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Improving body temperature measurement on a global basis

Medical Thermology 2020 -a literature survey with a focus on applications in the COVID19 pandemic

Immediate effect of a single cycle ergometry session on skin temperature of women with and without varicose veins: a case report

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[1] International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. Medical Education 1999; 33; 066-078

[2] www.consort-statement.org

[3]www.strobe-statement.org

[4]www.prisma-statement.org

[5] www.stard-statement.org

[6] www.care-statement.org

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Improving body temperature measurement on a global basis

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SUMMARY

The Covid-19 pandemic has brought into the spotlight something of which clinicians have been aware for some time, namely the general unreliability of body temperature measurement in health services and in public health settings more widely such as fever screening. This situation is being addressed by a multipronged initiative led by the International Bureau of Weights and Measures (BIPM) Consultative Committee for Thermometry (CCT). A Task Group on Body Temperature Measurement (TG-BTM) has been established whose aim is to improve body temperature measurement on a global basis. This paper gives the background to the issues surrounding poor body temperature measurement and introduces the activities undertaken by the task group to improve the situation

KEY WORDS: body temperature, thermometry, task group, action plan

ZUR WELTWEITEN VERBESSERUNG DER MESSUNG VON KÖRPERTEMPERATUREN

Die Covid-19-Pandemie hat etwas ins Rampenlicht gerückt, von dem Ärzte seit einiger Zeit wissen, nämlich die allgemeine Unzuverlässigkeit der Körpertemperaturmessung in der Gesundheitsversorgung und darüber hinaus auch im Gesundheitswesen zum Bespiel beim Screening nach Fieber. Diese Situation wird durch eine mehrgleisige Initiative unter der Leitung des Beratenden Ausschusses für Thermometrie (CCT) des Internationalen Büros für Gewichte und Maßnahmen (BIPM) angegangen. Es wurde eine Arbeitsgruppe zur Messung der Körpertemperatur (TG-BTM) eingerichtet, deren Ziel es ist, die Körpertemperaturmessung auf weltweit zu verbessern. Diese Artikel liefert Hintergrundinformationen über die Bedingungen unzulänglicher Ergebnisse der Körpertemperaturmessung dar und stellt die Aktivitäten der Arbeitsgruppe zur Verbesserung der Situation vor.

SCHLÜSSELWÖRTER: Körpertemperatur, Thermometrie, Aufgabengruppe, Aktionsplan

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Introduction

The issue of poor body temperature measurement has been known for some time. The recent papers by Crawford [1], Bolton et al. [2] and letter by Aw [3] are but examples of the distrust with which clinicians hold some types of electronic infra-red (IR) based clinical thermometers. Independent laboratory testing of clinical forehead/skin thermometers has also yielded disappointing results [4], despite the thermometers under test being approved for clinical use in Europe.

The Covid-19 pandemic has brought this issue more sharply into focus because poor body temperature measurement leads to poor detection of febrile individuals. In the early stages of the Covid-19 pandemic it was likely that people with a fever, brought on by a Covid-19 infection, were not diagnosed correctly allowing the disease to spread more quickly than it would otherwise have done. Similarly, IR temperature screening for fevers used at points of entry (e.g. into a country, retirement homes etc.) were potentially largely ineffective both due to the poor performance of the devices in use and the modality of operation.

The rise in poor body temperature measurement has coincided with the replacement of mercury (and other liquid-in-glass type) thermometers by an array of electronic thermometers which operate in different ways and measure temperature at different body sites. These electronic devices are, in general, less robust from a measurement perspective than their predecessors. In the work described here we focus on infra-red based devices, which are tympanic (ear) and forehead thermometers and thermal imagers.

The way the devices are used, and the measurement sites are both potential sources of uncertainty in the measurement. Certainly, none of the sites (ear, face/forehead) directly reflect core body temperature [5]), the optimum site for which is generally regarded as the temperature of pulmonary artery blood [6]. Each site, and indeed each thermometer modality, presents particular challenges for reliable body temperature measurement [7, 8, 9]

In response to this issue the Consultative Committee for Thermometry (CCT, a Consultative Committee of the International Committee of Weights and Measures (CIPM), which is ultimately responsible for the realisation and dissemination of the International System of Units (SI) on a global basis), which is made up of leading temperature metrologists from around the world, decided in June 2020, to establish a Task Group for Body Temperature Measurement (TG-BTM). The overall objective of the TG-BTM is to establish reliable clinical thermometry on a global basis and whose initial focus will be to improve infra-red methods of body temperature measurement (ear, forehead, thermal imager). The TG was formed though experts from the CCT volunteering their experience and time, the sub-TG chairs (see following section) were appointed because of their deep background knowledge and experience in the field of their sub-TG activities [10].

Here we describe the main activities of the Task Group and how they will address many of the current challenges posed by using IR based techniques for body temperature measurement. We then give a forward look at the TG outcomes over the next few years.

Key objectives of the CCT TG-BTM

The TG-BTM is organised into five sub-groups. This allows focus on particular issues facilitating rapid progress with the TG's overall objective. The five sub-group activities are:

- Lead a global comparison of calibrators for infra-red body temperature thermometers (ear/forehead/thermal imagers)
- Collect current best practice/standards of body temperature thermal imaging in a) health services b) screening situations around the world, and develop best practice recommendations
- Collect current best practice of infra-red body temperature measurement (ear, forehead) and develop best practice recommendations
- Review standards and work with appropriate standardisation bodies (e.g. ISO/IEC) concerned with producing standards for body temperature measurement devices
- Establish metrology, medical and manufacturer forums within the metrology regions to identify the problems with the current approaches to body temperature measurement and develop practical solutions and establish appropriate links to the World Health Organisation.

Note metrology is organised globally according to region and is supervised by Regional Metrology Organisations (RMOs). Within Europe metrology is supervised by the European Association of National Metrology Institutes (EURAMET).

Each of these activities will be described in more detail below.

Lead a global comparison of calibrators for infra-red body temperature thermometers (ear/forehead/thermal imagers)

Only limited comparisons of ear thermometer calibrators have been performed in the past [e.g. 11]. The purpose of this comparison is to demonstrate that the fundamental blackbody calibration standards held in the National Measurement Institutes (NMIs) around the world, for calibrating these thermometers, are consistent. This will establish a sound metrological platform for body temperature measurement on a global basis, demonstrably traceable to the International Temperature Scale of 1990 (ITS-90) [12] and by ensuring that the NMI calibration standards are internationally validated through an objective rigorous comparison. The ITS-90 is the globally recognised, realised and disseminated temperature scale established by international agreement. More information on the ITS-90 can be found at: https://www.bipm.org/en/committees/cc/cct/publications-cc.html. The first comparison will be in the period from Spring 2021 to Spring 2023 and will involve blackbody calibrators for infra-red ear and forehead thermometers. This will be followed in 2023-2026 with a comparison of blackbody calibrators for thermal imagers.

Blackbodies of temperatures known only to the comparison pilot and co-pilots will be circulated to the participating NMIs for calibration, namely measurement of their infrared radiance temperature. The comparisons will thus assess and verify the calibration capabilities of the participating NMIs.

Typically, the temperature uncertainty associated with the calibration of a blackbody source under test includes the following components: the contact thermometry techniques and standards used to determine the reference blackbody (that is the blackbody held by the NMI used for calibrating clinical thermometers) temperature; the emissivity and temperature uniformity of the reference blackbody; the radiance temperature scale realized by the reference blackbody and the techniques used to determine the infrared radiance temperature difference between the reference and the test (i.e. the circulated) blackbody. .

To reach the objectives of the comparison in the short timeframe,

- the **pilot laboratory**, the National Institute of Measurement (NIM, China) from the Asia-Pacific Metrology Programme (APMP, http://www.apmpweb.org/) region

will cooperate with three **co-pilot NMIs**

- the Physikalisch-Technische Bundesanstalt (PTB, Germany) from the European Association of National Metrology Institutes (EURAMET, https://www.euramet.org/) region,
- the National Research Council (NRC, Canada), from the Inter-American Metrology System (SIM, https://sim-metrologia.org/) region, and
- the D.I. Mendeleev All-Russian Institute for Metrology (VNIIM, Russia) from Euro-Asian Cooperation of National Metrological Institutions (COOMET, http://www.coomet.net) region.

The comparison will be conducted as a STAR-type among the participating RMOs, and as a round-robin type during the comparison within each region. The National Measurement Institute of South Africa (NMISA) will join the APMP loop since there are no other NMIs in the Intra-Africa Metrology System (AFRIMET) region that can join the comparison.

The pilot will prepare, in discussion with the participants, a common comparison protocol. This is necessary to ensure that all the measurements are performed in a uniform way around the world and so facilitating a reliable assessment of measurement capability in each participating institute.

Each co-pilot will prepare and test a set of transfer blackbodies for ear and forehead thermometers calibration (these will of 'unknown temperature' to the participants). These transfer blackbodies will be calibrated by the co-pilot before dispatch to the coordinating pilot laboratory (NIM, China). After all the transfer blackbodies are calibrated at the pilot institute (to provide the essential linkage for the comparison), they will be returned to the co-pilot who will then lead the comparison, among the participants, in their respective RMO. Each co-pilot will then prepare a report describing the comparison process, the equipment used, the results and uncertainties. These reports will then be sent to the pilot laboratory who will compile the reports into the final comparison report after all the measurements are completed. It is intended that the measurements will be complete by Spring 2023 and the comparison reported and completed by end 2023.

Collect current best practice/standards of body temperature thermal imaging in a) health services b) screening situations around the world, and develop best practice recommendations

This sub-group will collect current best practice and standards for body temperature measurement with thermal imagers either in health services (hospitals, health care units) or other entry points (airports, ports, borders, companies, retirement homes, education units, etc.) from around the world.

Given the current state of technology and practice of thermal imaging, thermal imagers should be used only for initial screening purposes, that is for the identification of potentially febrile individuals. A subsequent measurement using a recognised clinical thermometer would then need to be used to confirm either that the individual actually has an elevated temperature or that the thermal imager has made a false positive identification.

We note here that there is an IEC standard for body temperature screening, primarily intended to support febrile subject identification in for e.g. airports: IEC80601-2-59: "*Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening*" and an ISO standard ISO/TR 13154:2017 "*Medical electrical equipment - Deployment, implementation and operational guidelines for identifying febrile humans using a screening thermograph*", though they are not currently widely followed.

After analysis of these and other existing documents the sub-group will develop a best practice guide for body temperature screening with thermal imagers which will consist of a description of the thermal imaging technology, its advantages and limitations, and a description of test and calibration methods for thermal imagers to verify their technical specifications, especially the measurement accuracy and the measurement uncertainty in laboratory conditions. In the best practice guide recommendations will be given on the optimal body temperature measurement procedures in different circumstances (mass temperature screening or individual measurement) with an analysis of related influence parameters which either increase or decrease the measurement uncertainty in different practical situations. In all cases the objective is to guide the user to perform **reliable**, **accurate** and **traceable** (to National Measurement Standards) body temperature screening when using thermal imagers. Note that the issue of body temperature measurement, how it is defined and measured is a topic beyond the scope of this paper. The interested reader is referred, as a starting point, to [9] and references therein.

At the outset of the sub-group's investigations it was clear that the quality of a temperature measurement by a thermal imager is defined by much more than just the uncertainty specified by the manufacturer of the device. The manufacturer's specifications in general do not cover the particular circumstances associated with real measurement conditions. As a result, thermal imagers measure the temperature of different objects with widely different uncertainties and reliability dependent upon the specific measurement conditions. Low uncertainty temperature measurements require a good understanding of both the measurement instrumentation and the entire measurement process.

One final important activity of this sub-group is to identify open questions with regard to using thermal imagers for reliable body temperature measurement and to propose research activities aimed at addressing the identified deficiencies.

Collect current best practice of infra-red body temperature measurement (ear, forehead) and develop best practice recommendations

This sub-group will collect current best practice, standards and research published for body temperature measurement by infrared thermometry [13, 14] such as ear/tympanic and forehead/temporal artery thermometers(IRET and IRFT).

With this information, practical guidance for using IRET and IRFT for body temperature measurement will be prepared with the focus on the conditions of use and the uncertainties associated with using the devices. The aim of the guidance is to give users a comparative study of the two different approaches for measuring body temperature including an indication of achievable measurement uncertainty with the different devices.

To be specific the main sources of uncertainty related to the use of the IRET are: device resolution, repeatability, misalignment (positioning of the thermometer relative to the ear canal), ambient conditions, obstruction in the ear canal, influence of the probe cover (dispersion of the radiation on the non-ideal surface of a probe cover), heating of the thermometer when held in the hand or by the heat flux of a local heat source and drift in use (a periodic calibration is needed to minimise this effect and so maintain the accuracy of the thermometer).

Less information is available in relation to estimating the uncertainty in using the IRFT, but unless used in very carefully controlled conditions the uncertainty is likely to be significantly larger than for IRETs. The main sources of uncertainty in use for IRFTs are: device resolution, repeatability, size of source effect (note that forehead thermometers should be used as close as possible to the skin surface to achieve a minimum spot size from which a measurement is taken), distance effect (this is related with the previous one because increasing the distance means that the measurement region (forehead) will appear smaller to the thermometer), ambient conditions (solar radiation, wind, extreme ambient conditions (e.g. exposure to sub-zero temperatures immediately prior to measurement), air conditioning, heaters etc), skin emissivity (the actual emissivity of the skin has been reported to be in the range 0.99- 0.94 and this influences the measurement outcome), influence of the probe cover (this only affects temporal artery versions of IRFT), heating of the thermometer when held in the hand or by the heat flux from the target, thermal homogeneity of the measured area (differences between temperatures measured at different points of the forehead) and drift (a periodic calibration is needed to minimise this effect and so maintain the accuracy of the thermometer). In addition, the correlation between forehead temperatures and core body temperature has not been definitively established by traceable thermometry and so any correction to the device reading in order to provide equivalent body temperature will also introduce additional uncertainty. It must be stressed that this is a preliminary list of uncertainty components and may well be modified after discussion with other experts in the field, especially clinicians and clinical scientists.

After developing the draft best practice guides there will be consultations with clinical users and short form versions will be prepared for use by the medical community. In addition, the sub-group plans to prepare training materials for use by non-metrology specialists.

Review standards and work with appropriate standardisation bodies (e.g. ISO/IEC) concerned with producing standards for body temperature measurement devices

This sub-group aims to study the current situation with regard to international standardisation of non-contact clinical thermometers, to identify deficiencies (particularly in regard to their metrological characterisation) in those current international standards. The focus of the sub-group will be on ear/tympanic and, in particular, forehead clinical thermometers.

Due to the steep rise in demand for body temperature measurement induced by Covid-19, a very wide variety of forehead thermometers are being used in many countries. Many of them are not clinical thermometers but are simply the same as those used for general industrial temperature measurement applications. Even for those forehead clinical thermometers that claim conformance to international standards, the conformity is mainly to the laboratory performance validation only. This is because the current standards either do not require clinical accuracy validation or the specified clinical validation is not sufficient to cover the need i.e. is insufficient to demonstrate that reliable body temperature measurement is possible with the devices. For example, to obtain the body temperature through measurement of the forehead skin temperature, an empirical correlation between the forehead skin temperature and the body core temperature is built into the forehead thermometer. Currently this correlation is established by each manufacturer rather than by international consensus, and indeed may well lack the metrological traceability such an important correction merits.

In addition, and importantly, the forehead is an unsuitable body site for patient triaging (one-off measurement against a temperature threshold). This is because the forehead skin temperature is affected by a person's physical conditions such as sweating and makeup, and the surrounding environmental conditions such as air-conditioning and hot or cold weather, all of which can seriously affect the reliability of the measurement. As far as we are aware no clinical study quantifying the effect these have on the thermometer reading has currently been performed. It is, however, clear that forehead thermometers, at least for spot temperature measurements in an uncontrolled environment, are likely to be unreliable by as much as several degrees Celsius.

The sub-group will work together with standards committees and working groups to address these issues, and work towards both reviewing and updating the relevant international standards for body temperature measurement.

Establish metrology, medical and manufacturer forums within the metrology regions to identify the problems with the current approaches to body temperature measurement and develop practical solutions and establish appropriate links to the World Health Organisation

To facilitate an effective two-way communication with the communities interested in medical thermometry it was decided to establish regional stakeholder forums. The objective of these forums is, in the first place, to collect useful information about the current practice on the manufacturing, calibration and use of the different equipment used to measure body temperature. An on-line survey [15] has been developed with different technical questions mainly addressed to manufacturers and users. They are asked about factors such as their use of international or national standards in the manufacture and use of the medical thermometry equipment, the calibration procedures, calibration interval, etc.

The collated information will provide a picture of the status of the current practice of body temperature measurement around the globe and will give an idea of the real implementation of the international and national standards now in force. Furthermore, it could be used in the development of the practical guides by the sub-groups previously described.

The members of the stakeholder forums will also be informed of the development of the Task Group activities and the progress of the practical guides. In the longer-term engagement will be established with the World Health Organisation through the International Committee for Weights and Measures (CIPM) in order to inform it about the issues related to IR thermometry in public health and the steps required to improve the situation.

Outlook to 2025

The sub-groups will aim to deliver their objectives by 2024/25.

The comparison of IR thermometer calibrators is planned to start in Spring 2021 with the measurements completed by Spring 2023. Following this first global comparison there will be a second round of comparisons led by the Technical Committees for Thermometry of the individual RMOs. This will ensure that the clinical thermometer standards for ear and forehead thermometers of all the NMIs have been validated, via international comparisons by the mid-2020s.

The sub-group producing Good Practice Guides (GPGs) for ear and forehead thermometry aims to issue their first draft guidance by Spring 2021. This then will go out for consultation with the medical and other relevant user community for feedback by, at the latest, Autumn 2021. Final versions of the GPGs will be issued by Spring 2022. The GPGs for thermal imagers for body temperature scanning will follow a similar track but probably about 3 months later.

The aim of involving the medical community is to ensure that the guides are fit for purpose for use by clinicians whilst remaining metrologically sound. All-important estimates of likely and best uncertainties by the three techniques (ear/tympanic thermometers, forehead thermometers and thermal imagers) will also be given. Finally, open issues relating to the use of the different devices for body temperature measurement will be identified with the aim of stimulating targeted research.

Work is already underway to revise the clinical thermometer standards. The aim is to have sufficient and better high-quality metrology input into the new standard/s so that there is greater appreciation of the background operation of the devices and how that impacts the measurement and attainable uncertainty. It is hoped that the standards committee activity would be complete by end 2023 with, in particular, better differentiated standardisation for both ear and clinical forehead thermometers.

The user forum survey was launched at the end of August 2020 and the responses are beginning to arrive. Europe and South America are the most reactive regions, and the majority of the respondents are clinical users or calibration laboratories.

The preliminary findings show that not all manufacturers design and construct their equipment according to national or international standards, but almost all offer calibration of their products and recommend calibration periods. A clear majority of the users calibrate their instruments annually, in most cases according to internal procedures, though it is not clear whether their internal standards are ISO17025 accredited and so fit for purpose. As more responses come in further conclusions will be drawn.

Summary

The issue of poor body temperature measurement has come to the fore because of the Covid-19 pandemic, although clinicians have been aware of it for some time. Through coordination of global activity through the CCT TG for BTM it is clear that significant improvements can be made in a relatively short time frame. The work of the TG-BTM reported in this paper is only just beginning but is anticipated to deliver significant and long-lasting benefits for body temperature measurement in the years, indeed decades, to come around the world.

Acknowledgements

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Immediate effect of a single cycle ergometry session on skin temperature of women with and without varicose veins: a case report

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SUMMARY

BACKGROUND: Vascular diseases such as varicose veins can affect the distribution of skin temperature, and thermography can be a useful way to capture this. The aim of this case report is to show the changes in skin temperature induced by bicycling and to evaluate the thermal symmetry before and after physical activity in two women, one with and the other without varicose veins.

MATERIALS AND METHODS: Two women, one with varicose veins (subject 1) and a healthy volunteer (subject 2), were examined before and after a single session of one-hour lasting cycle ergometry. They were assessed by a FLIR T650sc infrared camera before, immediately after and 15 minutes after the session. Total body thermograms were taken with subjects 4 meters away from the camera, in anterior and posterior views, and 6 regions of interest (ROIs) were defined.

RESULTS: Subject 2, who used to exercise regularly, exhibited similar temperature values in the evaluated ROIs of the right and left body sides. In the subject 2, a more pronounced thermal symmetry was observed than in the subject 1 at all examination moments. In both individuals, the degree of thermal symmetry was not affected by cycling.

CONCLUSION: Varicose veins are associated with moderate thermal asymmetry, while the lower extremities of a healthy person appeared thermally symmetric. Both distribution patterns of skin temperature were not affected by single session of cycling exercise.

KEYWORDS: infrared thermography, varicose veins, exercise, case report

UNMITTELBARE WIRKUNG EINER EINZIGEN FAHRRAD-ERGOMETRIE-SITZUNG AUF DIE HAUT-TEMPERATUR VON FRAUEN MIT UND OHNE KRAMPFADERN: EIN FALLBERICHT.

HINTERGRUND: Gefäßerkrankungen wie Krampfadern können die Verteilung der Hauttemperatur beeinflussen, und die Thermographie kann eine nützliche Methode sein, um dies zu erfassen. Ziel dieses Fallberichts ist es, die durch Fahrradfahren induzierten Veränderungen der Hauttemperatur aufzuzeigen und die thermische Symmetrie vor und nach körperlicher Betätigung bei zwei Frauen zu bewerten, eine von ihnen mit und die andere ohne Krampfadern.

MATERIALIEN UND METHODEN: Zwei Frauen, eine mit Krampfadern (Probandin 1) und eine gesunde Freiwillige (Probandin 2), wurden vor und nach einer einzigen, eine Stunde dauernden Sitzung auf einem Fahrradergometer begutachtet. Sie wurden mit einer FLIR T650sc Infrarotkamera vor, unmittelbar nach und 15 Minuten nach der Sitzung untersucht. In einer Ansicht von vorne und von hinten wurden im Abstand von 4 Metern zur Kamera Ganzkörper-Thermogramme der Probanden aufgenommen, und 6 Messbereiche (ROIs) wurden definiert.

ERGEBNISSE: Die Probandin 2, die regelmäßig trainierte, bot in den ausgewerteten Messbereichen der rechten und der linken Körperseite ähnliche Temperaturwerte. Bei der Probandin 2 wurde bei allen Untersuchungszeitpunkten eine ausgeprägtere thermische Symmetrie beobachtet als bei der Probandin 1. Bei beiden Personen wurde der Grad der thermischen Symmetrie w durch das Radfahren nicht beeinflusst.

SCHLUSSFOLGERUNG: Krampfadern sind mit einer moderaten thermischen Asymmetrie verbunden, während die unteren Extremitäten einer gesunden Person thermisch symmetrisch erschienen. Beide Verteilungsmuster der Hauttemperatur wurden durch ein einmaliges Training auf einem Fahrradergometer nicht beeinflusst.

SCHLÜSSELWÖRTER: Infrarotthermografie, Varikositas, Training, Fallbericht

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Introduction

Thermoregulation is a mechanism responsible for the maintenance of core body temperature within a narrow range. Internal and external processes are involved in heat gain and heat dissipation and skin circulation has an important role as a barrier with variable thermal resistence. Adjustments between sympathetic noradrenergic vasoconstrictor system and sympathetic active vasodilator system control the rate of cutaneous blood flow and thereby the initial thermoregulatory responses. However, blood supply follow primarily nutritive demands, and thermoregulation comes second. Controlling the width of vascular beds is influenced by several factors, such as position, age, hydration level, hormonal status (progesterone and estrogen), physical exercise, and the existence of clinical conditions (e.g., diabetes, hypertension and cardiac insufficiency) [1,2] with different effect size in thermoregulation and nutrition. Skin is the interface between between the thermal body and the environment, contributing much to heat exchange necessary maintaining the central body temperature in a normal range (36.1-37.8°C) an important condition for preserving vital functions of human body [3].

During physical exercise there is an increase in metabolism and, consequently, an increase in internal temperature. Exercising is generating a redistribution of blood supply in favour of the working skeletal muscles [4].

An aspect that interferes with local blood circulation is the presence of venous reflux, a sign of chronic venous disease. It's a common condition affecting up to 25% of women and 15% of men in its early stages [5].

This venous reflux is usually the cause of varicose veins, reticular veins and telangiectasia. Mild cases may cause leg discomfort or aesthetic issues, but severe situations may lead to swelling and eventually to ulcer formation. Some of the risk factors are: family history, gender (female), advanced age, multiple pregnancies, standing for long periods, obesity and history of deep venous thrombosis. Varicose veins are affected by activity and lifestyle. Some conservative options to treat this condition are the use of compressive socks, analgesics, lower limb elevation, and exercise. In some cases, endovascular surgery is needed [5,6].

Successful applications of thermography as a diagnostic technique was reported for several clinical conditions including breast cancer, diabetic neuropathy, gynecological, skin, and cardiac diseases, and vascular problems among other [7]. Preliminary data from a small case series suggest that the thermal imaging technique is an effective technique for detecting small temperature changes in the human skin due to vascular disorders [8]

Thermography is a contactless method that allows the quantification of skin temperature and, to the best of our knowledge, there are no studies using thermography as a method to evaluate the change in skin temperature after one hour of active cycle ergometry in persons with varicose veins. It is important to acknowledge how skin temperature distribution behaves in these cases after such an exercise. Therefore, the aim of this case report is to assess skin temperature changes induced by an exercise session and to assess thermal symmetry before and after a single session of active cycling ergometry in two women, with and without varicose veins.

Case presentation

Subject 1

A Caucasian female, 33 years, 73.3 kilograms, 1.73m high, body mass index (BMI) of 25.51 kg/m², reported the presence of varicose veins for 10 years. A Colour Doppler Ultrasound performed in 12/01/2016 showed insufficient tributaries, reticular and perforator veins bilaterally. The mainly affected regions were the posterior thigh and leg. The woman reported a history of lower limb sclerotherapy in November 2017, and experienced frequently pain and discomfort, although these symptoms absent at the assessment day. When asked about physical activity practice, she reported a sedentary behaviour.

Subject 2

Caucasian female, 38 years, 59.1 kilograms, 1.68 m high, body mass index (BMI) of 20.94 kg/m². She reported good health and absence of pain or disease and regularly exercised 4 times per week for about 15 years.

Evaluation

After agreeing to the evaluation, the subjects were submitted on the same day to a thermography assessment and to a single 60-minute cycle ergometer session.

The evaluation was conducted in the Thermography Laboratory of the Instituto de Medicina Física e de Reabilitação (IMREA) do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (HCFMUSP). As this evaluation must follow standardized procedures, conditions and actions described in the literature were applied [4,9-13].

Subjects were instructed to stand upon on a mark on the floor, 4m away from the infrared camera and 0.4m away from the wall. Volunteers remained standing in the same position during the image capture protocol.

Subjects were instructed not to perform movements with arms or legs, or to scratch any region of the body before and during the procedure. Subjects were advised not to take hot baths or showers, spread creams or powder, to not exercise, to not take in stimulants, beverages containing alcohol or caffeine, not to use nasal decongestants and not to smoke 2h before the assessment [9,11,13]. Volunteers were asked to keep their lower limb areas exposed to room temperature for a 15-minute acclimation period. The temperature of the examination room was 22.1°C with 51% humidity.

Thermograms were captured using a FLIR T650sc infrared device, with a sensor array size of 640x480 pixels, at a frequency of 30Hz. Its sensor can collect images with a range of temperature from -40ºC to 70ºC, with precision of 1%, and a spectral band of 7,4 - 14 μm, Noise Equivalent Temperature Difference (NETD) <20mK. The skin emissivity was set to 0.98.

The camera was previously switched on for image and temperature stabilization fifteen minutes before data collection, was positioned perpendicularly to the subjects and thermograms were captured in both anterior and posterior views. The images were analysed with the software FLIR Tools®. Average temperature was measured in Celsius (ºC) in each region of interest (ROI). ROIs were rectangles determined by the following anatomical reference sites (figures 1-4): 1- hand: the junction of the 3rd metacarpal with the proximal phalanx and the ulnar styloid process, 2- forearm: the distal forearm and the cubital fossa, 3- arm: the cubital fossa and axillary line, 4- thigh: 5 cm above the superior border of the patella and the inguinal line, 5- knee and

6- leg: 5 cm below the inferior border of the patella and 10 cm above the malleolus [9,13,14].

Thermograms were obtained in the morning, before, immediately after and 15 minutes after the cycle ergometer session.

Exercise protocol

The cycle ergometry session was performed using a lower limb cycle ergometer (Movement - Model MD300C1) and an Oximeter (Pulse Oximeter), a heart rate device (Polar T31) and a Sphygmomanometer (Omron HEM-7200) were used to monitor vital signs.

The lower limb cycle ergometry protocol was conducted at 80% of maximum heart rate. After estimating maximum heart rate (HR_{max}) using the formula HR_{max} = 220 - age (187 beats per minute [bpm] for subject 1 and 182 bpm for subject 2), it was determined that subjects 1 and 2 should keep HR between 131-150 bpm and 127-146 bpm, respectively.

Both volunteers completed a 60-minute cycle ergometer session. Blood pressure was assessed before and after the exercise and perceived exertion was assessed at every 15 minutes with the Borg Scale [15]. Peripheral oxygen saturation and HR were registered before, at each 15 minutes during exercise, and after it, as shown in table 1.

Tables 2 and 3 report the subjects' skin temperature before, after and 15 minutes after the exercise session. Figures 1- 4 illustrate skin temperature distribution in anterior and posterior views of both subjects at each assessment period.

Table 1.
General data of the volunteers: 1- (varicose veins) 2- healthy

	Volunteer 1	**Volunteer 2**
BP initial	118/75 mmHg	108/71 mmHg
HR initial	77 bpm	80 bpm
Initial Saturation	99%	98%
HR 15’	123 bpm	141 bpm
BORG 15’	13	11
Saturation 15’	98%	97%
HR 30’	135 bpm	143 bpm
BORG 30’	13	11
Saturation 30’	98%	98%
HR 45’	137 bpm	141 bpm
BORG 45’	13	11
Saturation 45’	98%	97%
HR 60’	142 bpm	143 bpm
BORG 60’	13	11
Saturation 60’	98%	97%
Final BP	124/83 mmHg	111/75 mmHg
Final HR	98 bpm	107 bpm
Final Saturation	98%	98%
Total distance	30,3 km	33 km

BP- blood pressure, mmHg – millimeters of mercury,
HR- heart rate, bpm– beats per minute

Discussion

Thhis case report showed that the healthy subject, who reported practicing physical exercise regularly and having no comorbidities, exhibited a higher degree of skin temperature similarity between contralateral corresponding ROIs. The average difference between the right and left hemispheres was 0.06°C in the upper limbs and 0.18°C in the lower limbs, suggesting that, in a healthy person, the difference between skin temperature in opposite body sides are close to 0°C [13,16]. However, the woman with the history of varicose veins, presented a difference of 0.43°C in the mean temperatures of the upper limbs and of 0.58°C in the lower limbs. Literature suggests that a difference between the right and left hemispheres of the body higher than 0.5°C is suggestive of an abnormality [17]. The proband 1 presents with a venous disturbance, which interferes with normal skin temperature distribution, and may explain these findings.

It is well established that physical exercise is an approach to prevent and treat chronic vascular diseases. Exercise improves the vascular system function, especially the venous return [18].

Walking is considered an effective physical activity, as it activates posterior thigh and calf muscles which helps the venous return and the metatarsal phalanges joint mobilization [19,20]. However, in this study a cycle ergometer was chosen because it is the type of exercise that is frequently used in temperature assessment [21]. Reviewing the studies about physical exercise and skin temperature assessed with thermography [21] it was noted that in most of them a cycle ergometer was employed. A skin temperature decrease is expected during and immediately after the exercise because blood is directed to active muscles, and a cutaneous vasoconstriction is observed [21]. In the present case report, the temperature was measured before and after a single session of cycle ergometry. Data revealed that in the healthy subject (subject 2), the mean temperature in all ROIs was 30.8 ± 1.0°C before exercise, 29.8 ± 1.1°C immediately after the exercise and 30.3 ±0.7°C 15 minutes after the exercise. The ROIs average difference between body hemispheres was 0.1°C before, 0.2°C immediately after and 0.2°C 15 minutes after the exercise. A decrease in temperature of about 1°C was observed immediately after the exercise, and after 15 minutes, skin temperature tended to return to basal values. However, in the subject with history of varicose veins (subject 1), this pattern was not observed. The baseline skin temperature value was 29.3°C, increasing to 30.4°C immediately after the exercise and to 30.7°C 15 minutes after the exercise. The average difference between body sides was 0.5°C before, 0.7°C immediately after and 0.6°C after 15 minutes.

The distinct skin temperature pattern described in subject 1 could be interpreted that adjustment vasoconstriction may be ineffective in this subject. However, skin temperature is not the target of thermoregulation and varicose veins are not involved in the thermoregulatory response

Table 2
Distribution of body temperature between the sides before. after and 15 minutes after a physical exercise session on an active lower limb cycle ergometer of voluntary bicycle- volunteer 1 (varicose veins) R-right. L- Left. values in °C

		Pre-exercise	Side to side difference	Immediately post exercise	Side to side difference	15 min post exercise	Side to side difference
Anterior View	Hand R	26.3	0.9	30.1	1.2	30.6	0.3
	Hand L	25.4		31.3		30.9	
	Forearm R	30	0.8	28.8	1.5	30.8	0.7
	Forearm L	29.2		30.3		31.5	
	Arm R	30.9	0.3	30	0.5	30.7	0.6
	Arm L	31.2		30.5		31.3	
	Thigh R	29.6	0.9	31.6	1.3	30.6	1.3
	Thigh L	30.5		32.9		31.9	
	Knee R	29.4	1.1	31.6	0.8	31.3	1
	Knee L	30.5		32.4		32.3	
	Leg R	29.5	0.6	29.4	0.9	29.7	0.6
	Leg L	30.1		30.3		30.3	
Posterior View	Hand R	25.9	0.1	29.5	0.8	30.3	0.6
	Hand L	25.8		30.3		30.9	
	Forearm R	31.6	0.1	30.5	0.7	30.9	0.4
	Forearm L	31.5		31.2		31.3	
	Arm R	28.3	0.4	28.8	0	28.8	0.1
	Arm L	28.7		28.8		28.9	
	Thigh R	30.8	0.3	30.9	0	31.4	0.5
	Thigh L	30.5		30.9		30.9	
	Leg R	29.3	0.2	29.2	0.4	29.4	0.2
	Leg L	29.1		29.6		29.6	

Table 3
Distribution of body temperature between the sides before. after and 15 minutes after a physical exercise session on an active lower limb cycle ergometer of voluntary bicycle- volunteer 2 (healthy): R-right. L- Left. values in °C

		Pre-exercise	Side to side difference	Immediately post exercise	Side to side difference	15 min post exercise	Side to side difference
Anterior view	Hand R	30.3	0	31.8	0.1	30	0.2
	Hand L	30.3		31.9		30.2	
	Forearm R	31.4	0	29.5	0	30.5	0.0
	Forearm L	31.4		29.5		30.6	
	Arm R	32.9	0.1	30.3	0.1	31.7	0.4
	Arm L	33		30.2		31.3	
	Thigh R	30.3	0.1	30.7	0	30.7	0
	Thigh L	30.2		30.7		30.7	
	Knee R	29.8	0	29.6	0	30.2	0.1
	Knee L	29.8		29.6		30.1	
	Leg R	31.3	0.1	29.6	0.4	30.5	0.2
	Leg L	31.2		30		30.7	
Posterior view	Hand R	29.2	0.2	30.3	0.2	30.1	0.1
	Hand L	29.4		30.1		30.2	
	Forearm R	31.9	0.1	30	0.1	31.1	0.2
	Forearm L	32		29.9		30.9	
	Arm R	29.9	0	27	0.8	29	0.2
	Arm L	29.9		27.8		29.2	
	Thigh R	31.3	0.5	29.1	0.4	30.1	0.3
	Thigh L	30.8		29.5		30.4	
	Leg R	30.2	0.4	28.8	0.6	29.3	0.4
	Leg L	30.6		29.4		29.7	

Figure 1 -
Thermographic image of volunteer 1's (anterior view) at the moments: pre. after and 15 minutes after the end of the cycle ergometer session (from left to right)

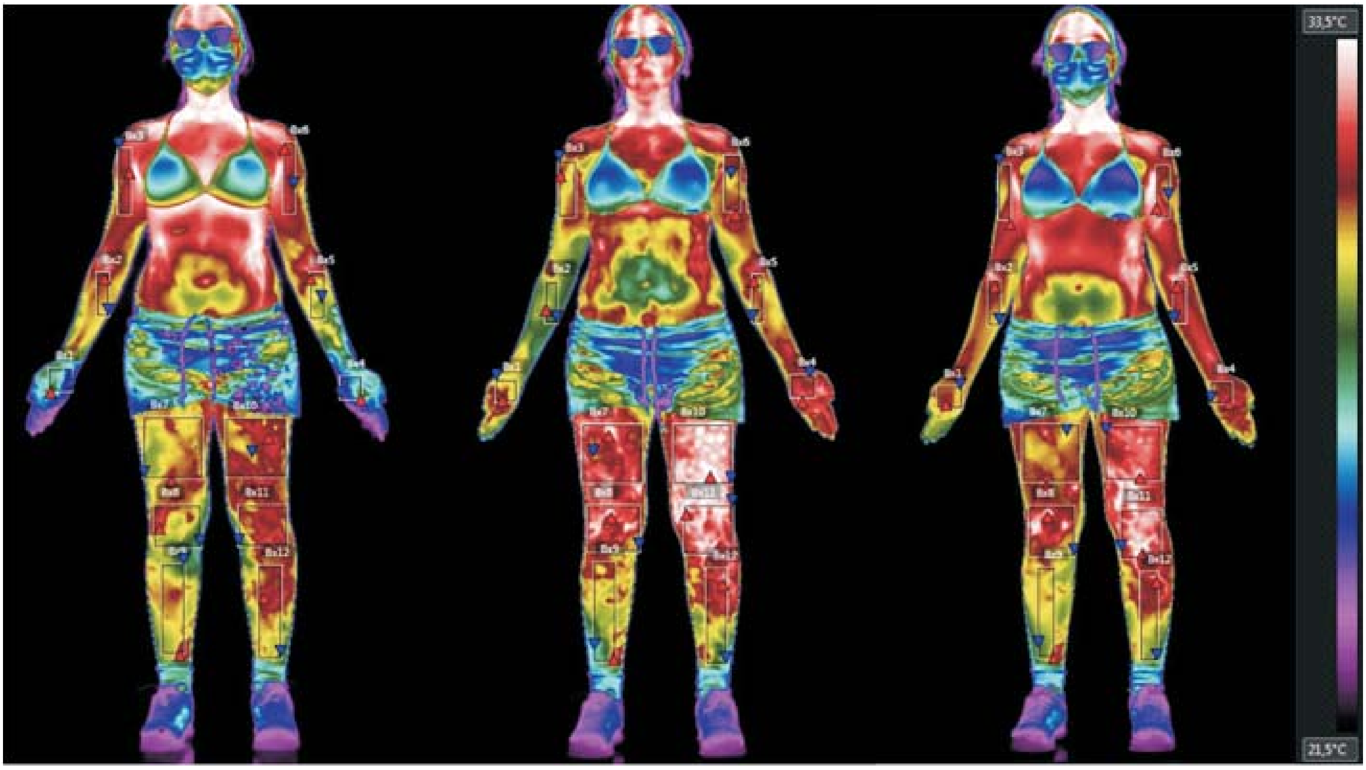


Figure 2
Thermographic image of volunteer 1's (posterior view) at the moments: before. after and 15 minutes after the end of the cycle ergometer session (from left to right)

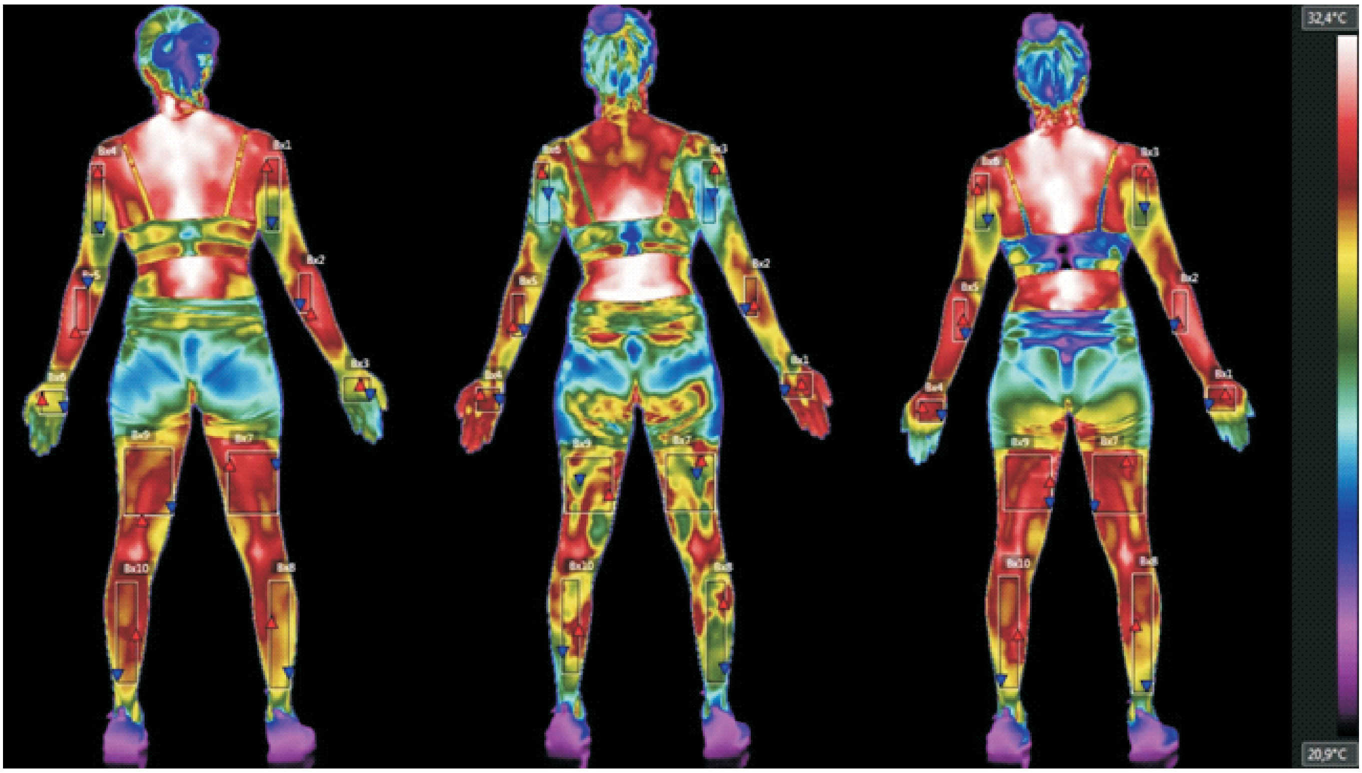


Figure 3
Thermographic image of volunteer 2's (anterior view) at the moments: pre. after and 15 minutes after the end of the cycle ergometer session (from left to right)

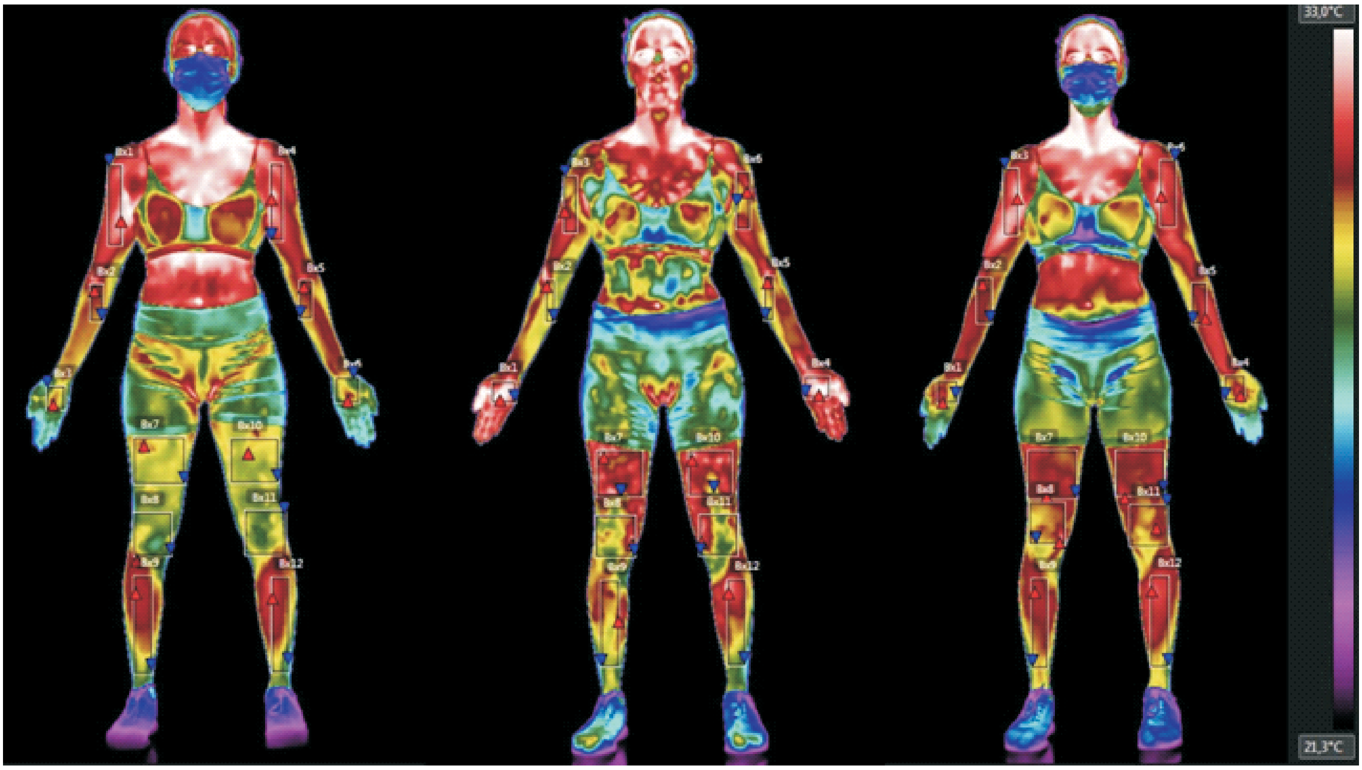
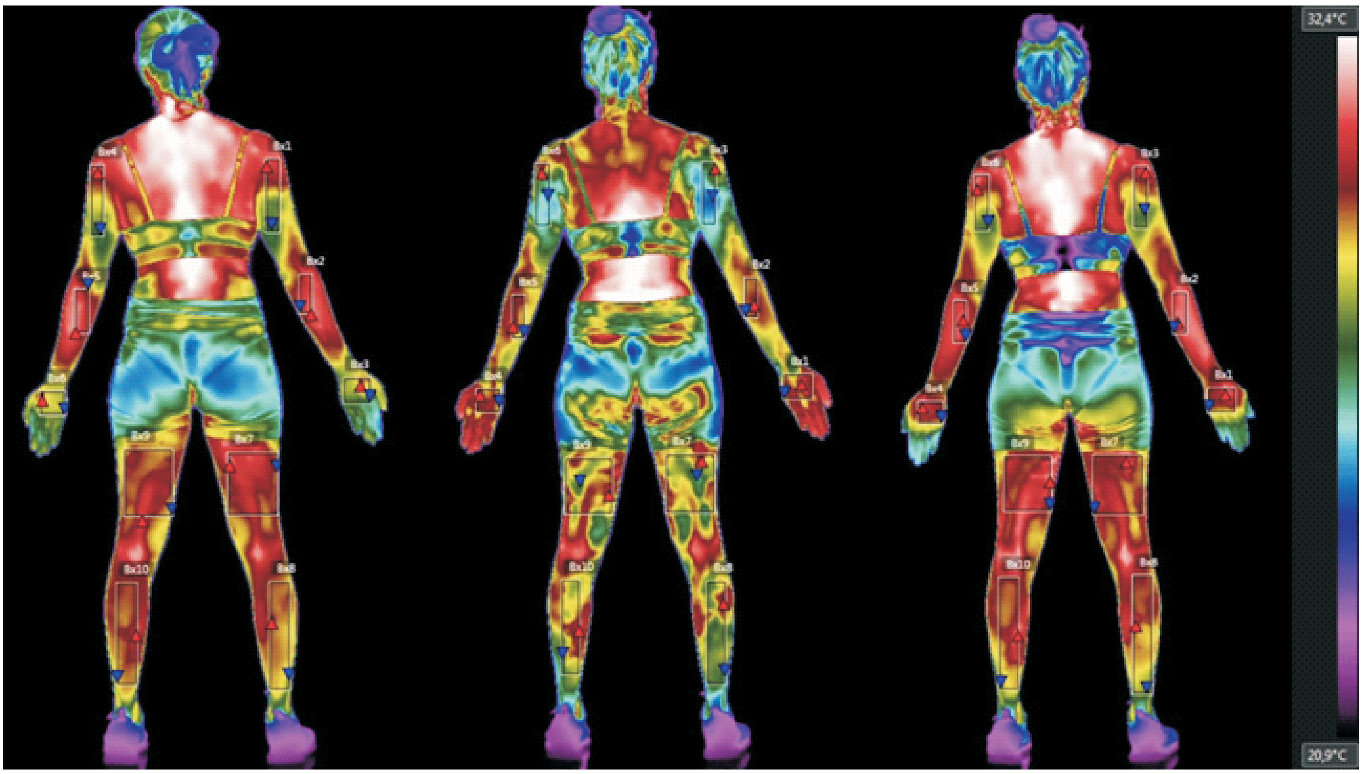


Figure 4
Thermographic image of volunteer 2's (posterior view) at the moments: pre. after and 15 minutes after the end of the cycle ergometer session (from left to right



of the very superficial vascular network of the skin. Varicose veins have a wide vascular bed. and when these dilated veins are located very superficial. their large blood volume represents a large area of which infrared radiation is emitted. Because exercise supports venous return in the extremities. the increased rate of venous blood flow enlarges the area of infrared emission resulting in an increase of skin temperature over varicose veins. thus overriding the effect of vasoconstriction induced by muscular work. Vasoconstriction leads to a decrease in skin temperature. which can also be detected in proband 1 on the end of cycling outside of the area of varicose veins. The closely above the ankle of the leg. is on a similar temperature level in both subjects and cooling of that area is clearly present after exercise.

Obviously exercise increased the thermal asymmetry in the woman with a history of varicose veins. Curiously. a study in a patient with cerebral vascular accident sequelae showed that. right after a session with robotic exercise. the patient exhibited a better temperature symmetry between body hemispheres [22]. However. it is worth noting that this robotic exercise was performed in supine position. as opposed to the cycle ergometry. which is conducted in sitting position. The patient had also no venous pathology on the lower extremities.

Possibly. these cases report results could be different if the volunteer's position was different. as for example. with the lower limbs placed at the heart level. which could decrease the gravity effects in the vessels. facilitating the venous lymphatic return [19]. Therefore. a future study considering this position should be conducted to verify the effect of the position of the cycle ergometer on blood circulation and. consequently. on the distribution of skin temperature.

The skin temperature variation pattern was distinct in both subjects. Subject 2. who presented with physical condition of good fitness. self-reported a lower exertion according to Borg Scale and covered a higher distance during the exercise. evidenced a normal pattern of blood flow regulation. seen as a decrease in skin temperature immediately after the exercise ending (probably due the blood flow being direct to the working muscles) and normal thermal symmetry values. However. subject 1. with varicose veins. evidenced thermal asymmetry at all assessment moments suggesting that one session of this type of exercise does influence skin temperature alterations caused by constantly dilated veins.

This case report has some limitations. Horizontal positioning was not employed in cycle ergometry. and the control volunteer was physically active. as opposed to the sedentary subject with varicose veins.

It seemsunlikely. that more exercise sessions would result in more thermal symmetry because exercise does not result in constriction of varicose veins. However. it is important to highlight that thermography proved to be a valuable tool to document skin temperature changes after exercise in the studied subjects.

Conclusion

Thermography was an effective method to document the course of skin temperature distribution after cycling in a healthy woman and a female suffering from varicose veins. In both subjects the thermal symmetry between both legs was not affected by cycling. The typical decrease of skin temperature immediately after exercising was masked by the increased temperature of varicose veins. Future studies in subjects with varicose veins should consider a different positioning for this type of exercise.

Patient Perspective

Both study volunteers demonstrated that the cycle ergometry session was conducted in adequate and recommended conditions of training. and thermographic assessment was as stated by literature: fast. visually elucidative. and free of discomfort for the subjects.

Informed Consent

Both volunteers gave their consent to participate in the study

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Medical Thermology 2020 - a literature survey with a focus on applications in the COVID 19 pandemic.

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SUMMARY

The annual literature search is restricted to articles dedicated to application of temperature measurements to manage the COVID-19 pandemic. A search strategy in the database Scopus obtained with the principal terms thermography and thermometry for 2020 in journals7852 hits, 1114 of them were related to medicine. 218 medical articles showed the keyword COVID-19. 149 of these 218 papers reported body temperature measurements used for fever screening or as first step of prevention measures to limit the pandemic or as a diagnostic tool and as an outcome measure. Due to the large number of asymptomatic and afebrile individuals tested positive for SARS-CoV-2, temperature measurements contributed little to mass screening for COVID-19. The prediction of a fatal disease course based on body temperatures was controversary interpreted. Body temperatures were rarely employed as primary outcome measure. Nevertheless, separation of febrile from afebrile individuals remains self-explaining procedure that opens the path for further testing for SARD-CoV-2 .

KEY WORDS: literature search, body temperature, thermometry, COVID-19,

MEDIZINISCHE THERMOLOGIE 2020 - EINE LITERATURÜBERSICHT MIT EINEM SCHWERPUNKT AUF DEM EINSATZ WÄHREND DER COVID 19-PANDEMIE.

Die jährliche Literaturrecherche beschränkt sich auf Artikel, die der Anwendung von Temperaturmessungen zur Bewältigung der COVID-19-Pandemie gewidmet sind. Eine Suchstrategie in der Datenbank Scopus mit den wichtigsten Begriffen Thermographie und Thermometrie für 2020 fand in Zeitschriften 7852 Treffer, davon waren 1114 auf die Medizin bezogen. 218 medizinische Artikel enthielten das Stichwort COVID-19. 149 dieser 218 Veröffentlichungen berichteten über Körpertemperaturmessungen, die für das Fieberscreening oder als erster Schritt der Präventionsmaßnahmen zur Begrenzung der Pandemie oder als diagnostisches Instrument und als Ergebnisparameter verwendet wurden. Aufgrund der großen Anzahl asymptomatischer und afebriler Personen, die positiv auf SARS-CoV-2 getestet wurden, trugen Temperaturmessungen wenig zum Massenscreening auf COVID-19 bei. Die Vorhersage eines tödlichen Krankheitsverlaufs auf der Grundlage der Körpertemperaturen wurde kontrovers interpretiert. Körpertemperaturen wurden selten als primäre Ergebnismaßnahme verwendet. Dennoch bleibt die Trennung von fiebrigen und nicht fiebrigen Menschen ein selbsterklärendes Vorgehen, das den Weg zu weiteren Tests auf SARD-CoV-2 öffnet.

SCHLÜSSELWÖRTER: Literatursuche, Körpertemperatur, Thermometrie, COVID-19

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Introduction

For more than 30 years reader of this journal can find in this place the results of a literature search on articles that reported last year's applications of thermography and temperature measurements in medicine and health science. But the year 2020 was exceptional, the COVID 19 pandemic controlled our lives worldwide requiring physical distance and face masks and resulted in numerous scientific publications about this novel spikes-carrying virus, and an ongoing hype in public and social media. Applying the traditional search strategy to the database Scopus, retrieved more hits than the searches in previous years and it became quickly obvious that the excess of hits was probably caused by articles on COVID-19.

Previous annual literature overviews have clearly shown, that in Scopus the allocation to science disciplines is not accurate and some articles allocated to medicine have little or no medical content [1]. Typically, medical articles are classified into more than one sub-discipline resulting in a cumulation of articles across the scientific fields. Selection of articles related to a specific field of interest such as a defined disease was the approach in the past to show the place and value of temperature measurements in this regard. In this review related to the year 2020, only articles are analysed reporting temperature measurement related to the COVID pandemic. .

Methods

A search in Scopus with the terms "thermology" OR "thermography" OR "infrared imaging" OR "thermal imaging" OR "temperature measurement OR" "thermometry" AND year 2020" yielded 8367 hits. After removal of articles in press, books and book chapters, a total of 7852 hits was obtained from Scopus (table 1). Restriction with the term "medicine" resulted in a reduction to 1114 hits

Table1
Search terms

Search terms	Hits in Scopus		
	all	Medicine	Health professions
TITLE-ABS-KEY (thermology) AND PUBYEAR = 2020	8		
TITLE-ABS-KEY (thermology OR thermography) AND PUBYEAR = 2020	2723	350	28
TITLE-ABS-KEY (thermology OR thermography OR “infrared thermal imaging”) AND PUBYEAR = 2020	2849	358	28
TITLE-ABS-KEY (thermology OR thermography OR “infrared thermal imaging” OR “infrared imaging”) AND PUBYEAR = 2020	4060	432	31
TITLE-ABS-KEY (thermology OR thermography OR “infrared thermal imaging” OR “infrared imaging” OR “thermal imaging”) AND PUBYEAR = 2020	4240	454	34
TITLE-ABS-KEY (thermology OR thermography OR “thermal imaging” OR “infrared imaging” OR “thermal imaging” OR thermometry) AND PUBYEAR = 2020	5162	578	42
TITLE-ABS-KEY (thermology OR thermography OR “thermal imaging” OR “infrared imaging” OR “thermal imaging” OR thermometry OR “temperature measurement”) AND PUBYEAR = 2020	8367	1224	70
TITLE-ABS-KEY (thermology OR thermography OR “thermal imaging” OR “infrared imaging” OR “temperature measurement” OR thermometry) AND PUBYEAR = 2020 AND (LIMIT TO (PUBSTAGE=final))	7852	1114	51

including 51 articles in the subgroup "health professions". All articles and commentaries from the journal "Thermology international", Vol.30, not yet listed in Scopus, were added resulting in a total of 1119 documents, which have been included in the collection of references related to thermology as Volume 6 "Published papers on Thermology or Temperature Measurement in 2019-2020". The document is now available from the webpage of Thermology international at: "www.uhlen.at/ Thermology international/ Publications on thermology and temperature measurement/ Volume 6". Volumes 1-6 of this reference collection can be accessed free of charge at "www.uhlen.at/ Thermology international/Archives.

The 1114 hits yielded were again refined by selecting all articles that show the term "COVID-19" resulting in 220 articles. Applying the term "body temperature measurement" resulted in a reduction to 167 hits. Almost all articles were available as full-length documents and were checked, to assure that the contents in line with the terms "COVID-19" and ""body temperature measurements". This procedure led to exclusion of 25 papers, of which the reasons of exclusion are described in the result section under the subheading "Excluded articles". Main results of the 149 remaining papers are reported in the format of a narrative review.

Results

143 out of 219 COVID articles were found with the keyword "body temperature measurements. Articles were allocated to the following seven fields.

Temperature measurements for pandemic control

A common statement in many articles was that the temperature was checked of hospital visitors [2,3,4], staff [3,4, 5,6,7,8], patients [3,4,5,7,8,9,10] or clients [11], but temperature data of these populations were not reported. Temperature measurement were performed to control the pandemic however the effect of this measure was not analysed [12,13,14]. In Singapore, temperature measurements have been employed at border and airport entries and all healthcare workers had to report temperature twice daily [15]. Temperature was also measured at the entrance of shops, hospitals and universities and the impact of this and other precaution measures on the perspective of radiographer students was reported [15]. Despite the authors' statement that they learned to live with these circumstances, it remains unclear if the rationale of temperature measurement in this preventive strategy was either clearly communicated or been fully understood by the population. Continuously performed temperature screening was recommended as part of post infection surveillance of health professionals who had recovered from COVID infection [17].

Elevated body temperature as sign of the disease

Table 2 list the total range of pathologies and concomitant diseases.

Many case reports describe increased body temperature associated with organ manifestation in infections caused by COVID solely or in combination with other virus such as HIV [18]. Following an influenza infection, a man who developed rapidly progressive pulmonary disease and, fol-

Table 2
Pathologies reported in case reports of COVID infected patients.

Primary pathology	Complications and/or manifestations outside of the respiratory tract	Comorbidities (number of cases)	Ref..
Pneumonia		HIV-infection (2)	18
		Preceding influenza infection	19
	Bacterial sepsis & activation of latent strongyloidiasis.	diabetes & hypertension (1)	20
		None (1/2) history of asthma & pulmonary embolus (1/2)	21
		X-linked agammaglobulinemia (3)	22
		type 2 diabetes	23
		History of asthma, diabetes, hypertension. Hyperlipdaemia, osteoporosis and psoriasis	24
	Pulmonary abscess	obesity(1)	25
	angioedema	hypertension, dyslipidaemia (1)	26
	portal vein thrombosis	none (1)	27
	superior mesenteric artery thrombosis	history of atrial fibrillation, chronic kidney disease & hypertension (1)	28
	Critical illness with pending multiorgan failure	end stage kidney disease (2)	29,30
paediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 infection (PIMS-TS)		None (7/8), autism (1/8), hayfever (1/8)	
PIMS-TS	giant coronary artery aneurysms	None	31,32
Pneumonia	spontaneous subcutaneous emphysema) with or without pneumomediastinum (11 patients)	hypertension (6/11), diabetes mellitus (5/11), asthma (3/11), dyslipidemia (3/11), and renal disease (2/11	33
	pulmonary embolism	type 2 diabetes (3/10), none (5/10) ischaemic heart disease (1/10), hypertension (2/10), bladder cancer & COPD (1/10)	34
	Focal epilepsy	Hypertension (1)	35
Focal status epilepticus		Hypertension & postencephalitic epilepsy	36
encephalitis (fatal)		Latent tuberculosis infection	37
Encephalitis(transient)		none	38
Psychotic relaps		schizoaffective disorder	39
Pneumonia	Kidney infarction	history of hypertension, Henoch–Schönlein glomerulonephritis & living related kidney transplantation in 2016 (1) history of obstructive sleep apnoea (1)	40
Pneumonia prevalence not reported	Liver injury	History of virus hepatitis(31/330) Diabetes and/or dyslipidaemia and/or hypertension (139/303)	41
Pneumonia	Acute myopericarditis	history of breast cancer	42
	Suspected myopericarditis and progressiverenal failure (fatal)	History of diabetes, atrial fibrillation & ostructive sleep apnoea	43
	Myocardial infarction and pulmonary embolism	No information on comorbitities	44
	Pulmonary embolism	No information on comorbitities	45
	Relapse of acute lymphoblastic leukaemia (fatal)	History of acute lymphoblastic leukaemia	47

lowing two negative tests, was diagnosed with COVID-19 on the basis of bronchoscopic biopsy and bronchoalveolar lavage after 9 days of illness [19]. A case of a COVID-19 patient was reported who developed co-infection with Streptococcus constellatus and Citrobacter freundii following treatment with high-dose corticosteroids and tocilizumab [20]. A consecutive fever peak was caused by disseminated strongyloidiasis.

Available are the fever profiles and results of PCR testing for SARS-CoV- 2 of sputum, nasopharyngeal swab, serum, urin and faeces from the first patient diagnosed with COVID-19 in Australia due to fever, cough, and radiological signs of viral pneumonia [23]. Fever started at hospital admission with 38,1°C, peaked on day 3 by 39.5° and recovered to 36.9°C on day 11. Sputum was tested positive from hospital admission to day 8, nasopharyngeal swab material remained positive from day 0 to day 4. No virus was detected in serum, urine, or faeces.

Case reports indicated that SARS-2 pneumonia was complicated by suspected myopericarditis [24], pulmonary abscess [25], angioedemia [26], portal vein thrombosis [27], superior mesenteric artery thrombosis [28] and critical illness with pending multiorgan failure [29, 30].

In London, UK, a cluster of eight children was observed presenting with hyperinflammatory shock, showing features similar to atypical Kawasaki disease, Kawasaki disease shock syndrome, or toxic shock syndrome. Clinical presentations were similar, with unrelenting fever (38-40°C), variable rash, conjunctivitis, peripheral oedema, and generalised extremity pain with significant gastrointestinal symptoms. All progressed to warm, vasoplegic shock, refractory to volume resuscitation and eventually requiring noradrenaline and milrinone for haemodynamic support. Only two of the children have tested positive for SARS-CoV-2, but antibodies against the virus were found in all children [31]. A case from Poland was complicated by giant coronary artery aneurysms [32].

In a case series of 11 COVID patients with spontaneous subcutaneous emphysema (SE) with or without pneumomediastinum, only 4 patients had baseline temperatures above 38°C [33]. 3 out of the 4 patients who did not survive, presented with baseline temperatures of 35.8°, 36.7°C and 37.8°C, respectively. A case series from UK reported the co-existence of pneumonia and pulmonary embolism [34]. Interestingly, fever was absent in 3 of the 10 patients (age range. between 53 and 75 years

The temperature course was well documented in a COVID patients whose initial symptoms were painful muscle cramps diagnosed as focal epilepsy [35]. The neurological symptoms resolved after the nasopharyngeal swab became negative for SARS?CoV?2 at day 22 of the disease. In Italy, a patient with motor deficit and aphasia after encephalitis presented as focal status epilepticus as initial manifestation of COVID-infection. Her high fever was no associated with pneumonia or respiratory deficit. After body temperature became normal and nasopharyngeal swaps negative, no other seizures occurred [36].

The COVID-infection of healthy five-year-old African American girl led to activation of a latent tuberculosis infection that resulted in encephalitis with fatal outcome [37]. An 11-year-old previously healthy child who presented with status epilepticus requiring anticonvulsant medications and cerebrospinal fluid evidence for encephalitis was tested positive for COVID-19 despite absence of respiratory symptoms [38]. Fever and encephalitis were completely resolved within 6 days without treatment.

A 36-year-old patient diagnosed with schizoaffective disorder lived an almost normal live under medication with clozapine 250 mg per day [39]. She was last admitted to psychiatric hospital in 2012. In March, she presented with respiratory symptoms and temperature peaks above 39°C and was isolated at home due to COVID suspect. After 7 days of quarantine her psycho-emotional condition deteriorated, and another psychiatric admission was necessary. Infection with SARS-CoV-2 was confirmed at psychiatric hospital. The authors expressed their opinion that rather the restriction in social contact than COVID symptoms may have cause the psychotic relapse.

Body temperature did not predict the fatal outcome of 76-year-old woman who died due to severe acute respiratory syndrome coronavirus-2 infection [24]. Fever was not an important sign in two patients who developed kidney infarction during COVID disease [40].

In a sample of 657 COVID patients, 303 patients presented with signs of liver injury of different severity [41]. The odds ratio of baseline maximal body temperature (? 38.5 vs.< 38.5°C) was 1.235 (95% confidence interval 0.975-1.565) for liver injury in a multivariate model. However, odds ratio was larger for NLR (neutrophil to lymphocyte ratio) and gender (male vs. female) with values of 2.038 and 2.154, respectively.

An acute myopericarditis was reported in a female 71 years old COVID patient with otherwise mild fever and little pulmonary involvement [42]. A 73-year-old man with hypoxaemic respiratory failure due to confirmed SARS?CoV?2 infection developed cardiac dysfunction explained by suspected myopericarditis [43]. He finally developed high fever combined to progressive renal failure and died on hospital day 18.

An 82-year-old man was diagnosed with COVID-19 following a positive test for SARS-CoV-2 in the presence of symptoms of fever and mild dyspnoea. Following self-isolation at home for 1 week, the patient was hospitalized due to severe respiratory distress with a febrile temperature of 39.0 °C at admission. The diagnosis of an acute infero-posterior ST-segment elevation myocardial infarction (STEMI) and an acute pulmonary embolism in the right pulmonary artery in combination with COVID pneumonia explained the critical condition of the patient [44]. A 50-year-old woman tested positive for SARS-CoV-2 and radiological signs of virus pneumonia developed a large saddle pulmonary embolism in the main pulmonary artery, right pulmonary artery and left pulmonary artery. She was discharged from hospital in good condition after 10 days of therapy [45].

Modern implantable cardiac monitors are capable in recording body temperature. In a case report of two patients, their data plots showed temperature peaks in March which were interpreted to be caused by COVID-19, although clinical data, particularly virus test results were not obtained from the patients [46].

Rather the relapse of previously diagnosed acute lymphoblastic leukaemia and a suspected bacterial superinfection than COVID-19 was interpreted as the reason for continuously raising fever and the fatal outcome of a 62-year-old woman [47].

Erythematous eruptions in the face accompanied mild fever in a man with suspected, but not confirmed COVID infection [48]. A case report of a 64-year-old woman with type 2 diabetes from France described an erythematous rash starting on both antecubital fossa and extending during the following days on the trunk and axillary folds on the fourth day of fever and weakness [49]. Her nasopharyngeal swab proved positive for SARS-CoV-2, her chest CT showed bilateral interstitial abnormalities, the rash disappeared five days after its beginning while fever persisted for another week. The patient took only, but repeatedly paracetamol, and all symptoms resolved finally at day 18.

A retrospective study in COVID diagnosed patients comprised of 42 pregnant, 14 non-pregnant women and 4 children, analysed clinical data and chest CT findings. Corona virus was confirmed in nasopharyngeal swabs in 16 pregnant women, COVID diagnosis in the remaining pregnant women was based on clinical signs. An initially no

Temperature measurements for screening or assisting diagnosis.

A short survey article written in German language emphasised the poor diagnostic sensitivity of temperature screening for the identification of patients infected with the corona virus [51]. Under the condition of outdoor temperatures between -5 and 0°C, core temperature is regularly underestimated when based on forehead temperatures recorded with an infrared thermometer immediately, 1, 3 or 5 minutes after entering the hospital [52]. A warning of neglecting the standards for infrared based fever detection was also addressed in an editorial authored mutually by the current EAT president Kevin Howell and the former EAT president James Mercer [53]. The author of a letter from Singapore addressed the unreliability of non-contact hand-held cutaneous infra-red thermometer for fever screening and emphasised the possible negative consequences on endeavours to limiting the pandemic [54].

Chinese authors proposed a temperature monitoring scheme for the detection of COVID infection [55] since their literature indicated that the median temperature of most COVID patients at hospital admission was 37.3 °C, one half degree above an assumed normal body temperature value of 36.8°C. The proposal is to average the temperatures recorded in the morning and the evening during the first 3 day of quarantine and continue to calculate the mean temperature for the consecutive 3 days periods until day 14. Any increase of basal temperature equal or greater than 0.5°C results in testing for viral nucleic acids particularly in combination with clinical symptoms. However, data to confirm this strategy are lacking.

A paper on the challenges for prevention of future pandemics in Africa includes temperature screening at entry points into the African continent as a preventive measure following a recommendation of the WHO from January 2020 [56,57,58]. In Singapore, the pandemic readiness and response plan of the Ministry of Health prescribed in the condition of low to moderate public health impact temperature screening of inbound passengers at border controls, becoming mandatory for all passengers at the next level of public health impact. Temperature screening in institutions had be performed on the levels 3.2 and 3.3 of public health impact depending on risk, and regularly on the highest risk level for public health [59]. Iran practiced preventive measures, such as testing individuals body temperature at the borders since late January 2020 [60]. A rapid review article attempted to evaluate the effectiveness of different point-of-entry screening strategies in achieving a reduction in imported COVID-19 transmission. Three of nine included articles investigated the effectiveness of entry-based thermal and body temperature scanning leading to the conclusion that entry-based infrared thermal or body temperature scanning for COVID- 19 was unlikely to be effective [61].

In a population of 724 radiotherapy patients who underwent chest simulation-CT's, only 3 patients presented with febrile temperature at entrance, however, only one of them developed a COVID infection at a later time-point during radiation treatment [62]. 2 out of 4 asymptomatic patients with suspicious CT scan tested positive for SARS-CoV-2.

A case series of COVID positive recipients of kidney transplants included 2 oligosymptomatic patients whose clinical symptoms did not qualify them on being tested for corona virus [63]. Since the course of the disease may be atypical in immune-compromised patients, the authors propose obligatory virus testing in such populations. In series with 7 of COVID positive recipients of kidney transplants had 2 patients a mild course, 4 had acute renal injury, 2 presented with acute respiratory distress syndrome and renal injury, both need ventilation, and 1 patient did not survive [64]. Body temperature contributed to the result of a prognostication score successfully applied in a corona virus positive recipient of kidney transplant for risk stratification [65].

A study conducted in two cohorts of approximately 4500 residents in US-American nursing homes investigated the diagnostic accuracy of body temperature for positive COVID tests [66]. Temperatures alone had a relatively low sensitivity/ specificity, even after lowering the threshold from 38°C to 37.2°C. A retrospective cohort study of Australian patients who tested positive for SARS-CoV-2 at a single centre detected fever in 16 (19%); of 86 of positive tests for corona virus [67]. With repeat testing, the detection rate raised to 24%. The authors concluded that temperature screening has negligible value for control of COVID-19. However, the recommendations for active symptom screening in nursing homes include temperature check at least once daily for residents and temperature check for all staff daily upon arrival [68].

A rapid Cochrane review on universal screening for SARS-CoV-2 infection analysed two approaches that included temperature measurement [69]. 6 studies comprising 14741 people applied the combination of temperature measurements, asking about international travel, exposure to known infected people and exposure to known or suspected infected people. This strategy yielded a high rate of false negatives as between 77 and 100 out of 100 infected people have incorrectly been identified as healthy. The rate of false positives was acceptable because only 0 to 10 out of 100 healthy people were classified as infected. Asking about symptoms plus temperature measurement was applied in 2 studies with a total of 779 people. This approach had a better sensitivity since only 31 to 88 out of 100 infected people were incorrectly identified as healthy and the rate of false positives was between 0 to 10 percent.

A study conducted in young traveling adults concluded that temperature screening is ineffective for the detection of COVID infected people, since a cut-off value of 38°C had only 18% diagnostic sensitivity but 100% specificity [70]. Lowering the threshold to 37.1°C increased sensitivity to 66% and lowered specificity to 95%. This poor performance of temperature measurement is not unexpected, since 83 percent of the subjects tested positive for SARS-CoV-2 had never fever during the observation periods.

Temperature measurement to promote prevention, decision on triage and monitoring

A pilot program for COVID-19 convalescent plasma collection included patients whose criterium for hospital discharge besides others was body temperature return to normal for more than 7 days [71]. In addition, preference was given to plasma donors who had a fever lasting more than 3 days or a body temperature exceeding 38.5°. Donors with the disease course of fever exceeding 38.5°C or lasting longer than 3 days exhibited high levels of specific IgG antibodies at the time of donation [71,72].

Measuring temperature in passengers and crew prior to boarding could not prevent an COVID-19 outbreak on a cruising ship. Of the 217 passengers and crew on board, 128 were tested positive for COVID-19. 24 of those were symptomatic; 8 required medical evacuation; 4 were intubated and ventilated; and 1 patient deceased [73]. The English abstract of an article in Chinese reports the favourable management of 4806 people on a cruise ship returning from Japan to Tianjin, China [74]. All 17 individuals highly suspected of COVID infection were tested negative twice at an interval of 2 weeks.

In Japan, the COVID outbreak was particularly challenging on the Diamond Princess cruise ship carrying 3700 crew members and passengers, of which 712 were diagnosed with COVID-19 and 13 died. Details were reported of two male patients, 70- and 72-year-old, who were among the infected passengers of the cruise ship [75]. Both febrile men developed an acute respiratory distress syndrome (ARDS) and were treated at the intensive care unit. The more severe ARDS in the older man with higher fever required 20 days veno-venous extracorporeal membrane oxygenation, followed by 5 days of ventilation, but he recovered after 71 days of treatment and was discharged from hospital. The less severe course in the 70-year-old required ventilation for 6 days, stayed on the intensive care unit for 12 days and was discharged from the hospital on the 25th day.

In the early phase of the COVID-19 pandemic, identification of possible infected persons had to rely on clinical signs and radiological findings. In patients admitted for emergency surgery suspicion of COVID-19 infection was defined as a body temperature higher than 37.2°C or an abnormal chest CT. This approach proved to be effective since positive corona virus swab test were exclusively detected in 6 out of 36 suspicious cases and in none of 52 patients unsuspected for COVID-19 [76].

An eye clinic in China based their triage of emergency patients on temperature measurements [77]. At admission, the results of non-contact measurements allocated patients unsuspected of fever to the eye emergency room or presumably febrile patients to the isolation room. Afebrile patients who needed further treatment after the initial consultation and examination underwent temperature measurements with contact-thermometers and were send to the fever clinic when febrile. The fever-clinic was also the second stop for patients who received preliminary ophthalmic treatment in the isolation room. All patients from the fever-clinic were transferred to the isolation ward. The choice of operation-room was based on the grade of emergency and suspected, but unproven COVID infection. Applying this scheme, a total of 6207 patients with eye emergencies were screened and 132 febrile patients were detected. 183 patients received eye surgery, and none of the 23 patients operated with suspected COVID infection developed the disease. A similar plan was developed in an ophthalmology hospital in Hong Kong, where identification of febrile visitors and patients was managed at a triage station in front of the hospital entrance [78]. Measuring the body temperature of the healthcare personnel was included in the prevention measures of an eye hospital in Milan, Italy [79].

In Italy, preventive measures against COVID-19 in dental practice include telephone and clinical triage supported by a questionnaire on recent symptoms and travelling, body temperature measurement, oral rinses with 1% hydrogen peroxide, and the use of specific personal protective equipment [80]. Implications of asymptomatic cases in children on the COVID infection risk of staff in a paediatric dental praxis were discussed [81]. Considering non-contact body temperature checks at the entrance is part of the recommendations for protecting patients and healthcare personnel from COVID-19 in a private practice for cardiovascular disorders [82]. Temperature screening at the hospital entrance is also part of the recommendation for otorhinolaryngologists. Body temperature measurement was recommended for outpatients and their companion when entering a urological practice in Italy [83]. As this group of physicians bear a high risk of becoming infected with COVID-19, personal protective equipment is the main focus of this guideline from Poland [84]. Protective equipment is of high importance in the practice of anaesthesiology, where it is also recommended to check the patient's temperature as the initial step of protective measures [85].

Measures for preventing nosocomial infection with SARS-CoV-2 in haematology departments and the role of temperature measurements in this strategy have been reported in detail [86]. Strictly application of this strategy resulted in maintaining zero infection among the medical staff and no cross-infection among patients and their family members. In a large haematological hospital in South Korea remote body temperature screening was the starting point in the separation of 7 classes of visitors who were further allocated to one of 12 groups in total [87]. Due to this carefully developed and controlled preventive strategy no cases of nosocomial onset or spread of COVID-19 occurred in the hospital, although the number of outpatient visit, mean number of inpatients each month, and the number of haematopoietic stem cell transplantation (HSCT) per month were comparable to those in the corresponding months of 2019 preceding the COVID-19 epidemic.

A large hospital in Chengdu weighted fever, respiratory symptoms, and possible contact with COVID patients in equal way, when starting the diagnostic pathway for identification of carriers of SARS-CoV-2 [88]. Their successfully applied prevention measures were based on PCR virus tests, while body temperature of patients was not considered for decision making.

Regularly repeated temperature screening played an important role in prevention of COVID-19 infections in an obstetrics hospital [89]. Body temperature measurements and questions on suspicious symptoms and traveling habits in the previous 2 weeks defined the triage of parents visiting their children at a neonatal intensive care unit [90].

Surgical hospitals in the Tuscany region combined body temperature screening with providing of face masks and disinfection facility for anyone entering the hospital, including employees [91]. A similar procedure was applied for fostering recovery of elective surgery in the USA [92] or to maintain metastatic melanoma treatment in a skin cancer centre in Italy [93]. Recommendations for Dermatology Hospitals in China [94] and USA [95] allowing only one accompanying person per patient, mask usage and temperature reading for people entering both inpatient and outpatient buildings, and the use of personal protective equipment by team members working with patients with suspected or confirmed COVID-19.

A blood bank in Karachi, Pakistan, accepted blood donations only when the presumptive donor was afebrile at the initial temperature measurement, had a negative history of fever, sore throat, cough, and absent contacts with true or suspected infectious persons and a negative result of a rapid corona screening test [96]. The strategy was successful since no staff was infected with SARS-CoV-2 despite the blood donation increased fourfold from April to May 2020. Measures currently being taken by blood collecting organizations in China include body temperature measurement; screening questions for symptoms or potential exposure; active post-donation information gathering; and product tracing and recall where indicated [97]. This strategy was also applied in India and supplemented with an educational list of frequent questions and answers for donors [98].

A haemodialysis centre in Turkey made the acceptance of patients dependent on temperature less 38°C as recorded prior to entering the bus transfer and at entrance to the dialysis facility [99]. Febrile patients detected on either occasion were transferred to the hospital by ambulance. Temperature measurement of patients before entering the waiting room was part of the prevention plan of a dialysis centre in Iran [100]. An analysis of contacts tracking suggested that that symptom screening, particularly temperature monitoring in the fever clinics may help to find suspected cases [101].

A survey in 3359 Greek citizens explored their self-reported behaviour to prevent COVID-19 spread [102]. Checking daily body temperature, monitoring for fever, cough, or dyspnoea, was the least applied preventive measure. A survey among community pharmacists in Saudi Arabia obtained that 69.4% of participating pharmacist indicate that they always checked the temperature of all clients and staff, 18.5% screened very often for body temperature [103].

Body temperature was one of three vital signs remotely collected from COVID infected migrant workers isolated in their dormitories in Singapore [104]. Temperature was less than 37°C in 93.1% of 12511 entries, and an alert was triggered in 5 of 11 cases whose body temperatures exceeded 38°C. In general, only 11 out of 372 alerts led to a visit of an hospital emergency service and there was no death among the 941 participants.

In Spain, a group of 224 out-patients tested positive for COVID was monitored by telemedicine using temperature and oxygen saturation data as recorded by the patients and their questionnaire responses [105]. 18 patients required in hospital treatment and two of them deceased. After discharge from the outdoor therapy, all 206 patients plus 98 patients, discharged from hospital care were telemonitored further. In this follow up period 1 patient was readmitted to the hospital. The role of temperature monitoring on decision making was not reported. A telemedicine consultation for COVID-19 should include information on body temperature as obtained by the patient's private clinical thermometer [106].

A report on two patients discussed the potential of a novel non-contact wireless sensor for vital sign sensing and body movement monitoring of patients on a COVID-19 isolation ward in Taiwan [107]. A wearable device that records continuously heart rate and surface temperature elicits an alarm when crossing a threshold and conventional fever measurement is used to validate alarming [108].

Based on the experiences with the SARS epidemy in Taiwan, where fever screening identified many suspected patients, fever, dry cough, and shortness of breath was used in the COVID-19 pandemic as clinical criteria to triage patients for quarantine in endemic areas when reliable diagnostic tests are not readily available. Consequently, all frontline clinical staff received daily temperature checks and/or COVID-19 tests, if available, to protect their families and the public [109]. Results of outdoor temperature measurement led to the allocation to the waiting areas for patients of high or low risk of COVID infections [110]. It was recommended to repeat the outdoor measured temperature of individuals indoors in a waiting area [111]. Care attendants were also monitored in Taiwan by regularly temperature records [112]. Follow-up by body-temperature monitoring was recommended for medical and midwifery staff who participated in a vaginal birth or caesarean section of mothers infected with COVID-19 [113]. In China, a supporting "eagle-eyed" observer team surveys medical staff and patients and performs remote body temperature when medical staff enter the isolation wards [114]. Temperature measurements at the entrance to hospitals and allocation of febrile patients to fever clinics developed as standard in the early pandemic in the Far East [59, 85, 115, 116,117,118,119,120,121,122,123,124], Europe [82, 83, 84] and Australia [125].

Application of the preventive strategy described above in Shenzhen China allowed early identification of COVID-19 cases and preventing a major outbreak in Shenzhen. Early identification of imported cases, prevention of transmission through family clustering, preventative measures in public areas and rigorous infection control procedures in the hospital setting were crucial to the successful control of outbreak in Shenzhen [124].

Temperature as an outcome measure

The Korean Centers for Disease Control and Prevention (KCDC) classified severity of COVID-19 into four categories, namely extremely severe, severe, mild, and asymptomatic [126]. To meet the sudden increase in medical and isolation needs in South Korea, the non-hospital facilities called "living and treatment centres (LTCs)" were established, where only mild or asymptomatic patients with confirmed SARS-CoV-2 infection by PCR tests were admitted. Detailed admission criteria were as follows: (1) alert, (2) younger than 50 years of age, (3) no or well-controlled underlying disease, (4) body temperature less than 38.0°C, irrespective of taking antipyretics, and (5) no dyspnoea. In a total of 113 patients disease progression was negligible since only 2 patients were transferred to the hospital where they did not develop severe COVID-19.

Contact tracing in the family an asymptomatic patient with positive PCR test detected in 4 of 6 family members SARS-CoV-2 infection, and signs of resolving pneumonia in CT-images of 3 patients although all seven were afebrile and felt well [127]. In another family cluster with 5 cases, the index patient who returned from Wuhan to Beijing remained clinically asymptomatic despite his nasopharyngeal swap was tested positive for corona virus and his chest radiograph demonstrated ground glass opacities [128]. He transferred the virus directly to 3 family members, one of them stayed completely asymptomatic. The 4th patient had contact with one of the 3 primary contacts of the index patient.

A 9-year-old girl with fever, headache and abdominal pain had a positive PCR result for COVID-19. Self-quarantine of all children, wearing FPP2 masks, regular disinfection of surfaces and quarantine of the whole family from the public, interrupted virus transmission within the family and to the public [129].

In clinical trials [130,131,132] on corona virus infections, temperature serves among several other secondary outcome measures for detecting treatment effects. Three [131] to seven [70,71] days without fever were used among others to define discharge from hospital. In some articles, however, temperature was only reported at baseline examination and not after treatment [44, 48, 133,134,135,136].

A 34-year-old man without comorbidities, suddenly developed fever, and shortness of breath, thereby admitted to the emergency department of a tertiary care hospital, Dhaka, Bangladesh [137]. He neither had a history of traveling to endemic COVID areas nor a direct contact of COVID positive patients. His chest X-ray revealed ground-glass opacity in the right middle and lower zone of the lung. His nasopharyngeal swab was tested positive for SARS-CoV-2 on day 2 and subsequent throat swab samples tested negative by PCR on day 6, 11, 12 and 17. His maximal body temperature was never beyond 38.5°C and he was discharged from hospital in an afebrile condition on day 12.

A better outcome was retrospectively obtained in patients with moderate COVID pneumonia after treatment with lopinavir/ritonavir plus baricitinib compared to the combination with hydroxychloroquine [138]. This treatment effect included recovery from fever within one week. A retrospective study found that 42 patients treated with lopinavir/ritonavir (test group) recovered from fever in a shorter time than 5 controls not treated with lopinavir/ritonavir [139]. Controls needed more time (12.0±0.8 days) to turn negative in their COVID tests than patients in the test-group (7.8±3.1 days). A case series of four patients at high risk for morbidity and mortality from SARS-CoV-2 infection experienced improvement such as recovering from fever and/or mild clinical course in association with doxycycline [140].

The therapeutic effect of IL-1 inhibition became visible among other laboratory findings as normalisation of core temperature in a paediatric patient with COVID-19-associated cytokine storm syndrome [141]. A patient with a neuromyelitis Optica spectrum disorder developed only mild respiratory and pulmonary symptoms despite immunomodulation, but a prolonged fever episode with short lasting temperature peaks up to 39°C [142].

A patient with psoriasis developed respiratory symptoms due to COVID-19 infection [143]. Her psoriasis was treated for long with the monoclonal antibody guselkumab. Surprisingly, the day after the scheduled administration of guselkumab, she reported a major improvement of her respiratory condition, a normalization of her body temperature and a progressive relief of myalgia and fatigue symptoms.

A severe Covid-19 pneumonia syndrome in a sickle cell patient responded favourable to a treatment with the anti-human IL-6 receptor monoclonal antibody tocilizumab, leading to quick recovery from febrile temperatures [144]. However, the answer to the interesting question how to follow-up patients who received tocilizumab in severe COVID-19 was not related to temperature course during the disease [145].

Administration of granulocyte-colony stimulating factor (GCSF), an established prophylaxis or treatment of neutropenia, may result in a severe course of COVID-19 within 72 hours of administration as observed in three patients [146]. However, fever determined the severity of the course of the disease only insignificantly. GCSF administration did not aggravate the mild course of COVID-19 in neutropenic patient [147]. These contradictory outcomes warrant the rigorous investigation of GCSF effects in COVID infected patients with neutropenia in a randomized clinical trial.

An analysis of mortality in 7614 COVID-19 patients from Mount Sinai in the New York area found no association between body temperature at admission and mortality [148]. Patients presenting with initial body temperature ? 36 °C had the highest mortality (26.5%). However, maximum body temperature during COVID-19 infection was significantly correlated with mortality rate which was as high as 42% in those with maximum body temperature > 40°C. Chinese authors analysed risk factors for death in 1859 subjects with COVID-19 [149]. Admission temperature per °C increase (hazard ratio (HR) = 1.32; confidence interval (CI): 1.07, 1.64) was among eight variables identified as independent risk factors for death. HR ranged from 1.04 for older age to 3.3 for log10 neutrophil-to-lymphocyte ratio (NLR).

Viability of the corona virus

A study from China showed that, virus inactivation by heating of serum at 56°C prior to testing significantly interferes with the levels of antibodies to SARS-CoV-2 [150]. Thus, the possibility of false-negative results should be considered if the serum sample was previously heated to reduce virus transmission.

Excluded articles.

Articles reporting temperature measurements were not considered when not applied for diagnosis, prevention, or management of patients with COVID infection. These include an interesting scoping review on in-ear devices for physiological monitoring [151], a case report of patients who did not suffer of COVID-19 [152] or case reports of patients, who's specific COVID problem was not explained by their temperature findings [153,154,155,156,157,158]. The personal view and thoughts of a surgeon who volunteered to help during the peak of the pandemic at the Mount Sinai Hospital in New York did not put much attention to the temperature of arriving patients [159]. A probable congenital SARS-CoV-2 infection in a neonate born to a woman with activeSARS-CoV-2 infection remains unexplained by the body temperature of both mother and neonate [160]. Body temperature proved unhelpful in diagnosing ventilator-associated pneumonia in COVID-19 patients [161]. Influenza-like illness is monitored in France for almost 40 years, and COVID-19 contributed to an increased prevalence in 2020, but the infection cause cannot be differentiated by temperature measurement [162].

A letter analysed the anxiety of educators, students and parents facing the COVID pandemic and preventive measures in the education sector in Indonesia [163]. Temporary separation of health care workers from their family protects their relatives from the risk of infection [164]. In southern Italy such a prevention was successfully organised and elevated temperature above 37.5°C was threshold for a diagnostic work-up by a physician. Since none of the health care workers developed fever and all were tested negative for SARS -CoV-2 after this 4 -week quarantine, temperature measurement did not contribute to the success of this measure.

Protective measures were also not based on temperature when endoscopic retrograde cholangiopancreatography (ERCP) was performed in an emergency patient presenting with impending sepsis due to biliary obstruction [165]. A model for risk estimation and prediction of the transmission of coronavirus disease-2019 in the mainland of China did not consider temperature data [166] nor did temperature play a role in management strategies for the nursing of COVID-19 patients [167].

Diskussion

Since the SARS-CoV-2 is a recently detected infectious agent, case reports on infected individuals are the predominant type of articles related to COVID and temperature measurement comprising together with letters to the editor 64 percent of the references of this review. Case reports reflect the variations in signs and symptoms of a disease, but do not allow conclusions on the quantitative distribution of disease characteristics. Because COVID-19 is a cause of fever, case reports have at least one information on body temperature, which is sometimes provided as a categorical, but mostly as an interval value.

The association between mortality and body temperature remains unclear. It is known from the literature that critical ill patients with infection, and high fever show a different risk of mortality in comparison to febrile patients without infection [168]. In non-neurological critically ill patients with mixed febrile aetiology. treatment with non-steroidal anti-inflammatory drugs (NSAIDs) or acetaminophen independently increased 28-day mortality for septic patients, but not for non-septic patients [169]. Deep body temperature shows negative correlation with the clinical outcome in sepsis. Fever predicts lower, while hypothermia higher mortality rates compared to normothermia. Septic patients with the lowest (< 25%) chance of mortality have higher body temperature than those with the highest chance (> 75%) [170]. Body temperature was a significant predictor of 90-day mortality in patients with acute respiratory distress syndrome (ARDS) of various causes. Higher temperature was associated with decreased mortality: for every 1°C increase in baseline temperature, the odds of death decreased by 15% [171]. Fever suppression may be beneficial for patients with traumatic brain injury and stroke, but for patients with central nervous system infection such as meningitis or encephalitis, the febrile response may be advantageous [172]. This supports the finding that in ischemic stroke, mortality was lower among patients with hypothermia and higher among patients with hyperthermia [173]. Based on the literature on the relationship between body temperature and mortality Drewry et al. [174] criticized the article by Tharakan et al. [148]. Large epidemiological studies that compare the temperature course in mild, severe, and very severe cases of COVID-19 are not yet available. Body temperatures were rarely employed as primary outcome measure in clinical studies (139,140]. With respect to the unclear protective effect of fever in critically ill patients, further epidemiological evidence is urgently needed.

Initially introduced in the Far East many countries all around the world established fever screening at country borders and at the entrance to institutions of the public and the health system such as hospitals, outdoor clinics, private health practices, nursing homes and others. Due to the large number of asymptomatic and afebrile individuals tested positive for SARS-CoV-2, temperature measurements contributed little to mass screening for COVID-19. Separation of a febrile from afebrile individuals is a self-explaining mechanism fostering triage decision in the health system, that opens the further path in testing for SARD-CoV-2. However, other preventive measures such as proactive corona antibody testing, physical distancing, aerosol reduction inside of rooms through face mask use play a bigger role than body temperature measurement in the containment of the pandemic.

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More case books by Jozef Gabrhel

Review of the book "Sonografické a Termografické Nalezy Lakta. Pripady Z Praxe by Jozef Gabrhel

(H.R.G spol. s.r.o 2021, ISBN 978-80-88320-68-5

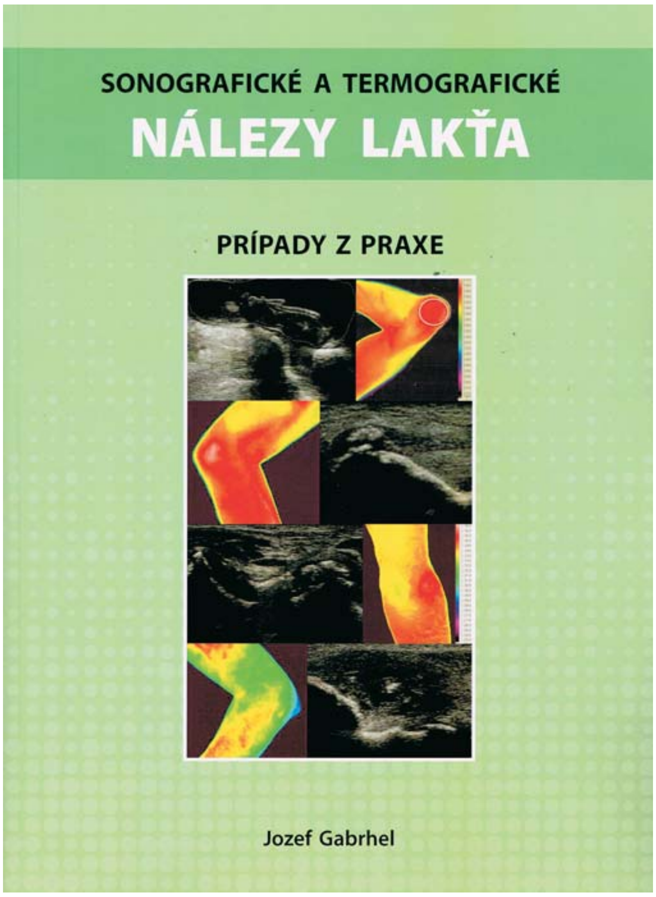
Kurt Ammer

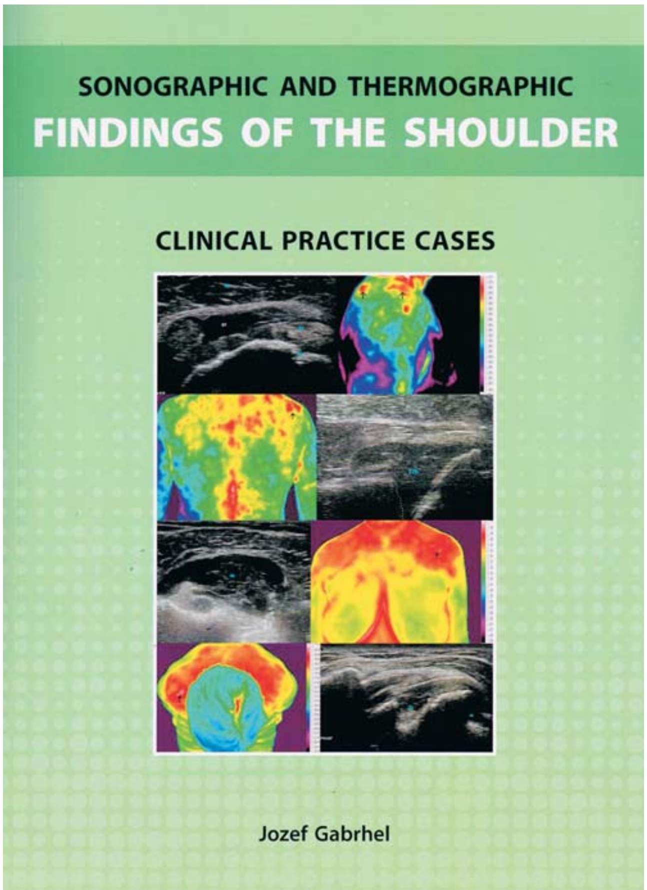
Editor in chief, Thermology international, European Association of Thermology, Vienna, Austria

MUDr Jozef Gabrhel started the year 2021 by publishing two other case books: a volume on the elbow in Slovakian language [1] and an English edition of the shoulder volume [2], that appeared in last autumn. The shoulder book shows the following touching tribute to Francis Ring:

I dedicate this monograph to the late scientist and friend of Slovakia, Professor Francis Ring, who promoted and governed the continuous development of medical thermography for more than 50 years with a gentle authority. His efforts in standardising the conditions and procedures to capture and evaluate infrared thermal images of the human body form the foundation of scientific medical thermography. Thereby, he helped to establish medical thermography as part of clinical medicine and its use as an adjuvant diagnostic imaging method in daily clinical practice. For supporting the promotion of medical thermography in Slovakia, he was awarded an honorary membership of the Slovak Medical Society.[2].

The link between Francis Ring and Slovakia was based on the personal friendship between Francis and Dr. Helena "Vara" Tauchmannova and her husband Dr. Miroslav "Miro" Tauchmann, both specialists in Physical and Rehabilitation Medicine. This relationship started prior to the foundation of the European Thermographic Association in 1972 [3] when Slovakia was still associated with the Czech Republic in a common state. Vara Tauchmannova, born in 1926, has been a national representative at the European Thermographic Association since 1974. She introduced thermography in the clinical practice of rheumatology in Czechoslovakia. Dr Tauchmannova applied in the late nineteen seventies thermography as an outcome measure in the evaluation of pharmacological therapy for connective tissue disease and for detection of effects of physical therapy in locomotor disorders. Her husband Miroslav worked as the medical director of one of the big spa hotels of the Health Resort in Piest'any. Both, Miroslav and Helena were mentors for Jozef Gabrhel, who became also a specialist in Physical and Rehabilitation Medicine. The volume on thermographic and sonographic images of the elbow is dedicated to the late Miro Tauchmann.





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The elbow volume is of similar structure as the shoulder book. A short introduction on anatomy of the lateral, the medial and the posterior aspect of the elbow is followed by examples of thermograms and sonographies recorded from the elbows of healthy subjects. Several disorders of the elbow region such as epicondylitis, bursitis, inflammatory arthritis, bone fractures, and corpora libera are illustrated in numerous short case reports by thermal images, sonographies, and occasionally other imaging modalities. This book collects on 112 pages detailed case information from individual patients displaying the wide variation one may expect in the evaluation of patients presenting with pain at the elbow.

A slight limitation is the fact, that some thermal images do not show a colour bar, making the estimation of the depicted temperature quite difficult. However, most of the data collected have already been sufficiently analysed in a previous article published in this journal [4].

Both volumes provide an insight in the frequency of upper extremity pain syndromes that can be expected in a private practice of Physical and Rehabilitation Medicine. Clinical examination and medical thermography in combination with ultrasonography are the suggested approach to successful diagnosis and treatment.

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A Tribute to Doc. MUDr. Helena Tauchmannová, PhD.

Jozef Gabrhel[1], Zuzana Popracová [1], Juraj Čelko [1], Kurt Ammer [2]

[1] Slovakia, [2] Austria

January 24, 2021 was witness to joyous celebrations of the 95th birthday one of the pioneers of medical rehabilitation and physical medicine in the former Czechoslovakia, and later in Slovakia, Doc. MUDr. Helena Tauchmannová, PhD. She first introduced thermography as an examination method to Czechoslovakia in the 1970s, and facilitated its incorporation into the practice of rheumatology and medical rehabilitation.

Helena Tauchmannová was born on January 24, 1926 in Bratislava. She attended primary and secondary school in Prague and later in Bratislava, where she graduated in 1945. She completed her medical studies at the Faculty of Medicine, Comenius University in Bratislava. After completing her internship on different hospital wards, she dedicated her further medical and research activity to rehabilitation and physical medicine, and contributed enormously to its advancement. From 1968 she was head of the wards at the National Institute of Rheumatic Diseases in Piešt´any. She extended her knowledge through active participation in international rheumatology congresses, e.g., in Brighton, Barcelona, Paris and Moscow, as well as congresses on medical thermography, e.g., in Bath, Lucerne, Basel, Vienna, etc.

In 1981 MUDr. Helena Tauchmanová was awarded the candidate of science degree, and in 1992 she passed the habilitation exams at Trnava University. Her publishing activity was also of great significance - she contributed eleven chapters to textbooks on rheumatology and medical rehabilitation, and was the author of more than 100 scholarly articles published in national and international journals. She was a member of the editorial board of several academic journals, and was also on the advisory board of the European Association of Thermology.

Doc. MUDr. Helena Tauchmanová had an extraordinary teaching skill. She always enjoyed tutoring and was never too busy to deliver individual consultations. In her training courses for physicians intending to become consultants in physical and rehabilitation medicine, she impressed students with, among other things, a large amount of quality photo documentation from her own clinical practice. This focussed primarily on rehabilitation and physical treatment of rheumatic patients. She was a pioneer in several areas of medicine in Slovakia, most notably rehabilitating the first total hip replacement patients at the National Institute of Rheumatic Diseases in Piešt´any. Based on the patients' clinical needs, Doc. MUDr. Helena Tauchmanová developed methodological guidelines for their rehabilitation which are still relevant today. She was always open-minded to complementary treatment methods such as acupuncture, and was the first to evaluate the effect of magnetotherapy in a large cohort of patients with inflammatory rheumatic diseases.

Doc. MUDr. Helena Tauchmannová PhD in 1996

She continues working even after her retirement, and until recently she was a student mentor for the master's degree in physiotherapy. She was awarded the "Gold Medal" of the Slovak Medical Society for her life's work, and in 2006 became an honorary member.

Dear associate professor, on the occasion of your 95th birthday, and on behalf of your many grateful students as well as the entire academic society, please accept our warmest wishes for the years to come; especially **good health, vigour and well-being!**

2021

25th – 28th July 2021

15th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics HEFAT2021

The Organizing Committee of the International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT) and the Editorial Board of Applied Thermal Engineering (ATE) are delighted to announce that we have established a partnership, starting in 2021. HEFAT will form the main forum for the board, authors, reviewers, and guests of ATE from all over the world, to meet and exchange ideas in overlapping research, innovation, and development areas. The HEFAT-ATE conference will form a regular opportunity for the Editorial Board of ATE to have its board meetings and allow authors and presenters theopportunity to meet both the board and representatives of the publisher, Elsevier.

The conference will be hosted **VIRTUALLY (online only**) instead of in Amsterdam, Netherlands. Oral and poster presentations will take place in real-time without sacrificing audience participation or networking, thanks to leading virtual conferencing technology.

The conference is co-sponsored by the International Centre for Heat and Mass Transfer (ICHMT) and the American Society of Thermal and Fluids Engineering (ASTFE).

Beyond inclusion in the proceedings of the conference, papers from the conference will be recommended for publication in dedicated special issues of ATE, best papers from ATE along with outstanding reviewers contributing to ATE will be announced and awarded at the conference.

Conference website: https://hefat2021.org

Journal website:https://www.journals.elsevier.com/applied-thermal-engineering

Abstract submission portal:
https://hefat2021.org/abstracts-papers/

Important Deadlines

28 February 2021: Deadline for submission of abstracts

31 March 2021: Deadline for submission of full papers

1st September 2021.
Short Course on Medical Thermography

Online

2nd - 3rd September 2021
XV Congress of the European Association of Thermology → **Online** ←

For further information on both events go to page 39

28th-30th September 2021

XIV International Conference THERMOGRAPHY AND THERMOMETRY IN INFRARED in Kazimierz Dolny, Poland

Conference "Thermography and Thermometry in Infrared" is the main conference on thermal imaging in Poland. It takes place every two years. It is a scientific and technical forum, where experts in various fields dealing with thermography can exchange their experiences, present the results of their research and discuss the use of thermography and thermometry in infrared. The conference helps in integrating the scientific and research community with industry.

The first organizer of the conference was Dr. Piotr Prêgowski. Thanks to him, the conference gained a high scientific rank and contributed to the integration of scientists and technicians involved in thermography. The actual organizer of the TTP Conference is the Institute of Electronics (Lodz University of Technology). The ambition of the TTP Conference organizers is to maintain the current conference profile, i.e. to promote and develop thermographic techniques in various fields of science and technology, with particular emphasis on quantitative thermography. The TTP Conference is accompanied by an exhibition of thermal imaging equipment, where the manufacturers present their latest hardware and software achievements.

CONFERENCE TOPICS

- Infrared detectors, detection of infrared radiation and radiometric temperature measurement
- Thermal imaging systems and their software
- Modelling and measurement of temperature distribution, thermal processes
- Non-destructive testing using infrared techniques
- Biomedical applications of infrared thermal imaging
- Industrial applications of infrared thermal imaging
- Civil engineering applications of infrared thermal imaging
- Scientific and technological applications of infrared thermal imaging

THERMOGRAPHIC SCHOOL

On 28.09.2021 the organizers invite for lectures and demonstrations during the thermographic school. The lecturers are specialists from Poland and abroad. The organizers issue certificates of participation in the thermographic course.

EXHIBITORS SESSION

As in previous years, there will be an exhibition of thermal imaging equipment during the TTP 2021 Conference. Manufacturers of thermographic hardware and software will be presenting their offer and their latest achievements. We offer two pages (full color) in conference proceedings and the possibility of presentation during Sponsors' plenary session.

PAPERS AND PUBLICATIONS

The organizers grant the possibility of publication of selected papers (in English or Polish) in the PAR Journal (20p).

PAR Measurement Automation Robotics

The papers will undergo a review process according to the PAR Editorial Office requirements. The hardcopies of PAR, entirely dedicated to the TTP Conference, will be delivered at the registration desk. For papers published in PAR, it is necessary to provide abstracts according to the template, which will be included in the electronic version of the conference proceedings (pendrive).

The deadline for abstract submission is 30.05. 2021.

Due to the review process, we kindly ask for submission of the papers in electronic form until 20.05.2021. The detailed guidelines for authors will be presented on the website http://thermo.p.lodz.pl/ttp and will be send to you later on.

POSTER SESSION

There is a poster session during the TTP 2021 Conference. Every exhibitor gets 0.5 m2 space for presenting his work. All the required stationery will be delivered by the organizers.

IMPORTANT DATES

01.04.2021 – registration via the website

20.05.2021 – submission of the full paper in electronic form (PAR) via the website http://thermo.p.lodz.pl/ttp.

30.05.2021 – submission of the paper in electronic form for publication in the conference proceedings, via the website http://thermo.p.lodz.pl/ttp.

28.09.2021 - Kazimierz Dolny

Start of the TTP Conference.

FEES

The conference fee covers the participation in the conference, accommodation (4 days), board, conference proceedings and an excursion.

- 350 EUR (1500 PLN) – payment before 01.06.2021
- 450 EUR (1900 PLN) – payment after 01.06.2021
- 250 EUR (1000 PLN) – student fee
- 300 EUR (1200 PLN) – accompanying person fee

Bank account number will be given on the conference website.

TIME AND VENUE

The TTP 2021 Conference will take place on

28 - 30 September 2021

Przedsiêbiorstwo Turystyczne

"Zajazd Piastowski" Sp. z o.o.

ul. Sloneczna 4, 24-120 Kazimierz Dolny

tel. 81 88 90 900, kom. 609 628 999

e-mail: zajazd@zajazdpiastowski.pl

Detailed information on conference venue can be found at the website http://thermo.p.lodz.pl/ttp.

ACCOMPANYING EVENTS

The TTP 2021 Conference will be accompanied by meetings, the main purpose of which is to integrate conference participants, scientists, engineers, practitioners and enthusiasts of infrared thermography. A sightseeing trip is also planned.

ADDITIONAL INFORMATION

Please send all the inquiries and comments to the conference secretariat. The preferred contact method is an electronic correspondence.

All important information will be sent in subsequent communications and will be posted on the conference website http://www.thermo.p.lodz.pl/ttp.

website http://www.thermo.p.lodz.pl/ttp.

ORGANIZING COMMITTEE

Dr inz. Mariusz Felczak - President

Prof. dr hab. Boguslaw Wiêcek

Mgr inz. Mieczyslaw Wilczyñski

Dr inz Marcin Kaluaz

Dr inz.. Robert Olbrycht

Mgr inz. Michal Kopec

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http://thermo.p.lodz.pl/ttp

e-mail: ttp@info.p.lodz.pl

XV Congress of the European Association of Thermology 2nd - 3rd September 2021, Online

IMPORTANT ANNOUNCEMENT

The XV Congress switches to online only. Abstract deadline extended to 31st March 2021

The EAT and Wroclaw University of Environmental and Life Sciences are delighted to invite you to participate in the XV EAT Congress, online from 2nd to 3rd September 2021. Due to the current pandemic situation in Europe, the EAT Board and Organising Committee have decided that the Congress will now take place online only, and the abstract deadline will be extended to 31st March 2021.
If you have already submitted an abstract, this will be considered for the online meeting, and you will be contacted by the Chair of the Scientific Committee once review of your abstract is complete.

Full details about the format of the online sessions, and how to register, will be posted on the EAT website at:

www.eurothermology.org/XVCongress.html

as soon as the information becomes available.
Please submit your abstract now, and check back regularly for the latest Congress news.

Dr. Kevin Howell,
President, European Association of Thermology

Dr. Maria Soroko,
Chair, XV Congress Organising Committee

The Congress is held under the honorary patronage of His Magnificence, Rector of the Wroclaw University of Environmental and Life Sciences.

Key dates

- 31st March 2021. Abstract submission deadline.
- 14th May 2021. Acceptance notification to authors.
- 17th May 2021. End of early registration.

- 1st September 2021.
  Short Course on Medical Thermography Online
- 2nd - 3rd September 2021.
  XV Congress Scientific Sessions Online.

The XV Congress of the EAT is supported by:

Thermetrix Limited
Making Life Better

About the Congress

The XV Congress of the European Association of Thermology will be an influential conference for professionals in biomedical temperature science. It is a unique opportunity for industry and scientists to meet and acquire new knowledge, as well as to exchange experience of temperature measurement in medicine and biology during oral presentation and poster sessions.

Key Meeting Themes

Key topics for the Congress will include:

- Infrared thermography in biomedicine.
- Temperature measurement in animal welfare, veterinary applications and equine physiology.
- Contact temperature measurement.
- Hardware and software solutions for infrared imaging.
- Biomedical applications: surgery, neurology, vascular and pain syndromes.
- Thermometry in exercise physiology, rehabilitation, and human performance research.
- Calibration and traceability in biomedical thermometry.

All abstracts will be published as an appendix of the EAT journal "Thermology International", indexed in EMBASE/SCOPUS

Prizes for:

Best oral presentation (**The Francis Ring prize**), and best poster (**The Kurt Ammer prize**)

Organising Committee

This committee is responsible for all operational aspects of the Congress, including delivery of the meeting at the local venue

- **Maria Soroko (POL), Chair**
- Kurt Ammer (AUT)
- Wanda Górniak (POL)
- Kevin Howell (GBR)
- Anna Jung (POL)
- Damian Knecht (POL)
- Alicja Kowalczyk (POL)
- Sebastian Opalinski (POL)
- Adam Roman (POL)
- Adérito Seixas (POR)
- Manuel Sillero-Quintana (ESP)
- Ricardo Vardasca (POR)
- Klaudia Wlazlak (POL)
- Anna Zielak-Steciwko (POL)

International Scientific Committee

This committee is responsible for reviewing all submitted abstracts to the Congress, and approving the final Congress programme.

- **Kurt Ammer (AUT), Chair**
- John Allen (GBR)
- Danilo Gomes Moreira (BRA)
- Kevin Howell (GBR)
- Anna Jung (POL)
- Mariusz Korczynski (POL)
- Robert Kupczynski (POL)
- James Mercer (NOR)
- Sebastian Opalinski (POL)
- David Pascoe (USA)
- Adérito Seixas (POR)
- Manuel Sillero-Quintana (ESP)
- Maria Soroko (POL)
- Hisashi Usuki (JPN)
- Mari Vainionpää (FIN)
- Ricardo Vardasca (POR)
- Ho Yeol Zhang (KOR)

Registration fees

	Early registration (until 17th May 2021	Late registration (from 18th May 2021
EAT member	€ 110	€ 130
Non-member	€ 130	€ 150
Student	€ 80	€ 100

Online registration for the XV Congress of the European Association of Thermology is now open , please click here.

Registration includes access to all congress live online sessions, our on-demand library of recorded presentations, and the online library of posters.

Attendance at the pre-congress Short Course on Medical Thermography requires a separate registration and payment. More information, when available, will be posted here .

Abstract submission

is now open, and **will close on 31st March 2021.**

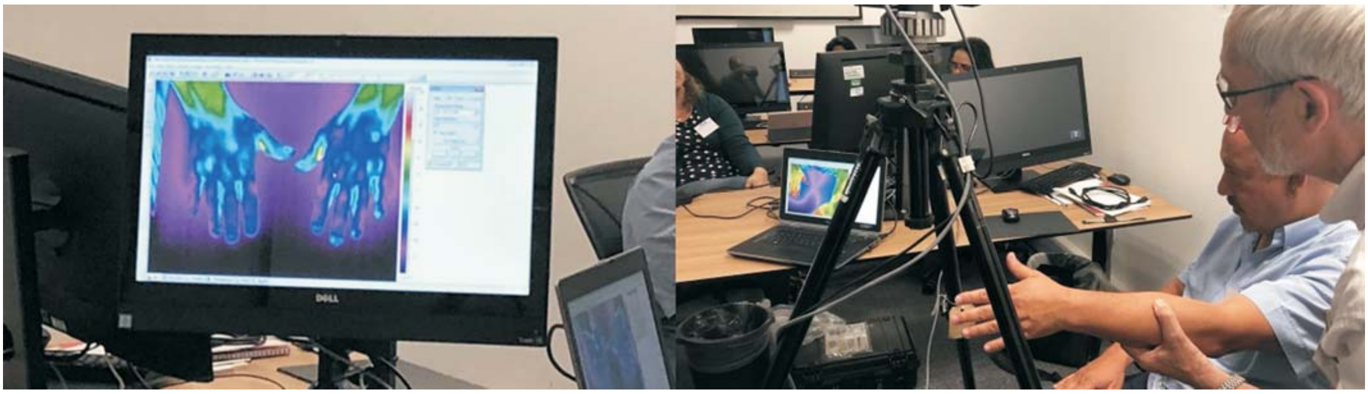
Abstracts should follow the style of the EAT Congress abstract template, which can be downloaded here

All abstracts should be uploaded using the Congress abstract submission form here.

Abstracts will be peer-reviewed for suitability by the International Scientific Committee, and a decision on acceptance will be communicated to authors by 14th May 2021.

Accepted abstracts will be published as an appendix of the EAT journal "Thermology International", indexed in EMBASE/SCOPUS

Authors may express a preference for oral or poster presentation of their work: this will be noted by the Committee, but it may not always be possible to fulfil preferences due to space limitations in the programme.



Short Course in Medical Thermography

The European Association of Thermology has education as one of its key aims. To that end, we offer the EAT "Short Course in Medical Thermography," taught by an experienced faculty of thermology researchers.

The Course normally takes place every three years, along with the Congress of the EAT, at a European venue.

The next edition of the Course will be on 1st September 2021, immediately prior to the XV Congress of the EAT at Wroclaw University of Environmental and Life Sciences, Poland.

Provisional main themes of the 2021 syllabus will include:

- Physical principles of heat transfer
- Principles of thermal physiology and skin blood perfusion
- Standardization of thermal imaging, recording and analysis
- Quality assurance for thermal imaging systems
- Producing a thermographic report
- Provocation tests
- Image analysis
- Hands-on supervised practice
- Educational resources

The full syllabus of the last Course in 2018 can be downloaded for Thermology International subscribers as a .pdf file

Check back to register for the next Short Course from Spring 2021