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Thermography hand temperature distribution in rheumatoid arthritis and osteoarthritis

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Abstract

Background and Purpose: *Earliest written medical text from ancient Egypt mentioned temperature as an indicator of a disease. Although already known, thermal imaging has not been routinely used in medicine. Inflammation of peripheral joints, close to skin surface, is the dominant type of presentation of rheumatoid arthritis and due to that, those joints are suitable for infrared thermal scanning. Considering the changes of the bones in the affected joints, as a control group, apart from healthy subjects, study was conducted on patients with osteoarthritis as well. Purpose of this paper was to investigate thermal images of the hands of patients with rheumatoid arthritis and osteoarthritis and analyze temperature distribution.*

Materials and Methods: *Thermographic images of both hands of healthy subjects, patients with rheumatoid arthritis and patients with osteoarthritis were made. On thermal images obtained, temperature distribution of certain regions was analyzed. Basic statistical analyses (minimum, maximum, standard deviation, mean, and variance) were performed.*

Results: *There is a statistically significant difference in finger and metacarpophalangeal joint mean temperature values on ventral and dorsal sides for both healthy patients and patients with rheumatoid arthritis and osteoarthritis. Also, there is a statistically significant difference of mean temperature values between the aforementioned patient groups. Temperature distribution curves of patients with osteoarthritis have been narrower than those of subjects with rheumatoid arthritis and normal subjects. Temperature distribution curves of patients with rheumatoid arthritis have been shifted towards higher temperatures than those of subjects with osteoartritis and normal subjects.*

Conclusion: *From the results obtained it was concluded that heat distribution over the skin surface apart from depending on the affected joint and on the intensity of the disease and given drug therapy also differs between the patients with rheumatoid arthritis and osteoarthritis, making the use of thermography a possible method of differentiating normal subjects and rheumatoid arthritis subjects and osteoarthritis subjects from each other.*

INTRODUCTION

Earliest written medical text from ancient Egypt mentioned temperature as an indicator of a disease. A number of internal and external factors affect the skin temperature *(1)*. Despite a large number of the individual factors that affect the skin temperature *(2)*, have shown

that measurement of a mean skin surface temperature has a potential to be an indirect method for measuring an inflammatory disease activity. It is difficult to compare the thermographic research throughout the history due to the differences in sensitivity of the used equipment as well as the variability of skin surface temperature over different body parts.

Traditional assessment of the activity of the rheumatoid arthritis includes measurements of the subjective clinical variables, laboratory values and radiographic findings *(3, 4)*. Considering the change of temperature being basic physical characteristic of the inflammatory process and related reactions *(5)*, it is justified to consider thermography as a potential, sensitive, noninvasive method for monitoring the severity of the inflammatory disease in both animal models and humans *(6)*. In this paper we have investigated the mean surface temperature and its distribution on the hands in patients suffering from rheumatoid arthritis, osteoarthritis as well as in healthy people.

MATERIALS AND METHODS

The Study was performed in University Hospital Center »Sestre milosrdnice«, at the Rheumatology, Physical and Rehabilitation Medicine Clinic. Subjects were 8 patients hospitalized due to rheumatoid arthritis (according to the standard clinical protocol), 7 patients hospitalized due to osteoarthritis (according to standard clinical protocol) as well as 6 healthy volunteers – members of the medical team who haven't had any signs or symptoms of the difficulties with the musculoskeletal system. All subjects have voluntarily participated in this Study, and have signed an informed consent for participation in the Study. The Study has been conducted pursuant to the ethical principles set forth by the Declaration of Helsinki, and has been approved by the relevant Ethics committee.

The imaging was performed using an infrared camera Thermo Tracer TH7102WL (NEC Sanei Instruments, Ltd., Japan) and analyzed using ThermoWEB system *(7)* and ThermoMED proprietary software developed at the Ruđer Bošković Institute. Air temperature and humidity of the imaging room were stable, with maximum temperature oscillation of ±1°C. Thermographic images of both sides of both hands for each subject have been made. A delayed set of images was performed after the 25 minute to 1 hour interval, what made a total of 8 images per subject. All thermographic images were made in the same room at approximately same time of the day (approximately 14:00h). On each image, an area of each finger has been manually selected as well as an area of metacarpophalangeal joints. For each selected area, the software has determined the minimum, maximum and the mean surface temperature. Basic statistic analysis has been performed (minimum, maximum, standard deviation, frequency and variance) while the differences between the observed groups has been established by 4 way ANOVA with LSD post hoc test using Statistica 7.0 (StatSoft, Inc.)

RESULTS

Mean value of the skin surface temperature of the dorsal side of the hand observed in healthy subjects was in the range from 25.4°C to 35.1°C, in people who suffered from osteoarthritis in the range from 25.6°C to 35.4°C, and in subjects with rheumatoid arthritis in the range from 24.8°C to 35.0°C. At the same time, mean skin surface temperature of the ventral side in all groups was a bit higher and in the healthy subject it was in the range from 24.8°C to 35.5°C, in subjects with osteoarthritis from 25.5°C to 35.6°C, and in subjects with rheumatoid arthritis from 24.8°C to 36.5°C.

Sample thermographic images obtained for the dorsal side of the right hand of one subject suffering from rheumatoid arthritis, osteoarthritis and from a healthy subject have been presented in Figures 1 to 3.

Four way ANOVA has identified a factor »2« as being statistically significant – so, there have been statistically significant differences in values between dorsal and ventral side ($p<0.01$). Statistical significance was also found for factor »4«- there have been statistically significant dif-

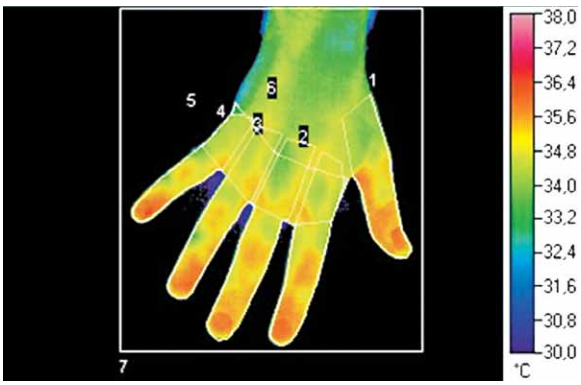

Figure 1. *Thermographic image of the dorsal side of the right hand of a healthy subject with marked areas for mean surface temperature measurements of the fingers I–V (labels 1–5) and metacarpophalangeal region (label 6).*

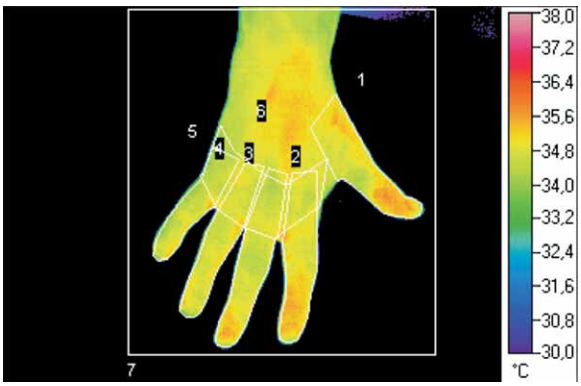

Figure 2. *Thermographic image of the dorsal side of the right hand of a subject suffering from osteoarthritis with marked areas for mean surface temperature measurements of the fingers I–V (labels 1–5) and metacarpophalangeal region (label 6).*

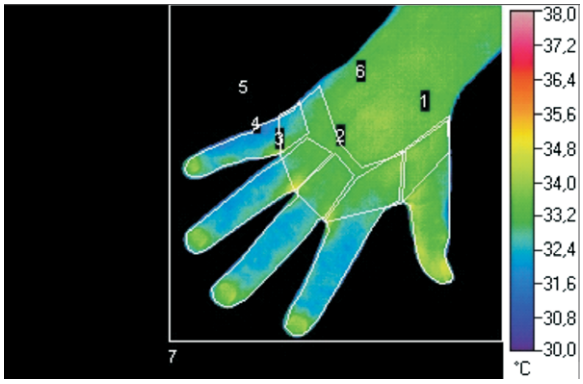

Figure 3. *Thermographic image of the dorsal side of the right hand of a subject suffering from rheumatoid arthritis with marked areas for mean surface temperature measurements of the fingers I–V (labels 1–5) and metacarpophalangeal region (label 6).*

ferences in values between the observed groups: healthy subjects, subjects with rheumatoid arthritis and subjects with osteoarthritis ($p<0.01$) (Table 1).

Temperature distribution curves obtained from thermal images have been made for each finger and metacarpophalangeal area for all subjects and compared to each other (Figure 4–6).

LSD post hoc test on mean skin surface temperature values of fingers and metacarpophalangeal region showed a statistically significant difference between the three observed groups (subjects with rheumatoid arthritis, subjects with osteoarthritis and healthy subjects) $p<0.01$.

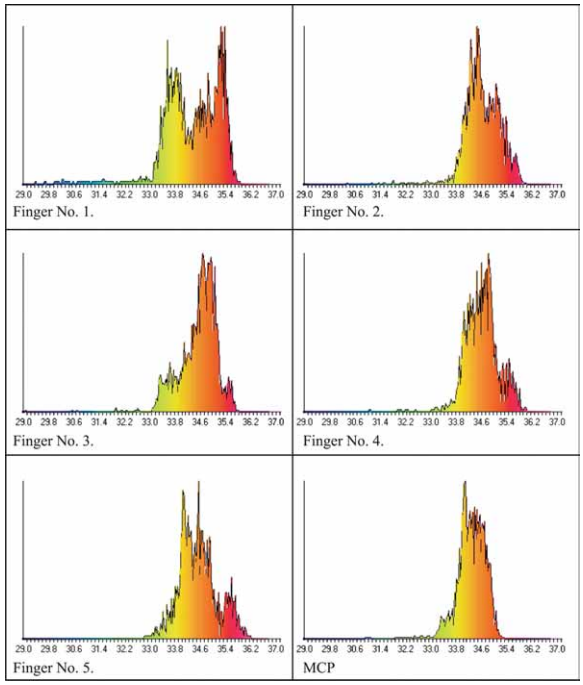

Figure 4. *A sample of graphic presentation of thermal distribution on dorsal thermal image of the hand of healthy subjects for each finger and metacarpophalangeal (MCP) area.*

DISCUSSION AND CONCLUSION

Surface skin temperature was higher in all observed subjects on ventral side, what was probably conditioned by the anatomic relations of the skin and the circulatory

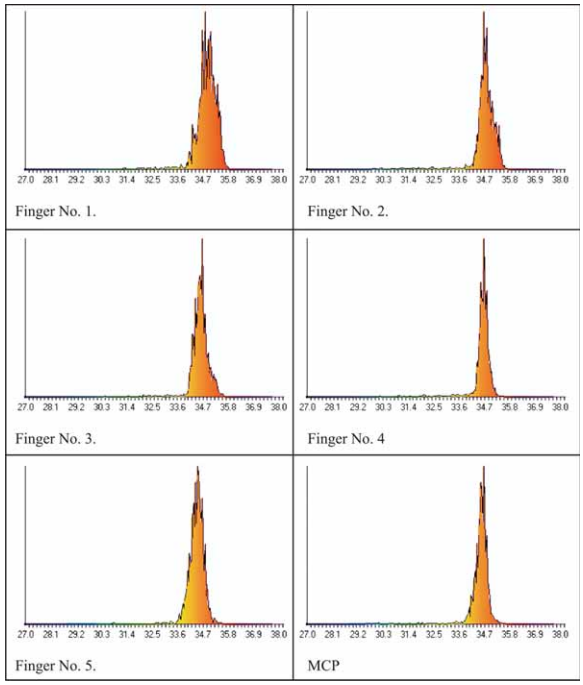

Figure 5. *A sample of graphic presentation of thermal distribution on dorsal thermal image of the hand for each finger and metacarpophalangeal area of a subject with osteoarthritis.*

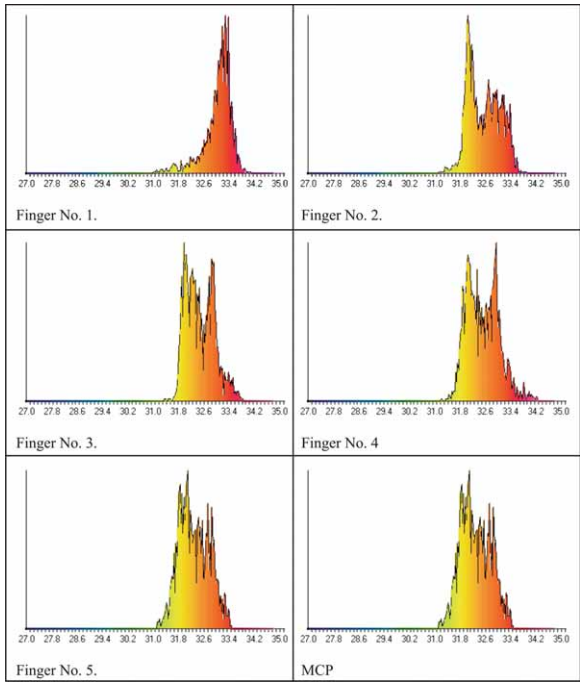

Figure 6. *A sample of graphic presentation of thermal distribution on dorsal thermal image of the hand for each finger and metacarpophalangeal area of a subject with rheumatoid arthritis.*

TABLE 1

Four way anova (factor: 1-finger, 2-dorsal side and ventral side, 3-right and left side, 4-healthy subjects-subjects with osteoarthritis – subjects with rheumatoid arthritis).

Factor	F	*p*
1	0.84551	0.517548
2	11.47854	0.000735
3	2.82446	0.093192
4	37.51040	0.000000
12	0.23962	0.944944
13	0.09308	0.993313
23	0.19950	0.655231
14	0.13917	0.999222
24	0.17222	0.841820
34	0.50971	0.600848
123	0.15987	0.977011
124	0.02883	1.000000
134	0.01898	1.000000
234	0.04855	0.952614
1234	0.02177	1.000000

system. Mean surface skin temperature has also shown a statistically significant difference between the observed groups so that it was the highest in patients with rheumatoid arthritis, lower in patients with osteoarthritis and lowest among the healthy subjects. Temperature distribution curves of patients with osteoarthritis have been narrower than those of subjects with rheumatoid arthritis and normal subjects. Temperature distribution curves of patients with rheumatoid arthritis have been shifted towards higher temperatures than those of subjects with osteoartritis and normal subjects. No statistically significant difference has been observed between the surface temperature values of the right and left side of the body, which leads to conclusion that the future researches could use images from only one hand, which would greatly simplify the use of thermography in diagnostics as well as treatment response monitoring. Considering that the subjects in this Study were hospitalized and under standard anti-inflammatory therapy, it would be interesting to observe the differences between the drug naive subjects. In this study thermographic imaging has been demonstrated as a potential simple, efficient and reproducible method for differentiation of healthy subjects and rheumatoid arthritis subjects and osteoarthritis subjects from each other.

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