Infrared Investigation on the Thermal Field in the Case of Influence of Low Frequency Magnetic Signals on the Human Body

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Abstract – **In this paper the subject of infrared thermal imaging cameras and their potential for medical applications are investigated. Two different medical physiotherapeutic appliances are reviewed in terms of heat emittance during a standard therapy session.**

Keywords – **infrared thermography, medical applications, therapeutic ultrasound, low frequency magnetic signals**

I. INTRODUCTION

Through the development of technics and technology, every day we are facing new perspectives in health care – both diagnostically and therapeutically. What is observed in the last few years is an increasingly more significant implementation of infrared thermal-imaging-based medical apparatus, generally in the diagnostic sphere. However the potential of this technology in contemporary medicine is still to be explored in further detail. The current paper is an attempt to broaden the view and deepen the understanding of some of the existing therapies through the analysis of data provided by a thermal camera.

II. CURRENT STATE OF THE PROBLEM

Currently, therapeutic ultrasound is widely used in physiotherapy, especially to facilitate the healing process in cases of ligament sprains, muscle strains, tendonitis, joint inflammation, plantar fasciitis, metatarsalgia, facet irritation, impingement syndrome, bursitis, rheumatoid arthritis, osteoarthritis, and scar tissue adhesion [1-6]. One of the primary reasons for its therapeutic abilities is the fact that stimulating the tissue beneath the skin's surface increases the temperature of the tissue, thus providing better blood circulation in the affected area.

The mechanism of low frequency magnetic signals therapy is based on a flow of electrical charges causing a net flow of ionic current for basic cellular restoration activities. Many studies show that healing effects are observed: cytoprotection of cells and the stimulation of growth factor synthesis [7]. Contemporary devices can generate signals with a different shape, frequency and length. The frequencies used are between 1 and 100 Hz, magnetic flux density being up to 100 mT.

III. EXPERIMENTS

The thermal camera used for data collection is FLIR E40, with thermal sensitivity of < 0.07°C, accuracy of ±2°C or ±2% of reading and temperature range of -4°F to 1,202°F (-20°C to 650°C) [1-4]. For maximum accuracy, the camera is fixed on a stand and movement of the object is avoided.

The general setting is shown in Fig. 1:

Fig. 1. Therapeutic procedure – thumb joints application

IV. RESULTS

To facilitate the data analysis, several measurement points and lines are used for the thermal images of both treatment methods. For the Ultrasound the points are SP1, SP2, SP3, SP4, SP5 and SP6, and the lines – L1, L2 and L3 (Fig.2):

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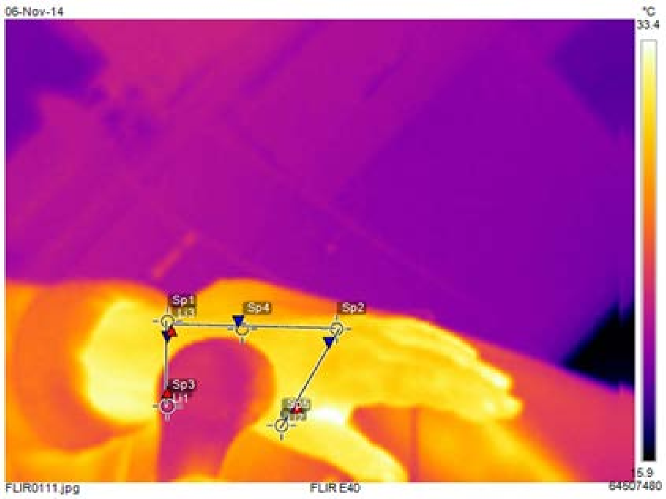

Fig. 2. Thermal Image of therapy – points and lines used for analysis

It is important to note that for each image the emissivity of human skin is considered through the coefficient ε=0.98 (Table 1):

TABLE 1. DATA COLLECTED FROM ONE THERMAL IMAGE OF ULTRASOUND THERAPY

Measurements		°C
Sp1		30.9
Sp2		30.6
Sp3		31.9
Sp4		29.8
Sp5		31.3
Li1	Max	32.1
	Min	30.7
	Average	31.4
Li2	Max	31.8
	Min	30.3
	Average	31.0
Li3	Max	30.9
	Min	29.6
	Average	30.1
Parameters		
Emissivity		0.98
Refl. temp.		20 °C

During the Ultrasound therapy 34 thermal images were taken in even time-intervals. The data is collected by examining the thermal changes in each analyzed point/line in the sequences of thermal images. Figs. 3-7 show the detailed upward tendencies for all 5 analyzed points:

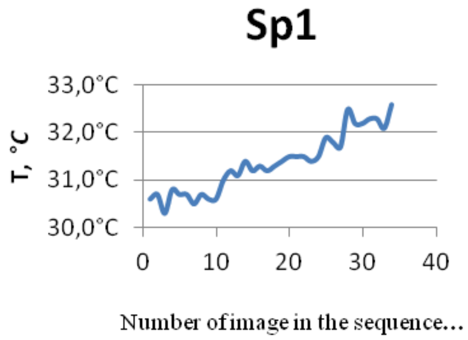

Fig. 3. Thermal changes in point Sp1

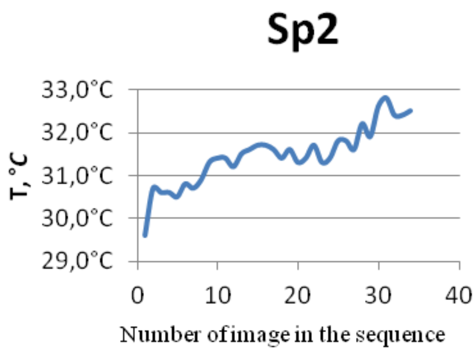

Fig. 4. Thermal changes in point Sp2

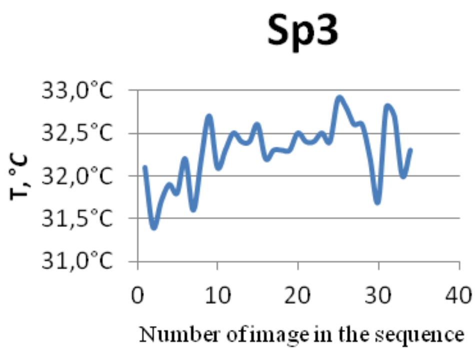

Fig. 5. Thermal changes in point Sp3

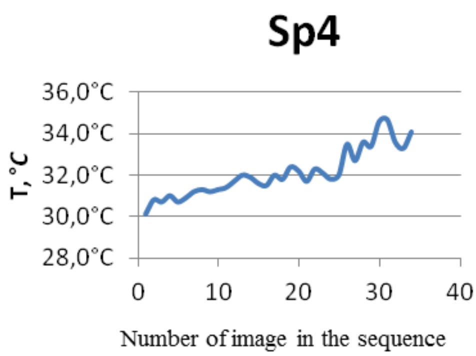

Fig. 6. Thermal changes in point Sp4

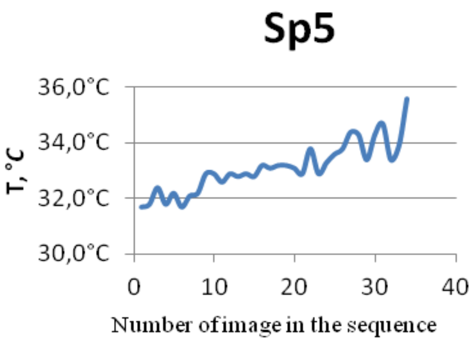

Fig. 7. Thermal changes in point Sp5

Fig. 8 shows the combined increase in temperature in all 5 examined points. What can be observed is the difference in the speed with which the temperature rises in the different points – for SP1 and SP2, which are chosen to be away from the direct field of application, the temperature increase is slowest, even though still significant. SP3 is on the head of the ultrasound appliance and the temperature there fluctuates a lot, with a total increase of below 1 degree. For SP4 and SP5, however, there is a more dramatic change – about 4 degrees rise throughout the ultra sound session.

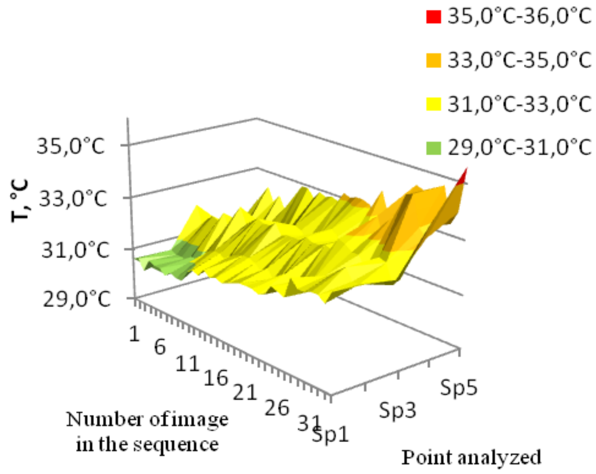

Fig. 8. Therapy – thermal changes in analyzed points (Sp1 – Sp5).

The next figures (Fig. 9, 10 and 11) show how the average temperature around the spot of application is changing through the therapy session. The upward tendencies are very obvious when the whole line is considered.

When all points in the lines are considered (finding the minimum, maximum and average), a more thorough image can be created explaining the entire thermal field in the close proximity of the spot of application and Fig. 12 shows the increase of temperature in further detail. This means that even though the ultrasound therapy is directly applied in a specific spot, it leads to a wider temperature rise, that goes as far as several centimeters from the point of application.

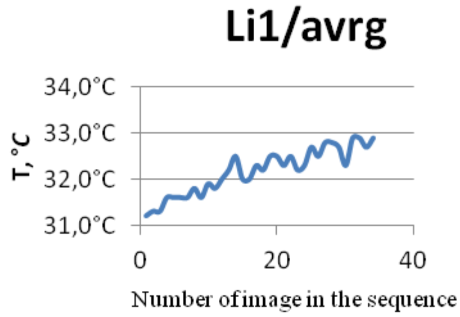

Fig. 9. Thermal changes in line Li1/avg

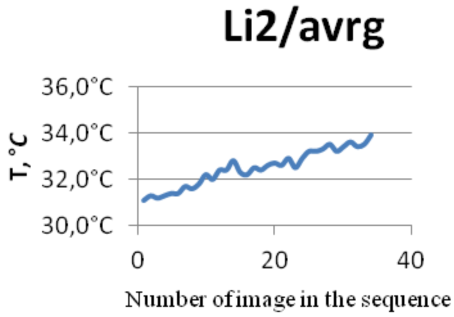

Fig. 10. Thermal changes in line Li2/avg

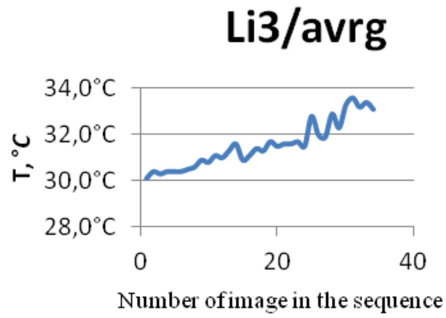

Fig. 11. Thermal changes in line Li3/avg

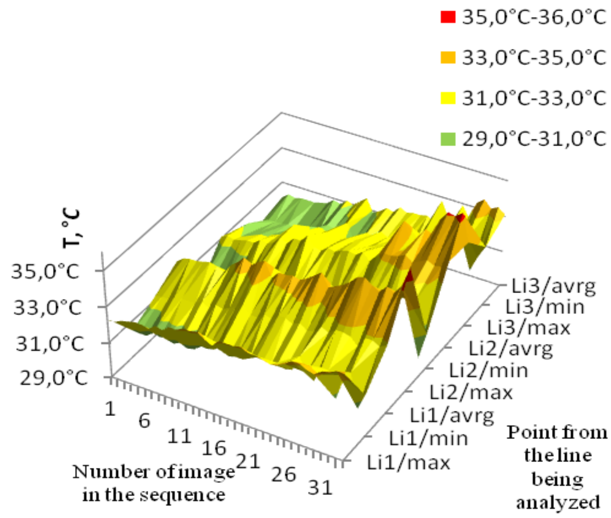

Fig. 12. Ultrasound Therapy – thermal changes in analyzed lines (the points in the lines that show min/max/avrg values of temperature)

In the case of magneto therapy, the infrared pictures were taken at intervals of 30 sec. for 15 minutes. The therapy duration was determined by the doctor in charge.

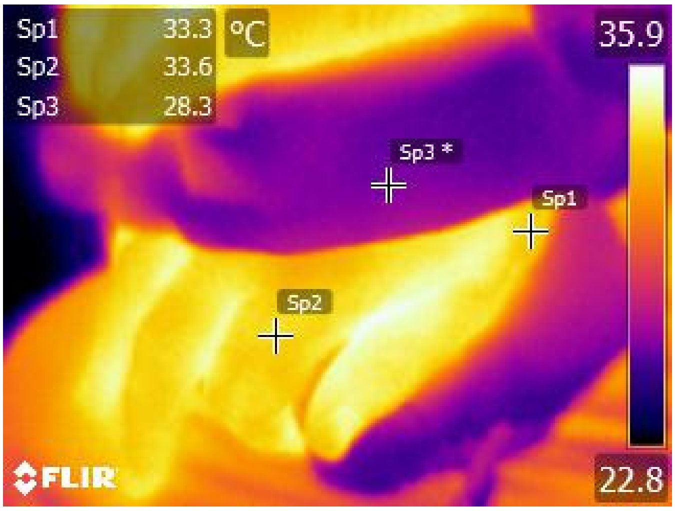

Fig. 13. An image from the magneto therapy series

Three points of interest were selected: Sp1 – in the area closest to the wrist; Sp2 – in the area of the index finger. Sp3 – on the textile wrapping of the magnet. We selected ellipses, not points, to eliminate probable human movements and noises. For the areas where the human skin is observed, a radiation coefficient 0.98 is selected and for the fabric-wrapped magnet a radiation coefficient 0.77 is selected.

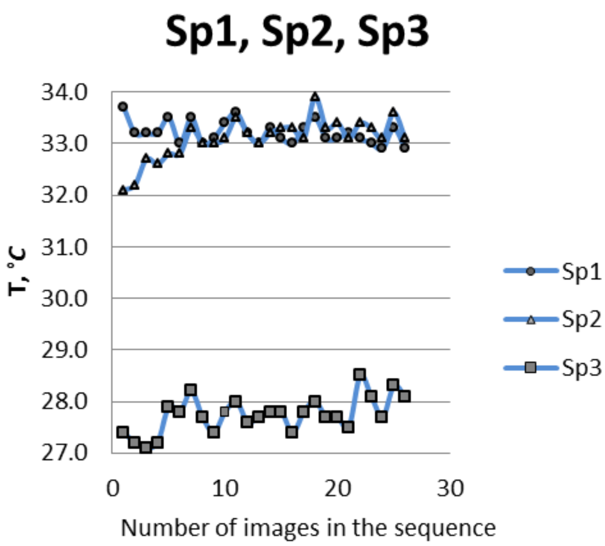

Fig. 14. Thermal changes in points Sp1, Sp2, Sp3

V. Conclusion

The analyzed data gives one more perspective of the countless applications of thermal imaging cameras for medical purposes. Such analysis can be very useful in providing a new understanding of widely-used technology in terms of safety and effectiveness. Since IR imaging is non-invasive and does not bear any risks, it can be implemented wherever it is useful and possible. It carries a great potential also for diagnostic medicine – early tumor/cancer detection, diagnosing neuropathies, all kinds of inflammation, scanning large groups of people for high body temperature, veterinary purposes and many others. In the near future IR thermography might become a valid single diagnostic method for many diseases that involve intricate changes in the temperature field.

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