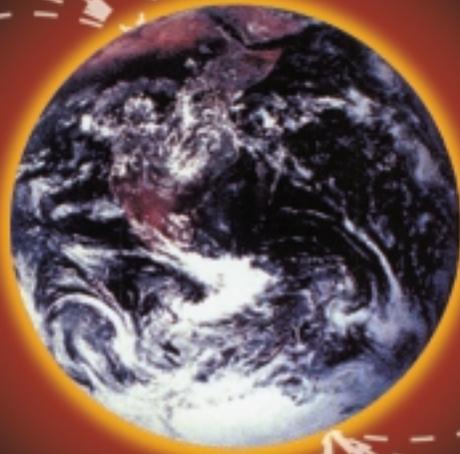


The Positive Benefits of Extremely Low, Pulsating, Electromagnetic Fields for All Life on Earth



an abstract on the
positive effects of published clinical
studies on health, illnesses and ailments

PULSE ELECTROMAGNETIC FIELD THERAPY: CLINICALLY PROVEN FOR OVER 20 YEARS TO HELP.

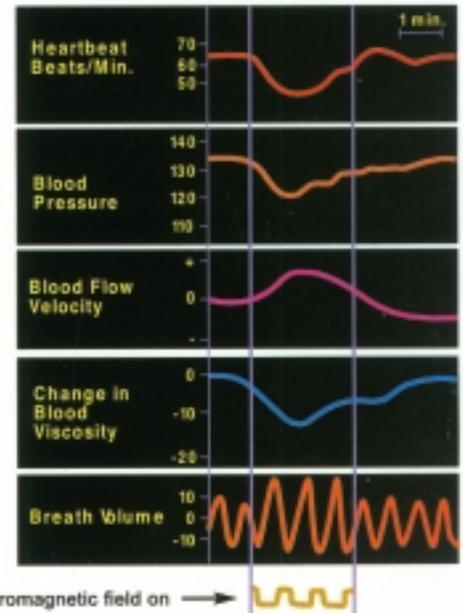
Pulsating Electromagnetic Field Generators (PEMF) have been clinically tested and used throughout the world for over 20 years. Pulse Electromagnetic Field Therapy has been proven to positively influence cells, organs, bones, and the organic system. It has been shown to stimulate and enhance the entire vital process of the body.

PEMF increases metabolism by accelerating the exchange of positive and negative ions through the cell membranes throughout the body.

By its direct and reflexive effect on the central nervous system, PEMF regulates the function of the endocrine glands, strengthening the body's immune system and its resistance to infection. Because of the PEMF's direct dilating effect on blood vessels and its lowering of blood viscosity, blood and lymph flow are improved, increasing the supply of oxygen and nutrients to the cells and reducing the possibility of harmful thrombosis (clotting).

Most painful symptoms respond to PEMF therapy in just a few days. However, long-standing injuries (chronic) or larger areas of injury may require additional time.

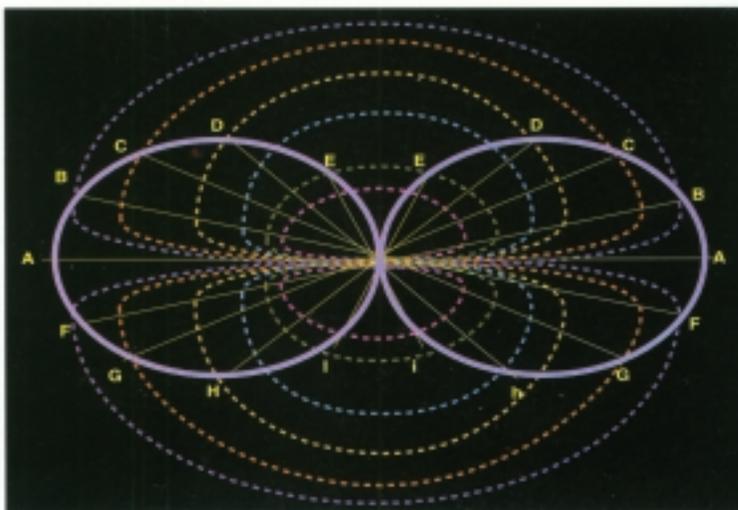
Summary schematic of some vital parameters with changes under the influence of a pulse electromagnetic field device.



The energy field of a PEMF device moves through the body without any harmful side effects while it provides these

Major Benefits

- Eliminates pain (acute and chronic)
- Reduces inflammation
- Directly dilates blood vessels
- Increases blood flow
- Enhances delivery and effect of medication
- Increases blood oxygen-carrying capacity
- Accelerates cellular metabolism
- Improves tissue vitality
- Stimulates cellular resistance to disease
- Regenerates body cells and bone structure
- Natural non-invasive alternative for pain relief
- May reduce need for medication



ELECTROMAGNETIC FIELD EFFECT ON LIVING ORGANISMS

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SUMMARY: This paper explains terms connected to the electric, magnetic and electromagnetic field as well as the field effects on living organisms. The importance of the field wave form is pointed out.

Introduction

The effect of electromagnetic field on organisms has become very important among scientists. The results of numerous researches deal with the sensitivity of organisms to the electromagnetic field effect. The effects may be useful and harmful depending on the intensity and frequency of the field, the period of exposure and the organism itself. Both effects seem to be very important for the human life and activity. There are different natural sources of electric, magnetic and electromagnetic fields on the earth which act on organisms. Besides, the man has created other sources of electromagnetic fields in his environment which differ in their frequency and intensity.

A good knowledge of electromagnetic field effects on organisms is of considerable practical importance. A complete understanding of electromagnetic field effects on organisms helps in curing numerous illnesses as well as protecting from dangerous effects of electromagnetic fields.

Different interdisciplinary studies are required for this purpose today. It is quite certain that ecology is one of them because every day man creates electromagnetic fields of different intensity and frequencies whose concentrations may be very significant. In order to understand the phenomenon it is necessary to know what is an electric, magnetic and electromagnetic field and what is their influence.

1. Electric, magnetic and electromagnetic field

To understand the fields it is necessary to begin with the electric charge. An atom consists of a nucleus and electrons that are in its orbit. Each electron possesses, a so-called negative charge and the nucleus is made up of protons and neutrons. Protons are positively charged whereas neutrons have no net charge. Each atom contains an equal number of electrons and protons, but their polarity is different and in nature they appear as multiples of equal elementary charge. Only the electrons in the outer orbit may be dislodged when an external force acts on them. These electrons, when conductors are concerned, are loosely bound, so we may say that conductors have so-called free electrons, while insulators require a strong force which would make the electrons leave its atom. In electrolytes, atoms are piled in molecules where there are so-called free ions (positive and negative).

Since like electric charges repel and unlike attract, this repelling and attracting between two stationary charges is called Coulomb force. Around each electric charge there is a specific state which may be explained by the existence of the electric field. So, the electric charge (Q) is the source of electric field (E), and the fundamental characteristic of the electric field is that it acts on the electric charge with the force ($F = QE$). The direction of the force depends on the direction of the field and the sign of the charge. Electric field strength is measured in V/m . If the two charges are in motion, however, then there is, beside Coulomb force, another force, the electric as well as a magnetic field around it. Since an electric current may be defined as a continuous movement of the charge, the following holds: when the current flows, a magnetic field of induction B is created. Magnetic induction is measured in Tesla (T). Magnetic field of induction B acts only on the charge in motion, the speed of the charge being v .

This force may be explained as follows: $F = Q(v \times B)$

The direction of the force is perpendicular to the plane (vector direction of magnetic induction B and vector speed direction v). The force is the strongest when vectors v and B are perpendicular and it is the weakest when vector directions overlap, it equals zero. In the first case the charge changes its direction and orbits around the magnetic induction vector B , while there is no change in the second case.

Considering the preceding explanation it is possible to represent the amounts of the charge and the forces between them in a simplified way by means of electric and magnetic field. If the observed electric or magnetic field does not change with time, then it is considered to be an electrostatic and a magnetostatic field, respectively. A permanent magnet possesses a typical magnetostatic field. Both fields possess the energy whose space density is proportional to the square intensity of the electric field. Hence, there is a corresponding energy in the above fields.

We have already noticed that charges in motion produce both electrical and magnetic field. This action is transmitted through the space with a finite speed like electromagnetic field. Electromagnetic field in motion is called electromagnetic wave. By introducing the electromagnetic field the unique explanation of the force transmission is given.

Being influenced by the field, the space is under tension, and this tension influences the objects which the object meets. Tension is transmitted through space with the finite speed which depends on the time changes in the fields. The basic characteristic of the electromagnetic field is that the time dependent magnetic field induces an electric field, and the electric field induces a magnetic field and that's why they are closely connected. When an electromagnetic wave hits the border between two different media (e.g. air and organism), then the wave induces polarization of the other medium, dipoles are created and current is induced. In this way that other medium opposes electromagnetic field by its polarization and induced currents.

Dipoles and induced currents polarized in this way have got their magnetic field which is superimposed to the outer one. The sum of both poles in the first medium gives a reflected wave, and in the other tube is a refracted one (wave reflection and refraction). As a consequence a tension is created in the other medium as well on the very border between the two media. Compared to the electromagnetic field, magnetostatic field passes through living organisms without difficulty. In so doing it produces magnetic polarization in the organism whose effects may be neglected and acts with a force only on ions which are in motion.

When electrostatic field reaches the human organism, it induces the separation of positive and negative charge, so that at the spot where it has entered, the surface is negatively charged and on the spot where it leaves, there is positive charge. Since the organism is not a perfect conductor it is difficult to say that there is no electrostatic field even after that short separation of charge. As the electrostatic field is a potential field it may disturb the electric potential and the normal functioning of the organism.

Electromagnetic field acts on free ions in liquids in the h. organism and in this way it also acts on reaction kinetics and other chemical processes as well as on molecule orientation and concentration. In tissue and bones, however, polarization occurs, so that additional tension is created whose oscillations depend on the electromagnetic field frequency and the amplitudes of these oscillations depend in the field amplitude. It is necessary to point out here that when natural oscillation frequency in the human organism equals the field frequency, so called resonance is created and very weak fields are required to maintain oscillations.

It is quite certain that in this way best effect are achieved. Increased field intensity results with greater tension in the organism which may lead to undesired consequences. With the electromagnetic field penetration into the organism a certain amount of energy is brought into it and it equals the sum of electric and magnetic field energy. A portion of this energy performs some work and this energy is converted into heat. This heat depends on field intensity square and frequency. Having all this in mind it is evident that the choice of field intensity and the form of electromagnetic wave is of great importance.

2. Field wave form

Electrostatic and magnetic field does not depend on time, while electromagnetic field changes with time. This time field change determines the so-called field wave form. These forms may be accidental and determined. Determined wave forms are mostly periodical and are repeated regularly after the time, T . In practice periodical wave forms are mostly used and sine wave form is the simplest form (Fig. 1). Fundamental characteristics of periodic wave forms is the time of their repetition, period T . The reciprocal value of period T is called frequency, $f = 1/T$, which relates to the number of impulses per second and is measured in Hz.

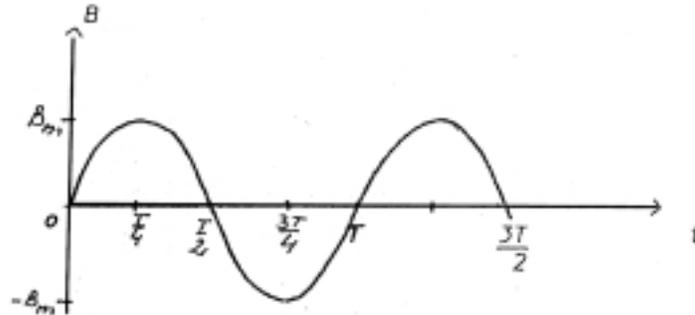


Fig. 1. Sine wave forms magnetic induction B

Electromagnetic wave diffusion depends on electromagnetic characteristics of the medium. The length of the wave also depends on electromagnetic characteristics of the medium and the wave frequency. In conducting medium, electromagnetic wave is choked, it is weakened, and its non - sine form is even distorted. That's why an electromagnetic wave in a conducting medium is said to have a certain depth of penetration which depends on medium conductivity and wave frequency. The greater the medium conductivity and wave frequency, the smaller wave penetration. This property is very important when electromagnetic wave is used in therapy and it requires a detailed research. Electromagnetic wave in living organism, not only stimulates cell functions but warms them as well. It is obvious that one should be very careful when electromagnetic wave is applied in therapy. As distinguished from electromagnetic wave, magnetic field penetrates into living organisms without any difficulties. It acts with a force only on electric charge which is in motion (equation 1), this being the basis of magnetic field influence on living organisms. Modern therapeutical devices are based on impulse magnetic field principle (Fig. 2).

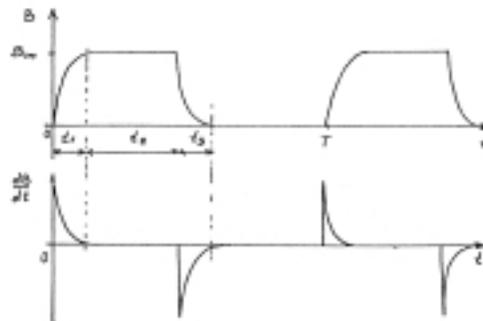


Fig. 2: a) magnetic induction impulse form, B b) magnetic induction impulse derivation

The ideal rectangular form of magnetic induction impulse cannot be achieved. Each impulse has got its time increase, t_1 , and its time decrease, t_3 whose amount is app. $10 \mu\text{s}$, while the impulse duration, t_2 is about $60 \mu\text{s}$. In t_2 , magnetic induction B is constant and there is no electric field (Fig. 2 a). Only during its setting up and decreasing, magnetic induction changes according with the time and only then the electric field is created and electromagnetic field exists. The speed of magnetic induction change (derivation) determines the form and the amount of electric field (Fig. 2 b). It is possible to state that such impulses are a combination of electromagnetic and magnetic effects. Maximal value of magnetic induction of an apparatus is app. $B_m = 150 \mu\text{T}$ and it decreases with the distance of the apparatus. Impulses may be repeated after the time T , and it determines the frequency at the same time. For example, for $f = 2 \text{ Hz}$, T is $0,5 \text{ s}$. For high frequencies this time is shorter, and for the given impulse it is possible to reduce the period $T = 100 \mu\text{s}$, frequency being 10 kHz . What is obtained regarding therapeutical sense? It is quite certain that due to electromagnetic waves, living organisms will be warmed up, so it is necessary to reduce electromagnetic field amplitudes. At lower frequencies it is possible.

PULSED MAGNETIC FIELD THERAPY - HOW DOES IT WORK?

An extract taken from a lecture delivered on 28th January, 1995

By Dr. D. C. Laycock Ph.D. (Med. Eng.); MBES; MIPEM; B.Ed. (Hons) (Phys. Sciences); CGLI (Ind. Electronics); Consultant Clinical Engineer, Westville Associates and Consultants (UK).*

All living cells within the body possess potentials between the inner and outer membrane of the cell, which, under normal healthy circumstances, are fixed. Different cells, e.g. Muscle cells and Nerve cells, have different potentials of about - 70 milli - Volts respectively. When cells are damaged, these potentials change such that the balance across the membrane changes, causing the attraction of negative sodium ions into the cell and positive trace elements and proteins out of the cell. The net result is that liquid is attracted into the interstitial area and swelling or oedema ensues. The application of pulsed magnetic fields has, through research findings, been shown to help the body to restore normal potentials at an accelerated rate, thus aiding the healing of most wounds and reducing swelling faster. The most effective frequencies found by researchers so far, are very low frequency pulses of a 50Hz base. These, if gradually increased to 25 pulses per second for time periods of 600 seconds (10 minutes), condition the damaged tissue to aid the natural healing process.

Pain reduction is another area in which pulsed electromagnetic therapy has been shown to be very effective. Pain signals are transmitted along nerve cells to pre-synaptic terminals. At these terminals, channels in the cell alter due to a movement of ions. The membrane potential changes, causing the release of a chemical transmitter from a synaptic vesicle contained within the membrane. The pain signal is chemically transferred across the synaptic gap to chemical receptors on the post synaptic nerve cell. This all happens in about one 2000th of a second, as the synaptic gap is only 20 to 50 nanometers wide (1 nanometer = 1/1000,000,000 of a meter). As the pain signal, in chemical form, approaches the post synaptic cell, the membrane changes and the signal is transferred. If we look at the voltages across the synaptic membrane then, under no pain conditions, the level is about -70 milli-Volts. When the pain signal approaches, the membrane potential increases to approximately +30 milli-Volts, allowing a sodium flow. This in turn triggers the synaptic vesicle to release the chemical transmitter and so transfer the pain signal across the synaptic gap or cleft. After the transmission, the voltage reduces back to its normal quiescent level until the next pain signal arrives.

The application of pulsed magnetism to painful sites causes the membrane to be lowered to a hyper-polarisation level of about -90 milli-Volts. When a pain signal is detected, the voltage must now be raised to a relatively higher level in order to fire the synaptic vesicles.

Since the average change of potential required to reach the trigger voltage of nearly +30 milli-Volts is +100 milli-Volts, the required change is too great and only +10 milli-Volts is attained., This voltage is generally too low to cause the synaptic vesicle to release the chemical transmitter and hence the pain signal is blocked. The most effective frequencies that have been observed from research in order to cause the above changes to membrane potentials, are a base frequency of 200Hz and pulse rate settings of between 5 and 25Hz.

**Member of the Institute of Physics and Engineering in Medicine.*

GOODBYE TO PAIN

New medical knowledge confirms that a combination of drugs and certain pulsed magnetic fields can result in sensational successes.

By Christian Wursthauer.

Almost exactly 8 years ago, "DIE APOTHEKE" ("The Pharmacy") reported on an - at that time - completely new type of physical therapy that used magnetic fields. Back then, the Viennese general practitioner, Dr. Andreas Kyriakoulis mainly treated patients afflicted with pain and achieved almost unbelievable results.

"DIE APOTHEKE" wanted to find out from Dr. Kyriakoulis what has become of this therapy and what experiences the physician has been able to accumulate during the intervening years.

Dr. Kyriakoulis in our original interview: "It has been clearly demonstrated during my practice of medicine and the treatment of innumerable patients that a physical therapy with pulsating magnetic fields of extremely low frequency can achieve very good results, especially in patients suffering from pain that is associated with a rheumatic disease. We often combine magnetic therapy with the requisite drugs. This potentiates their effectiveness and the time required for healing is significantly reduced."

Magnetism Already Known in Ancient Times

The archetype of magnetism is already found in the ancient Egyptian mysteries in which religious cult activity was closely associated with healing. Since then, the healing power of magnetism, in one form or another, has appeared in almost every cultural epoch. It attained its zenith at the end of the 18th century through Franz Anton Mesmer who claimed that it was his discovery. This is why magnetism is also often called Mesmerism. Despite spectacular successes, this form of physical therapy is still associated with the occult, the secretive and even charlatanism. However, one must still reject the type of magnetism as proposed by Mesmer, which cannot be examined scientifically, even today. The situation is completely different with the form of magnetic therapy that applies magnetic fields of varying intensity to the organism. This should, therefore, also more appropriately be called magnetic field therapy.

It has a long tradition. Already the famous physicians of ancient times, Hippocrates and Galen, used magnetic fields for healing purposes. Beginning at the end of the 18th century, an entire series of famous physicians used this form of therapy. Most notably, this included Christian Hufeland who, in addition to Goethe and Schiller, treated almost all the famous people of his day.

New Research Findings Justify the use of Magnetic Field Therapy

Today nearly 200 years later, science has become aware of the fact that relationships exist between magnetic fields and receptors found in the human body. Therefore, it was natural for medical research to focus on magnetic field therapy. Today, it is possible to precisely dose the strength of a magnetic field. Using the most modern examination methods, it is possible to follow the effect of these forces to the level of individual cells, even cellular components, in an organism. When reading the research results, the statement of the famous physicist and Nobel Prize laureate, Werner Heisenberg, spontaneously comes to mind:

“Magnetic energy is that elemental energy upon which all life in an organism depends.”

Dr. Kyriakoulis was the first Austrian physician to scientifically and practically investigate the type of especially short wave length, pulsating magnetic fields and their effects on the human organism. The physician discovered that the best results could be achieved with slowly pulsating electromagnetic waves whose strength was only slightly greater than that of the earth's own magnetic field. This magnetic field has no side effects and is a congenial partner for use in drug therapies.

According to Dr. Kyriakoulis: “Our magnetic field therapy is especially well-suited for the treatment of chronic pain associated with degenerative, rheumatic diseases. It facilitates regeneration processes which have a positive effect on the cartilage and the synovial fluid. Circulation is stimulated, as are certain groups of cells. The effect on the human immune system is especially important.”

The areas of application are numerous. Pain treatment (e.g., also including migraine headaches) has already been mentioned. It has been newly discovered that magnetic field therapy can also attain nearly sensational successes in the treatment of psoriasis. In bone fractures and other injuries, the healing process can be significantly accelerated.

Then Dr. Kyriakoulis mentions something that is very important: “The highest principle of this type of therapy recognizes that special indications exist for its use. However, every treatment also involves the entire organism in the therapeutic process. Therefore, we are essentially dealing with a form of total body treatment with a specific focus on a certain disease. This is important, because the effect of the pulsating magnetic fields significantly enhances the vitality of the organism as a whole.

In light of this, an application in the field of geriatric medicine would also prove advantageous. The physician is convinced that all possible areas of application for this form of physical therapy will not be known for a long time. He states: “Although the elimination of pain plays a central role in magnetic field therapy, it would not be proper to attribute all positive treatment results solely to this phenomenon. By means of the diverse interactions that have been scientifically documented so far and especially through the direct effect exerted on the individual cells, magnetic field therapy affects all biological processes in an organism and stimulates its natural resistance. The many therapeutic possibilities that are made available to the physician with such a system can be seen in its regenerative, anti-inflammatory, circulation-promoting and spasmolytic effects.

I am convinced that several important effects are still unknown. Perhaps, it will be possible to prove that this therapy can also be used in the treatment of cancer. However, this is certainly something that is still a long way off”

Asked about his most important discovery during the past several years, Dr. Kyriakoulis states: “In light of the suffering that chronic pain patients have had to endure, often for many years, it is certainly a great personal satisfaction for the treating physicians to possess a means, in the form of this therapy, with which ne can both pleasantly and comfortably reduce the symptoms of his afflicted patients.”

Three Important Observations

Based on experiences collected over many years and the results obtained with a great number of treated patients, three striking observations can be formulated:

1. Especially long-lasting successes were achieved in the treatment of women with osteoporosis. This is possible due to the induction effect of magnetic field therapy on the bone-forming cells (osteoblasts). The simultaneous use of certain drugs increases the success of therapy.
2. The possibilities for success are also similar in joint arthroses (spondylarthritis, gonarthrosis and omarthritis). Here too, therapy has a direct effect: on the cartilage-forming cells and the cells of the joint capsule which produce the synovial fluid.
3. It is noticeable that patients are more at ease and calm after therapy. As previously mentioned, this may be attributed to the whole body therapy which exerts a harmonizing effect on all body functions. In summation, it is clear that this type of modern physical therapy will have a bright future, not only in the treatment of pain.

For those individuals who are interested, we can make available reports of test results and double-blind studies at the University of Graz.

BIOLOGICAL EFFECTS OF NONIONISING ELECTROMAGNETIC RADIATION

by Jozse Gajsek, Institute of Quality Testing and Metrology, Ljubljana, Slovenia

Abstract

In the paper first the harmful effects of electromagnetic radiation to human beings are pointed out. The sources of electromagnetic energy encountered in occupational and general public environment are revealed and the thermal and nonthermal influences of their electromagnetic fields are briefly discussed. A survey of exposure limits adopted in different national and international standards and recommendations is given. A beneficial application of pulsating magnetic fields of extremely low frequencies is presented at the end.

Introduction

Facing a vast amount of devices that radiate electromagnetic waves in our environment, we are often wondering whether they have harmful effects to our health. The public awareness over this issue has been increasing in recent decades, while for a long time there had been little concern shown in this area even in the professional community. The interest has grown along with the multitude of man made electromagnetic fields.

The overflow of electromagnetic fields and radio- and microwave beams that nowadays surround the earth can be clearly illustrated by the following analogy: “If the electromagnetic radiation would be visible, today an observer from space would see the earth shining while at the beginning of the century the globe would be completely dark.” Quite often the allegation of electromagnetic pollution of the environment is encountered.

It is therefore not surprising that the questions have arisen concerning the potential health hazard from inevitable radiation produced by a number of devices in occupational and general public use beginning with HF-generators, through HV lines and radar transmitters, as well as radio-receivers, TV-sets and domestic appliances.

On the other hand, however, appropriately controlled application of electromagnetic radiation may have beneficial effects on certain physiological processes and can thus be used for therapeutic purposes.

Harmful biological effects of nonionising electromagnetic radiation

The mechanism of interaction of electromagnetic fields with organic matter can in general produce thermal and nonthermal effects. The thermal effects results into temperature rise of the exposed tissue which may cause hazardous damage in certain parts of the human body. According to the “ion theory” (Lazarev) the changes in the cells of the irradiated tissue occur due to periodic movement of ions. Their collision develops the heat which causes the coagulation of the albumin. Another theory on cellular changes was set by Deboj and his colleagues (“dipole moment theory”). Both theories are equally recognized yet neither explains in detail the various biological effects. According to Sebant, under the influence of radiowaves the molecular and cellular structure is being changed. A quantum-biological effect has been observed that affects the response to stimulation of cells as well as the permeability and dimensions in the cell structure (1,2).

The nonthermal effects include the effects that have been observed at low levels of electromagnetic energy below the intensities that produce significant heating. More frequent indispositions have been noticed amongst the workers exposed to radar beams, such as feebleness, chest pains, cardiovascular disturbances and disturbances in sense organs. Changes in the electroencephalograms have also been reported as the effect of electromagnetic waves on brain ganglia, as well as reduced sexual activity and spermatogenesis. Based on these observations and further investigations the nonthermal effects of electromagnetic radiation on human body have been explained and confirmed scientifically. A Theory has been set and confirmed by the experts that in the tissue exposed to electromagnetic field the electrical currents are induced causing the transfer of ions through the cell membranes, which can be hazardous at certain field intensities.

Nonthermal effects have been observed also in the hypothalamus in the form of stimuli in cell structure causing non-specific reactions in the organism.

The results of experiments on animals and the analysis of health state of persons occupationally exposed to electromagnetic radiation have proven that the nonthermal effects of electromagnetic fields are hazardous to living organism.

Functional changes occur in nervous and cardiovascular system as well as in bone marrow and other parts of the human body (3, 4, 5). Long term exposure of nervous system to low-level electromagnetic fields causes changes in the brain core. Amongst workers in television transmission stations and persons working near HF power generators a reduction of physiological reactions (difficulties in perception) has been observed at variations of field intensities between 10 to 20 V/m. The effects of this phenomenon were depression, decrease in attentiveness, and sleepiness. At the same time changes have been stated in reaction of sense organs of smelling and seeing - increased adaptation time to darkness and higher perception of smelling, respectively.

Several reports of research being conducted for several years claim that the exposure may provoke the vegetative dystonia.

Changes in conditional reflexes have been registered as well. The disturbances in the activity of the cholinesterase in the blood enables early detection of increased exposure to electromagnetic radiation.

In the central nervous system of a person working in ultra-shortwave electromagnetic field functional disturbances are likely to occur within a year. Consequently, even a short time exposure to electromagnetic radiation can be considered dangerous (2).

Harmful influence of electromagnetic radiation on living tissue depends primarily on the frequency (wavelength) and density of the field, on the operating condition of the radiation source, and the exposure time. The effects are intensified on higher frequencies and field densities. Further important factors are the functional state and the sensibility of the exposed organism. The vascularization of the irradiated parts and the distance from the radiation source have to be considered, too. The harmful effects are higher among female population.

The investigations have shown that the low-frequency (50 Hz) electromagnetic fields may cause harmful effects to human body, too. The results of the investigations revealed the hazards to the status and function of the central nervous system and to the cardiovascular system (changes in blood test specifications as well as blood pressure and pulse changes). Table 1 presents the changes of blood pressure and pulse vs. nominal voltage of the HV devices (10).

TABLE 1 CHANGES OF BLOOD PRESSURE AND PULSE VS. NOMINAL VOLTAGE OF THE HV DEVISE

Indication in cardiovascular system	Indication value		Deviation from normal state vs. voltage (50 Hz)		
	220 kV	330 kV 500 kV			
Max. arterial pressure		>100	3.1%	6.8%	16.9%
		< 100	4.7%	7.5%	8.88%
Min. arterial pressure		> 60	6.3%	8.3%	20.1%
		< 60	4.7%	6.0%	9.6%
Pulse		> 60	7.9%	7.5%	23.3%
		< 60	7.9%	7.5%	15.3%

Sources of harmful electromagnetic radiation

The sources of electromagnetic radiation can be found in different areas, e.g.:

As sources of potential harmful electromagnetic radiation are considered the devices which intentionally or unintentionally generate electromagnetic fields. The energy they produce being either controlled or not controlled is emitted into their environment, thereby causing the “electromagnetic pollution”. The power density of the electromagnetic radiation is expressed in W/m² and is related to field intensity, expressed in V/m or in A/m. The frequency range to be considered extends from 3 Hz to 300 Ghz.

- transmission equipment for speech, telegraph, and picture information
- radiobroadcast transmitters
- computer systems
- TV transmission equipment
- radio-location devices - radars
- TV-receivers
- HF-generators for diatherm
- HF generators for industrial applications (working of wood, metal and plastic)
- domestic appliances
- Devices operating at lower technical frequencies sound and ultrasound frequencies. According to some reports especially the electromagnetic fields within power supply plants, e.g. power lines and high voltage transformers, are hazardous.

Exposure Standards for Electromagnetic Fields

To provide protection against excessive nonionising electromagnetic fields of occupational and general public population the exposure standards have been adopted in most countries. In case national standards do not exist the international standard should be considered, e.g. IRPA standards, to assure that certain safety limits are met. The exposure limits adopted in this standard are quoted in Table 2 together with some national standards for illustration and comparison.

TABLE 2 EXPOSURE STANDARDS FOR ELECTROMAGNETIC FIELDS

Standard	Frequency Range	Exposure Limit	Permitted Exposure Duration
IRPA - 1984 International Radiation Protection Association	0.1 - 1 MHz	194 V/m; 0.51 A/m	8 hr
	1 MHz	194/ f* V/m; 0.51/f A/m	8 hr
	10 - 40 MHz	61 V/m; 0.16 A/m; 10 W/m ²	8 hr
	0.4 - 2 GHz	3f V/m; 0.008 f A/m	8 hr
	2 - 300 GHz	137 V/m; 0.36 A/m; 50 W/m ²	8 hr.
ANSI - 1983 USA	0.3 - 3 MHz	632 V/m; 1.58 A/m	unlimited
	30 - 300 MHz	63 V/m; 0.16 A/m	unlimited
	1.5 - 100 GHz	141 V/m; 0.35 A/m; 10 W/m	unlimited
U.S.S.R.-1976	0.06 - 3 MHz	50 V/m; 5 A/m	8 hr
	12/1/006-76 3 - 300 MHz	20 V/m	8 hr
	30-50 MHz	10 V/m; 0.3 A/m	8 hr
	50 - 300 MHz	5 V/m; 0.35 A/m; 50 w/m	8 hr
Germany - 1986 VDE 0848/2	0 - 10 Hz	40 kV/m	unlimited
	0.01 - 30 kHz	40 kV/m lin -> 1.5 kV/m	unlimited
	0.03 - 2 MHz	1500 V/m; 7.5/f A/m	unlimited
	0.03 - 3 GHz	3000/f V/m; 7.5/f A/m	unlimited
		100 V/m; 0.25 A/m; 25 W/m ²	unlimited
	12 - 3000 GHz	100.(f/300) V/m 0.25 (f/300) A/m 25. f/300 W/m ² 200 V/m; 0.5 A/m; 100 W/m ²	unlimited
Germany - 1984 DIN	50 Hz - 10 kHz (inductive heating)	0.4 - 5 mT	short durations
IRPA - 1988	27.12 MHz (diathermal therapy)	61 V/m; 0.16 A/m; 10 W/m ²	short durations
Eastern Europe Standards	50 Hz HV lines	5kV/m	unlimited
		10 kV/m	180 min
		15 kV/m	90 min
		20 kV/m	10 min
		25 kV/m	5 min

.f in MHz

Beneficial nonionising electromagnetic radiation

As already mentioned, adequately controlled electromagnetic radiation can be used for therapeutic purposes, e.g. for diathermal shortwave and microwave therapy. New possibilities have been discovered lately in pulsating magnetic fields of extremely low frequencies from 2 to 24 Hz. This radiation has proven to be successful in curing various diseases. The mechanism that forms the basis of the curing method is the increased dynamics of ions due to changes of the electrical potential in cell membranes caused by varying electromagnetic field. The effect is a better supply of cells with oxygen.

Beside large generators of pulsating electromagnetic fields, with big coils, intended for radiation therapy in hospitals, miniature pocket size generators are now available. They produce low-level radiation in near vicinity and can be used as handy and efficient aid in diminishing or eliminating different health and feeling troubles. The device can be applied to prevent bad disposition due to weather effects, to ease the pain in scars, to cure rheumatic diseases, headaches, and migraines, in case of sleeplessness, travel disease, nervousness, and problems with vascular system, it can also stimulate the growth of the tissue in case of bone rupture.

A small magnetiser ELMAG MK 75 MINI is available on the market, which has been tested by medical experts in several occasions. The frequency of pulsating fields can be adjusted between 2 to 24 Hz, as specific ranges have to be utilized for particular applications: e.g. 5 to 6 Hz for quieting and preventing of spasms, 8 to 9 Hz to ease pains, 15 to 20 Hz in case of fatigue.

Considering that electromagnetic radiation may cause harmful effects as discussed in the first part of the paper, the upper limits of the radiation of the magnetiser were determined to assure safety of the user. According to the exposure standards presented in Table 2 the effective continuous radiation of the sinowave generator at lowest frequencies should be 400 μ T. The magnetiser on the contrary, generates a pulsating field, with the peak magnetic flux density not exceeding 300 μ T. In the experts circles world-wide the pulsating fields are considered to be 1000 times less dangerous than the continuing fields of equal mean magnetic flux density (11). The radiation characteristics and performance of the magnetiser should nevertheless be inspected severely, to comply with the international exposure standards on the one side, and to assure beneficial effects on the other side.

The pulse of the magnetic flux produced by ELMAG MK75 is precisely controlled in order to meet the requirements set by medical experts on the basis of experiments (9). The characteristic parameters of the pulse shape are kept within the following values (measured in the vicinity of the device):

- peak magnetic flux density $B_t = 250 \pm 50 \mu\text{T}$
- rise time $t_n = 10 \pm 1 \mu\text{s}$
- pulse duration $t = 55 \pm 5 \mu\text{s}$
- frequency 2 to 24 Hz

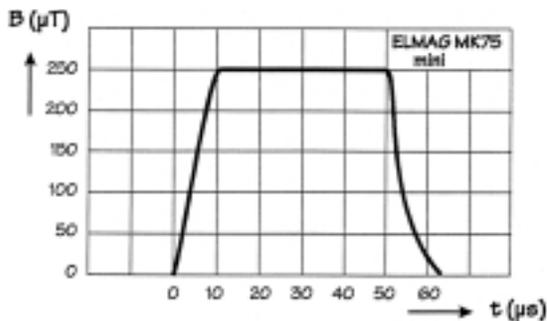


Fig. 1) Pulse shape of the magnetic flux density generated by ELMAG MK75 mini magnetiser

By *Joze Gajsek*
Institute of Quality Testing and Metrology
Ljubljana, 1990

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PULSED MAGNETIC FIELD THERAPY AND THE PHYSIOTHERAPIST

By *Dr. D.C. Laycock Ph.D. (Med. Eng.); MIPEM*, B.Ed. (Hons) (Phys. Sciences); MBES; CGLI (Ind. Electronics); Consultant Clinical Engineer, Westville Associates and Consultants (UK)*

The therapeutic effect of the application of pulsed magnetic field therapy (PMFT) has at last received world-wide recognition, although for a long time many practitioners saw it only as an aid to fracture union. Research has now shown that it has the potential to improve a wide range of conditions, although few understood just how it achieved its effectiveness. Extensive research has since been carried out to determine the mechanism by which this occurs. For physiotherapist, presented with a wide range of clinical problems, PMFT is an invaluable aid to the clinic.

Resolution of Soft Tissue Injuries

Over the past few years, research has shown that its effectiveness is not through heat production - as is the case with some modern treatments - but is at the cellular level. One significant outcome of this is the effect it has on soft tissue injuries. As early as 1940 it was suggested that magnetic fields can influence ATP (Adenosine Triphosphate) production; increase the supply of oxygen and nutrients via the vascular system; improve the removal of waste via the lymphatic system; and help to rebalance the distribution of ions across the cell membrane. This causes a steady flow of ions through its pores. In a damaged cell the potential is raised, and an increased sodium inflow occurs. As a result, interstitial fluid is attracted to the area, resulting in swelling and oedema.

The application of PMFT to damaged cells accelerates the re-establishment of normal potentials (Sansaverino 1980 1) increasing the rate of healing and reducing swelling. This can help to disperse bruising also. A magnetic field pulsed at 5Hz with a base frequency of 50Hz can have the same effect as an ice pack in that it causes vaso-constriction.

Effects on Fracture Repair

Acceptance of magnetic fields in medicine came about foremost in the field of orthopaedics. Low frequency and low intensity fields have been used extensively for the treatment of non-union fractures. By 1979 this method was approved in the USA as a safe and effective treatment for non-union fractures; for failed arthroses; and for congenital pseudoarthroses.

According to Basset 2 (1983) the method has been used by more than 6,000 surgeons. The success rate was over 80% for tibial lesions. No patient suffered complications and biological side-effects included improved healing and increased neural function.

In-depth research carried out to investigate this shows that magnetic fields influence the process of bone formation in the intercellular medium. Madronero 3 (1990) showed that bone healing was promoted by means of the influence of the magnetic field on the crystal formation of calcium salts.

Pain Reduction

Pulsed magnetic field therapy has been shown to bring about a reduction of pain, which again is due to action at the cellular level.

Chemical Synapse Action Potential in a Neuron

NERVE

IMPULSE +30.....

Pre-Synaptic Depolarisation

Neuron Synaptic Na^+ , Ca^{2+} , inflow Repolarisation

Vesicle 0..... K^+ outflow.....

Membrane

Transmitter - 55.....

-70.....

Synaptic Cleft

Post Synaptic -90.....

Receptor Neuron Membrane

Sites Potential m V Hyperpolarisation

(2a) (2b)

Nerve Synapses Cell Potentials

Fig. 2

Pain is transmitted as an electric signal which encounters gaps at intervals along its path (see Fig. 2a). The signal is transferred in the form of a chemical signal across the synaptic gap and this is detected by receptors on the post-synaptic membrane. A charge of about -70mV exists across the inner and outer membranes, but when a pain signal arrives it raises this to +30mV (see Fig 2b). This action causes channels to open in the membrane, triggering the release of a chemical transmitter and allowing ions to flow into the synaptic gap. The cell then re-polarises to its previous resting level.

Research by Warnke 4(1983) suggests that PMFT affects the quiescent potential of the membrane, lowering it to a hyper-polarised level of -90mV. Transmission is effectively blocked since the pain signal is unable to raise the potential to the level required to trigger the release of chemical transmitter. Again, the frequency of the applied magnetic field is important, as the most effective frequency to produce this effect was found to be a base frequency of 200 Hz pulsed at between 5 and 25 pulses per second.

Clinical applications

The value of pulsed magnetic field therapy has been shown to cover a wide range of conditions, with well documented trials carried out by hospitals, rheumatologists and physiotherapists. For example, the department of rheumatology at Addenbrookes Hospital 5(1984), carried out investigations into the use of PMFT for the treatment of persistent rotator cuff tendinitis. The treatment was applied to patients who had symptoms refractory to steroid injections and other conventional treatments. At the end of the trial, 65% of these were symptom free, with 18% of the remainder being greatly improved.

Lau⁶ (School of Medicine, Loma University, USA) reported on the application of PMFT to the problems of diabetic retinopathy. Patients were treated over a 6 week period 76% of patients had a reduction in the level of numbness and tingling. All patients had a reduction of pain, with 66% reporting that they were totally pain-free.

Many research studies, including Lau⁷, reported on the application of PMFT for conditions such as sports injuries and for patients with joint and spinal problems. Although these are too numerous to mention individually, in almost every instance there was a reduction, if not complete resolution of symptoms. Soft tissue injuries and joint pains tended to be resolved within 5 days of treatment. Patients with cervical problems and low back pain were also successfully treated, whereas previous treatment with ice, traction and other therapies had been unsuccessful. In yet another trial the effect of applying PMFT to sufferers of Multiple Sclerosis was investigated (Geseo A. 8 1987) 70% of sufferers had a reduction of weakness, pain and spasticity, with 50% reporting improvement of their bladder incontinence.

Through the evaluation of hundreds of research papers, a number of points have been established regarding PMFT:

- a) The field must be pulsed, with low frequency and low intensity to achieve the best effect.
- b) Different conditions require different frequencies. For example 5Hz causes vaso-constriction whilst 10Hz and above causes vaso-dilation.
- c) Biological effectiveness is achieved in just 10 minutes for most injuries, so that long treatment sessions are not required.
- d) When used at the correct level there are no recorded side effects. Although PMFT is not yet recommended for use during pregnancy or in the presence of tumours, there are papers to suggest that magnetic fields can inhibit the growth of tumours.

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TREATMENT OF CHRONIC WOUNDS BY MEANS OF ELECTRIC AND ELECTROMAGNETIC FIELDS

Part 1 Literature Review

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Abstract-The healing of a cutaneous wound is accompanied by endogenous electrical phenomena. Not knowing whether they represent merely a side-effect of the physiological processes which take course during healing or whether they play a much more important role as mediators of healing, externally applied electricity was examined as a therapeutic tool for the enhancement of natural regenerative processes. In the present review a historical literature survey dealing with human applications of electric current for wound healing acceleration is given. It presents a complete palette of heterogeneous studies, differing in the parameters of applied electric current, in delivery modes as well as in the types of wounds being stimulated. Because of all these differences, comparing the efficacy of the described methods is difficult and could hardly be objective. Therefore greater stress was laid upon the discussion concerning the problems in designing clinical studies (size of the sample observed, control group, ethics of the procedures), rationales for the employment and possible underlying mechanisms of particular methods, and problems of evaluating their efficacy. In spite of the extensive work performed in the field of electrical wound healing we remain only part way towards explaining the mechanisms by which electricity reinforces the regenerative capabilities of injured tissue as well as only part way towards the selection of the optimal stimulation method from among the published reports.

Keywords: Electric Stimulation, Electric Therapy, Skin Ulcer, Wound Healing

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Rehabilitation of hand after severe acute injuries

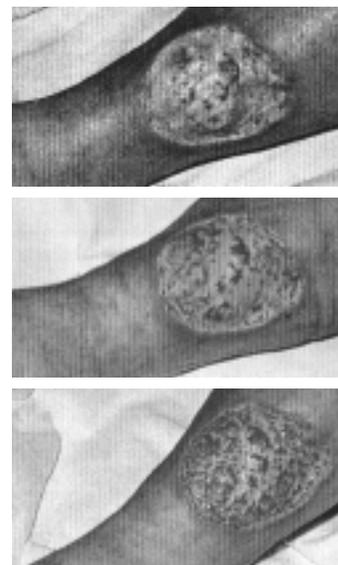
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Department for Plastic and Reconstructive Surgery

Department for Physical Medicine & Rehabilitation

Bitte Diese Grenze weder beruhren noch uberschreiten



In the year 1990 490 cases or patients with acute hand injuries have been treated in our Departments. There were 170 cases with flexor lesions, 132 cases with extensor lesions and 84 cases with damage in dorsal hand aponeurosis.

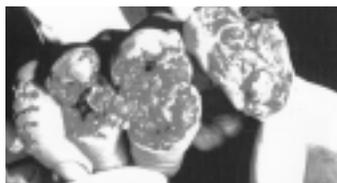
All of these lesions are complex, what means that were musculoskeletal - vascular - nerve system compound damages. Because of this we were made primary wound closure in 81 cases, in 81 cases we covered the wound with free skin transplants, in 56 cases local skin grafts and in 16 cases we covered the wound with distant skin grafts.

In the maintenance of these severe injuries we sewed digital nerve in 72 cases (neuroraphia), in 9 cases we sewed medial nerve, in 9 cases neuroraphia of ulnar nerve, in 5 cases we made neuroraphiam of radial nerve.

In 68 cases of bone fracture lesion we fixed them with Kirschner's wire or with screws, 23 fractures were fixed with periosteal sutures or with spongio-plastics.

In pooperative treatment all of patients have complex rehabilitation program. They were treated with kinesitherapeutic exercises, magnetotherapy (small pocket generator Elmag), electrotherapy and application of dynamic hand supports.

The achievements of this complex physical therapy was better range of motion, returny of lost function and less phenomens of Sudeck's dystrophy.



MAGNET FIELD THERAPY IN THE MANAGEMENT OF BENIGN PROSTATIC HYPERTROPHY

2001

27th General Meeting of the Austrian Urological Society and the Bavarian Association of Urologists Graz May 10-12, 2001

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The aim of the multicenter study presented here was to test how far the positive results from the application of electromagnetic fields that have been found by several other medical specialties can be documented in urology also. 27 patients with benign prostatic hypertrophy exclusively were treated during bedtime (about 8 hours) with a battery-operated, miniaturized (1. x w. x h. = 5 x 3 x 1 cm) magnetic field generator - the Prostameg from the Poznick Co., Celje.

Exposure Conditions: B/device = 7.9 μ T, impulse frequency; 19.5 Hz, square wave signal.

Device Placement: in the underwear, as close as possible to the prostate.

Study population with mean age of 63.6 years (range: 48.7 - 79.6) was randomized for the single-blind trial to a treatment group (n1 = 17) or placebo group (n2 = 10). At baseline and upon completion of the study the mean and maximum urine flow, PSA values, and prostate size were measured on ultrasound. In addition, as a survey of subjective experiences, the patients filled out the internationally known IPSS (*International prostate symptom Score) questionnaire designed to assess the symptoms of benign prostatic hypertrophy. No participant reported any worsening, or the occurrence of any other problems during or after treatment.

The statistically most significant result for the treatment group consists of a highly significant (P=0.0005) improvement in subjective symptom evaluation. By the end of the trial, prostate size in the field-treated group had decreased on the statistical curve by 12% (P=0.09) from 30.4 to 26.9 cm³. No other measurable medical events within the treatment group were noted. However, on the current analysis no statistically relevant differences could be determined between the treatment and placebo data by reason of the small population size (strictness of the exclusion criteria).

Because of the promise of these findings, plans were made for development of a wider follow-up study. Meanwhile, this kind of magnetic field therapy should be regarded by a greater number of doctors as a form of adjuvant treatment at least.

Over

IPSS - International Prostate Score, which is similar to the American Urological Association (AUA) Symptom Index.

PULSATING MAGNETIC FIELDS OF LOW INTENSITY (PMFLI): PROSPECTIVE RANDOMIZED TRIAL FOR PAIN REDUCTION IN PATIENTS WITH CRITICAL ISCHAEMIA OF LOWER EXTREMITIES

Flis V., Flis I., Turk Z.

Introduction

Critical ischaemia of lower extremities is still a challenging problem in clinical treatment of patients with such symptoms (Dormandy 1989). Clinical treatment is especially difficult in patients with distal intragenicular arterial disease (Bell 1985, Boobis and Bell 1982). Pharmacotherapy and surgery in patients with critical ischaemia of lower extremities (Dormandy 1989) and distal intragenicular arterial disease are not giving encouraging results (Bell 1985, Boobis and Bell 1982, Killon and Ambrous 1987).

It seems that no adequate clinical therapy exist for patients with severe disabling rest pain in the presence of obliterated bellow knee vessels. Patients with no gangrene are usually not willing to undergo amputation. So the main problem remains: severe disabling rest pain.

It has been reported (Adey 1974) that pulsating magnetic fields of low intensity could influence the central nervous system. So the aim of this study was to find out whether stimulation with pulsating magnetic fields of low intensity could decrease the defined daily dosis (DDD) of analgetics.

Patients and methods

The study included only patients with critical ischaemia of lower extremities in the presence of bellow knee vessels disease (Dormandy 1989). All patients had a complete medical and vascular studies (segmental Doppler studies) to establish a baseline of extremity perfusion. Standard arteriography was performed via the contralateral femoral artery to document the site and nature of arterial occlusion.

In this research the magnetic field was generated by a pocket generator. The device was made available by courtesy of (a firm) Elmag Co. in Slovenia (YU) and in the research frequency of 19,5 Hz was applied.

The fields from the described device spread in a spherical-symmetrical manner. The size of the device is 55 x 36 x 15 mm, its intensity between 0-10 cm distance is 40-1 microT.

In the sequential doubled trial made by Bross (Bross 1952) got the half of all patients - after the randomisation - a normal stimulation (VERUM), the other half got a machine (a pocket generator), which didn't operate (PLACEBO). The first part of the experiment has lasted for 4 weeks.

After that 4 weeks the order was exchanged: patients with the former PLACEBO - pocket generators got a normal stimulation (VERUM), the others (they had a normal stimulation before) got the PLACEBO. This part of the experiment has lasted for 4 weeks, too.

The Bross' test enables immediate statistical comparisons for the first part and the other part of our experiment was evaluated by the Wilcoxon's test (Johnson and Johnson 1977).

Results

The parameters measured out in a vascular laboratory (angio-sonographically determined segmental pressures i.e. segmental Doppler studies) in the beginning and at the end of the research were the same - they didn't change after the use of PMFLI.

Wilcoxon's test indicated that there aren't any statistically important differences on the pain reduction: $p < 0,05!$ between both groups of patients (1. testing group: PLACEBO versus VERUM and the 2. testing group VERUM versus PLACEBO).

The Bross' test showed, that among 44 patients there were 13 of that kind, where the use of analgetics after the stimulation with PMFLI was highly reduced. This difference is statistically important. That patients got a name: VERUM - reactors (29%).

The results also showed, that among 44 patients there were 5 of them, where the use of analgetics reduced, but they had PLACEBO-pocket generators, We nominated them PLACEBO - reactors (11%).

Discussion

Only the planning of this research was in touch with many methodical problems. Patients with a critical ischaemia of lower extremities (Dormandy 1989) were chosen because of two reasons: they have a very strong resting-pain, so that at such group of testing patients may subjective criterions fall away. At such group there is also possible to control defined daily doses (DDD) of analgetics and so to estimate every improvement or aggravation. Every change is visible in the intensity of the pain.

Because of the reasons:

- that no adequate clinical therapy exist for patients with severe and disabling pain,
- that the doctors doesn't dispose any suitable and effective medical treatment (Boobis and Bell 1985),
- that surgical therapy doesn't effective enough for the patients with peripheral obliterative arteriopathic disease (Bell 1985), all medicine-powers are directed to the alleviation of the state.

So we tried to find out if the use of PMFLI can reduce the consumption of analgetics.

The research showed that in the segmental arterial pressures (compared before and after using PMFLI) there weren't any changes and in this case we didn't expect them also.

Wilcoxon's test showed, that between both groups of patients there weren't statistical important differences in the reduction of defined daily doses (DDD) of analgetics, but there is interested that DDD of analgetics is lower for about 20% in both groups.

We counted for important just a reduction which was bigger or the same as 50%.

Bross' test showed the extra insight: the "undergroup" of 13 patients had statistically important reduction of DDD of analgetics. For this "undergroup" we can with a sure probability say that this reduction was the result of the PMFLI stimulation.

All results of our research we could carefully interpret with the fact that it exist a group of people who are more susceptible for PMFLI and where we can objectively observe the influence of PMFLI.

This agree with the opinion of some other "magnetic fields-explorers" (Becker and Marino 1982). They suppose that there are just 30% of living people susceptible for the pulsating magnetic fields of low intensity (PMFLI).

Certainly in this place immediately appears the question "why like this?" Maybe there is an interference with other magnetic fields from our environment? Is it maybe an inherential characteristic of all living creatures?

Anyway, it's important to answer that questions more exactly, because the results of this research are very positive. They also show some new possibilities: to affect and rise the life quality with using of pulsating magnetic fields of low intensity - even on such sick people like they was included in this pilot-research.

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EVALUATION OF THERAPEUTIC EFFICIENCY OF ELMAG-S IN PERIPHERAL FACIAL NERVE PALSY - USING ELECTROMYO-NEUROGRAPHIC METHODS

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We have been treating several hundreds of patients with peripheral facial palsy with ELMAG-S in our hospital. ELMAG-S is a high frequency electro-magnetic stimulator (high frequency pulsating electromagnetic field). We have performed a complete EMNG analysis at 15 adult patients (age 18-50, both male and female) with peripheral facial nerve palsy. They have all been treated without success with other methods and showed no significant improvement after 1-2 months. (Other methods include: lidocaine injections, corticoids, polyvitamins etc.) We have performed detection EMG analysis at all examined patients, measuring motor conduction velocity on both sides, and R1 response latencies. We have measured the amplitude, duration, and distal latency of M response, and determined latency of R1 response. M Response was registered in zygomatic muscle using Disa's concentric needle electrode. We have been using superficial electrodes for registration of R1 response in m. orbicularis oculi while stimulating m. supraorbitalis. EMNG recording has been analyzed before the beginning of treatment with ELMAG-S and fourteen and twenty eight days after the treatment has commenced. It was repeated at some patients after 45 and 60 days. Comparison of amplitudes of M response on healthy and affected side has shown no prognostic value. We have also performed audiometry, tympanometry and X-ray of mastoids by Stenvers at all patients. Each patient has been photographed and a video recording of some patients has been performed.

The patients have been using ELMAG-S for a period of three week to one month, depending on the clinical finding and EMNG recording. The device has been applied twice a day for one hour using frequency of 40 cycles. We have recorded improvement at each consecutive EMNG recording on all patients. Motor conduction velocity showed significant improvement within the average period of 28 days. It is also important to stress out that the clinical improvement has not directly been followed by the improvement in EMNG recording.

KEYWORDS: n. facialis, ELMAG-S, EMNG

MAGNETOTHERAPY IN LOOSENING OF THE ARTIFICIAL HIP JOINT

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For the patient with progressed secondary hip arthrosis or osteoporotic fracture, insertion of an artificial hip joint is the ideal solution. The characteristic pain of coxarthrosis is relieved postoperatively and the mobility of the joint itself improves. Sometimes the insertion of an artificial hip joint is connected with certain short-term (hematoma, seroma, pulmonary embolism, paresis of the sciatic nerve) and long-term complications (aseptic loosening of the artificial hip joint, osteolysis along the implant).

Ten years after artificial hip joint insertion, in 10% a revision operation is required due to aseptic loosening of one or both parts of the artificial joint. In the professional literature Harris was the first to describe localized bone dissolution in connection with loosened cement endoprostheses. Osteolysis in cement hip joints gave rise to the development and application of cementless artificial hip joints. When the occurrence of osteolytic lesions was established also in cementless prostheses, it became evident that numerous factors play a significant role in loosening of the prosthesis. Natural bone and materials from which implants are made all have a different elasticity. For this reason at a certain load microshifts always occur at the junction between bone and implant (a loosening occurs when the shifts are larger than those expected due to differences in material elasticity). The presence of connective tissue at the junction of different materials also increases the extent of the microshifts. A layer of connective tissue between cement and bone allows the intrusion of tiny particles, triggering chronic inflammation and the occurrence of osteolysis, in time also followed by a loosening of the artificial hip joint. The loosening is manifested clinically by hip pain during loading, particularly intorsion movements.

Our Results:

In 1998, 8 patients were treated for loosening of the hip prosthesis (6 women, 2 men, average age 68 years, a span of 60 -75 years). In all cases, apart from load relief by using a walking crutch, a low frequency magnetic field of 3 mT intensity and a frequency of 25 Hz/ 20 x half-hour session was applied. In 5 patients a remission of subjective symptoms and improvement of mobility in the affected hip joint was attained in a period of 6 months.



VETERINARY APPLICATION OF PULSED MAGNETIC FIELD THERAPY

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Research into Pulsed Magnetic Field Therapy

Although the therapeutic use of pulsed magnetic fields has long been in existence, understanding of its mode of action has been poorly understood. As early as 1940, Nagelshmidt proposed that its action was at the cellular level and this has now been supported by research. It has been shown that damaged cells have a reduced negative charge, with subsequent effect on the flow of ions. This causes a build-up of fluid and prevents the normal cellular metabolism from taking place. Research by Bauer and more recently by Sansaverino (1980), confirmed that pulsed electromagnetic fields can restore the ionic balance and return the cell to its normal functions.

Initially, pulsed magnetic fields were applied mainly to fractures, where it was shown that they could bring about a reduction in the time needed for resolution of the fractures. It has been shown that under the influence of a pulsed magnetic field, osteoblasts are attracted to treatment sites, where small eddy currents are then induced into trace elements of ferro-magnetic material within the bone. Also, work by Madronero has shown that calcium salts are purified, hence bone crystals become stronger. More recently, research by Bassett has been investigating the wider applications of pulsed magnetic fields in the area of orthopaedics.

Bassett also foresaw the extension of pulsed magnetic field therapy to other areas of medicine. This has now taken place, with an increase in scientific research and clinical trials in the UK, and throughout Europe, Russia and the USA.

The range of applications has covered:

Treatment of vascular disorders (Steinberg 1964)	Reduction of inflammation and oedema (Golden et al 1980)
Enhancement of the rate of healing in skin grafts (Golden et al 1981)	Reduction of pain (Warnke 1983)
Treatment of neuropathy (Lau)	Nerve regeneration (Hayne)
Reduction in symptoms of Multiple Sclerosis (Guseo 1987)	

Research into these and other areas have shown good rates of success, with no detrimental side effects. For optimum results, low-frequency sustained pulsed magnetic fields should be applied, with specific problems responding best to specific frequencies. For example, pain can be blocked using a base frequency of 200 Hz as this brings about hyperpolarisation of nerve cells and inhibits transmission of pain signals. For wound healing, a base frequency of 50Hz is most effective, with a pulse rate of 17.5Hz.

THE ROLE OF PULSED MAGNETIC FIELD THERAPY IN VETERINARY PRACTICE

Initially, pulsed magnetic field therapy was used primarily in treating horses for resolution of back and leg injuries. This was followed by widespread use with greyhounds, since these incur frequent sprains, ligament injuries and fractures, all of which respond well to pulsed magnetic field therapy. It is now used with other animals for similar injuries and has also been used to improve metabolism. The range of animals treated is wide - from elephants to buzzards! Pulsed magnetic field therapy has been found to be particularly effective in treating leg and wing fractures of small birds, as they often are difficult to splint and, in the worst cases, difficult to pin because of splintering of small bones. These injuries show a good response given daily treatment with pulsed magnetic field therapy.

The use of a 200Hz base frequency as a pain block also has been beneficial in facilitating the examination of an injured animal. Practitioners have found that an initial 10 minute treatment reduces an animal's distress, so that it will then tolerate further handling in order to apply treatment or to enable the manipulation of an injury.

German shepherd dogs are noted for suffering symptoms which resemble those of Multiple Sclerosis. In the UK, some success has been achieved by treating these symptoms with pulsed magnetic field therapy. There is also evidence from research that nerve regeneration has been achieved under the influence of pulsed magnetic fields.

Once a diagnosis has been made and the desired therapeutic frequency determined, pulsed magnetic field therapy is simple to apply and can safely be administered by the owner. This means that treatment can be given more than once a day on a regular basis between visits to the surgery - thus speeding up the rate of healing and reducing demands on the time of the practitioner. In the UK, trained animal therapists operate under the direction of veterinary surgeons to provide pulsed magnetic field therapy as part of a physiotherapy programme for animals. Students come from all over the world to a training centre to be taught the methods and how to use the equipment to optimum effect.

Equipment

There is a range of equipment available. The larger units have a blanket applicator on which the animal can lie during treatment. These also are particularly useful for treating back injuries in large animals. There are also strap-on applicator pads available. The desired frequency range and treatment time is selected on the control panel of the unit. Current research shows that long treatment sessions are not essential, as maximum therapeutic effect is generally achieved in a 10 minute session. Naturally the duration over which treatment is required is dependent on the severity of the injury. Fractures require longer treatment.

The latest equipment now coming onto the market is a smaller, battery operated unit which is particularly useful for small animals or where a small area is to be targeted for treatment, such as the legs and wings of birds. These units have a dual advantage. Firstly, the operator can easily transport the equipment, allowing prompt treatment anywhere at any time and removing the need to take the animal to the surgery. Secondly, this type of unit can be left with the owner on a hire basis to allow regular support treatment to be given between visits.

** Member of the Institute of Physics and Engineering in Medicine*

A PORTABLE PULSED ELECTROMAGNETIC FIELD (PEMF) DEVICE TO ENHANCE HEALING OF RECALCITRANT VENOUS ULCERS: A DOUBLE-BLIND, PLACEBO-CONTROLLED CLINICAL TRIAL

AU: Stiller-MJ; Pak-GH; Shupack-JL; Thaler-S; Kenny-C; Jondreau-L

AD: Ronald O. Perelman Department of Dermatology, New York University Medical Center, New York

SO: Br-J-Dermatol. 1992 Aug; 127(2): 147-54

CP: England

AB: A prospective, randomized, double-blind, placebo-controlled multicentre study assessed the clinical efficacy and safety of pulsed electromagnetic limb ulcer therapy (PE-LUT) in the healing of recalcitrant, predominantly venous leg ulcers. The portable device was used at home for 3 h daily during this 8-week clinical trial as an adjunct to a wound dressing. Wound surface area, ulcer depth and pain intensity were assessed at weeks 0, 4 and 8. At week 8 the active group had a 47.7% decrease in wound surface area vs. a 42.3% increase for placebo ($P < 0.0002$). Investigators' global evaluations indicated that 50% of the ulcers in the active group healed or markedly improved vs. 0% in the placebo group and 0% of the active group worsened vs. 54% of the placebo group ($P < 0.001$). Significant decreases in wound depth ($P < 0.04$) and pain intensity ($P < 0.04$) favouring the active group were seen. Patients whose ulcers improved significantly after 8 weeks were permitted to continue double-blind therapy until week 12, with the active treatment group continuing to show improvement. There were no reports of adverse events attributable to this device. We conclude that the PELUT device is a safe and effective adjunct to non-surgical therapy for recalcitrant venous leg ulcers.

THE EFFECT OF PULSED AND SINUSOIDAL MAGNETIC FIELDS ON THE MORPHOLOGY OF DEVELOPING CHICK EMBRYOS

AU: Farrell-JM; Litovitz-TL; Penafiel-M; Montrrose-CJ; Doinov-P; Barber-M; Brown-KM; Litovitz-TA
AD: Vitreous State Laboratory, Catholic University of America, Washington, DC 20064, USA
SO: Bioelectromagnetics, 1997; 18(6): 431-8

AB: Several investigators have reported robust, statistically significant results that indicated that weak (approximately 1 microT) magnetic fields (MFs) increase the rate of morphological abnormalities in chick embryos. However, other investigators have reported that weak MFs do not appear to affect embryo morphology at all. We present the results of experiments conducted over five years in five distinct campaigns spanning several months each. In four of the campaigns, exposure was to a pulsed magnetic field (PMF); and in the final campaign, exposure was to a 60 Hz sinusoidal magnetic field (MF).

A total of over 2500 White Leghorn chick embryos were examined. When the results of the campaigns were analyzed separately, a range of responses was observed. Four campaigns (three PMF campaigns and one 60 Hz campaign) exhibited statistically significant increases ($P > \text{or} = 0.001$) ranging from 2-fold to 7-fold, in the abnormality rate in MF-exposed embryos. In the remaining PMF campaign, there was only a slight (roughly 50%), statistically insignificant ($P = 0.2$) increase in the abnormality rate due to MF exposure. When the morphological abnormality rate of all of the PMF-exposed embryos was compared to that of all of the corresponding control embryos, a statistically significant ($P > \text{or} = 0.001$) result was obtained, indicating that PMF exposure approximately doubled the abnormality rate. Like-wise, when the abnormality rate of the sinusoid-exposed embryos was compared to the corresponding control embryos, the abnormality rate was increased (approximately tripled). This robust result indicates that weak EMFs can induce morphological abnormalities in developing chick embryos. We have attempted to analyze some of the confounding factors that may have contributed to the lack of response in one of the campaigns. The genetic composition of the breeding stock was altered by the breeder before the start of the nonresponding campaign. We hypothesize that the genetic composition of the breeding stock determines the susceptibility of any given flock to EMF-induced abnormalities and therefore could represent a confounding factor in studies of EMF-induced bioeffects in chick embryos.

ELECTROCHEMICAL THERAPY OF PELVIC PAIN: EFFECTS OF PULSED ELECTROMAGNETIC FIELDS (PEMF) ON TISSUE TRAUMA

AU: Jorgensen-WA; Frome-BM; Wallach-C
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SO: EUR-J-SURG-ACTA-CHIR-SUPPL. -/574 (83-86) 1994
LS: English

AB: Unusually effective and long-lasting relief of pelvic pain of gynaecological origin has been obtained consistently by short exposures of affected areas to the application of a magnetic induction device producing short, sharp, magnetic-field pulses of a minimal amplitude to initiate the electrochemical phenomenon of electroporation within a 25 cm(2) focal area. Treatments are short, fast-acting, economical and in many instances have obviated surgery. This report describes typical cases such as dysmenorrhoea, endometriosis, ruptured ovarian cyst, acute lower urinary tract infection, post-operative haematoma, and persistent dyspareunia in which pulsed magnetic field treatment has not in most cases, been supplemented by analgesic medication. Of 17 female patients presenting with a total of 20 episodes of pelvic pain, of which 11 episodes were acute, seven chronic and two acute as well as chronic, 16 patients representing 18 episodes (90%) experienced marked, even dramatic relief, while two patients representing two episodes reported less than complete pain relief.

PROTECTION AGAINST FOCAL CEREBRAL ISCHEMIA FOLLOWING EXPOSURE TO A PULSED ELECTROMAGNETIC FIELD

AU: Grant-G; Cadossi-R; Steinberg-G
AD: Department of Neurosurgery, Stanford University, California 94305
SO: Bioelectromagnetics, 1994; 15(3): 205-16

AB: There is evidence that electromagnetic stimulation may accelerate the healing of tissue damage following ischemia. We undertook this study to investigate the effects of low frequency pulsed electromagnetic field (PEMF) exposure on cerebral injury in a rabbit model to transient focal ischemia (2 h occlusion followed by 4 h reperfusion). PEMF exposure (280 V, 75Hz, IGEA Stimulator) was initiated 10 min after the onset of ischemia and continued throughout reperfusion (six exposed, six controls). Magnetic resonance imaging (MRI) and histology were used to measure the degree of ischemia edema on MRI at the most anterior coronal level by 65% ($P < 0.001$). On histologic examination, PEMF exposure reduced ischemic neuronal damage in this same cortical area by 69% ($P < 0.01$) and by 43% ($P < 0.05$) in the striatum. Preliminary data suggest that exposure to a PEMF of short duration may have implications for the treatment of acute stroke.

PEMF IN THE TREATMENT OF STENOCARDIA

Orlov L.L. et al.
1996
Journal article ISSN: 0006-3029

AB: This influence of PEMF, antianginal drugs and their combination on physical load tolerability, hemodynamics and functional state of hormonal system in patient with stable Angina Pectoris was studied. PEMF produced marked antianginal effect in patient with 1-2 class angina and it was effective in combi-

nation with antianginal drugs in class 3 angina. The reduction of attack frequency and significant physical load tolerability improvement was determined. The correcting influence of PEMF on hypophysis -thyroid system hormones was revealed, that correlates with physical load tolerability and myocardial contractility improvement.

ENHANCED POTENCY OF DAUNORUBICIN AGAINST MULTIDRUG RESISTANT SUBLINE KB-CHR-8-5-11 BY A PULSED MAGNETIC FIELD

AU: Liang-Y; Hannan-CJ Jr; Chang-BK; Schoenlein-PV

AD: Department of Radiology, Research and Nuclear Medicine, Medical College of Georgia, Augusta 30912, USA

SO: Anticancer-Res. 1997 May-Jun; 17(3C): 2083-8

AB: Tumor cell resistance to many unrelated anticancer drugs is a major obstacle during cancer chemotherapy. One mechanism of drug resistance is thought to be due to the efflux of anticancer drugs caused by P-glycoprotein. In recent years, magnetic fields have been found to enhance the potency of anticancer drugs, with favorable modulation of cancer therapy. In this study, KB-ChR-8-5-11, a multidrug resistant (MDR) human carcinoma subline, was used as a model to evaluate the ability of pulsed magnetic fields (PMF) to modulate the potency of daunorubicin (DNR) in vivo and to determine the appropriate order of exposure to drugs and PMF using an in vitro cytotoxicity assay. Solenoid coils with a ramped pulse current source were used at 250 pulses per second for both in vivo and in vitro experiments. For the in vivo study, KB-ChR-8-5-11 cells were inoculated into thymic Balbe-nu/nu female mice. Treatment was begun when the average tumor volume reached 250-450 mm³. Treatment consisted of whole body exposure to PMF for one hour, followed immediately by intravenous (i.v.) injection of 8 mg/kg DNR designated as day 0, and repeated on days 7 and 14. Among the various groups, significant differences in the tumor volume were found between PMF + saline and PMF + DNR groups ($p = 0.0107$) at 39 days and 42 days ($p = 0.0101$). No mice died in the period. For the in vitro studies, the sulforhodamine blue (SRB) cytotoxicity assay was used to determine the effect of the sequence which cells are exposed to PMF and/or DNR. Cells were exposed to PMF either before (pre-PMF) or after (post-PMF) drug was added. Results showed that the IC₅₀ was significantly different between controls and pre-PMF + DNR groups ($P = 0.0096$, $P = 0.0088$). The IC₅₀ of the post-PMF + DNR group was not found to be significantly different from control groups. Thus, the data in this report demonstrates that PMF enhanced the potency of DNR against KB-ChR-8-5-11 xenograft in vivo, while the efficacy of DNR was potentiated in vitro by PMF exposure only when PMF exposure occurred in the presence of drug. The data in vitro suggest that the mechanism by which PMFs modulate DNR's potency may be by inhibition of the efflux pump, P-glycoprotein. Further work to determine conditions for maximum modulation of drug potency by PMF's warranted.

ACUTE TREATMENT WITH PULSED ELECTROMAGNETIC FIELDS AND ITS EFFECT ON FAST AXONAL TRANSPORT IN NORMAL AND REGENERATING NERVE

AU: Sissen-BF; Jacob-JM; Walker-JL

AD: Center for Biomedical Engineering, University of Kentucky, Lexington, KY 40506, USA

SO: J-Neurosci-Res, 42/5 (692-699) 1995

LS: English

AB: The mechanism whereby low-frequency electromagnetic fields accelerate axonal regrowth and regeneration of peripheral nerve after crush lesion is not known. One candidate is an alteration in axonal transport. In this study we exposed unoperated rats for 15 min/day, and rats that had undergone a crush lesion of the sciatic nerve; for 1 hr/day for 2 days, to 2-Hz pulsed electromagnetic fields. To label fast transported proteins, [(3) H]-proline was microinjected into the spinal cord, and the sciatic nerves were removed 2, by counting sequential 2-mm segments of nerves. The following transport rates were found; in unoperated normal sciatic nerve not exposed to PEMF, 373 n 14 mm/day; in unoperated normal nerve exposed to PEMF, 383 n 14 mm/day; in sham crush nerves not exposed to PEMF, 379 n 19 mm/day; in sham crush nerve exposed to PEMF, 385 n 17 mm/day; in crushed nerves not exposed to PEMF, 393 n 16mm/day; and in crushed nerves exposed to PEMF, 392 n 15mm/day. The results of these experiments indicate that 1) a crush injury to the sciatic nerve does not alter the rate of fast axonal transport, and 2) low-frequency pulsed electromagnetic fields do not alter fast axonal transport rates in operated (crush) or unoperated sciatic nerves.

ENHANCEMENT OF FUNCTIONAL RECOVERY FOLLOWING A CRUSH LESION TO THE RAT SCIATIC NERVE BY EXPOSURE TO PULSED ELECTROMAGNETIC FIELDS

AU: Walker-JL; Evans-JM; Resig-P; Guarnieri-S; Meade-P; Sissen-BS

AD: Division of orthopaedic Surgery, Center for Biomedical Engineering, Univ. Kentucky College of Medicine, Lexington, KY, United States

SO: Exp-Neurol, 125/2 (302-305) 1994

LS: English

AB: Previous studies showed that exposure to pulsed electromagnetic fields (PEMF) produced a 22% increase in the axonal regeneration rate during the first 6 days after crush injury in the rat sciatic nerve. We used the same injury model to assess the effect on functional recovery. The animals were treated with whole body exposure to PEMF (0.3 mT, repetition rate 2Hz) for 4 h/day during Days 1-5 while held in plastic restrainers. Functional recovery was serially assayed up to Postinjury Day 43 using recently described video imaging of the 1-5 toe spread and the gait-stance duration. Footprint analysis was also used with calculation of a sciatic function index. Those animals treated with PEMF had improved functional recovery, as compared to sham controls, using the tests for video 1-5 toe spread and gait-stance duration ($P = 0.001$ and $P = 0.081$, respectively). This effect was found throughout the 43-day recovery period. No effect was found using the sciatic function index. This study confirms that functional recovery after nerve crush lesion is accelerated by PEMF and has broad implications for the clinical use of these fields in the management of nerve injuries.

NEUROMODULATION OF DETRUSOR HYPER-REFLEXIA BY FUNCTIONAL MAGNETIC STIMULATION OF THE SACRAL ROOTS

AU: Sheriff-MKM; Shah-PJR; Fowler-C Mundy-AR; Craggs-MD

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SO: BR-J-UROL. 78/1 (39-46) 1996

LS: English

AB: Objective: To investigate the acute effects of functional magnetic stimulation (FMS) on detrusor hyper-reflexia using a multi-pulse magnetic stimulator. Patients and methods. Seven male patients with established and intractable detrusor hyper-reflexia. After optimization of magnetic stimulation of S2-S4 sacral anterior roots by recording toe flexor electromyograms, unstable detrusor activity was provoked during cystometry by rapid infusion of fluid into the bladder. The provocation test produced consistent and predictable detrusor hyper-reflexia. On some provocations, supramaximal FMS at 20 pulses/s for 5 s was applied at detrusor pressures which were >15 cmH₂O. Results: Following FMS there was an obvious acute suppression of detrusor hyper-reflexia. There was a profound reduction in detrusor contraction as assessed by the area under the curves of detrusor pressure with time. Conclusions: Functional magnetic stimulation applied over the sacrum can profoundly suppress detrusor hyper-reflexia in man. It may provide a non-invasive method of assessing patients for implantable electrical neuromodulation devices and as a therapeutic option in its own right.

INTRACORTICAL FACILITATION AND INHIBITION AFTER TRANSCRANIAL MAGNETIC STIMULATION IN CONSCIOUS HUMANS

AU: Nakamura-H; Kitagawa-H, Kawaguchi-Y; Tsuji-H

AD: H. Nakamura, Department of Othopaedic Surgery, Faculty of Medicine, Toyama Medical Pharmaceutical Univ., 2630 Sugitani, Toyama 930-01

SO: J-Physiol. 498/3 (817-823) 1997

LS: English

AB: 1. Changes in excitability of the motor cortex induced by a transcranial magnetic stimulation (TMS) were examined by simultaneous recording of the evoked corticospinal volley and the compound surface electromyographic (EMG) response in the biceps brachii following paired-pulse. TMS in five conscious subjects. The effects of a varying interstimulus interval (ISI) and a conditioning stimulus intensity were also investigated. 2. A submotor threshold conditioning stimulus inhibited the test responses at ISIs of 2-5 ms. A supramotor threshold conditioning stimulus inhibited the test responses at ISIs of 100-200 ms. Both of these inhibitions were prominent in late I waves. 3. There was a facilitation of the test responses at an ISI of 25 ms that was prominent in late I waves. The facilitation evoked by the supramotor threshold conditioning stimulus was more prominent than that evoked by the submotor threshold conditioning stimulus. 4. It is concluded that single TMS induced the triphasic changes of the motor cortex, excitability in conscious humans that resulted in changes in EMG responses following paired TMS.

THE MF TREATMENT OF DEPRESSION AND ANXIETY ASSOCIATED WITH SUBSTANCE ABUSE WITHDRAWAL

Mary Ellen O'Conner, Faust Bianco and David Morris

The University of Tulsa, OK, USA

International Symposium Nov. 1997; Magnetic Fields: Recent Advances in Diagnosis and Therapy 74104

After reviewing 180 CES studies reported between 1964 and 1987 in a meta-analysis in order to evaluate the studies using so many different methodologies and statistical analysis. There was a revealed significant group difference, with evidence for reduction of anxiety in both self report and observer ratings in the CES group. Depression was reduced in the stimulated group, and showed clinical effect in the alleviation of anxiety during withdrawal from polysubstance chemical dependence.

MAGNETIC FIELDS AND BRAIN ELECTRICAL ACTIVITY: POSSIBLE IMPLICATIONS FOR THE TREATMENT OF EPILEPSY

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11.1997

Given the observed sensitivity of human brain to ELF-fields, it was clearly of importance to examine the possible influence of both static and ELF fields on abnormal brain electrical activity, such as occurs during epilepsy. The initial concern was that ELF fields might possibly trigger epileptiform activity in epilepsy patient. Geomagnetic field alterations during geomagnetic storms have been correlated with altered seizure frequency and intensity. ELF field exposure has been found to produce a reduced sensitivity to epileptiform activity and genesis and such fields have been suggested as possible therapeutic agents in control of brain epileptiform activity in patients.

PEMF MAY REDUCE DEPRESSION FOLLOWING TRAUMATIC BRAIN INJURY

Baker-Price-Persinger

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Percept Mot Skills 1996 Oct, Vol 83 (2), P: 491-8, ISSN: 0031-5125

AB: Many patient who display psychological depression following a traumatic brain injury do not respond completely to antidepressant drugs. There was a significant improvement of depression and reduction of phobias while physical symptoms and other complaints were not changed.

THE EFFECT OF PEMF ON OCULAR HYDRDYNAMICS IN OPEN ANGLE GLAUCOMA

Tsikel-skii-luv

1990; Ophthalmol-Zh (2), p: 89-92, ISSN: 0030-0675

AB: PEMF in the open angle glaucoma. Over 150 patients (283 eyes) with latent initial and advanced glaucoma have shown that the usage PEMF exerts influence on hydrodynamics of the eye in open glaucoma; stimulates the rise of aqueous outflow and production, the reduction of Becker's coefficient. At the latent stage of disease, normalization of outflow was recorded in 25% of cases, at the initial and advanced stages in 17,8% and 16% of cases respectively. The investigation carried out allow to recommend the mentioned method for a complex treatment of open angle glaucoma

EFFECTIVENESS OF PEMF IN OPTIC NERVE ATROPHY, A PRELIMINARY STUDY

Zobina L., et al.

J-Vestn-oftalm 1990 Sept-Oct. Vol: 106 (5), P: 54-7, ISSN: 0042-465%

AB: PEMF effects in visual functions (vision acuity and field), on retinal bioelectric activity, on conductive vision system and on intraocular circulation in 88 patients. Vision acuity of patients with its low (below 0.04 dp) values improved in 50% of cases. The number of patients with vision acuity of 0.2 dp has increased from 46 to 75. PEMF improved ocular hemodynamics in patients with optic nerve atrophy, it reduced the time of stimulation conduction along the vision routes and stimulated the retinal ganglia cells.

BENEFICIAL EFFECTS OF ELECTROMAGNETIC FIELDS

Bassett L., Adrew C.

Bioelectric research center, colombia University, riverdale, New York, USA

Journal of cellular Biochemistry 51: 387-393

1993

AB: PEMF's were basic in the treatment of a quarter million patients with chronically ununited fractures worldwide. Many of the athermal bioresponses at the cellular and sub-cellular levels, have been identified and found appropriate to correct or modify the pathologic processes of which PEMF's have been used. Not only is efficiency supported by these basic studies but by a number of double blind trials. As understanding of mechanisms expands, specific requirements for field energetics are being defined and range of treatable ills broadened. These include nerve regeneration, wound healing, graft behavior diabetes, and myocardial and cerebral ischemia, among other conditions. Preliminary data even suggest possible benefits in controlling malignancy.

EARLY EFFECTS OF ELECTRICAL STIMULATION ON OSTEOGENESIS

AU: Yonemori-K; Matsunaga-S; Ishidou-Y; Maeda-S; Yoshida-H

AD: Department of Orthopaedic Surgery, Faculty of Medicine, Kagoshima University, 8-35-1 Sakuragaoka, Kagoshima 890, Japan

SO: Bone. 19/2 (173-180) 1996

LS: English

AB: The mechanism by which electrical stimulation causes osteogenesis is unknown. Bone marrow of the rabbit was stimulated by direct electrical current or electromagnetic fields to clarify the mechanism of osteogenesis by electrical stimulation. A total of 105 rabbits were separated into five groups; a pulsed electromagnetic fields stimulation (PEMF) group; a PEMF with Kirshner wire insertion group; a Kirshner wire insertion group; and an intramedullary drilling control group. Measurement of intramedullary new bone formation and determination of alkaline phosphatase activity within the bone marrow were performed. Arglyophilic nuclear organizer region (AgNOR) staining was done to evaluate the change in proliferative activity of the osteoblasts during electrical stimulation. In the direct current stimulation group and the PEMF accompanied by the insertion of the Kirshner wire group, alkaline phosphatase activity in the bone marrow and AgNOR staining increased at 7 days after surgery. At 14 days after surgery, alkaline phosphatase activity and proliferative activity of osteoblast were significantly higher in these two groups than in the other groups (PEMF group, Kirshner wire insertion alone group, intramedullary drilling group). Intramedullary new bone formation was most active in the direct current stimulation group. Electromagnetic stimulation of the inserted Kirshner wire also promoted bone formation significantly. The Kirshner wire insertion alone group and the intramedullary drilling group showed bone formation, but it was significantly less. Electromagnetic stimulation without the insertion of the Kirshner wire showed little bone formation. These findings revealed that the degree of osteogenesis induced by electrical stimulation is influenced by the tissue environment, and that osteogenesis is promoted markedly when electrical stimulation is provided in the environment of inflammation and reactive cells.

EFFECT OF PULSED ELECTROMAGNETIC FIELDS ON BONE FORMATION AND BONE LOSS DURING LIMB LENGTHENING

AU: Eyres-KS; Saleh-M; Kanis-JA

AD: WHO Collaborating Ctr Metab Bone Dis, University of Sheffield, Beech Hill Road, Sheffield S10 2RX, United Kingdom

SO: Bone, 18/6 (505-509) 1996

CP: United-States

LA: English

AB: We examined the effect of pulsed electromagnetic fields (PEMFs) on bone formation and disuse osteoporosis sustained during limb lengthening in a double-blind study. Seven males (mean age 13 years, range 11-19 years) and six females (mean age 12 years, range 9-19 years) were randomly allocated to receive either an active or an inactive PEMF coil. Limb lengthening was performed by the Villarubbias technique using either a unilateral or circular frame system. Sequential bone density measurements were made using dual energy X-ray absorptiometry and compared to traditional radiographs. Ten segments (eight tibial and two femoral) in seven patients were lengthened under the influence of active coils and eight segments (six tibial and two femoral) in six patients using inactive coils. There was no difference in the rate nor the amount of new bone formed at the site of distraction between the two groups. Bone loss in the segments of bone distal to the lengthening sites was observed in both groups but was significantly more marked using inactive coils (BMD reduced by 23% n SEM 3% and 33% n 4% control values after one and two months respectively; $p < 0.0001$) than using active coils (BMD reduced by 10% n 2% at 2 months). These differences were greater at 12 months after surgery (reduced by 54% n 5% and 13% n 4% respectively; $p < 0.0001$). Stimulation with pulsed electromagnetic fields has no effect on the regenerated bone, but does prevent bone loss adjacent to the distraction gap.

THERAPY WITH PULSED ELECTROMAGNETIC FIELDS IN ASEPTIC LOOSENING OF TOTAL HIP PROTHESES: A PROSPECTIVE STUDY

AU: Konrad-K; Sevcic-K; Foldes-K; Piroška-E; Molnar-E

AD: Országos Reumatol./Fizioter. Intezet, Pf:54, 1525 Budapest 114, Hungary

SO: Clin-Rheumatol. 15/4 (325-328) 1996

LA: English

AB: Aseptic loosening is the most common problem of hip arthroplasties, limiting its long term success. We report a study of pulsed electromagnetic field (PEMF) treatment in 24 patients with this complication. At the end of treatment, six months and one year later, pain and hip movements improved significantly with the exception of flexion and extension. There was significant improvement in both isotope scans and ultrasonography, but not in plain X-ray. The decreased pain and improved function suggest that PEMF is effective in improving symptoms of patients with loose hip replacement. No improvement, however, can be expected in patients with severe pain due to gross loosening.

PULSED ELECTROMAGNETIC FIELDS INFLUENCED HYALINE CARTILAGE EXTRACELLULAR MATRIX COMPOSITION WITHOUT AFFECTING MOLECULAR STRUCTURE

AU: Liu-H; Abbott-J; Bee-JA

AD: Department Veterinary Basic Sciences, Veterinary College, Royal College Street, London NW1 0TU, United Kingdom

SO: Osteoarthritis-Cartilage. 4/1 (63-76) 1996

LA: English

AB: Pulsed electromagnetic fields (PEMF) influence the extracellular matrix metabolism of a diverse range of skeletal tissues. This study focuses upon the effect of PEMF on the composition and molecular structure of cartilage proteoglycans. Sixteen-day-old embryonic chick sterna were explanted to culture and exposed to a PEMF for 3h/day for 48h. PEMF treatment did not affect the DNA content of explants but stimulated elevation of glycosaminoglycan content in the explant and conserved the tissue's histological integrity. The glycosaminoglycans in sterna exposed to PEMF were indistinguishable from those in controls in their composition of chondroitin sulfate resulting from chondroitinase ABC digestion. Specific examination with [(35)S]-sulfate labels showed that PEMF treatment significantly suppressed both the degradation of pre-existing glycosaminoglycans biosynthetically labeled in ovo and the synthesis of new [(35)S]-sulfated glycosaminoglycans. The average size and aggregating ability of pre-existing and new synthesized [(35)S]-sulfated proteoglycans extracted with 4 M guanidinium chloride from PEMF-treated cartilage explants were identical to controls. The chain length and degree of sulfation of [(35)S]-sulfated glycosaminoglycans also were identical in control and PEMF-treated cultures. PEMF treatment also reduced the amount of both unlabeled glycosaminoglycans and labeled pre-existing and newly synthesized [(35)S]-sulfated glycosaminoglycans recovered from nutrient media. [(35)S]-Sulfated proteoglycans released to the media of both control and PEMF-treated cultures were mostly degradation products although their glycosaminoglycan chain size was unchanged. These results demonstrate that exposure of embryonic chick cartilage explants to PEMF for 3h/day maintains a balanced proteoglycan composition by down-regulating its turnover without affecting either molecular structure or function.

TREATMENT OF DELAYED UNIONS AND NONUNIONS OF THE PROXIMAL FIFTH METATARSAL WITH PULSED ELECTROMAGNETIC FIELDS

AU: Holmes-GB Jr

AD: University Orthopaedics, 800 South Wells Street, Chicago, IL 60607, United States

SO: Foot-Angle-Int. 15/10 (552-556) 1994

LS: English

AB: Nine delayed unions and nonunion of the proximal fifth metatarsal were treated with pulsed electromagnetic fields (PEMF). All fractures healed in a mean time of 4 months (range 2-8 months). Those fractures treated with both pulsed electromagnetic fields and a nonweightbearing cast healed in a mean time of 3 months (range 2-4 months). The average duration of follow-up was 39 months (range 24-60 months). There were no refractures. When compared with reported healing times and morbidity for conventional casting, medullary curettage with inlay bone, and closed axial intramedullary screw fixation, pulsed electromagnetic fields provided an effective alternative for the treatment of delayed unions and nonunion of the proximal fifth metatarsal.

EFFECTS OF ELECTROMAGNETIC STIMULATION ON MICROHARDNESS OF BONE NEW FORMED INSIDE DIAPHYSEAL TRANSCORTICAL HOLES: PRELIMINARY STUDY

AU: Cane-V; Botti-P; Muglia-MA; Remaggi-F; Soana-S

TO: Effetti Della Stimolazione Elettromagnetica Sulla Micro-Durezza Dell'osso Neodeposto in Fori Transcorticali Dia-fisari: Studio Preliminare

AD: Istituto di Anatomia Umana Normale, Policlinico, Via Del Pozzo, 71, 41100 Modena, Italy

SO: Ital-J-Miner-Electrolyte-Metab. 8/1 (23-30) 1994

LA: Italian

AB: The microhardness testing technique was applied to investigate on possible effects of low-frequency pulsed electromagnetic fields (PEMFs) on the degree of the primary mineralization of bone formed during the repair process of transcortical holes. At the mid-diaphyseal level of the left and right metacarpal bones of 2 adult horses, 1 trans-cortical hole (4.5 mm diameter) was drilled. The hole in the left side was exposed for 30 days to PEMFs characterized by 28 Gauss peak amplitude, 1.3 msec rise time, 75 Hz repetition rate. The right contralateral untreated hole was taken as control. The results indicate that both the amount of bone formed during 30 days and its microhardness are significantly greater ($P < 0.01$ and $p < 0.001$ respectively) in PEMF-treated holes than in contralateral untreated ones. In both PEMF-treated and untreated holes the values of microhardness (a) decrease from endosteum towards periosteum; (b) is higher ($p < 0.001$) in woven non lamellar bone than in lamellar bone. On the basis of these preliminary findings, the increase in the physical resistance of the primary reparative PEMF-treated bone seem to be related to the improvement of reparative process promoted by PEMFs. Nevertheless we cannot exclude that PEMFs interfere with mineral fraction and/or matrix components of bone.

PULSED MAGNETIC FIELDS IMPROVE OSTEOBLAST ACTIVITY DURING THE REPAIR OF AN EXPERIMENTAL OSSEOUS DEFECT

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SO: J-Orthop-Res. 11/5 (664-670) 1993

LS: English

AB: The influence of pulsed low-frequency electromagnetic fields (PEMFs) on bone formation was investigated in studies of the healing process of transcortical holes, bored at the diaphyseal region of metacarpal bones of six adult horses, exposed for 30 days to PEMFs (28 G peak amplitude, 1.3 ms rise time, and 75 Hz repetition rate). A pair of Helmholtz coils, continuously powered by a pulse generator, was applied for 30 days to the left metacarpal bone, through which two holes, of equal diameter and depth, had been bored at the diaphyseal region. Two equal holes, bored at the same level in the right metacarpal and surrounded by an inactive pair of Helmholtz coils, were used as controls. All horses were given an intravenous injection of 25-30 mg/kg of tetracycline chloride on the 15th and again on the 25th day after the operation and were killed 5 days later. The histomorphometric analysis indicated that both the amount of bone formed during 30 days and the mineral apposition rate during 10 days (deduced from the interval between the two tetracycline labels) were significantly greater ($p < 0.01$ and $p < 0.0001$, respectively) in the PEMF-treated holes than in the controls. As did a previous investigation, these preliminary findings indicate that PEMFs at low frequency not only stimulate bone repair but also seem to improve the osteogenic phase of the healing process, at least in our experimental conditions.

EFFECTS OF ELECTRICAL AND ELECTROMAGNETIC STIMULATION AFTER ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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SO: J-Orthop-Sport-Phys-Ther. 17/4 (177-184) 1993

LS: English

AB: A need exists to develop new methods of neuromuscular electrical stimulation (NMES) that are both effective and relatively pain-free. The purpose of this pilot study was to determine the effects of both NMES and a new method of electromagnetic (NMES/PEMF) stimulation for reducing girth loss and for

reducing pain and muscle weakness of the knee extensor muscles in patients during the first 6 weeks after reconstructive surgery of the anterior cruciate ligament (ACL). Seventeen patients receiving ACL reconstructive surgery participated as a control group (N=3), as an NMES group (N=7), and with combined NMES and magnetic field stimulation (NMES/PEMF) (N=7). Patients receiving NMES/PEMF rated each type of stimulation for perceived pain and were measured for their torque. Torque results revealed a mean decrease of 13.1% for NMES/PEMF patients. The mean percent of thigh girth decreased 8.3% for controls, 0.5% for NMES and 2.3% for NMES/PEMF patients. The NMES/PEMF patients rated NMES as causing about twice the pain intensity as NMES/PEMF during treatment. As a result of this data, the authors concluded that both NMES and NMES/PEMF are effective in reducing girth loss and that NMES/PEMF is less painful than NMES alone in treating patients after ACL reconstruction.

A DOUBLE-BLIND TRIAL OF THE CLINICAL EFFECTS OF PULSED ELECTROMAGNETIC FIELDS IN OSTEOARTHRITIS

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SO: J-Rheumatol. 20/3 (456-460) 1993

LS: English

AB: Objective. Further evaluation of pulsed electromagnetic fields (PEMF), which have been observed to produce numerous biological effects, and have been used to treat delayed union fractures for over a decade. Methods. In a pilot, double-blind randomized trial, 27 patients with osteoarthritis (OA), primarily of the knee, were treated with PEMF. Treatment consisted of 18 half-hour periods of exposure over about 1 month in a specially designed noncontact, air-coil device. Observations were made on 6 clinical variables at baseline, midpoint of therapy, end of treatment and one month later; 25 patients completed treatment. Results. An average improvement of 23-61% occurred in the clinical variables observed with active treatment, while 2 to 18% improvement was observed in these variables in placebo treated control patients. No toxicity was observed. Conclusion. The decreased pain and improved functional performance of treated patients suggests that this configuration of PEMF has potential as an effective method of improving symptoms in patients with OA. This method warrants further clinical investigation.

A CASE STUDY OF AN ACCELERATED REHABILITATION PROGRAM ON KNEE FUNCTION FOLLOWING ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

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SO: J-Sport-Rehabil. 2/1 (53-62) 1993

LS: English

AB: This paper discusses function changes during an accelerated rehabilitation program at 6, 10, and 52 weeks postsurgery for a college athlete following anterior cruciate ligament reconstruction/meniscectomy of the left knee. The effects of combined pulsed electromagnetic field (PEMF) and neuromuscular electrical stimulation (NMES) on knee extensor torque, thigh girth, and pain level are presented. PEMF-NMES decreased stimulation pain by 76%. Knee extensor isometric torque increased by 23%, and thigh girth decreased less than 5% at 6 weeks. Knee extensor isokinetic torque was 13% and 3% deficient at 90 degree /s and 240 degree /s, and standing single-leg broad jump distance was 19% deficient at 10 weeks. Knee extensor isokinetic torque was 1% and 1.5% greater at 90 degree /s and 240 degree /s, and standing single-leg broad jump distance was 11% deficient at 52 weeks. Knee anterior laxity was 2mm at 10 weeks and 3mm at 52 weeks. PEMF-NMES appears to comfortably enhance knee extensor torque gains and diminish thigh girth loss. Despite early return to practice, functional deficit remained and anterior laxity was increased at 52 weeks.

PULSED ELECTROMAGNETIC FIELDS MODULATE ENZYMIC ACTIVITY DURING THE EARLY STAGES OF BONE REPAIR

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SO: Electro—and-Magnetobiology. 1997; 16 (2): 143-152

LA:English

AB: The goal of this study was to investigate whether PEMFs influence enzymatic activities during the early stages of bone repair. Two transcortical holes (4.5 mm diameter) were drilled at the same diaphyseal level in the lateral margin of the right and left metacarpal bone (McIII) of six adult male horses. The left McIII were exposed to PEMFs (75 Hz; 2.8 mT, 1.3 ms impulse width) 24h/day; the right untreated McIII were used as controls. Horses were sacrificed 8 and 15 days after the operation. The bone segments containing the holes were fixed, dehydrated in ethanol solutions, and, undecalcified, embedded in methylmethacrylate. The midlongitudinal sections of the holes were either stained with soluidine blue or processed for evaluation of the total alkaline phosphatase (TRAP) and the tartrate-resistant acid phosphatase (TRAP). In PEMF-treated holes we found; (1) TALP is strongly positive with respect to the controls; (b) the newly formed bony trabeculae are more abundant than in the controls; (c) in both treated and control holes, no TRAP-positive osteoclasts were observed on the hole surface, whereas several osteoclasts were located on the newly formed bone trabeculae. On the basis of these data, it may be concluded that PEMFs accelerate the healing process of transcortical holes and enhance the enzymatic activity of repair tissue.

PULSED MAGNETIC AND ELECTROMAGNETIC FIELDS IN EXPERIMENTAL ACHILLES TENDONITIS IN THE RAT: A PROSPECTIVE RANDOMIZED STUDY

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SO: Archives-of-physical-medical-and-rehabilitation. 1997; 78 (4) : 399-404

AB: Objective: To investigate the effects of pulsed magnetic fields (PMF) and pulsed electromagnetic fields (PEMF) on healing in experimental Achilles tendon inflammation in the rat. Design: Prospective randomized trial. Setting: University medical school. Methods: Exposure of the Achilles tendon and injury by a weight of 98.24 gm falling from the height of 35cm in 180 male Sprague-Dawley rats. Intervention: A daily 15-minute session with PMF of 17 Hz or 50 Hz or PEMF of 15 Hz or 46 Hz, or a sham session. Outcome Measures: Random sacrifice 2 hours after the operation, and at 1, 3, 7, 14, or 28 days. Assessment of water content, weight, and histological appearance of the tendons. Results: The time from injury and the various treatment modalities exerted a significant influence on the water content of the tendon after the injury (two-way ANOVA, $p = .02$). At day 3, the water content of the PEMF 46 Hz group was significantly higher than in the other groups, decreasing sharply by day 7 and being similar to the other groups thereafter. By the end of the experiment, the PEMF 15 Hz group was not significantly different from the control group. At day 7, the PMF 50 Hz group showed significantly lower water content than the control group ($p = .03$), but at 14 days the PMF 50 Hz group was not significantly different from the control group. PMF 50 Hz suppressed the extravascular edema during early inflammation. PMF 17 Hz showed a similar initial trend, producing a consistent lower water content throughout the experiment, reaching statistical significance by the end of treatment. By the end of the experiment, the collagen fibers had nearly regained their normal alignment in all groups, with a more physiological alignment seen in the

PEMF 17 Hz group. Conclusions: The tendon returned to histological normality in all groups, but the PMF 17 Hz group showed better collagen alignment by the end of the study. PMF 17 Hz resulted in a greater reduction of inflammation, with a better return of the tendon to histological normality. Different PMF and PEMF could be applied according to when treatment is started after the injury. If there is no delay between injury and beginning of pulsed magnetic treatment, PMF 17 should be used.

THE RESULTS OF A DOUBLE-BLIND TRIAL OF PULSED ELECTROMAGNETIC FREQUENCY IN THE TREATMENT OF PERTHES' DISEASE

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SO: Journal-of-pediatric-orthopedics. 1997, 17 (2) : 264-265

LA: English

AB: A double-blind trial of the use of pulsed electro-magnetic frequency (PEMF) in the treatment of Perthes' disease was constructed by using this therapy to supplement a long practised non-weight-bearing orthotic treatment, the Birmingham Containment Splint. Twenty-one boys with Perthes' disease were treated with this combined regimen; they were divided into two groups. All wore the orthosis but the treatment coil was inactive in one group; the state of the coil activity was unknown to clinic staff or patients. The duration of non-weight-bearing orthotic treatment needed to achieve a stated degree of femoral head reconstitution was recorded; there was no discernible difference between the two groups, treatment time being 12 months in one group and 12.5 months in the other. It was concluded that PEMF cannot be offered for the therapy of Perthes' disease.

EARLY EFFECTS OF ELECTRICAL STIMULATION ON OSTEOGENESIS

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SO: Bone-New-York. 1996; 19 (2) : 173-180

AB: The mechanism by which electrical stimulation causes osteogenesis is unknown. Bone marrow of the rabbit was stimulated by direct electrical current or electromagnetic fields to clarify the mechanism of osteogenesis by electrical stimulation. A total of 105 rabbits were separated into five groups: a direct current stimulation by Kirshner wire insertion group; a pulsed electromagnetic fields stimulation (PEMF) group; a PEMF with Kirshner wire insertion group; a Kirshner wire insertion group; and an intramedullary drilling control group. Measurement of intramedullary new bone formation and determination of alkaline phosphatase activity within the bone marrow were performed. Argylophilic nuclear organizer region (AgNOR) staining was done to evaluate the change in proliferative activity of the osteoblasts during electrical stimulation. In the direct current stimulation group and the PEMF accompanied by the insertion of the Kirshner wire group alkaline phosphatase activity in the bone marrow and AgNOR staining increased at 7 days after surgery. At 14 days after surgery, alkaline phosphatase activity and proliferative activity of osteoblast were significantly higher in these two groups than in the other groups (PEMF group, Kirshner wire insertion alone group, intramedullary drilling group). Intramedullary new bone formation was most active in the direct current stimulation group. Electromagnetic stimulation of the inserted Kirshner wire also promoted bone formation significantly. The Kirshner wire insertion alone group and the intramedullary drilling group showed bone formation, but it was significantly less. Electromagnetic stimulation without the insertion of the Kirshner wire showed little bone formation. These findings revealed that the degree of osteogenesis induced by electrical stimulation is influenced by the tissue environment, and that osteogenesis is promoted markedly when electrical stimulation is provided in the environment of inflammation and reactive cells.

EFFECTS ON PEMF ON FRESH FRACTURE-HEALING IN RAT TIBIA.

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SO: Bangladesh-Med-Res-Counc-Bull. 1993 Dec; 19 (3) : 103-12

AB: The present experiment was designed to find out whether PEMF can act as a healing agent on induced fracture of rat tibia. Eighty rats were taken for this experiment. Under general anaesthesia mid-shaft of tibia and fibula of all rats were osteotomied, Intramedullary nailing was done for proper alignment of the fractured fragments. The animals were then divided into two groups: group-1 and group-11. Each group contained forty animals. Out of these forty animals twenty were treated as experimental and twenty as control. From the third day of osteotomy, PEMF was applied to experimental rats around the osteotomy sites for a period of nine hours a day. PEMF was not applied to the control rats. The animals of group-1 and group-11 were sacrificed after applied one week and three weeks of PEMF, respectively. Radiological and microscopical examination of the callus were performed. Gross and microscopic measurements of the callus were statistically analysed. The growth of callus was taken as a criterion of fracture healing. The results of the present experiment revealed significant enhancement of fracture healing. The results of the present experiment revealed significant enhancement of fracture healing in group-1. The results of the radiological evaluation of group-11 experimental animals were also consistent with the morphological analysis. It was concluded that healing of fractured rat tibia was enhanced by the application of PEMF and this effect of PEMF was more pronounced at the end of third week.

OPTIMIZATION OF ELECTRIC FIELD PARAMETERS FOR THE CONTROL OF BONE REMODELING: EXPLOITATION OF AN INDIGENOUS MECHANISM FOR THE PREVENTION OF OSTEOPENIA

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SO: J-Bone-Miner-Res. 1993 Dec; 8 Suppl 2: S573-81

AB: The discovery of piezoelectric potentials in loaded bone was instrumental in developing a plausible mechanism by which functional activity could intrinsically influence the tissue's cellular environment and thus affect skeletal mass and morphology. Using an in vivo model of osteopenia, we have demonstrated that the bone resorption that normally parallels disuse can be prevented or even reversed by the exogenous induction of electric fields. Importantly, the manner of the response (i.e., formation, turnover, resorption) is exceedingly sensitive to subtle changes in electric field parameters. Fields below 10 micro V/cm, when induced at frequencies between 50 and 150 Hz for 1h/day, were sufficient to maintain bone mass even in the absence of function. Reducing the frequency to 15 Hz made the field extremely osteogenic. Indeed, this frequency-specified sinusoidal field initiated more new bone formation than a more complex pulsed electromagnetic field (PEMF), through inducing only 0.1% of the electrical energy of the PEMF. The frequencies and field intensities most effective in the exogenous stimulation of bone formation are similar to those produced by normal functional activity. This lends strong support to the hypothesis that endogenous electric fields serve as a critical regulatory factor in both bone modeling and remodeling processes. Delineation of the field parameters most effective in retaining or promoting bone mass will accelerate the development of electricity as a unique and site-specific prophylaxis for osteopenia. Because fields of these frequencies and intensities are indigenous to bone tissue, it further suggests that such exogenous treatment can promote bone quantity and quality with minimal risk or consequence.

AUTORADIOGRAPHIC STUDY OF THE EFFECTS OF PULSED ELECTROMAGNETIC FIELDS ON BONE AND CARTILAGE GROWTH IN JUVENILE RATS.

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SO: Arch-Oral-Biol. 1993 Jan; 38 (1): 67-74

AB: Application of pulsed electromagnetic fields (PEMF) has been used in growth and repair of non-union bone fractures. The similarities between the fibrocartilage callus in non-union bone fractures and the secondary cartilage in the mandibular condyle, both histologically and functionally, lead naturally to study the effects of PEMFs on growth in the condyle. The purposes of this study were: (1) to describe the effects of PEMFs on the growth of the condyle using autoradiography, [3H]-proline and [3H]-thymidine, and (2) to differentiate between the effects of the magnetic and electrical components of the field. Male pre-adolescent Sprague-Dawley rats (28 days old) were divided into three experimental groups of five animals each: (1) PEMF-magnetic (M), (2) PEMF-electrical (E) and (3) control, and were examined at three different times-3, 7 and 14 days of exposure. Each animal was exposed to the field for 8 h per day. Histological coronal sections were processed for quantitative autoradiography to determine the mitotic activity of the condylar cartilage and the amount of bone deposition. The PEMF (magnetic or electrical) had statistically significant effects only on the thickness of the articular zone, with the thickness in the PEMF-M group being the most reduced. Length of treatment was associated with predictable significant changes in the thickness of the condylar cartilage zones and the amount of bone deposition. (Abstract Truncated at 250 words)

EFFECT OF A PULSING ELECTROMAGNETIC FIELD ON DEMINERALIZED BONE-MATRIX-INDUCED BONE FORMATION IN A BONY DEFECT IN THE PREMAXILLA OF RATS.

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SO: J-Dent-Res. 1992 Dec; 71(12): 1920-5

AB: A 2-mm non-healing bony defect was prepared in the premaxilla of male Wistar rats weighing about 180 g as a simulation of an alveolar cleft, for determination of whether a pulsing electromagnetic field (PEMF) could promote regeneration of bone induced by demineralized bone matrix (DBM). The defect was either treated with 7 mg DBM or was left as a non-grafted control. The rats were exposed to a PEMF with a frequency of 100 Hz, a 10-ms-wide burst with 100 microseconds-wide quasi-rectangular pulses, repeating at 15 Hz, and magnetic field strength of 1.5-1.8 G. Alkaline Phosphatase activity increased significantly from day 7 in the DBM-graft-plus-PEMF group and from day 10 in the DBM-graft group, reaching a maximum on day 14. A greater-than-two-fold rise in alkaline phosphatase activity and a three-fold rise in the amount of ⁴⁵Ca incorporation in the DBM-graft-plus-PEMF group were attained compared with those of the DBM-graft group. The DBM-graft-plus-PEMF group produced more bone with almost complete osseous bridging in the defect sites than did the group treated with DBM only on day 35. The findings indicate that PEMF had an enhancing effect on the bone-inductive properties of the DBM through the stimulation of osteoblast differentiation induced by DBM.

TREATMENT OF SCAPHOID NONUNION WITH CASTING AND PULSED ELECTROMAGNETIC FIELDS A STUDY CONTINUATION

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SO: J-Hand-Surg-Am. 1992 Sept; 17(5): 910-4

AB: This article presents a continuation of a study of the treatment of scaphoid nonunion with pulsed electromagnetic fields (PEMF) and cast immobilization. Fifty-four patients were reviewed. The overall success rate for healing has decreased since the previous review from 80% to 69%. Proximal pole fractures healed in 50%. Success in nonunions with associated radiographic evidence of avascular necrosis decreased from 89% to 73%. Although we believe that the indications for use of PEMF have not changed significantly, this study suggests that a successful outcome with PEMF and casting is less likely than previously reported. We believe that until additional clinical studies have further defined the indications, treatment protocol, and efficacy of this method PEMF treatment should be a secondary alternative to bone-grafting procedures.

TREATMENT OF UNUNITED TIBIAL FRACTURES: A COMPARISON OF SURGERY AND PULSED ELECTROMAGNETIC FIELDS (PEMF)

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SO: Orthopedics. 1992 Jun; 15(6): 711-9

AB: The use of pulsed electromagnetic field (PEMF) is gaining acceptance for the treatment of ununited fractures. The results of 44 articles published in the English language literature have been compiled to assess the effectiveness of PEMF vs surgical therapy. For ununited tibial fractures, 81% of reported cases healed with PEMF vs 82% with surgery. After multiple failed surgeries, the success rate of PEMF is reported to be greater than with surgery; this discrepancy increases with additional numbers of prior surgeries. In infected nonunions, the results of surgical treatment decreased by 21% and were less than the results utilizing PEMF (69% vs 81%). In open fractures, surgical healing exceeded PEMF (89% vs 79%). In general, PEMF treatment of ununited fractures has proved to be more successful than noninvasive traditional management and at least as effective as surgical therapies. Given the costs and potential dangers of surgery, PEMF should be considered an effective alternative. Experience supports its role as a successful method of treatment for ununited fractures of the tibia.

RESPONSES OF HUMAN MG-63 OSTEOSARCOMA CELL LINE AND HUMAN OSTEOBLAST-LIKE CELLS TO PULSED ELECTROMAGNETIC FIELDS

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SO: Bioelectromagnetics. 1997; 18 (8) : 541-547

LA: English

AB: We have studied the effects of low-energy, low-frequency pulsed electromagnetic fields (PEMF) on cell proliferation, in both human osteoblast-like cells obtained from bone specimens and in human MG-63 osteosarcoma cell line. Assessment of osteoblastic phenotype was performed both by immunolabeling with antiosteonectin antibody and by verifying the presence of parathyroid hormone receptors. The cells were placed in multiwell plates and set in a tissue culture incubator between a pair of Helmholtz coils powered by a pulsed generator (1.3 ms, 75 Hz) for different periods of time. [³H]-thymidine incorporation was used to evaluate cell proliferation. Since it had previously been observed that the osteoblast proliferative response to PEMF exposure may also be condi-

tioned by the presence of serum in the medium, experiments were carried out at different serum concentrations. [H-3]thymidine incorporation increases in osteoblast-like cells, when they are exposed to PEMF in the presence of 10% fetal calf serum (FCS). The greatest effect is observed after 24 hours of PEMF exposure. No effects on cell proliferation are observed when osteoblast-like cells are exposed to PEMF in the presence of 0.5% FCS or in a serum-free medium. On the other hand, PEMF-exposed MG-63 cells show increased cell proliferation wither at 10% FCS, 0.5% FCS and in serum-free medium. Nevertheless, the maximum effect of PEMF exposure on MG-63 cell proliferation depends on the percentage of FCS in the medium. The higher the FCS concentration, the faster the proliferative response to PEMF exposure. Our results show that, although MG-63 cells display some similarity with human bone cells, their responses to PEMF's exposure are quite different from that observed in normal human bone cells, (C) 1997 Wiley-Liss, Inc.

BIOLOGICAL EFFECTS OF PEMF (PULSING ELECTROMAGNETIC FIELD): AN ATTEMPT TO MODIFY CELL RESISTANCE TO ANTICANCER AGENTS

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SO: J-Environ-Pathol-Toxicol-Oncol. 12/4(1193-197) 1993

LS: English

AB: Pulsing Electromagnetic Field (PEMF) effects lead to a modification of the multidrug resistance (MDR) of cells in vitro and in vivo. The murine leukemic doxorubicin-resistant cell line, P388/Dx, subject to PEMF irradiation in vitro, showed a significant difference in thymidine incorporation when the concentration of doxorubicin reached a level of 1 $\mu\text{g/mL}$, which corresponds to the inhibition dose 50 (ID-50). The human lymphoblastic leukemia vinblastine-resistant cell line, CEM/VLB-100, also showed a significant modification under the same experimental conditions at the in vitro ID-50 corresponding to a vinblastine concentration of 100 ng/mL . BDF1 mice transplanted with P388/Dx cells also had an increase in their life span when doxorubicin was injected intraperitoneally in fractionated doses, while being subjected to PEMF irradiation.

RELIEVING PAIN IN DISEASE OF THE MUSCULOSKELETAL SYSTEM WITH SMALL APPARATUSES THAT PRODUCE MAGNETIC FIELDS

W. Wagner, W. Kobinger** G. Fischer***

Despite (a) periodically published reports concerning the developments of cancer in children and adults who have been exposed to magnetic fields associated with power line frequencies (high-voltage overhead lines, house wiring) (W.R. Hondee and J.C. Boteler, 1994 and the anonymous literature cited there 1994; M. Nagakawa, 1994), there are still physicians who support and use "magnetic field therapy" as they have also done in the past. Currently under discussion in this context is mainly the effectiveness of this stationary magnetic field therapy equipment with its greatly variable field parameters and certainly high field strengths for use in adjuvant therapy or even exclusive treatment of disorders in the healing of bone fractures and other diseases of the musculoskeletal system (K. Ammer et al., 1990; I.H. Pages et al., 1985; G. Pscheider, 1987; Z. Turk et al., 1990).

From a biomedical and technical perspective, the critical to negatively tainted debate over results obtained with battery-operated small apparatuses that produce significant weaker field strengths than do stationary magnetic field therapy facilities (typically a factor of 100) is even more contradictory. According to one of the not thoroughly consistent classification systems of the field strengths, they are more likely to be classified as "weak" (Fischer et al., 1990).

Materials and Methods

Within the scope of scientific cooperation with the manufacturer of a magnetic field generator having the dimensions of a matchbox ("Elmag MK 75", Medicinska Oprema Co., Celje/SLO), several of these battery-operated apparatuses were made available to an internist with a general practice for testing purposes. This individual was well-versed in the subject matter and had been successfully active in this field for many years.

The report of collected experiences that is presented here exclusively used functioning equipment. Therefore, the results are not as valid as those obtained in a single-blind or double-blind experiment. After the completion of conventional drug therapy, patients who had been supplied with the "Elmag MK 75" apparatus were selected on the basis of a physician's diagnosis to be exclusively treated with the low-frequency, pulsed, magnetic fields produced by the equipment.

Figure 1 describes the medical findings of 16 patients (8 men, 8 women) who were affected by 17 different acute and chronic conditions involving the musculoskeletal system, as well as the therapeutic successes achieved in each case. The women ranged in age between 19-74; the men were between 36-63 years old. The mean age for the overall patient collective was 53.1 years. The duration of the individually designed applications ranged between 11 and 120 days in the women and between 26 to 132 days in the men. The overall patient collective was treated with magnetic fields for 72.8 days on average. There was a variety of 15 possible pulse repetition frequencies "frep" and the associated effective field strengths "B" at the surface of an apparatus, Frep/B (Hz/ μT); 2/2.52; 3/3.08; 5/3.98; 6.5/4.54; 8.5/5.19; 10/5.63; 12/6.17; 13/6.42; 15/6.89; 16/7.12; 18/7.55; 19.5/7.86; 21.5/8.25; 22.5/8.44; 24/8.72. Based on empirically determined values (P. Kokoschinegg and G. Fischer, 1992; W. Wagner, personal correspondence, 1993), the physician preferably used the higher frequencies during the day while the lowest equipment frequency, namely 2 Hz, was generally selected during the night in order to promote sleep. The sole exceptions were 2 patients taking psychopharmacological drugs for whom magnetic field therapy ceased at night. The duration of the magnetic field application at the location of the pain was also individually adjusted; it ranged between 2 times for 4 hours each week to constant application. However, application at night should mainly occur near the head, e.g., beneath the pillow.

The physician evaluated the success of therapy according to the "Dole" scale which uses range of numbers from 0-10. For purposes of statistical evaluation, the differences arising between the beginning of treatment and its end were classified analogous to a school grading system into the categories: "very good, good, satisfactory, sufficient and unsuccessful." This became necessary due to the small size of the patient collective. The subjective classifications of success by the

Patient No.	Symptom No.	Physician's Final Diagnosis	Sex	Age (years)	Success	Dole Scale (Beg. minus End)
1	1	omarthritis	f	73	v. g.	8
2	2	lupus crythematosus	f	29	v. g.	7
3	3	fracture of lower leg, delayed callus formation	m	36	g.	7
4	4	omarthritis + injury of rotator cuff	m	50	0	1
5	5	chronic cervical syndrome with a protruding intervertebral disc C 4-6	m	50	v. g.	9
6	6	omarthritis	m	59	v. g.	8
7	7	post-inflammatory Sudeck's syndrome (left midfoot)	f	33	sat.	5
8	8	chronic cervical syndrome (after several intervertebral disc operations)	m	62	v. g. (obj.) g. (subj.)	8
9	9	omarthritis	f	74	v. g.	9
10	10	epicondylitis (right humeroulnar joint)	f	52	v. g.	9
11	11	epicondylitis radialis (tennis elbow)	m	52	v. g.	10
12	12	primary chronic polyarthritis (fingers, hand and knee joints)	f	44	0	0
13	13	femoropatellar chondropathy on the right (damaged cartilage: patella and head of the femur)	f	66	v. g.	8
14	14	degenerative omarthritis	f	58	v.g.(obj) g.(subj)	8
15	15	gonarthrosis, left side	m	57	g.	9
16	16	postraumatic gonarthrosis	m	51	g.	8
16	17	epicondylitis radialis (tennis elbow)	m	51	v. g.	9

Fig. 1: Summarized results according to the diagnosis of the treating physician (v. g. = very good; g. = good; sta. = satisfactory; 0 = unsuccessful)

patient and the improvements as noted after the physician's examination failed to agree in only two cases, more refined differences within the individual diagnoses could not be separately evaluated on a statistical basis. In the applicable biometric methods, the classification once again had to be reduced to the two categories: "improved" or "not improved."

<p>"Improved"</p> <p>a. Very good therapeutic success: omarthritis (3 cases), lupus erythematosus, chronic cervical syndrome, epicondylitis rad.</p> <p>b. Good therapeutic success: gonarthrosis (2 cases), fracture of the lower leg</p> <p>c. Satisfactory therapeutic success: Sudeck's syndrome</p> <p>"Not Improved"</p> <p>d. Unsuccessful therapy: omarthritis, primary chronic polyarthritis (PCP) with relapses</p>

Figure 2: Summarized original classifications of therapeutic success according to the physician.

Evaluated according to the previously mentioned guidelines, the following results (See Figure 2) were obtained for the application of pulsating magnetic fields to diseases of the musculoskeletal system. Figure 3 shows the statistical evaluations of magnetic field therapy.

Discussion and Conclusions

On the basis of this report which used relatively small collective of patients afflicted with diseases of the musculoskel system, it was documented, consistent with internationally available litature, that "magnetic field therapy" (with its parameters of curve form, pulse repetition frequency, field strength, daily or total duration of application) can at least play a role as a form adjuvant treatment. Furthermore, as confirmed in individual cases, it can even be successfully used as the sole methodof pain therapy. Because of its lack of any side effects, this latter property currently is of increased importance, especially with respect to any form of drug intolerance that may be present.

Naturally, the compliance of the participants could not be checked by the physician in each individual case. Despite this limitation, the results are encouraging and permit one to draw the conclusion that further research in the field of magnetic field treatment with "weak" fields of already evaluated frequencies or other possibly therapeutic frequencies for the benefit of all is welcome and should be supported. However, the unsupervised, self-administration of this type of treatment is to be discouraged. Optimal therapeutic successes can only be expected while under the care of appropriately experienced physicians.

In the future, physicians plan on making additional patient questionnaires available so the analyses can be conducted separated according to sex, identical frequencies or individual specific diseases.

Summary

A patient collective (8 men, 8 women) afflicted with 17 characteristic diseases of the musculoskeletal system was almost exclusively treated with a small, battery-operated apparatus that produced weak, pulsating magnetic fields.

1. Non-parametric Evaluation Methods

- Sequential Range Test: The limits of significance ($p < 0.05$) were clearly exceeded so that at this level an improvement was confirmed.
- Maximum Test: Here one compared the positive (and negative) differences between the Dole scale values (beginning of treatment minus end of treatment). Extremely significant differences ($p < 0.001$) were found. These corresponded to a mitigation of pain through magnetic field applications.

2. Parametric Test

One dimension chi2 procedure with one degree of freedom:

	"Improved"	"Not Improved"
Observed	5	2
hi2 = 9.94:		N = 17

Consistent with the non-parametric methods, this result proved to be extremely significant ($p < 0.01$).

Fig. 3: Statistical evaluations of therapeutic success

The patients (mean age 53.1) were treated for between 11 and 132 days without the additional administration of any analgesics. Magnetic field application occurred as close as possible to the location of the pain. The frequencies and, thereby, also the field strengths were individually selected to have values between 2 and 24 Hz or 2.53 - 8.72 μ T while employing a square-wave form. The duration of application varied between 2 times 4 hours per week and continuous application. The ten-step "Dole" scale was used by physicians to classify the results; these were then placed into the simpler classes of "improved" and "not improved." Evaluations according to the non-parametric test methods of the "sequential range test" and the "maximum test" yielded a significant or extreme significant pain reduction. The "chi square test," the parametric procedure, even yielded an extremely significant mitigation of pain. Presently, other treatment programs are underway to further objectify and substantiate the successes of this form of magnetic field therapy.

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LOW-INTENSITY PULSED MAGNETIC FIELDS AS ADJUVANT THERAPY IN SEVERELY POLYTRAUMATIZED PATIENTS

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For the most part, polytraumatic injuries cause a state of shock and represent a threat to the vital functions at least of one organ. The consequence of severe lesions lies mainly in changes in the circulatory or cardiovascular and neuroendocrine systems. These can be caused by excessive blood loss or by the pathophysiological and traumatically provoked sequence of diverse impulses which come over the afferent impulse pathway from the injured tissue or the corresponding receptors. The consequences of polytraumatic injuries are disturbances in the clotting system (production of blood clots, thromboembolisms or fat embolisms, consumption coagulopathies, and/or bacteriotoxic damage). The following life-sustaining circulatory centralization produces the classic hypoperfusion and microcirculation problems in the periphery. Depending on the duration of the hypoperfusion and the patient's hypoxia tolerance, irreversible damage can occur in the affected areas due to hypoxia and hypoxemia.

Concerning the regeneration of polytraumatized patients, several classifications of the trauma should be differentiated:

1st classification: corresponds to moderate injuries without sign of hemorrhagic shock. The oxygen partial pressure is within its normal range of 10.00-13.33 kilopascals (kPa).

2nd classification: Here there are serious lesions, however the life of the affected person is not directly threatened. There are already symptoms of the compensatory hemorrhagic shock with simultaneous loss of about 25% of the blood volume. The partial pressure of oxygen is reduced to as low as 8.00 kPa.

3rd classification: The life of the injured person is in immediate danger. The blood loss is already at least half of the blood volume. There is a severe hypovolemic shock close to physiological compensation. The partial pressure of oxygen is below 8.00 kPa.

The purpose of this work was to perform a preliminary pilot study based on the results of *Warnke* (1980a, 1980b) to probe the effectiveness of pulsed magnetic fields used as an adjuvant to conservative rehabilitation measures in polytraumatized patients having initial P_{O_2} values of just over 8.00 kPa. Although there are several reasons to have a critical view of *Warnke's* results, this study was carried out without other supporting literature.

Methods

From January 1 to June 30, 1991 an adjuvant magnetic field treatment was carried out successively on 24 polytraumatized injured persons. In order to exclude interfering factors, smokers and chronically ill patients were excluded from the study. Magnetic field and placebo treatments were begun only after the final surgical care was completed. The investigation group contained exclusively men; the average age was 38 years (the age range was 30-50 years). The control group was analogous to the real population, and comprised 24 male patients having almost identical constitution; the mean age was 36 years (the age range of 30-50 years). Randomized assignment of patients to the comparison group (placebo, real) upon admission to the hospital was able to keep the oxygen partial pressure values almost identical. A pronounced respiratory distress syndrome was diagnosed in all patients.

The patients of the two groups had injuries which placed them exclusively in the 2nd classification, however the mean values (of the oxygen partial pressure) were just on the border with the most severe damage classification ($P_{O_2} < 8.00$ kPa).

The P_{O_2} data were determined using the automatic pH value and blood gas analyzer "AVL 990". This involved withdrawing 40 ml of blood at each of the three stages of the investigation.

The application guidelines for the placebo devices were the same as in the test group, i.e., all-day use. In the framework of the double-blind study the (placebo) devices were nonfunctional in that although the function control light seemed to indicate that the device was functioning normally, it did not produce any magnetic field. The magnetic field generator is a battery-operated, match box-sized device which was used after the surgical care by hanging it around the neck in a leather bag in the breast area. The magnetic intensity at the surface of the device was 240 pT (+/- 10%). The pulse repeat frequency was 24 Hz, and the shape of the curve was approximately rectangular.

GRAPH GOES HERE

Duration of therapy (days)

Figure 1: Changes in oxygen partial pressure during the course of rehabilitation of polytraumatized patients with adjuvant magnetic field therapy (pulsed magnetic field, $f = 24$ Hz, $B = 240$ pT) compared with the placebo-treated controls.

Results

The blood samples of the real subjects taken from the Arteria radialis before the use of the magnetic field had a mean value of 8.05 kPa (the range values was 8.00-8.30 kPa). At the end of the first week of magnetic field treatment the mean was found to be 10.41 kPa (10.00-11.0 kPa); at the end of the magnetic field application after two weeks, the mean value was 11.60 kPa (11.0-12.00 kPa).

The mean oxygen partial pressure in the control group before the conventional treatment began was 8.10 kPa (8.00-8.30 kPa). After the first week of conventional rehabilitation procedures without the use of a magnetic field the mean oxygen partial pressure was determined to be 10.31 kPa (10.00-11.20 kPa). The results after two weeks had a mean of 11.30 kPa (11.0-12.00 kPa).

At the end of the first week of treatment both populations showed a rise in the oxygen measurements in the group receiving additional magnetic field therapy was higher than the placebo group, despite the slightly lower initial value, however the difference turned out not to be significant. After the second week of therapy a highly significant increase in the oxygen partial pressure was found in the real group. The evaluation was done using a two-sided Student's t-test.

Discussion

These results are presented as a contribution to our knowledge of the extent to which the use of relatively low-intensity pulsed magnetic fields in the rehabilitation phase can have an influence on speeding up the recovery of polytraumatized patients. The partial pressure of oxygen in the blood was used as a criterion for this. In particular, the point was to find any differences which might occur between the two treatment groups in the behavior of the oxygen partial pressure, which is increased by the natural healing process.

A few confirmed mechanisms and a series of hypothetical ones have been proposed to explain the interaction between alternating magnetic fields and biological tissue. Low-frequency magnetic fields induce currents in exposed tissue, which flow predominantly in the intercellular space. The induced current densities increase linearly with the length of the eddy current pathway and the frequency; in the most unfavorable case, at 50 Hz main power frequency action potentials can be triggered only at over 1 mT, which, however, is out of consideration for the field strengths applied here ($B_{eff} = 8.72$ pT). The other two recognized mechanisms of interaction are the Hall effect and the magnetohydrodynamic effect. These occur during the movement of charge carriers (blood, diffusion processes, and ion flows). The effects in the (sub)cellular are still under discussion, and a final evaluation of them cannot yet be made (changes in membrane permeability for various ions, window effects concerning frequency and field strength, cyclotron resonance).

Among the mechanisms of interaction which are considered hypothetical, let us list the following here according to their value (*Warnke* 1980b, *Pscheider* 1987); the influence of paramagnetic and diamagnetic molecules and radicals, biological superconducting structures (the Josephson effect), NMR and electron spin resonance, quantum mechanical processes, interaction with transient paramagnetic free radicals, and a change in the angle of hydrogen bonds.

Some investigations (*Warnke* 1980b) have found that exposure to a low-frequency alternating magnetic field substantially improves the blood supply in the tissue, which has been demonstrated using contactless thermographic methods. However, other authors (*Pages et al.* 1985) have had negative results concerning this. *Warnke* (1980a, 1980b) and *Wagner and Gruber* (1985) describe a highly elevated oxygen demand in the damaged tissue. It is theoretically conceivable that a force is caused by the magnetic field which is followed by ions collecting on the cell membrane, causing an increase in oxygen utilization and energy turnover (a rise in ATP) (*Jerubek* 1989, *Gusco et al.* 1987).

It can be deduced from the results of this first study that such magnetic field therapy in postoperative treatment can clearly contribute to quicker rehabilitation of polytraumatized patients. It is without doubt that there is no confirmation of this from independent research authorities, but the encouraging results jus-

tify corresponding follow-up investigations. However, this investigation still did not taken into consideration all factors that could have had an influence on the oxygen partial pressure; during transport of gas in the blood a change in the pH value should be taken into account (the Bohr effect), acidity reduces the binding power of hemoglobin, and alkalosis raises it. There is also an inversely proportional temperature dependence. Other parameters are: hemoglobin deficiency, blood losses, hypoxia, respiratory disturbance (ventilation, diffusion, and perfusion disorders), impairment of the respiratory muscles (injuries), and functional disturbances of the respiratory center.

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THE INFLUENCE OF LOW-INTENSITY PULSED MAGNETIC FIELDS ON BIOLOGICAL SYSTEMS

G Fischer and P. Kokoschinegg

Growth experiments with plants have shown that the growth of the plants is noticeably influenced by the interaction of a static magnetic field only on irrigation water. Water is influenced in a lasting manner by the magnetic field. This is only conceivable if it is assumed that water has transregional order structures which contain an information potential. The same thing has also been demonstrated by high-frequency high-voltage photographs of liquids, which showed more order criteria in highly structured liquids, such as, e.g., symmetry and sharpness of the lines.

Current research shows very clearly that magnetic fields with an induction of several hundred nT to pT have biological effects. The level on which they act in humans might be the vegetative nervous system, as has been described by Pischinger. Liquids in biological systems represent active control systems which are capable of reacting to magnetic fields.

Earlier publications have already discussed the effectiveness of pulsed magnetic fields with frequencies from 4 Hz to 10 Hz. It should only be stressed that magnetic fields have been used since antiquity for the most varied complaints.

It is necessary to distinguish between the use of static and pulsed magnetic fields. In earlier times static magnetic fields in the form of magnetites and horse-shoe magnets were used in therapy. Current research has shown the use of magnetic foils with a special magnetic structure in the therapy of cicatricial keloid, circulatory disturbances, and pain attacks of various origin.

Pulsed magnetic fields with magnetic flux densities of about 1-10 mT are used in medicine for bone growth disturbances. All these investigations and therapeutic procedures are based on the fact that magnetic fields exert a force on ions which is known as the "Hall effect". This effect causes charge transfers on the cell membranes, and thus changes in cellular metabolism.

As has been demonstrated by Warnke, a strong biological resonance is obtained from human biological systems, even if only relatively weak magnetic fields of about 100-200 pT are used. In this case other regulatory mechanisms must also be assumed in addition to the charge transfers in the cell membranes. The basic (regulatory) system described by Pischinger certainly represents an essential factor in this case.

The magnetic fields in those studies were produced with 2 different pocket generators, which were set to the fixed repetition frequency. Depending on indication, 4 Hz was used for sleep disturbances, 10 Hz for meteorosensitivity, 15 Hz for acute and chronic rheumatic diseases, and 19.5 Hz as pain therapy for inflammatory diseases of the spine. The field intensities are not easy to detect, since those fields have high gradients.

Therefore, we did not use microcoils for measurement, but rather coil of 15 x 30 mm, which certainly also reproduces a value which will be effective on the body. The fields spread in a somewhat spherically symmetrical way; we give only the value in the axial direction; The device of the furchner company has the dimensions 80 x 60 x 20 mm, and has intensity values of 7-1 pT between 0 and 10 cm.

The device of the Elmag company is smaller, and has the dimensions of 55x36x15 mm, and intensity values of 40-1 pT between 0 and 10 cm.

The frequencies were copied from the main frequency ranges of the EEG: frequencies of 3 to 7 Hz corresponds to theta waves, 8 to 12 Hz to alpha waves, and 13 to 25 Hz to beta waves.

Experimental Assumptions and Methods

The Experiments were intended to clarify whether the pocket magnetic field generator is effective for indications of sleep disturbances, meteorosensitivity, and rheumatic diseases. All experiments were carried out in the form of a double-blind study which lasted 6 weeks.

The selection criteria for the subjects were first that they not have any serious organic disease and second that they suffer from symptoms of the corresponding area of indication. The meteorosensitive subjects were classified according to the Harlfinger selection test.

The doctors who carried out the study had to mark on the test protocols the primary disease and additional diagnoses, the readings from the devices which were supplied, and data about the age, sex, and occupation of the subjects. The quantities of sleeping medications and analgesics which were administered during the course of previous and/or current therapies also had to be listed. The "Notes" rubric provided space for detailed comments on the diagnosis or the success of the treatment. Special experiences or incidents could also be recorded. 80 devices were used in the test, with only 50% being functional, while the other half functioned as placebos. The doctor was not informed about whether the device was functional, so that the prerequisites of a double-blind study were met.

During the study the subjects were instructed to wear the magnetic field generators directly on their bodies, or to use them no more than 50 cm away, depending on the indication. The purpose of this work also to achieve a result which might be better with regard to symptoms than was the case in a previous investigation, due to better compliance.

Results for Sleep Disorders *Use of 4 Hz, exclusively at night*

A positive effect was expected for all indications, perhaps in the form of a "stimulation therapy"; therefore, outcomes in the presence of a severe primary disease were of less interest. For example, cases with unambiguous depressive components were excluded. This also applied to severe cases of migraine.

The indication of "insomnia" had the following additional diagnoses listed:

- *difficulties falling asleep and staying asleep without detailed information;*
- *neurovegetative dystonia;*
- *overwork syndrome;*
- *sleep disturbances when working shifts;*
- *hyperkinetic heart syndrome;*
- *reactive depression;*
- *duodenal ulcer;*

but also:

- *cerebrovascular and coronary insufficiency;*
- *degenerative diseases of the locomotor and support apparatus;*
- *chronic leukosis.*

Figure 1 - Results with 4 Hz/SLEEP DISTURBANCES

Investigation	Device	Total N	Improved		Not Improved		Chi ²
			N	%	N	%	
1st Investigation after 2 weeks	working	23	18	75%	5	22%	5.37 *
	placebo	28	13	46%	15	54%	
2nd Investigation after 6 weeks	working	23	19	63%	4	17%	5.37 **
	placebo	28	12	43%	15	57%	

Chi² test; the difference between the groups is:

* not significant **significant ***very significant ****most highly significant

Figure 1 shows the results of the study using 4 Hz with sleep disorders. Compared with the high placebo success rates, which are common with such test designs, a significantly improved result was obtained even after two weeks of use. The final investigation, i.e. after another four weeks of use, showed the success to be highly statistically significant. This means an increase of therapeutic effectiveness with longer use.

Results for Meteorosensitivity *Use of 10 Hz throughout the day*

With regard to the general definition of the symptoms of meteorosensitivity, the majority of these patients suffered from mood swings and circulatory instability, poor concentration, headaches, and attacks of dizziness shortly before or during sudden changes in weather.

A small number were affected by dyscardias, menopausal complaints, as well as spinal and lumbar spinal syndrome, mild migraines, bronchial asthma, and hyperthyroidism.

Figure 2 shows the results of this part of the study. The use of a frequency of 10 Hz against the symptoms of meteorosensitivity showed substantial improvement.

The first part of this study already showed success which is evaluated as highly statistically significant. At the end of the second phase, after 6 weeks of use, this success proved to be most highly significant compared with the placebo group.

Figure 2 – Results with 10 Hz/METEOROSENSITIVITY

Investigation	Device	Total N	Improved		Not Improved		Chi ²
			N	%	N	%	
1st Investigation after 2 weeks	working	38	21	55%	17	45%	7.48 *
	placebo	37	9	24%	28	76%	
2nd Investigation after 6 weeks	working	38	27	71%	11	29%	14.54 **
	placebo	37	10	27%	27	73%	

Chi² test: the difference between the groups is:

* not significant **significant ***very significant ****most highly significant

Results for Rheumatic Diseases

Use of 15 Hz throughout the day and night

The results of the study at 15 Hz also showed very positive factors in combination with conventional methods of treating rheumatic diseases.

The “acute” cases were defined as those which began one week before the beginning of therapy, and “chronic” cases were classified as those whose suffering had already lasted longer than this.

The age of the patients in the study was also widely scattered. Their mean age was 47.7 years. The youngest subject was 20, and the oldest was 81 years old. The group contained 38 men and 42 women, and 50 cases were classified as “acute”, and 30 as “chronic”.

The 15 Hz frequency was especially indicated for supporting conventional methods of therapy in the treatment of soft tissue rheumatism or myalgias.

Exclusion criteria were:

Advanced degenerative joint diseases and highly acute root compressions.

The following symptoms were prominent within the individual diagnoses:

Myalgia, cervical syndrome, shoulder-hand syndrome, spondylogenic neuralgia, but also gonarthrosis and coxarthrosis. Figure 3 shows the results of this part of the study.

Figure 3 – Results with 15 Hz/ACUTE AND CHRONIC RHEUMATISM

Investigation	Device	Total N	Improved		Not Improved		Chi ²
			N	%	N	%	
1st Investigation after 2 weeks	working	39	27	69%	12	31%	8.89 **
	placebo	39	14	36%	25	64%	

Chi² test: the difference between the group is:

*not significant **significant ***very significant ****most highly significant

These results represent a comparison of the chronic and acute cases after two weeks of therapy: despite the expected relatively high placebo effect, the therapeutic success with the functional devices was highly statistically significant. All other statistical comparisons – 2 weeks compared with 6 weeks of therapeutic treatment, 6 weeks of treatment compared with 6 weeks of placebo, and 2 weeks of placebo compared with 6 weeks of placebo – were not statistically significant.

Figure 4 shows the results of the group with chronic symptoms. The results after 2 weeks of treatment of chronic rheumatism show a significant improvement. After 6 weeks of treatment the results were highly significant. This means that when the devices are used for chronic cases, the treatment success increases with the duration of use. It was possible to observe reactions after 7 days, on the average.

Figure 5 shows the results for patients with an acute rheumatic situation. The results show that no therapeutic effect could be found in this group. In any case, “acute” patients were less willing to comply strictly with the magnetic field treatment; they had more trust in the individual therapeutic procedures of conventional medicine, such as injections (Ambene), in order to be fit once again as quickly as possible, for professional or personal reasons. By contrast, even more motivation could be seen in “chronic” patients, who had already exhausted all the possibilities of conventional medicine, with greater or lesser success.

Figure 4 – Results with 15 Hz/CHRONIC RHEUMATISM

Investigation	Device	Total N	Improved		Not Improved		Chi ²
			N	%	N	%	
1st Investigation after 2 weeks	working	19	16	84%	3	16%	6 *
	placebo	10	4	40%	6	60%	
2nd Investigation after 6 weeks	working	19	17	89%	2	11%	illegible **
	placebo	10	4	40%	6	60%	

Chi² test: the difference between the group is

*not significant **significant ***very significant ****most highly significant

Figure 5 – Results with 15 Hz/ACUTE RHEUMATISM

Investigation	Device	Total N	Improved		Not Improved		Chi ²
			N	%	N	%	
1st Investigation after 2 weeks	working	22	11	50%	11	50%	1.39 *
	placebo	27	9	33%	18	67%	

Chi² test: the difference between the group is:

*not significant **significant ***very significant ****most highly significant

**Preliminary Results for
Degenerative Diseases of the Spine
Use of 19.5 Hz, day and night**

The study with 19.5 Hz is still in progress as this is being written, and is taking place in cooperation with senior physician Dr. Barovic and senior physician Dr. Turk in the Medical Rehabilitation Department of Maribor General Hospital.

So far, patients with inflammatory diseases of the spine have been tested, 33 or 53.2% of them with the real generator and 29 or 46.8% with a placebo.

After 30 days a comparison between the real generator and placebo group showed a partial improvement in bending forward (p<0.1).

A clear alleviation was also found with regard to posture (p<0.05) and the severity index (p<0.05); the number of waking moments per night due to pain also declined (p<0.01).

Figure 6 shows an evaluation from the perspective of the doctor and the patient. Statistical analysis shows high significance between the real generator and the placebo (patient: p<0.01 and doctor: p<0.001).

Therefore, it is possible to say that for this indication a characteristic improvement in patients' mobility and a reduction in their pain situation occurs after 30 days.

Moreover, the experience from the results just shown indicates that the use of pulsed magnetic fields of certain frequencies and the lowest field strengths, even in the presence of isolated severe primary diseases, is also sometimes capable of reducing the general mental trauma, and can even achieve savings on drugs.

Figure 6 – Results for 19.5 Hz/DEGENERATIVE DISEASES OF THE SPINE



Discussion

It was possible to approach the question of possible interactions of magnetic fields and biological systems from various perspectives.

First, it had to be taken into consideration that magnetic fields penetrate the organism without any losses. Second, two thirds of the organism consists of water, whose structure can be affected by pulsed magnetic fields.

Third, it has recently been proven that the nonthermal components of electromagnetic fields also affect humans.

These investigations indicate that extremely weak magnetic fields with an induction of a few hundred nT to a few pT have biological effects.

The level on which they act in humans might be the "basic vegetative (regulatory) system". Liquids in biological systems represent active control circuits which are capable of reacting to magnetic fields of even the smallest field strength. In considering the humoral milieu as a detector for exogenous influence factors, it should be taken into consideration that every vegetative nerve ends in the interstitial fluid, which is capable of active reactions.

Growth experiments on plants have shown that they react differently to irrigation water treated with magnetic fields of different polarity. This is supposed to be the result of a modified water structure, i.e. a changed order state of this vital fluid, which it was possible to document using square wave voltametry or high-frequency Kirlian photographs.

Human beings are composed, to a great extent, of water. Even the interstitial fluid is, to a great extent, water, and also contains control circuits which can react to the smallest magnetic inductions.

A different information potential, and thus altered regulatory behavior, affects the different conduction pathways by stimulating the various thick nerve fibers.

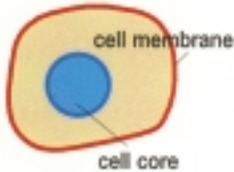
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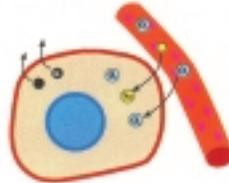
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Illustration of the effect of Pulse Electromagnetic Fields on cells to accelerate metabolism and ignite the body's healing power.

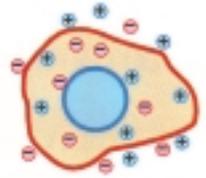


Cells are the building blocks of the human organism. Cells build tissue, organs and bones and consist mainly of water, collagen and minerals.

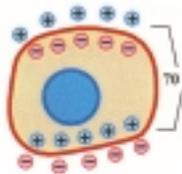
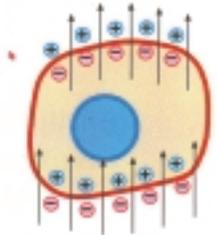
Most cells, except the brain, have a short life span and renew themselves constantly. For proper function and cell renewal (division) cells need a healthy functioning metabolism.



When electrical potential is lost, cells are no longer able to exchange ions and cellular metabolism is adversely altered. These weakened cells then become vulnerable and the tissues they comprise become ripe for disease.



By acting at the cell level, PEMF produces a specific frequency to help stabilize and reorganize the cell membrane and therefore restores the electrical voltage potential that the cells need for optimal ion exchange.



The cell membrane of a healthy cell has positive and negative charges creating a potential of 70 to 90 mV. This is required for the exchange of potassium, sodium and calcium ions. Healthy cells maintain this potential through active ion movement.

PEMF is both Effective and Safe

The human body itself is an electromagnetic machine; each living cell is electromagnetic and is designed to operate optimally against the backdrop of the earth's natural electromagnetic field. The health and integrity of each cell determines the overall health of the tissue it compromises. The healthy cell membrane has a voltage potential of 70-90 mV that is created by, and also helps facilitate, the exchange of charged particles called "ions". During cellular metabolism these ions are freely exchanged into and out of the cell. The most common ions are sodium, potassium, calcium, and magnesium. During cellular metabolism, the cell takes on oxygen from the bloodstream and eliminates waste products through the permeable cell membrane. The end result of healthy cellular metabolism is growth and regeneration.

When the cell is injured or diseased, ion exchange, membrane potential, cell permeability and oxygen uptake are adversely affected. As the cells in injured tissue accumulate waste products (e.g. lactic acid), a chain of chemical mediators (histamine, prostaglandins, etc.) is released initiating the inflammatory process. The result of such cellular injury is pain, swelling (edema), and diminished function.

The application of pulsed electromagnetic field rapidly restores the necessary ion exchange at the cellular level by attracting and repelling ions (charged particles) in the blood. As the ions in the blood separate, there is a release of heat that dilates the blood vessel. As the blood vessels dilate, more oxygen-rich blood circulates to the injured tissue cells and more cellular waste and debris are removed. This increase in cellular metabolism leads to accelerated healing and regeneration of the altered cells in injured tissues.

From experience, athletes and their trainers know the importance of stimulating blood flow to an injured joint or muscle. Whirlpools, steam rooms, ultrasound, microwave diathermy, and heating pads have long been used to reduce sub acute swelling and hasten healing. Today's professional trainers are now incorporating pulsed electromagnetic therapy into their

rehabilitation regimens because PEMF provides a safer, more predictable increase in blood flow at much deeper tissue levels than traditional therapy methods. In addition, PEMF enhances and improves the delivery of helpful anti-inflammatory medications, antibiotics, etc., by virtue of the increased blood flow to the injury.

In sharp distinction to the mass offerings of static magnet devices, PEMF therapy bases its claim on 20 years of rigid clinical testing throughout Europe and the Far East. PEMF has been used to treat a variety of maladies including muscular skeletal injuries, arthritis, osteoporosis, menstrual cramping as well as migraine headaches, high blood pressure, sleep disorders, depression, etc.

Over many years of testing various conditions with differing frequencies of PEMF in hospitals and clinics, it has been clearly determined that specific conditions respond best to specific electromagnetic frequency ranges. Identifying and producing the correct frequency is essential to the effectiveness of PEMF therapy.

• Is PEMF safe?

After 20 years of widespread clinical testing in Europe and the Far East, PEMF therapy has been clearly demonstrated to not only be effective, but it also has been proven to be safe for use in a wide variety of applications for humans and animals, with virtually no harmful side effects.

Because there are no reported contraindications to repeated exposure to low frequency electromagnetic fields, PEMF can be used as long as desired with no risk. In fact, most patients report a more rapid and longer lasting resolution of symptoms when PEMF is used continuously. Longstanding (chronic) injuries or larger areas of tissue injury may require longer duration of treatment for symptoms to resolve.

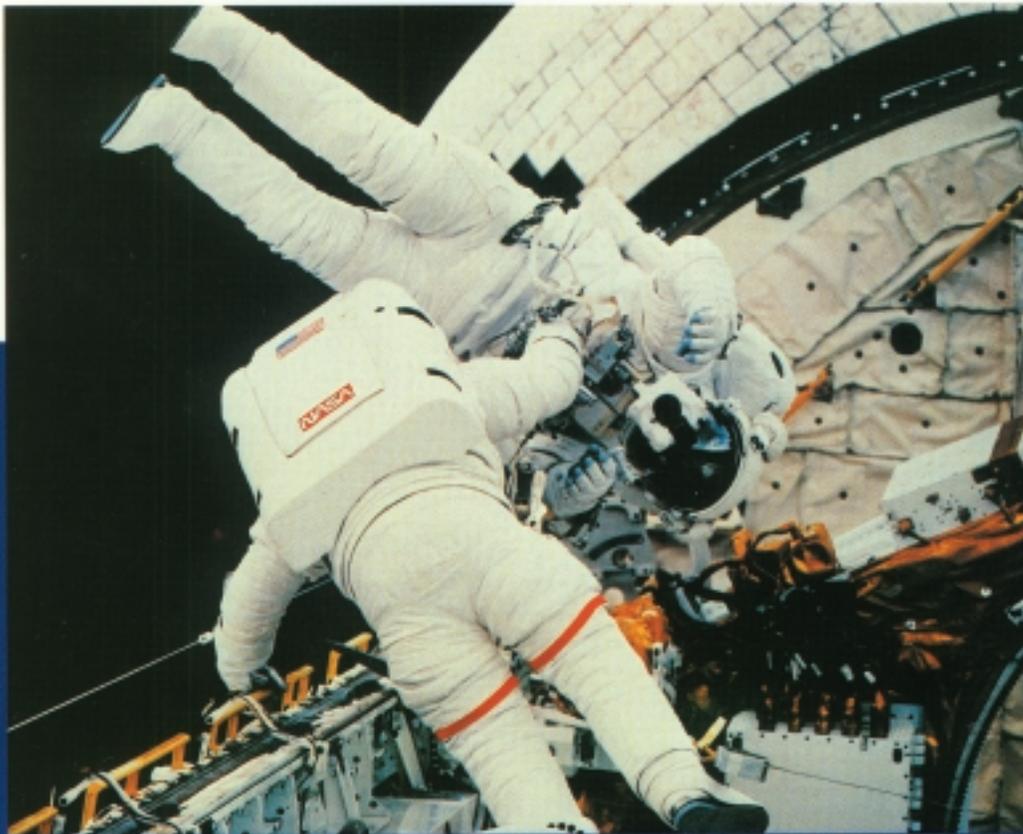
DID YOU KNOW?

Without the Earth's electromagnetic field (EMF) there would be no life on our planet. Humans, animals, and plants depend on the existence of the Earth's EMF. There would be no atoms, no biology, nor chemistry without electromagnetism. Without EMF, the so-called 'Sun Winds', which the EMF shields against, would eliminate all life on earth.

... and did you know

Astronauts receive PEMF treatment while in space. After being in space for long periods of time, astronauts need an artificial electromagnetic environment to counter the effects of prolonged weightlessness and being outside the natural Earth's constant electromagnetic field.

Earlier space flights have shown that time in space without the exposure to PEMF resulted in reduced metabolism, causing physical weakness and other problems when the astronauts return to Earth. However, by employing PEMF treatment during the space flights today, these problems have been eliminated entirely.



PULSATING ELECTROMAGNETIC FIELD THERAPY