biophysic & medicine report

Science and Clinic July 2/81

Verlagsgesellschaft
für Biophysik und Medizin

Sperberweg 2
6200 Wiesbaden

Infrared Radiation and O_2 Partial Pressure in Human Surfacial Tissue as Indicators of the Therapeutic Effects of Pulsating Magnetic Fields of Extremely Low Frequency (ELF)

Report by Dr. Ulrich Warnke, University of Saarbrücken,
at the 2nd International Congress on
Magnetomedicine, November 8–9, 1980, Rome, Italy
(revised by the publishers)

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Zusammenfassung

1. Magnetische Impulsfelder mit Impulsfolgefrequenzen überwiegend größer als 10 Hz verändern die Infrarotstrahlung lokaler Bereiche der Körperoberfläche beim Menschen. Dies bereits bei Induktionswerten um 500 µT (= 10fache des Erdmagnetfeldes), 20 Hz Impulsfolgefrequenz, wenn das Magnetfeld im Kopfbereich appliziert wird. Die Reaktion tritt an Armen und Händen meist innerhalb von 2 Minuten auf. Die Thermogramme lassen eindeutig erkennen, daß die unter Magnetfeldeinfluß kontinuierlich steigende Energieabstrahlung des Körpers von den Blutgefäßen ausgeht.

2. Die direkte Folge einer veränderten Durchblutung des Gewebes durch bestimmte Magnetfelder ist eine Änderung des Sauerstoffpartialdruckes (pO_2). Pulsierende Magnetfelder obengenannter Charakteristik können den transkutan gemessenen Sauerstoffpartialdruck im Abschlußgewebe rapide steigern. Bei 58 Probanden lag der Durchschnitt bei ca. 200%. Die Standardabweichungen zeigen, daß die Werte interindividuell sehr verschieden sind.

In diesem Effekt vermuten wir letztlich den Wirkungsmechanismus für einen therapeutischen Nutzen bestimmter pulsierender Magnetfelder.

Summary

1. The infrared radiation of local areas of the body surface is modified by magnetic fields with impulse frequencies bigger than 10 Hz. If they are applied at the head area this modification takes place with induction values as low as 500 µT (= approx. 10 times the value of the earth's magnetic field), and 20 Hz frequency of impulse sequences. This reaction appears in most cases within 2 minutes on arms and hands. Under the influence of magnetic fields thermograms clearly show a steadily increasing energy radiation originating in the blood vessels.

2. A change of O_2 partial pressure (pO_2) is the direct consequence of an altered blood circulation of the tissue. The transcutaneously measured O_2 partial pressure in human terminal tissue may be increased rapidly by pulsating magnetic fields. In experiments with 58 test persons an average of about 200% was reached. Standard deviations show intraindividually highly different values.

We suppose that lastly this effect is the action mechanism for a therapeutic use of certain pulsating magnetic fields.

Historical Aspects of Magnetic Field Therapy

All Old World cultures had accounts on the effect of magnetic forces upon man. At that time magnetic energy was obtained from magnetite or lodestone. These stones were pulverized and then eaten or used to make eating utensils. The stones were also placed on wounds or stroked over the whole body. From a physical point of view, a continuous magnetic field was thus applied and modulated through the stroking movement of the priest/healer. Such treatments were rediscovered in the Middle Ages and, at that time, became quite common.

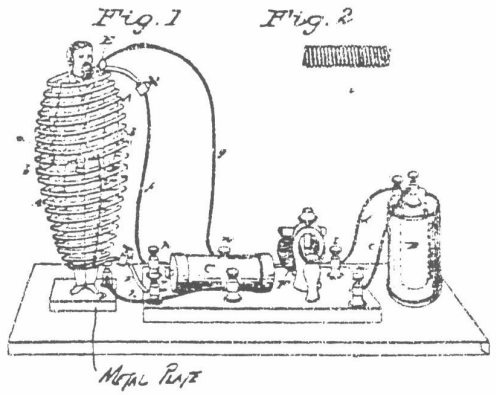

Fig. 1: Magnetic field therapy device by E. Smith. Patent application No. 96,044 (Oct. 1869).

Reports on the clinical use of alternating magnetic fields with stabilized frequencies are quite recent. Beginning in the 1900's quite a few publications enthusiastically reported about extremely low frequency alternating magnetic fields as an aid in clinical therapy. Especially organic and psychogenic nerve deficiencies as well as affections of muscles and joints were successfully cured with magnetic energy. Even chronic, pathologically manifest symptoms were treated.

In the period between 1920 and 1960 Professor Lenzi from Modena/Italy was the only one to produce valuable results in the research on the "Effects of Magnetic Energy". Only after 1960 clinical application was practiced again on a large scale.

Today the search for alternative therapies is increasing, partially because the big "boom" of the drug industry has not always proven to be necessarily beneficial for mankind. Therefore, the healing effects of magnetic energy are once again analysed for their clinical value.

Reports from Research and Practice

Today there is a large amount of literature, which, at first glance, appears to contain ununiform results. In some publications the physiologic effect of magnetic energy is denied completely while in others it is affirmed convincingly. There are cases in which the effects of magnetic energy upon animals and humans are presented as harmful, in other cases as beneficial. In order to clarify this conflicting evidence it has proven useful to examine every scientific work in detail.

For this purpose the following criteria must be considered:

- the exact aim of the investigation by the research team
- the kind of animal or human material used
- the institute by which the investigation was carried out
- the part of the body exposed to the magnetic field

and, most importantly:

- frequency, impulse form, amplitude and/or gradient of the applied magnetic field.

From our present point of view we know now that the literature can be compared effectively only under such systematic aspects.

Resuming the facts, two notable points of interest remain:

a) Through continually improved measuring methods – going hand in hand with growing knowledge in physics and chemistry – more and more results from biological and medical experiments with magnetic fields are published in the western states and especially in eastern countries, for example as to navigation, orientation, genetic information, cell growth, central nervous mechanisms, reaction coordinates of effective etc. Aspects concerning industrial medicine are described as well.

b) The good therapeutic effects of magnetic energy are mainly published on an empiric basis by medical science since 1900, giving a wide range of indications. Proof for the therapeutic effects could not be established in all cases by the sporadic results of the clinical scientific tests. Therefore, a final and valid statement cannot yet be made in this respect.

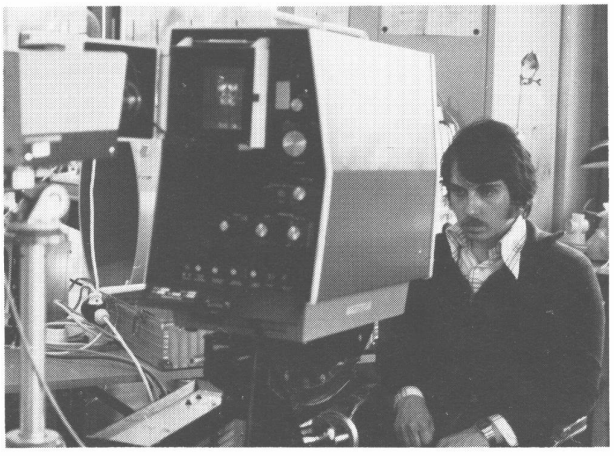

Fig. 2: Thermography of a test person (UTI).

Further detailed results from tests as well as parameter effects are expected.

Own Experimental Results

The physiologic effect of magnetic fields upon plants, animals and man has been investigated by us since 1975. Here we only want to report about the effect of alternating pulsating magnetic fields of extremely low frequency (ELF).

Test Conditions

For the tests we set the following conditions:

a) The evaluation of an exogenous, physiologically active physical magnitude is only possible if clear on-off effects can be measured in the organism. These effects can be taken as indicators for variable parameters like frequency, field gradient, impulse slope, etc.

b) To keep methodically caused postexperimental reactions and psychosomatic irritations, particularly in clinical tests, at a minimum the test method must be non-invasive.

Indicators

We have found 3 indicators corresponding to conditions a) and b) for the effectiveness of alternating pulsating magnetic fields, which simultaneously signalize the possibility of therapeutic application in human medicine:

1. the active widening of blood vessel diameters,
2. the O_2 partial pressure in terminal tissue,
3. the local perfusion and velocity of capillary blood flow.

Before reviewing the individual tests we would like to stress that the results were achieved optimally with specific magnetic field gradients. This does not exclude that magnetic fields with other physically specific characteristics may have completely different, though optimal, effects on the organism, especially if we consider the Lorentz forces in ionic migration, the blood circulation and oscillations originating from certain types of aggregates, etc.

Methods and Results

The body radiation of man constitutes approx. 60% of the total heat emission in an environment at normal temperature and basic turnover rates and should thus be regarded as the main factor of the characterizing radiation criteria.

This radiation is essentially different from other components of heat emission such as conduction, convection or vaporization. Most importantly, infrared radiation does not require a physical intermediary which could distort test results.

Ad 1.: The infrared radiation of local areas of the body surface is modified by magnetic fields with certain impulse frequencies as low as 500 µT (i.e. approx. 10 times the value of the earth's magnetic field). This reaction appears in most cases within two minutes on arms and hands.

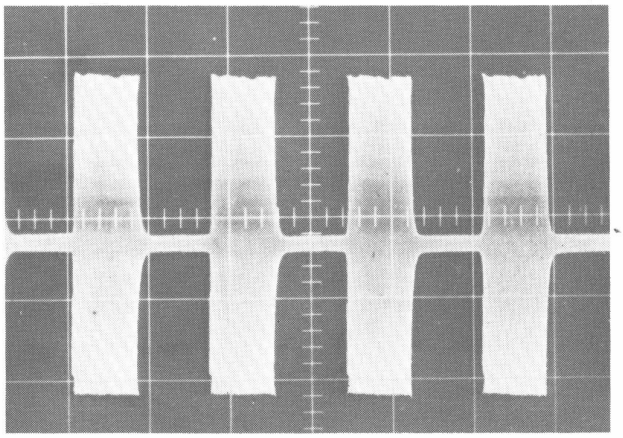

Fig. 3a: Example of an impulse package frequency of the magnetic field coil used in the experiment.

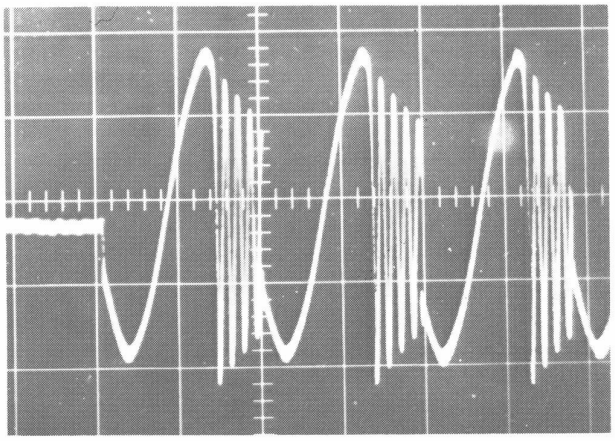

Fig. 3 b: Detail of sinusoid form of the impulse package.

Under the influence of magnetic fields thermograms clearly show a steadily increasing energy radiation from the body originating in the blood vessels and continually becoming lighter in color and gradually covering the surrounding tissue when observed on the monitor. Evidently, dilatation of the blood vessels is the cause of this phenomenon (for comparison, see 9, 10, 12).

It is noteworthy

a) that the large blood vessels dilate as well as the nutritive capillaries of the periphery,

b) that pulsating magnetic fields applied to the head, need the lowest induction intensity for a reaction, whereas magnetic fields applied locally to other body parts do not produce a reaction until the distance between head and magnetic field allows a sufficient induction value in the head area. The question of the central function of the head area will be the focus of further research, for here are hidden indications for action mechanisms.

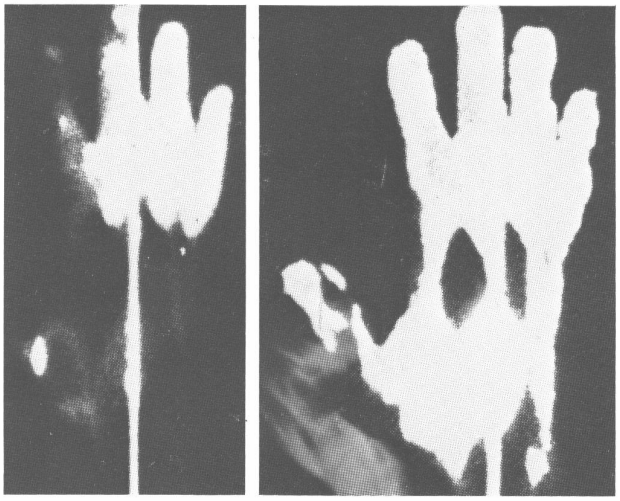

Fig. 4: (a) Increased energy radiation from the hand in the temperature range of approx. 10 µm under the influence of a magnetic field bigger than 10 hz impulse package frequency. (b) When the magnetic field is applied to the head an induction of only approx. 500 µT is sufficient to trigger off the effect in some cases.

Ad 2.: A variation of oxygen partial pressure is a direct consequence of a modified circulation in tissue through certain magnetic fields. Pulsating magnetic fields with the above-mentioned characteristics are able to increase rapidly the pO_2 in the terminal tissue measured transcutaneously (for comparison, see 4, 5, 11, 14).

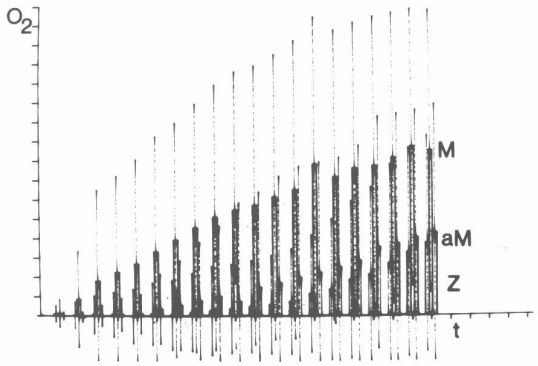

Fig. 5: Mean pO_2 increase of 58 test persons depending on time.
Z = Zero curve (double protocol)
M = MF effect (approx. 200% increase vs. Z)
aM = postexperimental effect with MF switched off

With the aid of probes, pO_2 has been measured directly on the skin of the extremities, and as diffusion gradient from the total body surface or parts of it (arms and hands) into a pure nitrogen atmosphere at the start of the test. For this reason gasproof glass cubicles had been constructed and built in order to measure the quantity of oxygen per unit of time diffusing from the body under constant physical environmental parameters.

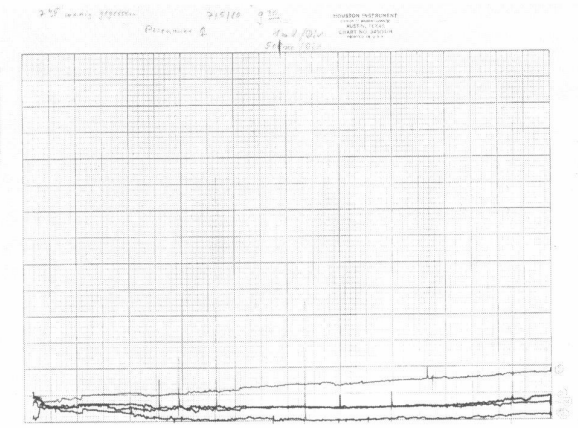

Fig. 6: Original graph of pO_2 measurement during MF-application (6 measurements). No reaction.

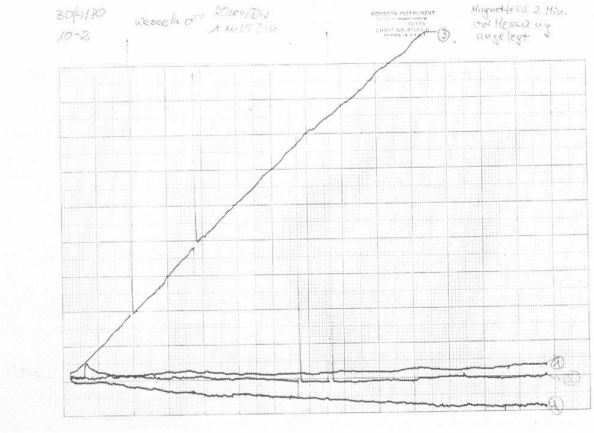

Fig. 7: Original graph showing increase of pO_2 during MF application (3 mT, 20 Hz. 10 min.).

Ad 3. (tests are still being carried out, no statistic significance as yet): Under the influence of pulsating magnetic fields the flow rate in the capillaries increases in some cases in humans (methodologic difficulties in measuring isothermic blood flow through mutual leveling of counteracting effects), in all cases in frogs and fish (high-frequency cinematographic video recording) (for comparison, see 2, 3, 7, 8, 13). Especially the characteristic "stop and go" of many capillaries turns under the influence of magnetic fields into a more or less uninterrupted flow.

Physiologic Causes of Magnetic Field Effects

The theoretically determinable physiologic causes for the on-off effects described under items 1. to 3. are at the same time problems which are to be solved by individual experiments:

Theoretical causes:

Ad 1. Dilatation of blood vessels including the effect of magnetic fields applied to the head:

1.1 large vessels:
the human skin tissues are, contrary to those of animals, excludingly sympathicus innervated (also the kidney). The dilatation of large vessels observed under the influence of magnetic fields seems to confirm a magnetically induced reduction of sympathicotonus. Electrophysiologic clinical tests have to be carried out to clarify whether an activation of the depressor centers in the formatio reticularis area is responsible.

1.2 peripheric vessels:
the improved peripheric circulation can have different causes:

1.2.1 closure of arteriovenous anastomoses
1.2.2 dilatation of metarteriols
1.2.3 opening of precapillary sphincters
1.2.5 metabolites and CO_2 action.

As far as items 1.2.1 to 1.2.3 are concerned the influences of sympathicotonus could also be efficacious.

Ad 2. Causes for magnetically induced pO_2 increase in the terminal tissue:

2.1 hyperemia (see item 1.)

2.2 the vasodilatation and improved diffusion conditions from the blood vessels into tissue are a consequence of the reduction in the diffusion passages

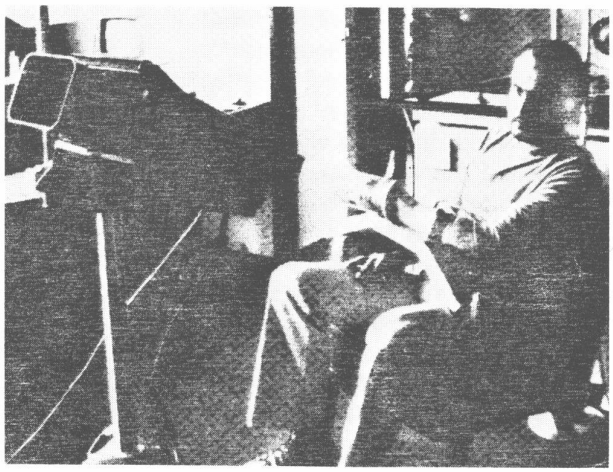

Fig. 8: Measurement of surfacial O_2 diffusion of the hand and thermography of the other hand under the direct influence of a magnetic field.

2.3 increased diffusion processes in the cell membrane (often mentioned in magnetic field publications)

2.4 peripherally weakened binding capability of O_2 to hemoglobin by various physicochemical changes

2.5 improved flowing properties of blood

Ad 3. Causes for magnetically induced and increased rate of blood flow in capillaries:

3.1 viscosity reduction:
i.e. an increase of the shear degree, reduces the erythrocyte aggregation. This is caused by the phenomenon that erythrocytes clod together at rest (like coin rolls) and desaggregate with increasing rate of blood flow.

3.2 Reduction of frictional resistance:
Mechanical microvibrations by magnetic alternating effect with the paramagnetic hemoglobin or the diamagnetic oxyhemoglobin, respectively (although O_2 is paramagnetic it will become diamagnetic with ionic and covalent bondage), and the activator where a decrease of friction at the walls of the vessels and inside the cells might appear.

3.3 Improved bullet shape of the erythrocytes:
The pliability of the erythrocyte membrane is influenced by different physico-chemical environmental changes. Only by this pliability the capillary permeability in tiniest vessels is determined.

Statistical Significance

The higher the capillary flow rate, the higher (not proportional but superlinear) the transported quantity of oxygen. Evidently, with the aid of magnetic fields oxygen is delivered to the tissue in certain cases and can be measured as an increased pO_2 (see item 2.). We assume in this effect the systematic action of pulsating magnetic fields for a therapeutic application.

Our future aim is to investigate the effects described for their statistical significance according to scientific criteria and to demonstrate their physiologic causes. In the course of the next 4 years and with the aid of public grants, tests are to be repeated on a larger scale for this purpose as well as an investigation into parameters of various genesis which have an influence on these effects.

Our specific reasons are as follows: Up to now the described pilot tests on human beings show statistically significant results only intraindividually, i.e. some of the test persons react to the magnetic field in a clear and reproducible way which is convincing as far as parameters are concerned (increase of pO_2 by 400% compared to controls). In repeated tests other test persons show wide deviations of parameters (increase of pO_2

approx. 100–500%), and a further group of test persons did not react convincingly (smaller than 100%), or not at all to the magnetic field.

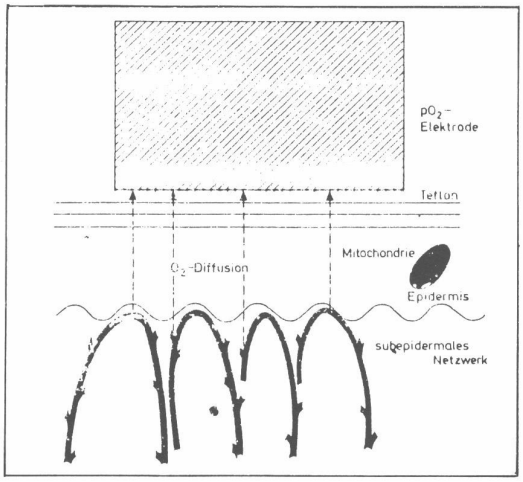

Fig. 9: Schematic graph of blood circulation of the skin and transcutaneous measurement of pO_2 (after Strossek, 1977).

Some phenomenologic marginal results make it clear that the range of deviation of results observed is caused on the one hand by the nature of the chosen test methods as well as individual characteristics of test persons:

- the best results we obtained with weak pulsating fields (approx. 0.5 mT) applied to the head. Stronger fields don't show any better results, in many cases even less as far as 1.–3. is concerned;
- form and frequency of impulse or frequency of impulse cascade, respectively, play a decisive part. Frequencies of impulse cascades below 6 Hz show no effect as far as 1.–3. is concerned;
- children show in many cases the strongest reaction;
- test persons lying down in a relaxed and private atmosphere react better than persons standing up or sitting down in laboratory surroundings;
- sleeping persons show an optimal on-off effect (up to now only 2 experiments);
- test persons who carried out at least 15 minutes of intensive movement outdoors before the test (jogging with gymnastic exercises) show a stronger reaction than the physically unfit.
- stimulation modalities with a preferential response reaction, i.e. conversation, meals, mental stress situations, etc. overlay sometimes the reaction to the magnetic fields (masking effect).

Action Mechanisms

These examples show already that the magnetic field has completely different mechanisms of action than electromagnetic fields of higher frequencies which can trigger off diathermia and thus overcome physiologic controls of the organism.

Theoretical physico-physiological causal action mechanisms of the effect of low frequency pulsating alternating or constant magnetic fields are in accordance with classical physics and are determinable parameters as far as the organism is concerned.

Parameters in question are as follows:
- induced voltage boosts
- induced eddy currents
- Lorentz forces
- Hall voltages
- mechanical microvibrations

Based on induced field strength of about 15 mT (gradients 1.5 mT/cm) and considering all field variables the calculated values alone would not suffice energetically to provoke an unspecific stimulation of the intact total organism according to known physiologic rules. However, such theoretical considerations are in total controversy to the above-mentioned magnetically induced on-off effects.

For this reason it is discussed whether not so much the energy potential but, more important, the information potential of induced voltages and currents play a decisive role.

For us there is no doubt that the described effects are of central-nervous or humoral origin, respectively. At this time we are investigating whether the magnetic field is triggering off these effects causally or whether these effects are merely to be regarded as a consecutive reaction. For this purpose we are following the guide-lines stated below:

a) with the help of the computer we can simulate model cases in which induced voltage impulses are grafted onto static miniature potentials in the neuron which in turn are stored and added up at synapses and are able to trigger off postsynaptically an action cascade after a certain period of time.
   As far as storage and adding-up time is concerned, it is known that there are considerable differences between synapses of the sympathicus and parasympathicus of such miniature potentials which finally lead to the action potential. Should there exist similar differences of the time constants between pressor and depressor centres the specific direction of action of the effects of certain magnetic fields could be explained more easily as far as working hypotheses are concerned.
b) We are also watching with great interest the discussion about the neuron structures in certain brain

areas, newly discovered in recent years, which transfer information with the help of microvoltage potentials. (Voltage boosts in the range of µV in defined structures of the organism have already been achieved with low inductions of magnetic fields.)
With the help of the indicators tests have to be carried out to determine whether the head area comprises the centre of perception for magnetic magnitudes of the defined characteristics. For these tests two different, though identically looking helmets are to be used, of which one is lined with magnetically unpermeable Mu-metal.

Significance of the Effects under Investigation for Magnetic Field Therapy

The significance of a centrally caused, magnetically induced increase of p02 in the tissue should be highly regarded.

The deficiency conditions of the cells or of the cell organelles of the organism or of single organs should be considered more often as the primary cause of numerous diseases and crisis conditions (1). The lack of oxygen in tissue takes a key role here. It does not only represent a phenomenon that appears in old age but also affects younger generations due to lack of movement, vessel contraction under stress and cardiopulmonar reduction of efficiency through air pollution.

Examples for O_2-deficiency symptoms: anginal attacks, circulatory insufficiency, scleroses, precancerous conditions with reduced detoxification function of the liver and kidneys. Through magneto-electrically induced hyperemia and higher perfusion, reduction of pain, spasmolysis and an unspecific antiinflammatory effect can be expected as first results. This has been confirmed by numerous successes in medical laboratories and in practice.

Based on this the main indications of magnetic field therapy are:

- inflammatory degenerative diseases of the system of support and locomotion, i.e. arthritis, arthrosis, M. Bechterew
- sport injuries
- neuritis, neuralgias
- herpes, ulcus etc.

Also for these indications there are enough confirmations from clinical practice.

For patients with only rhythmically recurring crisis conditions due to chronic periodic O_2 deficiency symptoms a treatment with pulsating magnetic fields would represent prophylactic treatment and prevent pathologic manifestations.

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