AN IMPORTANCE OF CAMERA – SUBJECT DISTANCE AND ANGLE IN MUSCULOSKELETAL APPLICATIONS OF MEDICAL THERMOGRAPHY

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ABSTRACT

Medical thermography is non-invasive, non-radiation, painless and non-contact imaging technique with numerous medical applications including musculoskeletal system, its disorders and injuries. Often it is useful to cross-reference the resulting thermograms with visual images of the body; either to see which part of the musculoskeletal system is affected by a certain disease or injury or to judge the efficacy of the treatment. Presented paper deals with application of the thermal imaging to measure lower extremities surface temperature distribution in 20 healthy individuals. The aim was to asses the proper technical way of the measurement. To confirm the results in humans, the blackbody calibration device was used.

Keywords: *thermography, thermogram, calibration blackbody*

1. INTRODUCTION

Musculoskeletal system in human body is responsible for movement and locomotion. It consists of several organs (or tissues), which are represented by their functions. Injuries or diseases in musculoskeletal system are often associated with temperature variations on skin surface (inflammations, pathological vasoconstrictions or vasodilatations, paresis or plegia, atrophy, etc.) which are visible by the use of medical thermography.

Numerous studies were realized since 1960’s, but there is visible increase of musculoskeletal applications of medical thermography nowadays. The main reason is an improvement of technical parameters of thermovision systems and knowledge in medical fields. Progel et al. in the year 1996 presented study on asessment of trapezius muscle symptoms of patients with temporomandibular disorders by the use of liquid crystal thermography. The objective was to test the hypothesis, that these neuromuscular symptoms of patients with temporomandibular disorders that occur in the upper back and neck can be evaluated by recording the temperature patterns in the skin overlying the muscles.

Sherman et al. in 1996 used videothermography, infrared beam thermography and contact thermography to detect asymmetries in temperatures between paired limbs. The skin over both lower limbs was imaged with each technique sequentially on 139 male and 15 female patients reporting lower limb pain.

Infrared thermography was used for examination of skin temperature in the dorsal hand of office workers by Gold, et al., 2004. Reduced blood flow may contribute to the pathophysiology of upper extremity musculoskeletal disorders (UEMSD), such as tendinitis and carpal tunnel syndrome. The study objective was to characterize potential differences in cutaneous temperature, among three groups of office workers assessed by dynamic thermography following a 9-min typing challenge. Infrared thermography appears to distinguish between the three groups of subjects, with keyboard-induced cold hand symptoms presumably due, at least partially, to reduced blood flow.

An overview of the temperature measurements made in the arms of 8 pianists during regular piano practice sessions was presented (Herry et al., 2005). Most of these disorders are inflammatory in nature, and therefore involve temperature changes in the affected regions.

Different study where hands were imaged by infrared thermography was published by Harrison et al., 2005. In order to investigate the possible clinical usefulness of the distal-dorsal temperature difference, thermographic images from patients who had attended for routine Raynaud’s assessment were analysed retrospectively.

Lower extremities surface temperature distribution in spinal cord injured individuals was measured in studies presented by Hudak et al., in the years from 2005 to 2007. In order to importance of measurement methodics, the following parameters were considered: human skin emissivity, ambient temperature and humidity, camera – subject distance, etc.

Only in few studies was importance of camera – subject distance and angle highlighted. Presented paper shows correlations between skin surface temperature measured by infrared camera and the camera position towards the subject of measurement. Confirmation of the results using calibration blackbody was carried out.

2. METHODS

In this study 20 subjects (10 males and 10 females) with the average age of 22 years were measured by Fluke Ti55/20 (Fluke, USA) infrared camera. Camera works in the spectral band from 8 to 14 µm (human body infrared radiation is highest in the band around 9,5 µm) and the temperature range -20 – 100 °C. Measurements were realized in the air conditioned room with temperatures in the range from 18 – 21 °C during all measurements. Lower extremities were measured at 5 camera – subject distances (0,2 m, 0,5 m, 1 m, 1,5 m and 2,5 m) and 8 camera subject angles (0°, 10°, 20°, 30°, 40°, 50°, 60°, 70°, 80°). The zero angle was in the position of the camera in front of the measured subject at the distance of 2,5 meters. The subject documentation consists of the following parameters: sex, weight [kg], height [cm], age, body mass index (BMI), etc.

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These parameters were obtained by questionnaires, where also the behaviour of the patients before measurement was described (nutrition, metabolism, exercise, etc.). Ambient temperature and humidity, oral and axillar temperature were recorded (Thermoval Classic, Hartmann, Germany and ALMEMO 2690, AHLBORN, Germany). Temperature in same marked and specified point was measured by thermocamera at 5 above mentioned distances and 8 angles (Figure 1).

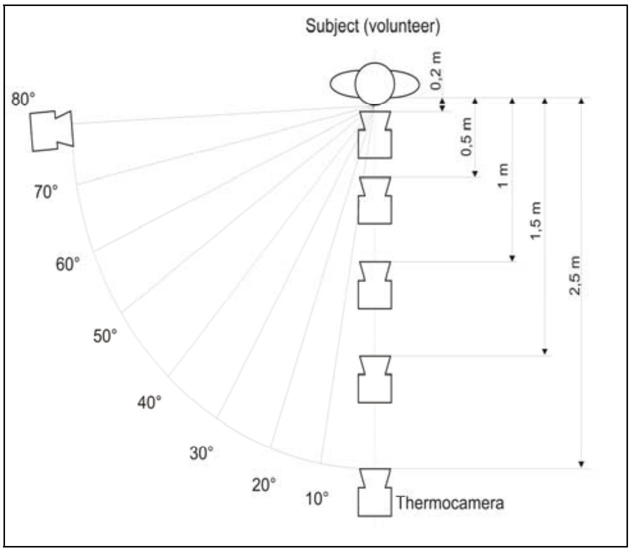

Fig. 1 The methodics of subject - thermocamera positioning (distance and angle adjustment)

Figure 2 shows thermograms at three selected distances (Figure 2a, 2b and 2c) and three selected angles (Figure 2d, 2e and 2f). The aim of measurements was to evaluate importance of camera – subject distance and camera – subject angle at the thermographic measurements in musculoskeletal applications.

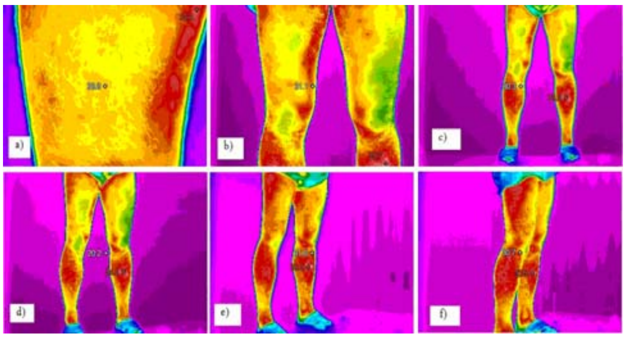

Fig. 2 Thermograms of lower extremities: a) temperature at the distance 0,2 m; b) temperature at the distance 1 m; c) temperature at the distance 2,5 m; d) temperature at the angle 20°; e) Temperature at the angle 50°; f) temperature at the angle 80°

To confirm experiments in humans, the calibration blackbody FLUKE – HART SCIENTIFIC 4180 (FLUKE/HART, USA) was used. The calibration black body 4180 reaches temperatures from –15 °C to 120 °C. With accuracies as good as ± 0.35 °C, the device can meet its specifications without additional emissivity-related corrections. Displayed temperature stability of the device is ± 0.05 °C at 0 °C and ± 0.10 °C at 120 °C. The same camera – calibration blackbody distances and angles were used as in measurements in humans. The figure 3 below shows methods of analysis: 2 circles, center point and hot cursor.

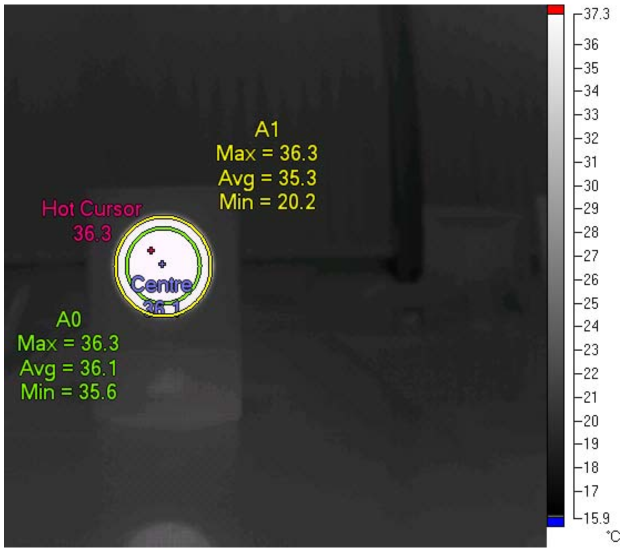

Fig. 3 Thermogram of the black body plate with software analysis, using point, hot cursor and circle area

Tabales 1 and 2 show differences between the maximum and minimum value of the distance and minimum and maximum value of the angle.

Table 1 Camera – blackbody distance dependence in temperature reading

Distance [m]	Tmax [°C]	Tavr [°C]	Tmin [°C]	Tcen [°C]
0,2	38,3	37,3	36,8	37,5
2,5	36,6	36,4	35,1	36,5

Table 2 Camera – blackbody angle dependence in temperature reading

Angle [°]	Tmax [°C]	Tavr [°C]	Tmin [°C]	Tcen [°C]
0	36,6	36,5	36,3	36,5
80	32	31,8	31,5	31,9

3. RESULTS AND CONCLUSION

Initial measurements of lower extremities skin surface temperature in 20 healthy individuals were realized. Results show differences among subjects in the range from 26°C to 33°C. Oral and axillar temperatures were in all subject higher (33,5 °C – 37 °C) than skin surface temperature.

There was no correlation found between oral or axillar temperature and skin surface temperature on lower extremities. Only small difference (0,2 °C) was observed at the different angle and different distance in camera – subject adjustment (overlayed points in both graphs). Camera – subject distance and camera – subject angle are less important parameters.

Data obtained by measurement of the calibration blackbody show $\Delta T = 1°C$ between the maximum and minimum camera - blackbody distance and $\Delta T = 4{,}6°C$ between the maximum and minimum camera - blackbody angle using center point analysis. In comparison with measurements in humans, there is a correlation of the output temperatures with camera – blacbody distance and angle.

More statistically significant experiments in humans with the specific point recognition markers are planed to explain the conflict in obtained results (research in humans and black body analysis).

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Jozef Živčák is a professor of biomedical engineering at Technical University in Košice, Slovakia. He was born in 1958. He received his MS and PhD degrees from Technical University in Košice in 1995. Prof. Živčák is from 2009 Doctor Honoris Causa of Uzhorod National University. His research interests include human biomechanics, medical sensorics, medical thermography and rehabilitation technology. Today Mr. Zivcak is a vice-dean for science, research, foreign relations and PhD study at the Faculty of Mechanical Engineering, Technical University in Kosice and head of Department of Biomedical Engineering, Automation and Measurement. Since 1998 he is an expert witness in machine and electrical technology. Professor Zivcak has more than 120 publications in home and foreign journals. He is an author and co-author of 2 monographies and 6 books.