

The importance of Electromagnetic field therapy: a clear advantage despite many contrasts.

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Abstract

In recent years, the number of chronic diseases has reached alarming dimensions despite rapid progress in medical knowledge and corresponding therapeutic approaches. The increasing postponement of the onset of such diseases to younger, even childhood age groups is particularly alarming. Under this pressure, therapy concepts are being developed which, on a physical and chemical level, meaningfully supplement treatment methods previously used in medical practice. Electromagnetic field therapy offers a promising approach here. Like all other methods of maintaining and restoring health, it is aimed at supporting the underlying self-preservation mechanisms. After discussing the physical background involved in influencing the biological reactions, the following paper discusses the significance of this form of treatment in terms of pros and cons. It is not intended to do this in the manner of a meta-analysis based on quality analyses of existing data, but rather to focus on the criteria for objective evaluation of the significance - especially in the sense of assistance for those who are less familiar with the physics of this form of therapy. Conclusion: Despite many avoidable contrasts, with more professional competence, it is a clear plus for the future. The conditions for this are in place.

Health and vitality a momentary image of highly complex networked regulation and adaptation processes

Health is a state of physical, mental, social, and therefore, also psychological and spiritual well-being. According to the meaning of the word "well-being", it is a state that can be objectively described by anamnesis, laboratory parameters, genetic, or otherwise, defined markers. Among other things, it is characterized by physical and mental performance corresponding to the age of the patient.

From a Physico-chemical point of view, health is based on regulatory processes that are highly selective and sensitively networked in the organism over time and space. These processes regulate, among other things, the conversion of the energy resting in organic substances into structures, work, and heat according to the laws of nature. The formation and activation of proteins mediated by signaling substances, adhesion molecules, and genetic material play a special role in this process. Health thus reflects the current state of a natural adaptation to internal and external conditions, which is constantly evolving with evolution, and geared towards the preservation of life.

Living, working, and environmental conditions - in particular poor nutrition, lack of exercise, and social stress - can, however, overwhelm these regulations, resulting in lasting health disorders often heralded by precursors such as malaise, pain, anxiety, and depression.

It is the common goal of therapeutic measures to compensate for such disorders as comprehensively and gently as possible. Be it the use of medication, physical-therapeutic, psychological, or other measures, they all aim to support and strengthen the self-preservation mechanisms.

Prevention before problematic symptom-oriented interventions

For obvious practical and methodological reasons, therapeutic measures, despite mature diagnostics, are mostly oriented towards the symptoms induced by such overloads, but not towards their actual causes. They often occur only within the sequence of disease developments that may have been concealed and protracted by additional - often cost-intensive - subsequent disorders, and which may also be additionally promoted by multi-medication.

In contrast, interventions that compensate for such disorders as close to their causes as possible, in a gentle and broad-based manner, even in their early stages, or - in the sense of prevention - not even allowing their occurrence in the first place, would be advantageous.

The concept of applying electromagnetic fields

All health-relevant regulations are based on interactions between ions, atoms, molecules (Gray et Riedel 2011), i. e. interactions between the electron clouds bound to these particles and their effects on organic tissue parts further coupled to them (such as membranes, cells, fluids, organs, etc.). However, these interactions are only made possible after the supply of the activation energy.

(Fig. 1)

The form of energy increasing this reactivity is generally electromagnetic. Accordingly, it is obvious to influence and support the reactivity of the components involved in health-relevant regulations through suitable externally (non-invasive¹) applied electromagnetic fields on a non-drug basis.

Comparable to the effects of enzymes or catalysts, activation essentially leads to an increase in the number of reactive molecules and thus, an increase in the probability of reactions, and even to a compensation for a lack of substance concentrations, i. e. a reduction in the number of drugs administered or their dosage.

The possible places where the effect of the electromagnetic field begins are still the subject of discussion and research. The genetic material plays an essential role in these control and regulation functions by forming and modulating the activity of the molecules involved.

It is undisputed that external electromagnetic fields lead to physiological effects: Depending on their respective changes in intensity over time, electromagnetic fields in the infrared range lead to the perception of heat, in the higher frequency range of visible light to colour recognition, at even higher changes in the UV range to the influencing of chemical bonds (sunburn, UV sterilization) and finally, at extremely high changes over time - this is called radiation - in the ranges of X-rays, radioactive (gamma) and cosmic radiation to the ionizing destruction of molecular bonds.

Accordingly, the efficiency of the effect of electromagnetic fields is related to the energy transmitted through different rates of change (slightly inaccurately through frequencies, see below): the higher their frequency, the more efficient but also riskier is their biological effect. Nevertheless, in the narrow frequency range of visible light from 500-800 nm, even the slightest frequency differences significantly alter colour perception.

(Fig. 2)

The energies transmitted in this process are extremely low. They are usually expressed in electron volts (eV), where 1 eV is the (kinetic) energy that accelerates a single charged particle, such as an electron or proton, in a vacuum in an electric field of 1 volt. For example, the binding energies between atoms and molecules are between 2 and 7 eV per bond. Particularly low binding energies of 0.18 to 1.7 eV per bond are observed for hydrogen bonds (such as the complementary base

¹ Non-invasive and minimally invasive are terms used in medicine to describe procedures in which devices or catheters either do not penetrate the body at all (non-invasive) or penetrate it to a lesser extent than usual (minimally invasive). These terms are typically used to emphasize the low level of discomfort and risk associated with certain procedures. It is incorrect to assume that non-invasive or minimally invasive procedures are necessarily associated with lower risk. For example, depending on the disease and the patient's condition, not having a cardiac catheter examination may be riskier than performing it, non-invasive ventilation may cause more complications than conventional ventilation, and minimally invasive heart valve surgery may give worse results than conventional surgery.

pairing within the double helix). A photon of red light with a wavelength of 620 nm has an energy of 2 eV. The thermal energy of a molecule is of the order of **1 eV. $1\text{eV} = 1.6022\text{E}-19\text{ J} = 3.8293\text{E}-20$ calories = $1.6022\text{E}-12\text{ erg.}$** ²

Static and time-varying magnetic fields

Static magnetic fields have their origin in constantly moving charges, such as in permanent magnets or conductors through which direct current flows. They manifest themselves through force effects on magnets, magnetizable bodies, and moving charge carriers.

Variable magnetic fields are created as a result of changes in the movement of charges over time, and consequently as a result of the changes in the electric field caused by these charges.

Independent of this, however, every change in a magnetic field also induces an electric field (Faraday's laws). Alternating with each other, they move away from their place of origin as electromagnetic fields (or waves or, in the case of very high rates of change, as rays) at the speed of light.

In contrast to electromagnetic fields, permanent magnetic fields penetrate organic material largely undisturbed - and accordingly transmit only little energy. It is still unclear to what extent the effects induced by alternating electromagnetic fields can be divided into the electric and/or magnetic field components (Meschede 2015).

Electromagnetic field therapy: Design and forms of application

The total or partial physical application of magnetic and electromagnetic fields has in the meantime secured itself a firm place in the health care system because of its simple, patient-friendly, non-invasive, and pain-free form of application as "magnetic field therapy", especially independent of age and symptoms (Vallbona 1999). Notwithstanding the previously described differentiation between static and variable, i.e. electromagnetic fields, it is used to maintain and restore performance, well-being, quality of life, and vitality at all stages of life, both in private home use, in sports, and medical and clinical practice (Saliev et al. 2018).

This refers to the physical exposure to low-frequency (i.e. slowly changing) electromagnetic fields that are unchanging (static) over time and intensity. Because the latter is often applied in a pulsed form (with pulse repetition rates in the range of 1 to approx. 1000 Hz), they are also called pulsed electromagnetic fields (PEMF). Conventional systems, still used in therapy today, often work with sinusoidal, arc, sawtooth or trapezoidal pulsed (magnetic) field intensities of up to several milli-Tesla and repetition rates of 0.001 to about 1000 Hz. However, the frequent use of 50 or 60 Hz should not be interpreted as an indication of their particular effectiveness. Rather, these frequencies and forms owe their popularity to their preferred use in electrotechnical laboratories due to their easy technical implementation (Markov 2007).

Depending on the intended purpose, the devices are used either as wellness³ or medical products. The difference is based on legal regulations (Section 3 of the Medical Products Act, MPG, also see the section Relative contraindications for electromagnetic exposure).

² For example, to lift a chocolate bar of approx. 0.5 kg by approx. 30 cm, approx. $1.4\text{E}+7\text{ erg}$ or $10\text{E}+20\text{ eV}$ would be required.

³ Wellness also often called well-being can be defined by a questionnaire on well-being made up of only five questions, the WHO Five Well-Being Index.

Electrosmog, a colloquial term for the highly controversial daily exposure of humans and the environment to all technically generated (artificial) electric, magnetic, high-frequency, and ionizing electromagnetic fields, particularly in the microwave (especially G5) or terahertz (personal scanner) range, is not the subject of this paper.

Stimulation with strong magnetic fields such as those generated by coils of up to 1500 amperes (McClintock SM et al. 2018) is also not included. For example, short-term transcranial stimulation with high magnetic flux densities (200 to 600 μ s, up to 3 Tesla) via magnetic coils applied tangentially to the skull leads to electrical potential changes and thus to the triggering of action potentials in the cerebral cortex near the skull.

Depending on the manufacturer of the magnetic field generator, static or pulsating (electromagnetic) fields controlled by different intensity-time courses are used (Saliev et al. 2018). Static magnetic fields (permanent magnets) are used in the form of plasters, insoles, bracelets, etc. Electromagnetic fields are applied in a few cases through a moving permanent magnet incorporated in various forms of applicators, but mostly using flat coils supplied with currents that change over time.

(Fig. 3)

The field strengths used are usually in the range of up to 1000 microTesla - adapted to the respective valid limit values (NISV, 26th BImSchV, DIN VDE 0100-710, International Commission on Non-Ionizing Radiation Protection 1998). For comparison, the static Earth field in Europe is about 50 microTesla.

The electromagnetic energy of a flat single-layer air-core coil with a diameter of 350 mm, 40 turns, wire diameter 0.25, and distance between the turns 1.5 mm is $3.8115E-07$ J, i.e. approx. $2 \cdot 10^{12}$ times less (e.g. Lieberherr M 2009 and Wikibooks Der elektr. Strom, Part II). Furthermore, the efficiency of Physico-chemical interactions also depends on the mobility (polarizability) of the electron clouds and thus - in the manner of a key-lock principle - on activation energy lowered by mutual steric adaptation.

The latter assumptions are also supported by the highly selective activations through catalysts and proteins (Fig.2). Findings from odour physiology also point in a similar direction: without chemical changes to the odour molecules having to occur in the primary odour-initiating interaction, a preliminary structural adaptation of the odour molecule to specific receptor structures is decisive here, which then leads to the triggering of receptor potentials via very weak bonds and, in further processes, to the recognition and differentiation of thousands of substances, even if odour substances only vary minimally physically and chemically. It is precisely this key-lock principle that helps to keep the activation energy low (Kafka et al. 1973, Fiedler 2019).

Irrespective of the similar physical background, the devices are often offered with different names: Magnetic field resonance, frequency, vascular, quantum, pulsating signal therapy, etc. (see also section: Publications and authorship).

Electro-magnetic active ingredient properties

The biological effect of the applied electromagnetic fields is dependent on the temporal intensity sequence of the applied electromagnetic fields owing to the multitude of atomic, molecular, or ionic interaction partners involved in the regulatory mechanisms and their correspondingly different activation energies. Comparable to the active substances in medication, this time course can be seen as a kind of electromagnetic agent. Instead of using chemical formulas, it can be quantified according to the known rules of school mathematics as an additive superimposition of sinusoidal and cosinusoidal components suitably superimposed with regard to frequency and amplitude, e.g. by its characteristic amplitude-frequency (Fourier) spectrum. The broader the amplitude-frequency spectrum of the applied fields, the broader the activation possibilities and thus, eventually, the more

efficient and widely spread the expected biological effect would be. However, even if a device with a broadband field application already contains many of the intensity time histories used in other devices, it must not be assumed that this also covers their effects. This is because - similar to medication with multifunctional active ingredients - synergistic effects (resulting from their interaction) must also be taken into account here. In this respect, the temporal sequence of different forms of electromagnetic stimulation could also play a role.

(Fig. 4)

Although the non-invasively used magnetic or electromagnetic form of treatment supports the body's maintenance regulations like any other medical measure, it is classified as alternative or complementary medicine, a collective term for treatment methods that are understood as an alternative to scientifically based methods of (conventional) medicine (Köbberling 2017).

Relative contraindications for electromagnetic exposure

The commissioning of magnetic field therapeutic devices, especially when they are classified as medical devices, requires both a safe use (e.g. conformity with equipment technology, CE, GSE, ISO standards, electromagnetic compatibility, compliance with limit values (International Commission on Non-Ionizing Radiation Protection 1998)) and proof of effectiveness (e.g. within the framework of one of the study protocols described below according to Directive 93/42 EEC Annex II Complete Quality Assurance System).

Their use is also subject to certain inclusion and exclusion criteria. For example, persons with electronic implants (pacemakers, cochlear implants, chips, etc.) should only be treated after a competent medical examination. To avoid rejection reactions after fresh foreign body transplants, it still seems advisable to start electromagnetic treatment only after medically diagnosed normalization of the immunological defence reactions.

However, there is no risk of heat development due to induced currents in metallic implants (they act like antennas), or due to re-magnetizations triggered by the alternating field (implants consist of non-magnetizable material).

In principle, magnetic field therapy should never replace professional medical treatment. However, medical advice on magnetic field therapy should only be obtained from medical experts competent in this field (see text Fig. 4).

Documentation on Electromagnetically Induced Biological Effects

The number of publications on the biological effects of static and low-frequency pulsating electromagnetic fields is extensive and continues to grow. Apart from the references in this paper, reference is made to the extensive material in the National Library of Medicine https://pubmed.ncbi.nlm.nih.gov/?db=PubMed&orig_db=PubMed&term=pmf+therapy, the internet information platform EMF-Portal of the RWTH Aachen University and the Federal Office for Radiation Protection <https://www.emf-portal.org/de>, the Federal Institute for Drugs and Medical Devices (BfArM) <https://www.dimdi.de/dynamic/de/das-dimdi/>, the Cochrane Library <https://www.cochranelibrary.com/cdsr/reviews/topicsa>, (Cochrane 1972, Cecchi 2020), and also to the numerous patent applications <https://patents.google.com/>.

However, it should be pointed out here that the study results, which are particularly requested by the medical sector, are only in a few cases consistent with the individual circumstances due to the exclusion criteria (age, gender, diseases, medication, etc.). Therefore, if you are interested in using them, it would be advisable to aim for a frequent "trial use". (See also footnote 4).

Some examples of magnetic field therapeutic applications (National Library of Medicine)

A small random selection of peer-reviewed⁴ publications indicate a broad spectrum of magnetic field therapeutic effects:

- Reduction of polyneuropathological **pain states as a consequence of oxidative stress after chemotherapy, knee osteoarthritis, and injuries** (Mert 2017), (Gabrys 2004), (Hedén and Pilla 2008), (Khooshideh et al. 2017), (Battisti et al. 2004), (Rokyta et al. 2012), (Ryang et al. 2014), in contrast (Menini et al. 2016) and (Beaulieu et al. 2016)
- **Strengthening the body's defence mechanisms** with improved immunity and protection against chemical stress factors (Wojcik-Piotrowicz al. 2017), (Guerriero and Ricevuti 2016).
- Protection against **chemical stress factors**, in particular, the reduction of chemically (by the teratogen cyclophosphamide) induced malformations in the ontogenesis of warm-blooded vertebrate embryos in the model of chicken eggs (Jelínek et al. 2002)
- Improvement of **orthopaedic clinical pictures**, especially in the rehabilitation sector with reduction of lumbar-initiated chronic back and movement pain and its consequences: Insomnia, anxiety Depression (Klasen et al. 2006), (Bernatzky et al. 2007)
- Accelerated wound and bone healing, including **diabetic wounds** (Callaghan et al. 2008, Patruno et al. 2018) and **bone healing, back pain** (Assiotis et al. 2012), (Furlan et al. 2010), (Krath al. 2017) (Ryaby 1998), (Schmidt-Rohlfing et al. 2011), (Pieber et al. 2007), contradicted by a Cochrane report by Griffin et al (2011)
- Influence on **sleep quality** is improbable according to Hong et al. (2001) or even disturbing with continuous exposure according to Bagheri et al. (2019)
- Improving **well-being and quality of life**, particularly in geriatrics and palliative care, multiple sclerosis (Bistolfi 2007), (Guerriero and Ricevuti 2016)
- **Increase in performance** in top-class sport through the delayed onset of muscle soreness, reduction of fatigue, the formation of energy-rich compounds, in particular, adenosine triphosphate (ATP) and bis-2,3-phosphoglycerate (BPG) in human erythrocytes; Spodaryk K (2001, 2002), Spodaryk and Kafka (2004)
- Improvement of **hemoglobin-oxygen affinity** in healthy adults (Kafka WA 2003), (Kafka and Spodaryk 2003)
- **Increasing cell replication and proliferation rates, and influencing the activity of proteins** in defined stem cells of the human bone marrow as an approach to treating bone diseases such as osteoporosis and fractures (Kafka et al. 2005)

⁴ A peer review is a procedure for quality assurance of scientific work by independent experts from the same subject area. The authors of the peer-reviewed work must take any criticism seriously and correct any errors discovered or explain why the comments of the reviewers are inaccurate before the study can be published. Disadvantages, apart from fake journals: In the case of cross-border scientific topics (e.g. natural science-medicine), the necessary interdisciplinary competence of most medical reviewers are often lacking and, because of the great trust placed in their statements, this also has negative consequences for the insured (also see the section on magnetic field therapy: Yes, but which system? Some decision-making aids).

- Formation in the form of differential (**up- and down-regulated**) **gene expression of proteins** of defined stem cells of human bone and cartilage cells as an approach to treating bone disease (Walther et al. 2007)
- **Influencing the activity of different growth factors**; epidermal growth factor (EGF), insulin-like growth factor 2 (IGF-2), fibroblast growth factor (FGF), nerve growth factor (NGF), transforming growth factor-beta (TGF- β) and the bone morphogenesis proteins 2 and 4 (BMP-2, BMP-4) (Ruoff 2008), Sylvester et. al (2005)
- **Reduced medication - cancer** (Moiseeva and Kunin 2018), (Vadalà et al. 2016), (Ruiz-Gómez et al. 2002), (Cheng et al. 2017)
- **Functional state of the microcirculation and improved adaptation to the flow of blood cells**, blood plasma, and signal substances in the smallest blood vessels, which is dependent on changing metabolic needs, as well as the activation of the Klopff metabolism (2008). Despite the use of identical stimulation systems with partly identical analysis systems, neither Schuhfried et. al (2005) nor Gschwandtner et. al (2008) was able to confirm such findings.

In summary: magnetic field therapy influences different biological regulations without adverse health effects

Concerning the differently induced biological effects, in particular the simultaneous up- and down-regulation in gene expression, it can be assumed, as mentioned at the beginning, that stimulation with different electromagnetic pulse formations influences the course of different molecular processes. Even if it is still unclear to what extent the biological effects induced can be assigned to the spectral components of the applied stimulation signals, the available findings support the assumption that the width of the biologically inducible effects is associated with the spectral width of the stimulation signals.

However, similar to multifunctional medications, potential synergistic effects must also be taken into account in the application. Particular attention should be paid to the development of pulse sequences optimized for specific spectral compositions (Kafka 2009).

Conspicuously and in contrast to the many studies on electromagnetic influences in higher frequency ranges, there is, in agreement with the reports of the WHO, the Federal Institute for Radiation Protection, and the bodies notified as Class IIA medical devices (LGA) for the approval of certification, no evidence of adverse health effects (electromagnetic fields (EMF) ff. <http://www.who.int/peh-emf/en/>; http://www.who.int/topics/electromagnetic_fields/en/; LGA-Bericht 2005).

Criteria for assessing the significance of electromagnetic field therapy

However, the absence of negative health effects should not hide the fact that the health benefits of magnetic field therapy are automatically attributed a high priority. This only results from the quality of testimonies and the individual utility value that can be derived from them.

It is not intended here to determine the significance based on analyses of the extensive available data. With explicit reference to the criteria below, we refer you to the databases cited above. The main purpose of this paper is to give those interested in magnetic field therapy relevant and value-free assistance in the evaluation of the significance of electromagnetic field therapy for the expected personal benefit. This evaluation is based on the criteria listed below:

Clinical Studies - Study Design - Evidence-Based Medicine - Scientific Quality

Proper clinical trials (study design: Good Clinical Practice, GCP) are based on a study plan, which defines the target parameters, the exact description of the stimulation, the type of control (placebo, open, single, double-blind, inclusion and exclusion criteria of test persons), the flow chart of the trial, the form of documentation for the findings (including serious adverse events or negative reactions) as well as the plan for biometric evaluation and the procedure for statistical evaluation. The trial plan contains the guidelines for the investigator, the written consent of the test person or patient, the vote of an ethics committee, the notification to the state authorities, and the patient insurance companies. See also <https://flexikon.doccheck.com/de/Studiendesign>.

The inclusion and exclusion criteria are intended to ensure that the persons in the control groups roughly match in the variables age, sex, health status, etc. Here, open = the treatment is known to the investigator and the subject, simple = open only to one of the participants, either investigator or subject, double-blind = neither investigator nor subject is informed about the treatment to avoid self-suggestion.

The therapeutic statements obtained from studies determine their scientific quality by quantitatively clarifying to what extent an application geared to the investigation of certain target parameters is of practical significance for health.

Since every person comes into contact with static or oscillating magnetic fields (loudspeakers, cars, trains, natural magnetic fields) with different frequencies and field strengths daily, placebo controls in the form of isolation of electromagnetic field effects are, however, only possible with difficulty!

Contrasts:

- The scientifically proven significance does not prove practical relevance. For example, in the treatment of low back pain, a significant improvement in the flexion angle of 1 or 2 cm is bare of practical relevance. The same applies to explanations that end with the words: "... further investigations must show ...".
- Significant laboratory and "petri dish" experiments or animal experiments Physiological or therapeutic relevance does not guarantee therapeutic efficiency in humans.
- The findings of clinical studies are often only of limited use in individual cases due to the required inclusion and exclusion criteria for reasons of individually different physical, physiological, psychological, and other sensitivities.
- Beware of pseudo-journals. These are fraudulent business models of certain open-access publishers (robber journals, English predatory journals (Eckert 2029)) which claim to publish fully-fledged, peer-reviewed scientific journals. They charge authors the usual article processing charges in the Open Access segment without providing the editorial and publishing services of reputable scientific journals.
- High impact factors⁵ or journal evaluations do not guarantee high scientific quality.
- The interest in the promotion of medical scientific knowledge, which is often proclaimed by manufacturers, is frequently only a marketing argument to make the documents presented on the effectiveness of the products appear more serious.

⁵ The Impact Factor (IF) or Journal Impact Factor (JIF), is used for bibliometric comparison of different journals. It is not a measure of the quality of the articles in a journal but provides information on the number of articles in a particular journal cited in other publications.

- Some reviews compiled from peer-reviewed publications, e.g. Bodewein et al. (2019), Saliev et al. (2018) or Quittan et al. 2000) refer to the dependence of biological effects on pulse repetition rate and field intensity - obviously due to a lack of physical background knowledge - but not to their variations in intensity over time. Their scientific and practical utility is correspondingly low.
- Studies on therapy with static magnetic fields (especially for low back pain) are, due to their low quality, not meaningful enough to assess the benefit and harm in acute and chronic low back pain (Pittler et al 2007). The "Nationale Versorgungsleitlinie Kreuzschmerz" (National Guideline on Low Back Pain), drawn up by about 30 professional associations, gives a clear recommendation: "Magnetic field therapy should not be used for the treatment of acute and chronic non-specific low back pain" (Deutsches Ärzteblatt 2014).

Publications and authorship

See sections: Clinical studies, Meta-analysis, Evidence-based medicine, Experiential medicine, and Case descriptions

Cons:

- Daily press publications, self-published brochures, and books are less or not suitable for testing scientific validity. If, however, only such publications are available, their seriousness should be checked alternatively by intuition to see if the examination methods described there correspond to the specifications of clinical studies and are technically verifiable as well. Here is an example (without reference): Considering the scientifically recognized health-relevant importance of the microcirculation of the blood, it is claimed that before and after observations can be positively influenced by special electromagnetic field effects. The necessary reproduced retrieval in the micrometer range was achieved without further technical aids by visually controlled manual search in online comparison with image material, the production of which (described elsewhere) is in the hourly range. The contradiction is obvious, not only because of the online comparison in question but also because of the purely manual retrieval in the micrometer range, which is hardly credible in this way. - Apart from this, it cannot be excluded that the possibly positive findings are due to completely different transduction mechanisms.
- Unsuitable, and relatively easy to verify through internet research, are statements that can be attributed to collisions between scientific, economic, financial, and political interests. This applies in particular to any kind of positive evaluations which are to be regarded as a consideration for a result desired by the client, e.g. by experts, consultants, or other stakeholders (see below: clinical studies, patent developments, pseudo-journals).
- Misleading naming with a deliberate avoidance of the term "magnetic field or electromagnetic field therapy", which has been mentioned in press releases (also see sections: Electromagnetic field therapy: design and forms of application ff.).

Meta-analyses - Cochrane Reviews - Evidence-based medicine

Often, a single trial is not large and meaningful enough to reliably answer a research question, and often, several trials on the benefits of one treatment come to contradictory results. To order to find reliable answers to these questions, it is necessary to systematically examine as many trials as possible in the sense of a "study about studies" in the form of meta-analyses of a particular research

question (Cochrane 1972, Cecchi 2020). If expertise is required, the overall result, often in the form of guidelines developed from it, is much more meaningful than the results of individual studies (Deutsches Ärzteblatt 2014).

Evidence-based medicine refers to medical care that treats a patient's illness based on the best available sources of knowledge or data. Evidence-based medicine evaluates and classifies clinical studies according to their significance. For this purpose, studies are divided into different evidence classes from Ia to IV according to the recommendations of the Agency for Healthcare Research and Quality. Higher evidence classes provide better scientific justification for a therapy recommendation.

For example, studies in evidence class Ia, meta-analyses of randomized controlled trials (systematic review), have the highest significance. The classification into evidence classes results in an evaluation based on degrees of recommendation for certain therapy options. Class A is documented by conclusive literature of good quality (evidence classes Ia, Ib) (<https://de.wikipedia.org/wiki/Evidenzgrad>), which includes at least one randomized trial.

Class B is proven by well-conducted, non-randomized clinical trials. (Level of evidence IIa acceptable and useful, IIb well-proven benefit, therapy alternative for experienced patients, III not indicated, not useful, possibly even harmful).

Class C is documented by expert reports and opinions or clinical experience of recognized authorities. There is a lack of directly applicable clinical studies of good quality for evidence level IV.

Evidence-based medicine has its origins in a book published by Archie Cochrane, which contains the basic idea of scientifically justifiable medical acts (Cochrane 1972).

Depending on the quality of a clinical trial in terms of form and content - defined by the above evidence levels - the costs of the therapy are sometimes covered by statutory health insurance companies - possibly also for advertising purposes - even if the legal requirements are not met, i.e. the right to adequate, needs-based medical treatment in line with the generally accepted state of medical science.

Contrasts

- as mentioned under clinical studies.

Empirical medicine - Case descriptions

Empirical medicine includes examination procedures and healing methods that have been developed in different cultures as a result of many years of case reports of individual patients and their disease courses. The term is used in various contexts and has strong overlaps with alternative medicine and naturopathy. In contrast to orthodox medicine, empirical medicine does not draw its knowledge from controlled clinical studies, but from individual observations of the course of the disease and therapy.

Contrasts: as under clinical studies.

- Since individual therapy observations have less scientific evidence, the methods of empirical medicine are often controversial. Experience and individual case descriptions do not fulfil the conditions of scientific clarity. They serve only as possible working hypotheses for further examination planning.

- This also applies to indications of long-term positive health experiences, such as the use of magnetic stones by Chinese doctors about 2000 years ago, or magnetic jewelry in ancient Egypt, as well as the so-called animal magnetism of Franz Anton Mesmer in Europe in the 18th century.
- Although magnetic field therapeutic effects apply in individual cases, case law (especially in the case of competition disputes) still refers to studies. This leads to an open contradiction in itself, as such studies only allow a limited generalisation due to defined selection criteria and, also, often lack the necessary interdisciplinary (scientific) competence.

Application - Patents - Certification - Award ceremonies - Winner certificates

The advertising of products is essential in a market economy. It must clearly describe the intended purpose of the product and its safe handling. Any deception is punishable by law.

Contrasts:

- Despite the clear legal situation, applications are often overflowing with full-bodied, dubious, pseudo-scientific arguments and contradictory, widely scattered promises of healing. With a skillful mix of text, pictures, film, and other conceivable background material
- of patents and certifications, or even product names, many profit-seeking entrepreneurs try to avoid the accusation of misleading.
- Treatment evaluations prepared "on-site" at trade fairs or similar, or data collection via sensor systems of any kind (oximeters, skin resistance measurements, ...), image presentations (blood-darkfield, Kirlian and aura colours ...), or even esoteri
- c media lack basic scientific principles, they are aimed at advertising and attracting attention
- In the product ranges of many manufacturers, there are often additional devices which, with the help of reference values determined elsewhere, are said to be able to achieve individually optimal stimulation conditions. These also rarely fulfil the basic requirements of scientific working methods.
- Patents primarily serve economic purposes. What is essential is the technical novelty. Similar to the certification of wellness and medical products, compliance with strict scientific standards
- are only required to a limited extent in order to obtain protective rights.
- Award ceremonies, winner's certificates are regarded as honorary awards for special achievements in various fields, such as culture, sport, science, or art. (Nobel Prize, Oscar, Grammy Awards, etc.). Behind them lies an enormous economic potential. Scientific prizes and awards are often homemade or may even be for sale under the table.

User manual - Consultations - Hotlines

User manuals must indicate, among other things, the intended purpose, possible settings, forms of application, and safety regulations to be observed. Regarding usage, these are often linked to references to empirical values (see above), training, hotlines, and possibilities for further distribution.

Cons

- Counseling is often provided partly by self-proclaimed "experts" who are sometimes not familiar enough with scientific thinking and/or are paid to spread wishful thinking (cf. section on publications). Here, empirical values are suggested. However, following them excludes the possibility that other uses might lead to better therapeutic outcomes.

Conclusion: Electro-magnetic field therapy and its prospectively high significance

From the numerous positive findings, which are widely spread in terms of health, but particularly that according to reports of many professional organizations such as the WHO and the LGA, negative effects are not to be feared⁶, magnetic field therapy would be of great importance. This is not only due to the sales figures which are in the billion Euro range because their users have certainly opted for this form of treatment not only based on recommendations, placebo, or empathy effects (procurement can sometimes cost well over 5000€!).

This is true despite the many contradictions. Because these are mainly self-inflicted and therefore, are generally avoidable. As mentioned above, many studies, including peer-reviewed meta-studies and Cochrane reports, are of insufficient scientific quality due to the lack of a complete description of the form of electromagnetic stimulation (see text Fig. 4). Statements are often based on insufficient expertise or are over-interpreted as wishful thinking. In connection with obvious conflicts of interest, results continue to be frequently linked to semi-scientific or pseudo-scientific and factually contradictory assertions - boldly erroneous representations cannot be ruled out. Subsumed under the umbrella term "magnetic field therapy", such deficiencies have considerably damaged the reputation of therapeutic applications of especially pulsed electromagnetic fields, with great effects also on health insurance companies. Often, a lack of interdisciplinary expertise is also partly responsible for this - unfortunately even within medical circles, as their statements are trusted by many.

However, because the cons are avoidable, a further, scientifically based approach in research, development, advertising, and distribution of electromagnetic field therapy, and its multimodal and cost-reducing application possibilities, offers a promising future.

With these guidelines and precisely because the non-invasive, non-drug treatment option is a therapy option that is simple for the doctor and pleasant for the patient with practically no side-effects, modern electromagnetic field therapy - despite the above-mentioned contra-indications - can be assigned a prospectively high significance both in a private home application and in medical practice.

Therefore, it is to be hoped that in the future, together with manufacturers and distributors, and independent scientific institutions with interdisciplinary competence, more attention will be paid to the health effects of electromagnetic fields. The necessary scientific and technical background is given, (Bhavsar 2020), (Cecchi 2020), (Kafka 2009), (Panda 2019), anonymous patent application E2020,0098-AA-X (2020).

⁶ Negative influences are probably already being regulated away as a result of natural self-preservation mechanisms.

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For reasons of clarity and to save space, only incompletely listed references are also referred to the quotations in the following. Further literature under PubMed, DIMDI, Cochrane, etc. If necessary, the author is available for a system-independent consultation.

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Figs: 1-4

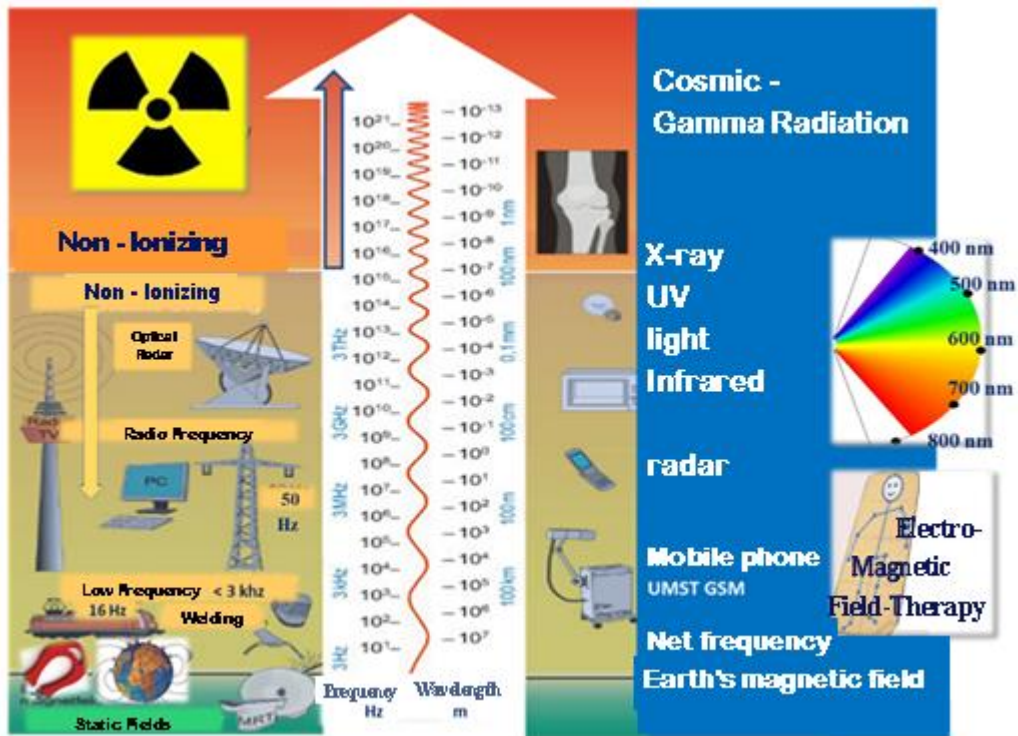


Fig. 1: Electromagnetic spectrum Biological effect and application (see Text)

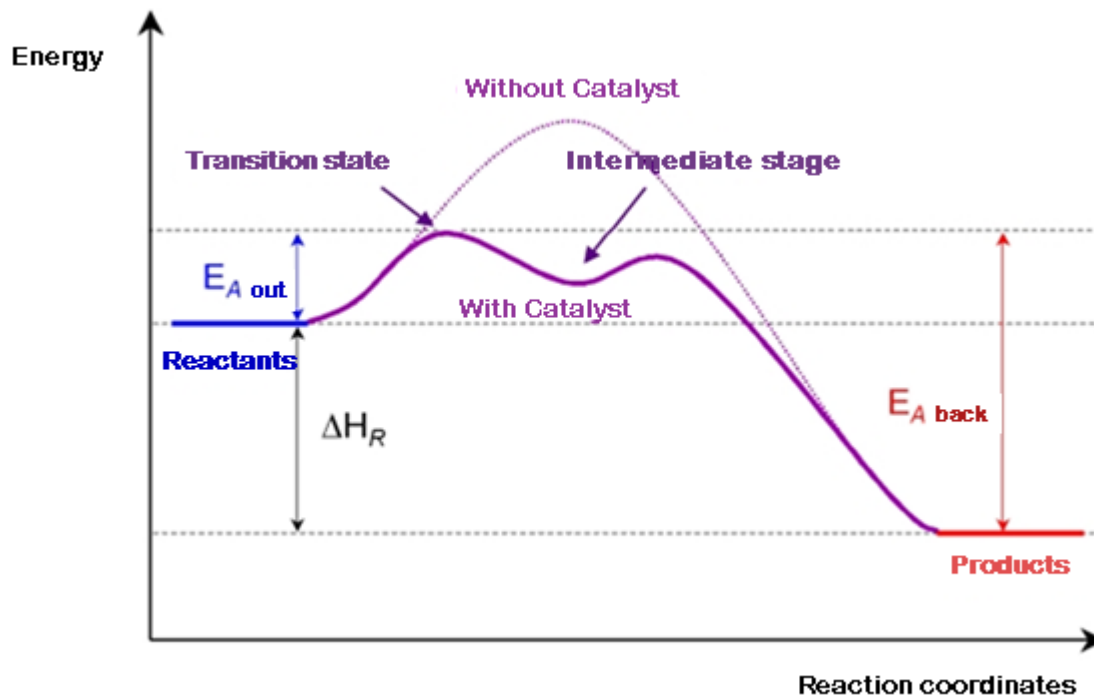


Fig. 2: Activation energy and reaction sequence of Physico-chemical interactions with and without catalyst ($E_{A \text{ out}}$ = activation energy, $E_{A \text{ back}}$ energy released during the interaction; ΔH_R = energy state before and after the interaction) Here, the electromagnetic field effect only has a controlling effect.

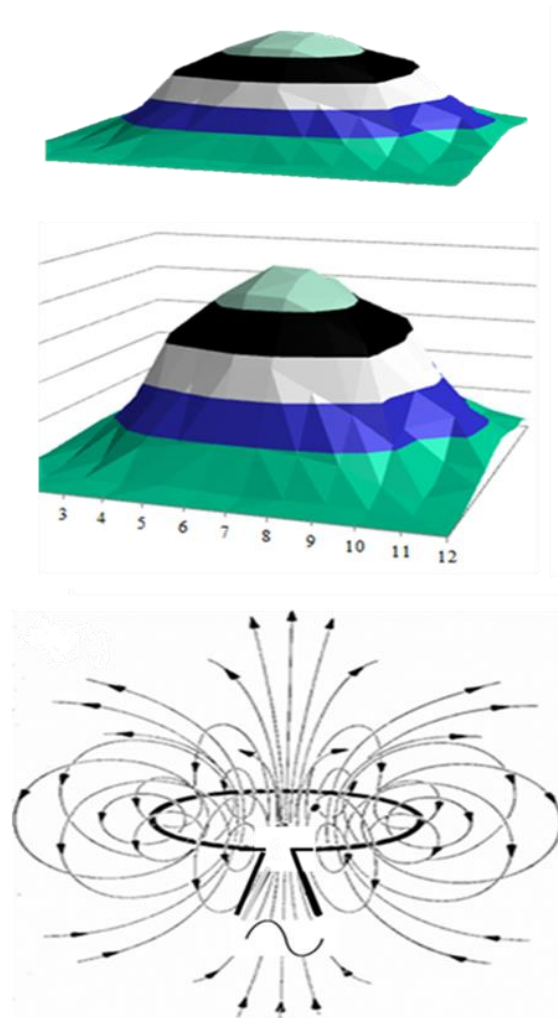


Fig.3: 3-D field distribution (magnetic flux density) around a ring-shaped air-core coil. The field intensity is strongly dependent on the distance to the coil surface. In the schematic example, each at a vertical distance of 0 and 15cm.

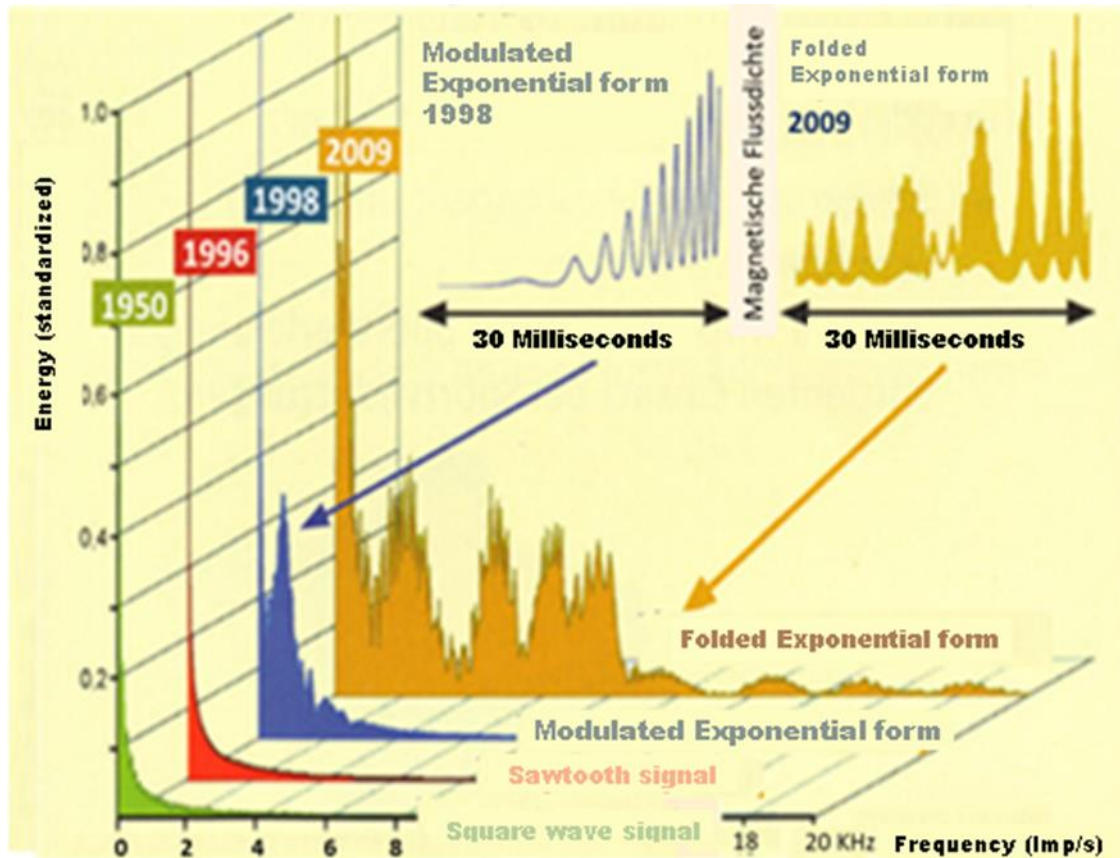


Fig. 4: Spectral composition and effective width. Measured by the number and size of the components contained in a stimulation signal, a Fourier analysis in the lower part of the figure shows the clear superiority of the folded exponential form (Kafka 2009). The temporal field intensity distribution is of similar importance as the structure-activity relationships of drug substances. Descriptions of effects merely through information on frequency and intensity - often even in many peer reviews - are thus completely inadequate. Not only do they testify to a lack of expertise, but they may even be the cause of contradictions in magnetic field therapeutic findings that are often presented but do not exist (see text, section Conclusion).