Infrared investigation on the thermal field in the case of influence of low frequency magnetic signals on live tissue

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Abstract – **This paper presents a study on human skin surface warming during physiotherapy with electromagnetic field. The case is for low-frequency magnetic signal therapy with frequencies lower than 100Hz. For the experiment was used the connection between the optical radiation of the objects themselves and their temperature. The study was conducted under clinical conditions during regular physiotherapy sessions with patients. The measurements were done simultaneously at many points by using an infrared camera. The conditions in the rooms and the condition of the patients were taken into account. The emissivity coefficients of the objects studied were also considered.**

Keywords – **Infrared thermography, medical applications, magneto therapy.**

I. Introduction

With the development of 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 (magneto therapy with low frequency magnetic field) through the analysis of data provided by a thermal camera [7-13].

Physiotherapy is a branch of medicine. Its power lies in using energy sources directed to particular areas of the body. This energy is directed in a specific way, for the prophylactics or treatment of different diseases. The sources can be natural or artificially created by people. In some cases, physiotherapy is applied as an accompanying treatment in aid of the main one. It is conducted by doctors (therapists) which define the parameters of the procedures and the course of the treatment very precisely. Physiotherapy is applied for different ages and diseases and it provides wide possibilities for influencing the human organism (electrotherapy, inductothermia, ultra-high frequencies treatment, aero-ionisation therapy, magnetic-therapy, ultra-sound therapy, lasers, magnet and laser, light-treatment, electrophoresis, diadynamic therapy, amplipulse therapy in ophthalmology, transcranial and transvertebral micropolarization, muscle toning, cryotherapy, inhalers, oxygen therapy, water treatment, warm-treatment, etc).

The effects on the human body caused by high intensity electric fields, such as muscle stimulation, electroporation and heating, are relatively well studied. We are interested in the effects caused by low intensity magnetic fields. [14-24]. The biological processes which occur are mainly related to signal transduction at the cell membrane and subsequent biochemical processes. The physical mechanisms of conversion from an electric or magnetic field to biochemical process are however subject of science studies at the present time. It is also a subject of study which aspect of the applied or environmental field is important. Properties such as duration, polarization and harmonic content of the signal, may turn out to be as important as amplitude. The effectiveness of the applied field will also be influenced by the biological, chemical and mechanical condition of the organism. A few experimentally observed results show specific biological effects which are caused directly by the magnetic field or by the electric field that is induced in the tissue by a time varying magnetic field. For fields larger than about 100 μT direct effects have been suggested and the presence of magnetite particles in some tissues may also play a biological role. Experiments suggest that effects of induced electric fields are particularly likely when their magnitudes at the tissue or cell level are relatively large and when multiple cells are connected by gap junctions. Most proteins have a small net electrostatic charge and nucleic acids are polyelectrolytes with large net charge and are surrounded by counterions. Induced fields mainly affect the moving ions on the cell surface and possibly the structural fluctuations of nucleic acid molecules. The mechanisms for direct interaction of time varying magnetic fields with biological processes are the subject of many studies.

Other experimental results have suggested that the relative magnitude and direction of a static magnetic field (such as that of the Earth) can determine the biological effectiveness of a simultaneously present alternating field in some biological systems under controlled laboratory conditions.

Very few scientific studies consider a simultaneous investigation of the effects caused by a low frequency magnetic field with infrared thermography [25-27].

II. Current State of the Problem

In this paper, we are going to focus on the application of magnetic-therapy. More specifically, we are going to consider the extent to which we can neglect the surface warming of the

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skin during the conducting of this therapy [15,17,18,20,21,23,24].

The mechanism of this type of 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. 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. There are 3 established physical mechanisms through which pulsed magnetic fields interact with living matter: magnetic induction, magnetomechanical effects and electronic interactions, which is thought to be responsible for the vasodilatation, analgesie, anti-inflammatory, anti-edematous and spasmolytic activity and healing acceleration. There is an overall improvement of the microcirculatory processes and local blood circulation.

Depending on the cases (diseases, people), suitable inductors are used.

Usually the period of the therapy includes 20 procedures every day or every other day. In the case of special medical recommendation it is possible to do two procedures per day (in the morning and in the afternoon).

The magneto therapy is well combined with other physical factors (laser therapy, interfered currents, ultrasound therapy, water and mud treatments). The magnetic field can be well combined with drug treatment, too.

III. Experiments

The thermal camera used for data collection was FLIR E40, with thermal sensitivity of < 0.07°C and temperature range of (-20°C to 650°C) [28]. For maximum accuracy, the camera was fixed on a stand and movement of the object was avoided. All examinations were performed in a sitting position in a quiet room at a constant room temperature of 20±0.5°C following an acclimatization period of 20 min keeping the hands free of any contact to the rest of the body or other objects [29]. Equally, the relative humidity showed stable values over time (50%). All temperature maps were archived using the internal SD memory. For the final analysis temperature values were determined and given in degrees Celsius (°C). All images were corrected using an emissivity factor of 0.98 for the human skin and appropriate emissivity factors for the fabric and plastic, respectively 0.77 and 0.91. For the human hair emissivity factor we assume the value of 0.98.

In this study, a series of images was made between certain intervals of time. The infrared pictures were taken at intervals of 30 sec. for 15 minutes. The therapy duration was determined by the doctor in charge. The infrared pictures do not influence the main therapy, so there are no special requirements on the part of doctors apart from the general requirements for hospital hygiene and rules.

The processing was made with the original software of the camera - version FLIR Tools+ 5.3.1 (5.3.15320.1002).The setting is shown in fig.1.

During the experiment were taken 30 pictures. The first one is shown in fig. 2.

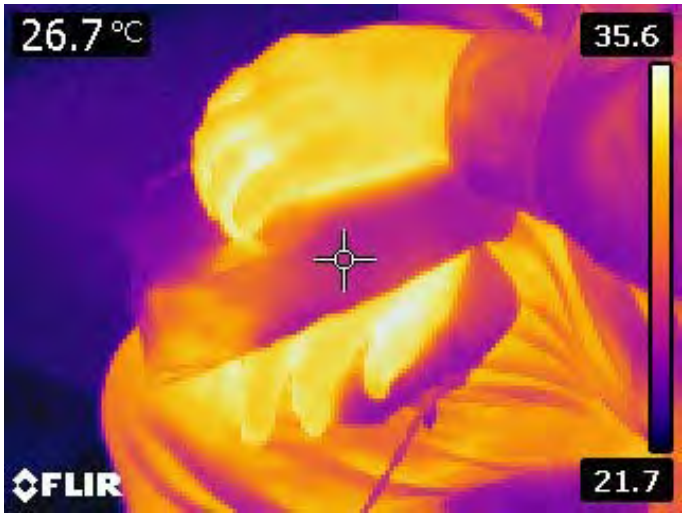

Fig. 1. Therapeutic procedure

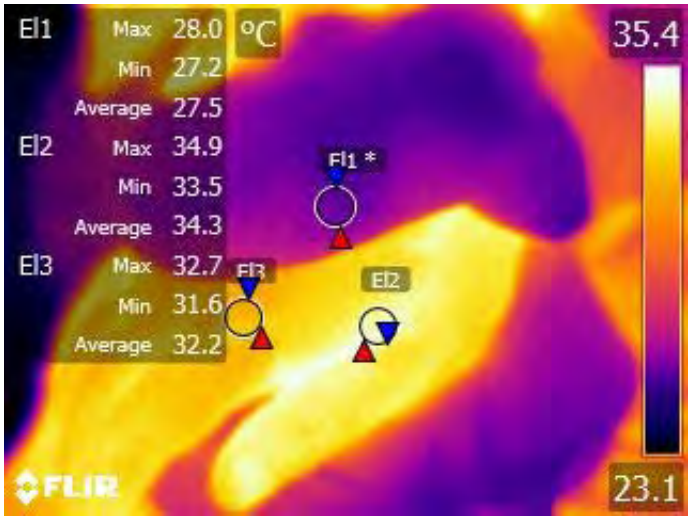

Fig. 2. An image from the magneto therapy series

Three ellipses of interest were selected: El1 – on the textile wrapping of the magnet; El2 – in the area of the most intense thermal radiation of the hand; El3 – in the area closest to the metacarpophalangeal joint. We selected ellipses, not points, to eliminate probable human movements and noises. For the areas where the human skin is observed, is selected a radiation coefficient 0.98 and for the fabric-wrapped magnet is selected a radiation coefficient 0.77 [12].

IV. Results

The first calculations, of course, are related to the mathematical expectation, dispersion and standard deviation. By using the respective formulae [30,31], we derive (Table I):

A. MAGNETO THERAPY

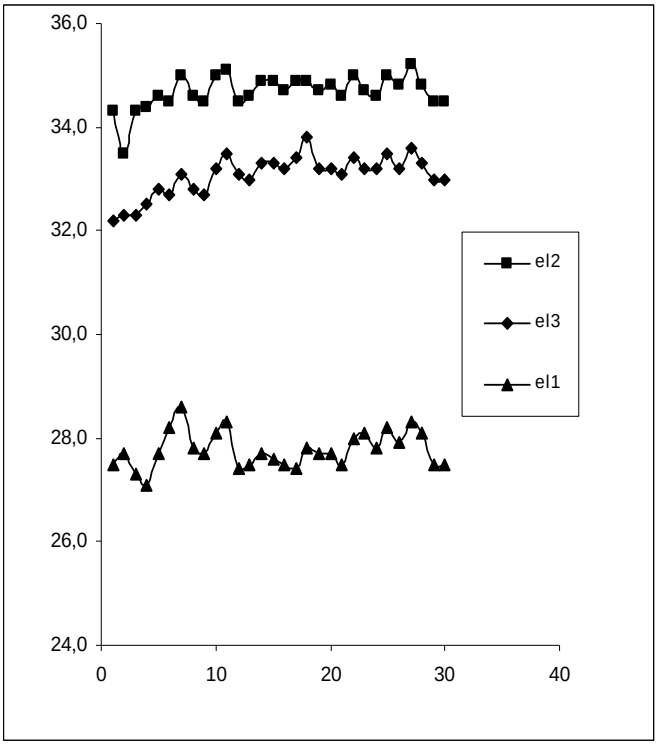

Fig. 3. Graphic representation of measurements during the experiment with magneto therapy (x-axis – number of experiment; y-axis – temperature)

TABLE I. CALCULATION OF THE AVERAGE VALUES, DISPERSIONS AND STANDARD DEVIATIONS

	El1	El2	El3
AVG	27,773333	34,68	33,07
VAR	0,1192644	0,105103	0,151138
sqrt(VAR)	0,3453467	0,324197	0,388765

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 in physiotherapy. Since IR imaging is non-invasive and does not bear any risks, it can be implemented wherever it is useful and possible. It also carries a great potential for diagnostic medicine to search for different connections between the points of the temperature filed and completely different phenomena.

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