets of tea have exchanged hands when we met at scientific meetings- a lovely tradition that we still keep up.

Dear Francis, my wife Liz and I wish you all the best for your 80th birthday and for many more to come.

James

Prof James Mercer PhD  
Tromsø, Norway

Past President and lifetime honorary member of the EAT.

### From Porto, Portugal

I have met Francis in the 1st June 2005 at the J150 office, at the University of Glamorgan Thermal Physiology Lab, we had a chat about research opportunities in medical infrared imaging and I was looking for an opportunity to pursue my career, I can say that that meeting changed the spectrum of my life forever.

I did not succeed that year to get the funding for starting my research under his supervision, but hope and persistence made it possible in the following year. Francis has been the perfect advisor, confident, supervisor and specially a great friend that I take the chance to call "family". In the hardest moment during my PhD, the 17th December 2006, my paternal grandfather passed away, he supported me, giving me

comfort at that difficult moment. He shared with me knowledge, experience and wisdom, which were fundamental for obtaining my objectives and for making me a better person. Since we started our quest together we have been together in 11 countries (UK, Poland, USA, Austria, Germany, Portugal, Brazil, Argentina, Spain, France and Ireland) were we had good moments.

I wish Francis a fantastic 80th birthday, hoping to share with him much more unforgettable moments in the future. For finishing, I have to say that Francis is a good man and a good friend that I can always count with and he will have me always as a close friend and disciple.

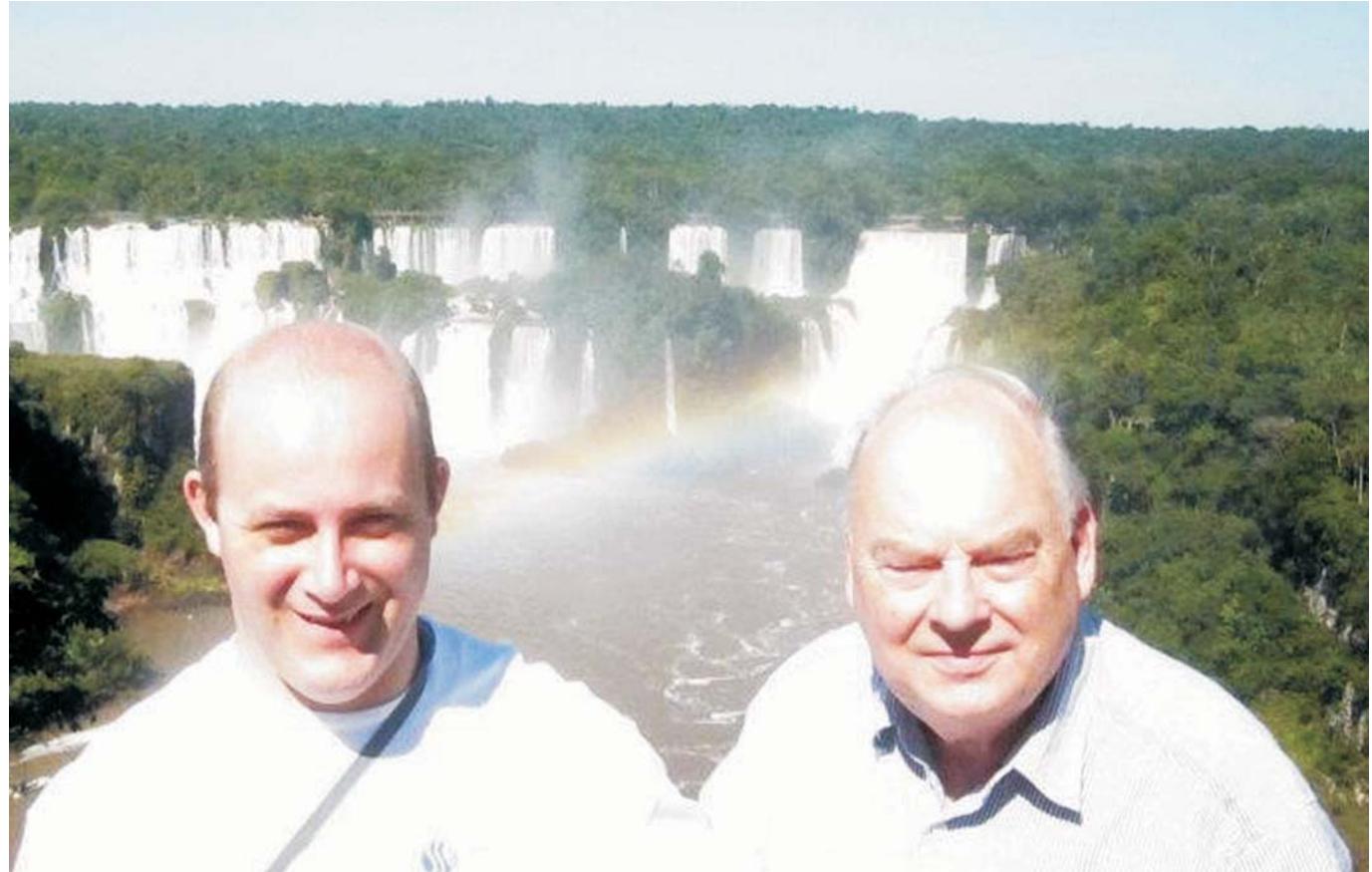
Ricardo

Ricardo Vardasca PhD  
Faculty of Engineering, University of Porto,  
Porto, Portugal  
General Secretary of the EAT

### From Bucharest, Romania

#### About Prof. Dr. Francis Ring

I remember the first meeting with Francis in Vienna, some years ago, where his presentations struck and enjoyed me through a mixture of history, experience, desire for communication and permanent update of all information, everything was fresh. I perceived Francis as warm-hearted, gentle man whose attitude remained unchanged over the



At Iguazu falls (Brazil), Ricardo Vardasca and Francis Ring, November 2011.

years with full educational interventions, meaningful stories and reflections.

All this has meant a pleasure for me to meet him again, and expect his comments on presented projects or queries, which he analyzed with critically spirit and rare sense of humour, open, friendly, a good adviser, who provided tactful proposals combined with the wish to stimulate creativity.

Initially, I felt him like my father, close, open and honest, and everything was created in the special atmosphere in the meetings in Zakopane.

Thanks for sharing your knowledge and experience at meetings in Vienna, Zakopane, Mannheim, Porto, Bucharest and at the University of Glamorgan. Thank you Francis because I had the opportunity to be with you, to see, to reflect and to share your enthusiasm. I always enjoyed listening to you at our meetings in which you played a decisive role. For me, you are an important model and a landmark and more, you are wonderful, living history, which I hope, will persist for many years!

HAPPY BIRTHDAY!

Best Regards,  
ADRIANA

Prof. Dr. Adriana Sarah Nica  
Head of Rehabilitation Department,  
University of Medicine "Carol Davila"  
Bucharest, Romania

From Madrid, Spain

Dear Francis,

It has been an honour to be your friend for little period of your 80 years. I remember your visit to INEF Madrid and how you gave your best going up and down around the training centre... I would like to be as strong as you are when I am your age!

I hope that you keep on fit for many years and I am able to enjoy your friendship and knowledge about thermography and general wisdom for a long time.

Congratulations and best wishes.

Manuel

Prof Manuel Sillero PhD  
INEF, Madrid, Spain  
Board member of the EAT

From Porto, Portugal

Dear Francis,

We met personally in July of the year 2011 during the 1st practical course in medical thermography in Portugal. Your name was a constant on almost every article I read about

thermal imaging and I was very excited to finally meet you, one of the references in the field, and I was eager to listen to what you had to teach. Your talks were so engaging, the passion on your words was so inspiring that it seemed clear I was in the right place to learn about thermal imaging. You are one of the role models to new scientists in this field and as one of those who were captivated I congratulate you on your 80th birthday. I wish you a day filled with joy and a year that is all you could hope for. Please continue to inspire us as you have until this day.

Happy Birthday!!!

Adérito

Aderito Seixas Msc  
Universidade Fernando Pessoa  
Porto, Portugal  
Board member of the EAT

From Vienna, Austria

I would like to summarise the main messages from the congratulations above. It is obvious that Francis has friends of all ages, from the mid thirties to the eighties and they live all around the world. All agree that Francis' contributions to the development of clinical thermometry, particularly to infrared thermal imaging are enormous and a landmark and cornerstone for all users of this technique. All made the experience, that Francis is a gentle, friendly man who is always happy to help and share his knowledge. It is also clear, that Francis have a lot of other interests beyond thermography such as photography, astronomy, science history, travelling, music etc. Personally, I also have similar memories related to the skills, knowledge and friendship of Francis Ring. In the last 27 years, I had the privilege of meeting Francis annually on at least two occasions. It is always a pleasure to discuss and work with him, and becoming involved in plans of expanding the application field of infrared imaging in medicine. But my favourite in recent years is to play music together with Francis, him on the piano and me on the double-bass.

I wish you Francis all the best on your 80th anniversary and wish, selfish as in my congratulation 10 years ago, that many more birthdays will follow for you in good health and ongoing strong enthusiasm for thermology.

Very best wishes

Kurt

Prof Dr med Kurt Ammer PhD  
Editor of Thermology international  
Treasurer and lifetime honorary member of the EAT,  
Vienna, Austria

## 2016

17<sup>th</sup>–21<sup>th</sup> April 2016

Thermosense: Thermal Infrared Applications XXXVIII in Baltimore, Maryland, USA

*Venue:* Baltimore Convention Center

Thermosense is the oldest and largest international technical conference focused on scientific, industrial and general uses of infrared imaging, infrared temperature measurements, and image analysis. Its regular printed proceedings are found in most scientific and engineering libraries, providing an unequaled depth and breadth of technical information and reference data. Further information regarding Thermosense can be found at: [www.thermosense.org](http://www.thermosense.org) .

Thermal/infrared related papers are solicited in the areas listed below, and are also welcome in other areas.

Aerospace Applications

Automotive Industry

Building Applications

Calibration

Detection Of Gas And Other Leaks

Environmental And Agricultural Monitoring

Fiber Optics For Infrared

- Detection of hazardous chemicals
- Remote sensing in high temperature and corrosive environments
- Medical applications.

Fire Analysis And Detection

Food Processing And Handling

Infrastructure

IR Image Fusion Applications

- biological and medical
- field security
- process monitoring
- hyperspectral
- structural analysis.

Manufacturing And Processing Industries

Materials Evaluation And ndt

Medical

- health screening and diagnostics
- veterinary applications.

NDT (Nondestructive Testing)

Power Generation And Distribution

Research And Development

REMOTE SENSING AND SECURITY

Further information at <http://www.spie.org/Si110>

3<sup>th</sup>–4<sup>th</sup> July 2016

XX<sup>th</sup> Meeting of the Polish Society of Medical Thermography Combined with The European Association of Thermology at the University of Technology in Gdansk, Poland

All are warmly invited to a meeting at Gdansk University of Technology.

This is a special pre QIRT conference meeting.

Gdansk is an attractive historic city, situated on the north coast of Poland.

There are good connections from the airport to the city.

Registration fee of **700.-PLN** by bank transfer in advance includes

Welcome Sunday evening 3rd July

Scientific Sessions Monday 4th July

Accommodation (2 nights in Technical University residence) / meals registration.

*EARLY RESERVATION FOR ACCOMMODATION ESSENTIAL*

Bank account details will be announced EAT website

Abstract deadline for Polish/EAT meeting May 1st 2016

Send to Prof. Anna Jung...

4<sup>th</sup>–8<sup>th</sup> July, 2016

QIRT Conference 2016

Gdansk University of Technology Gdansk – Poland

Scope of the Quantitative InfraRed Thermography Conference:

State-of-the-art and evolution in the field of infrared scanners and imaging systems allowing quantitative measurements, and related data acquisition and storing systems.

Calibration and characterization of infrared cameras and related problems like certification, standardization, emissivity determination, absorption in media, spurious radiations, three dimensionality of observed objects.

Data reduction and image processing related to infrared thermography.

Application of infrared thermography to radiometry, thermometry, and physical parameters identification, in all fields: fluid mechanics, solid mechanics, structures and material sciences, non-destructive evaluations, electromagnetism, medicine and biomedical sciences, remote sensing, environment, industrial processes, etc.

Key dates:

- Abstract submission deadline: November 20, 2015
- Acceptance notification: February 15, 2016
- Paper submission deadline: April 30, 2016

## • Conference Fees

### Regular participants

- Early rate (deadline: May 20, 2016): **2600 PLN**
- Late rate (deadline: June 17, 2016): **3000 PLN**
- Very late registration before July 4: **3500 PLN**

### Students

- Early rate (deadline: May 20, 2016): **1600 PLN**
- Late rate (deadline: June 17, 2016): **1800 PLN**
- Very late registration before July 4: **2000 PLN**

### Accompanying persons

- Rate (deadline: June 27, 2016): **1000 PLN**

### Further information:

Prof. Nowakowski [antowak@biomed.eti.pg.gda.pl](mailto:antowak@biomed.eti.pg.gda.pl)

Biomedical Engineering Dpt. Electronics, Informatics and  
Telecommunication Faculty Narutowicza Str. 11/12  
80-233 Gdańsk Poland

Website : [www.qirt2016.gda.pl](http://www.qirt2016.gda.pl)

10<sup>th</sup>- 11<sup>th</sup> September 2016

Annual Scientific Session of the American Academy of Thermology (AAT) in Greenville, South Carolina.

A Pre-Meeting Physicians Member Certification Course will occur on September 9th.

A Pre-Meeting Technicians Member Certification Course will occur on September 8th.

### Further Information:

<http://aathermology.org/>



### Direct flights to Gdańsk



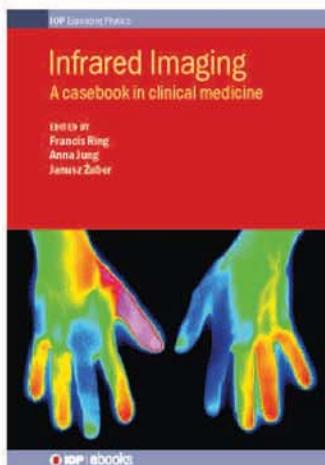
and many more via Warsaw.



# QIRT 2016



July 4-8, 2016



161pp

**ISBN** 978-0-750-31143-4 (electronic)

**ISBN** 978-0-750-31144-1 (print)

#### **Readership**

Practising and training radiographers, medical physicists and clinicians

#### **Key features**

Guide to correct use of the right technology and clinical case studies of applications in medicine. Built on real life case studies and latest imaging technology. Francis Ring is an acknowledged leader in the field.

# Infrared Imaging

A casebook in clinical medicine

#### **Edited by**

Francis Ring

Anna Jung

Janusz Źuber

#### **About the book**

Infrared thermal imaging is a rapid and non-invasive procedure for mapping skin temperature distribution of the human body. Advanced software and high-resolution infrared detectors has allowed for a renaissance in the use of infrared thermal imaging or thermography in medical research and practice. After a review of theory, technology and methodology of medical infrared imaging, the remainder of the book consists of a collection of clinical case studies demonstrating the wide variety of applications of thermography in modern medicine. The combined expertise from a number of centres is used to create this database of images and cases that will be invaluable for medical researchers and practitioners in making diagnoses and measuring treatment efficacy. This book is recommended reading for practising and training radiographers, medical physicists and clinicians.

#### **About the editors**

Francis Ring is a pharmacologist and clinical scientist with 50 years' experience in quantitative infrared thermal imaging in medicine. He currently leads the Medical Imaging research Group at the Faculty of Advanced Technology, University of Glamorgan, UK, and has published more than 300 papers in this area. Anna Jung is Professor of Paediatrics and Nephrology at the Military Institute of Medicine in Warsaw, Poland and is experienced in the application of thermographic methods in paediatric diagnostics and has twice served as the President of the European Association of Thermology. Janusz Źuber is a specialist physician in allergic medicine at the Military Institute of Medicine in Warsaw, Poland, with many years' experience of applications of thermography and thermovision in allergology and other branches in medical diagnostics.