# MEASUREMENT OF THERMAL SYMMETRY OF THE HUMAN SPINE BY THE USE OF MEDICAL THERMOGRAPHY

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*Abstract*

*The Aim of the study was to identify the temperature symmetry on physiologically healthy dorsal parts of torso. Because of problems with the correct focus on the central values of temperature on the dorsal side of the torso, the methodology of 3D body scanning was included. For the purposes of this study, two databases of 23 thermograms and 23 scans of dorsal trunks were created. The measured value of the average difference was 0.4°C. The 3D human body scanner was used for calculation of the length and size of spinal curvature in the sagittal plane. An important contribution of the study has been to establish a process for obtaining thermograms through the identification of focus area with 3D Body Scanner.*

## Introduction

The goal of presented paper is to detect the thermal symmetry or asymmetry of the dorsal side of torso of young physiological healthy people, what often refers to several diseases and injuries of the human spine or back. For this purpose were used technologies of thermal imaging and 3D body scanning.

The database will help in the diagnostic process of various diseases such example in oncology, neurovascular diseases, dermatologic diseases, studies of inflammatory responses, pain (management/ localization/ control), sleep research, pain related thermal dysfunctions, Anesthesiology, Acupuncture and Complementary Medicine, Physical Medicine and Rehabilitation, cardiovascular diseases, etc. [1].

Medical thermography can be a beneficial tool for diagnostics of surface temperature of the human body. It is because it represents non-invasive, non-contact, safely, no-radiation and painless image technique, which could be used for diagnostic of pain (management/ localization / control), etc. Symptoms of many diseases are often associated with temperature variations on skin surface such as inflammation, paresis or plegia, pain or athrophy, which could be visible by the use of medical thermography [1].

Current studies have shown temperature symmetry to be well conserved in homologous area in the absence of pain. Uematsu et. al. studied 32 normal subjects and 30 patients with peripheral nerve impairment who ranged in age from 12 to 65 years. They found that in normal persons the skin temperature difference between contralateral sides of the body was only $0.24°C_{\pm 0.073°C}$. He noted that skin temperature differences between corresponding sites on one side of the body compared to the other were not only extremely small, but also very stable throughout the body. Uematsu concluded that there is minimal temperature variation between corresponding sites on different sides of an individual's body [2, 6].

Due to the conservation of temperature symmetry in homologous regions of the body, in the absence of pain or in the presence of bilateral pain, researchers at the Kathryn Walter Stein Chronic Pain Laboratory undertook an alternative approach to the analysis of thermography. A retrospective analysis of thermography imaging data of 110 patients (904 views) was performed. Data were categorized for 28 major body areas derived from mapped body areas (10 areas from 28 were located on dorsal parts of torso). The objective of this study was to establish a normative database that may be used for comparison, particularly in patients with bilateral pain [2, 3].

On the spine from sagittal plane are located four spinal curvatures. They have a very important mechanical role to increase the flexibility of the spine and its strength, but they have also caused problems in focusing on the central values of temperature. Therefore, we used body scanning to determine the biomechanical of curvature of dorsal torso.

## Methodology of Measurement

For this study was created a database of reference thermograms ($n=23$) and 3D scans obtained by 3D human scanner. Because of problems with the correct focus on the central values of temperature on the dorsal part of the torso, was added to the methodology the 3D body scanner. TC$^2$ Body Scanner was used due to the calculation of the length and size of spinal curvature in the sagittal plane. Our calculations have been focused on dorsal surface of torso. The examined persons had to acclimate the bare torso before the actual measurement in the room at a temperature range from 19°C to 25°C.

For each measurement (thermography, 3D scan) was used Standard Anatomical Position. The international standard anatomical position is the position that provides a reference point for describing the structures of a human body. In this position, the body is standing erect with good posture and the face is looking directly forward. The feet are about six inches apart, flat on the floor and the toes pointing forward. The arms are down at the sides with the palms turned forward and thumbs pointing away from the body. Anterior and ventral both mean toward the front of the body, while posterior and dorsal mean the back of the body.

This position is the standard reference point in which all positions, movements, and planes are described. The anatomical position allows us to describe the position of structures in relation to their surroundings.

Each of normal thermograms was obtained in detail view of interesting area and from the same angle.

### Object of measurement

The study is based on comparison of temperatures on areas of healthy backs/spines, which represents reference thermograms. Database was divided on 24 female thermal polygons from 12 healthy backs ($_F n=12$; $\Sigma_f x_{2sin/dex}=24$) and 22 male polygons from 11 men ($_M n=12$; $\Sigma_m x_{2sin/dex}=22$). The database consists of 23 right ($n_{dex}=23$) and 23 left ($n_{sin}=23$) healthy symmetrical half of backs without any pain or injury symptoms. The database is composed of healthy young people in the average age of 21.7 years, with the average *BMI* 22.6 (normal weight). They have been young people with occasional sport activity.

All volunteers were asked to complete a questionnaire regarding his/her general information. The volunteers who had a history or physical examination suggestive of diabetes mellitus, excessive alcohol consumption, or exposure to toxins were excluded. The back/spine with wounds, acute infection, and injury or with any problems of the spine was also excluded from the measurements.

Instructions before infrared imaging

- no application / removal of skin creams and cosmetics on the study area;
- avoid eating and excessive intake of tea or coffee immediately before the examination (cca2 hours);
- ban the use of drugs (completely) and smoking (about 2 hours before the examination) [4];
- avoid higher physical stress (eg, rehabilitation, training, etc.) or mental stress;
- prudent to avoid medicaments affecting the cardiovascular, musculoskeletal or neurovascular system (unless contraindicated by physician).

### Conditions of Measurement for Environment

Measurements have been carried out under the same conditions, still in the same room with the ambient temperature about *23.1°C $_{\pm0.7°C}$* for three months. In this room were retracted blinds to avoid the impact of solar radiation and the room was equipped with air conditioning to maintain the same temperature at each measurement [1, 5, 8].

### Methodology for obtaining Thermograms

Skin temperature on dorsal part of torso was measured with the Infrared Thermal Imaging Camera (ThermaCam Fluke Ti55/20, Fluke, USA). This thermographic camera produces a matrix (representing image points) of temperature values. The thermal sensitivity of the thermograph is 0.05°C at 30°C. Camera works in the spectral range from 8μm to 14μm (human body infrared radiation is highest in the spectral range around 9.66μm) and the calibrated temperature range from -20°C to 100°C. Camera resolution is 320×240 pixels (total 76800 pixels). [8]

Emissivity of the skin was set in the camera software to 0.98 [8], the ambient temperature was measured by infrared (laser) thermometer (Pyrometer Testo 810) and for the control of trunk symmetry was used 3D scanner (TC$^2$ Body Scanner).
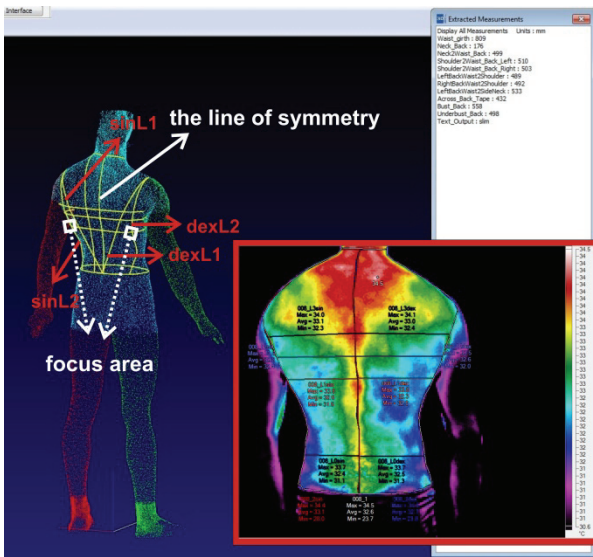
*Fig. 1: 3D scan with marked lengths and the corresponding thermogram.*

Because of problems with the correct focus on the central values of temperature on the dorsal part of the torso, was added to the methodology the 3D body scanner. Figure shown (Fig. 1) the focus area which was determined by basic biomechanical principles with 3D scanner. For the purpose of this study was established the line along the vertebral, that has divided the body into the two symmetrical half. At the beginnig of each measurement this line was recognized with 3D body scanner.
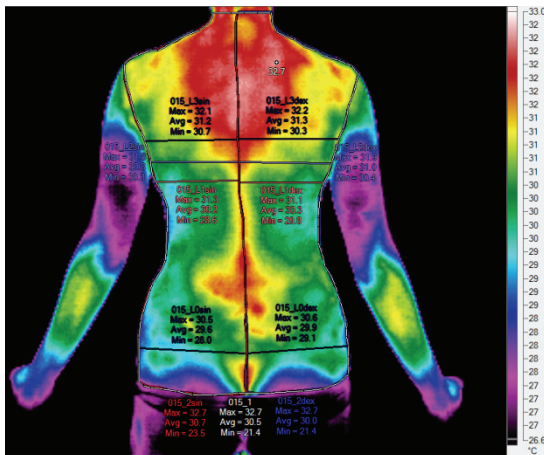


*Fig. 2: The difference in lengths on dorsal side of torso.*

All thermograms (*n=23*) were processed with special software (SmartView 2.1, FLUKE, USA). All thermograms from our database have been focused in grayscale. It is the best palette for distinction of human eye [8]. After in SmartView software was set Palette High Contrast, there it is possible to narrow the

temperature interval. For analyze temperature for medical application is usually used Palette of High Contrast (Fig. 2). Processing thermogram begins by deduction of background temperatures and identifying key areas of interest.

The temperatures in database were obtained from tracing two symmetrical half from dorsal sides of torso (back) of each individual. It was the way for creating polygons from interesting areas of temperature measurement (Fig. 2).

## Result

The 3D Body Scanner has confirmed the hypothesis about dimensional symmetry of physiological healthy human torso. The results showed that 48% of scans of symmetrically transverse curvature and body length varies by ≤5mm and 30% of scans vary about ≤10mm.
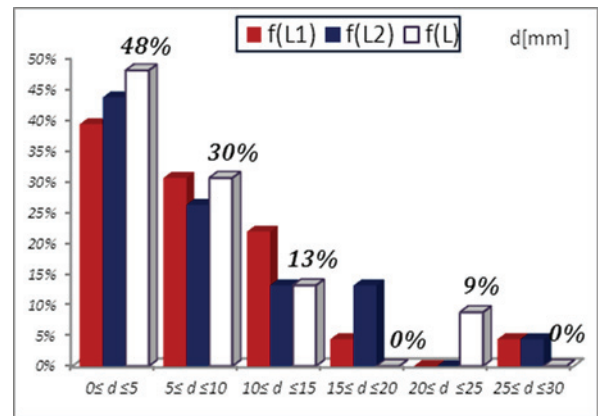


*Fig. 3: The difference in lengths on dorsal side of torso.*

From the graph (Fig. 3) the *f(L$_1$)* and *f(L$_2$)* represent relative abundance of the element (lenghts on *dex/sinL$_1$* and *dex/sinL$_2$* see Fig. 1), expressed as a percentage. The *f(L)* is relative abundance of the element obtained from calculation lenghts on *dex/sinL$_1$* and *dex/sinL$_2$*, expressed as a percentage [7].

From thermography measurements was found that average temperature of dorsal torso was cca $T_1=32.1°C_{\pm2°C}$. The main difference in thermal symmetry between sinister *(sinT$_2$)* and dexter *(dexT$_2$)* part of torso was in minimal temperatures *(sin/dexT$_2$)*. The biggest difference was 6.7°C which was measured on male thermogram (Fig. 4).
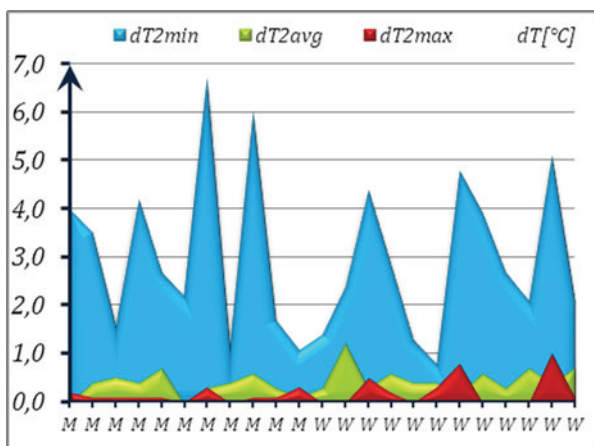
*Fig. 4: The difference in thermal symmetry*

Because of a small number of volunteers can not exactly determine the impact of asymmetry in the length of the spine to the temperature difference (Fig. 5).
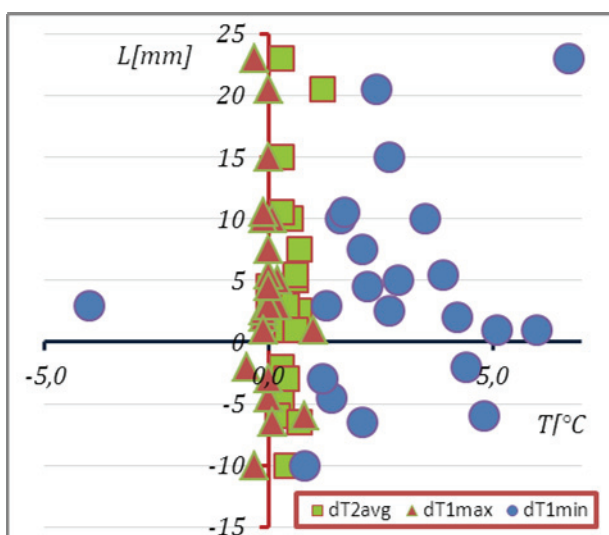


*Fig. 5: The relationship between differences in length and temperature in symmetry.*

## Conclusion

We have not found significant symmetry differences between sinister and dexter part of torso yet. The measured value of the average difference was 0.4°C. For a small number of volunteers has not found significant variations of temperature between the sexes yet. We are going to expand the database of volunteers. An important contribution of the study has been to establish a process for obtaining thermograms through the identification of focus area with 3D Body Scanner.

## Acknowledgement

## References

[1] Ammer, K.: Thermology 2009- *A computer- assisted literature survey*; In: Thermology International; Published by the Austrian Society of Thermology and European Association of Thermology; Vol.20, No.1; 2010; p.5-10; ISSN 1560-604X

[2] Cabrera, I. N.; Cohen, J.M.; Downing, L.: *Thermography Techniques*; In: Rehabilitation Medicine and Thermography; ISBN: 978-0-6151-8721-1; p.25-32

[3] Cabrera, I. N.;Wu, S.S.H.; Haas, F.; Lee, M.H.M.: *Computerized Infrared Imaging*: Normative Data on 110 Patients. Arch Phys Med Rehabil, 2001; 82:1499

[4] Miland, A.O.; Mercer, J.B.: *Effect of a short period of abstinence from smoking on rewarming patterns of the hands following local cooling*. Accepted: 9 June 2006 / Published online: 28 July 2006, © Springer-Verlag 2006, Eur J Appl Physiol (2006) 98:161–168, DOI 10.1007/s00421-006-0261-2

[5] Ring, E; Ammer, K.: *The technique of infrared imaging in medicine*. Thermology International 2000; 10:7-14.

[6] Uematsu, S.; Edwin, D.H.; Jankel, W.R.: *Quantification of thermal asymmetry*; Part I: Normal values and reproducibility. J. Neurosurg; 1988; 69:552-5

[7] Zvarová, J.: *Základy statistiky pro biomedicínské obory I.;* Biomedicínska statistika; Univerzita Karlova v Prahe; Nakladateľstvo Karolinum; 2007; ISBN 978-80-7184-786-1

[8] http://www.infraredinstitute.com/basic.thermography.html

[9] http://spectronir.com/

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