

Therapeutic use of moderate magnetostatic fields

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Abstract

A big debate is still dividing the scientific community about detrimental or beneficial effects of Static Magnetic Fields (SMFs) exposure on living matter. The heterogeneous findings are depending on the different experimental set up used, *i.e.*, magnetic induction from 10^{-7} to more than 10 T, homogenous or inhomogeneous field, time of exposure and on the biological samples, *i.e.*, from *in vitro* cultured cells to living organisms. In spite of the amount of publications providing medical evidence for the beneficial effects of SMF exposure can exert on living matter, a researcher must keep his obligatory scepticism due to the difficulties comparing different measurements, to the commercial interests and to poor scientific rigor. Nevertheless, their use has gained wide community acceptance for pain relief but not for more serious diseases, such as cancer. In this mini-review we will discuss on the studies on the therapeutic use of moderate magnetic induction SMFs, focusing on those produced by permanent magnets.

Introduction

The effect of SMF exposure on living tissues is namely like sport. Few have adequate knowledge about it, while many have opinion or prejudice. It is also not widely acknowledged that in the past 60 years, parallel with the discovery and development of Nuclear Magnetic Resonance Spectroscopy (NMRS) and its entry to medical diagnosis (as Magnetic Resonance Imaging or MRI), serious research has been done resulting in 7 Nobel Prize winners.

Permanent magnet therapy is classified by the US National Institutes of Health Centre for Complementary and Alternative Medicine under the item 'Methodology #3-Energy' [1]. Various products containing magnets, like

shoe insoles, bracelets and other jewellery, mattress pads, bandages, etc., are often marketed for many different types of pain. However, the answer to laypeople as well as professionals to the real 'functioning' of these magnetic devices is still "we don't know. They may be". Indeed some arrangements, structures of permanent magnets exert measurable (patho) physiological effects when living tissues are exposed to them. Scientific evidences about the use of magnets for pain relief have had contradictory results. For example, it has been found in *in vivo* studies on animals that the exposure to an Extremely Low Frequency-Pulsed Magnetic Field (ELF-PMF) (magnetic induction comparable with a moderate SMF), could positively affect

oxidative stress parameters (e.g., Reactive Oxygen Species (ROS) generation) in heart, plasma [2-3], brain [4] and skeletal muscle [5]. Conversely, studies of SMF therapy for treatment of insomnia [6], different types of neuromusculoskeletal pain (e.g., knee, hip, wrist, foot, back, and pelvic pain) [7], diabetes [8], allergic inflammation [9], osteogenesis [10], erosive gastritis [11] and other diseases, suggested a benefit from using magnets. Interestingly, after the first finding of Yakovleva *et al.* in 1995 [12] that suggested the ELF magnetotherapy to treat breast cancer, other studies have supported its effectiveness, as an adjuvant factor, for the treatment of urogenital tumors [13-14]. Unfortunately, to date the efficacy of SMFs, generated by permanent magnets, in the treatment of cancer has not been ascertained. Permanent magnets certainly 'act' at the psychosomatic level. The placebo effect itself has a good reputation and an evidence-based foundation in medicine.

Current research and unresolved issues

An even increasing annual number of reports about evidence-based medical research from that living objects respond to external MFs in a wide range of frequencies is published. However, as reported in the Research Agenda for Static Fields of the WHO (2006) "For SMFs, research carried out to date has not been systematic and has often been performed without appropriate methodology and exposure information. Coordinated research programs are recommended as an aid to a more systematic approach. There is a need to investigate the importance of physical parameters such as field intensity, exposure duration and field gradient on biological outcome." Again, in another citation issued by Scientific Committee on Emerging and Newly Identified Health Risks of the EU from 2009, in the Health Effects of ElectroMagnetic Field (EMF) Exposure, "Although a fair number of studies have been

published since the last opinion, the conclusion drawn there stands: there is still a lack of adequate data for a proper risk assessment of SMFs. More research is necessary, especially to clarify the many mixed and sometimes contradictory results. Short term effects have been observed primarily on sensory functions for acute exposure. However, there is no consistent evidence for sustained adverse health effects from short term exposure up to several Teslas". The official statement of WHO and the EU in effect says that up to a magnetic induction of 8 T, the human body will not be jeopardized by an external SMF. 80,000 gauss After the early reports that were only simple phenomenological observations and descriptions, current research is still focusing on the mechanism(s) of action, although the elective site of action of SMF seems to be the plasma membrane [15-17]. In our research, we have succeeded in getting a little beyond the level of phenomenology by revealing some of the possible background mechanisms in action. It seems obvious today that a living object that has self-motion in an external SMF is subject to an induced time-dependent magnetic flux and, consequently, to internal electric potential differences; however, the point whether these changes can be scientifically measured in the biological response is still open for discussion. By now, it is widely accepted that SMFs can achieve well defined observable bioeffects under a broad range of experimental and clinical physiological and pathological conditions [18-22]. The plethora of the results are also suggesting that there are some forms of dose-responsiveness related to SMFs produced by permanent magnets, which depend on their magnetic induction, polarity and application time [7]. Thus, from the point of view of the experimental model chosen, some kinds of SMF are more suitable than others. We recently studied the effects of inhomogeneous SMF (ranged between 200.6 and 212.9 mT) on the molecular mediators of

inflammation in monocyte-derived macrophages [23] and on the effects of inhomogeneous SMF (ranged between 31.7 and 232.0 mT) on the efficacy of cisplatin (*cisPt*) treatment on neuroblastoma SH-SY5Y cells [24]. Our results demonstrated that SMF exposure: (i) induced release of the anti-inflammatory cytokine IL-10 and the suppression of the pro-inflammatory cytokines IL-6, IL-8, TNF- α ; (ii) was able to prevent *cisPt* cytotoxicity. These data suggest that the exposure to inhomogeneous SMFs of moderate intensity could be used for the treatment of inflammatory diseases and in the prevention/reduction of the side effects of *cisPt*-based chemotherapy.

What role can SMF exposure have in therapy? In order to legitimate definitively the use of magnets as a substitute or support element of pharmacological methods, many controversies have to be addressed. For example, it is not yet clear if SMFs play an effective role in the management of pain, due to the lack of systematic research and for the poorness of many studies (small number of participants, time of investigation too short and inadequate controls). In addition, one of the main factors complicating interpretation of results is that there are many 'dosing' and application variables to consider when applying magnetic therapy, e.g., polarity, field strength, penetration, and perhaps configuration of field patterns. Thus, the majority of rigorous trials have found no effect on pain [7]. In addition, even if magnets are generally considered safe when applied to the skin, they may not be safe for some people because may interfere with the devices, such as pacemakers and implantable cardioverter-defibrillators or insulin pumps [25-28].

Future perspectives and conclusion

Some of the above discussed researches, ours included, are encouraging a medical use of permanent magnets. In all honesty, we must admit that not all experiments provided

evidence for the beneficial effect of SMF exposure on the specific biological response tested. Even if a positive response was found, it was not always convincing that it was the exclusive action of SMF exposure. Therefore, we had to differentiate between several options to the best of our knowledge, keeping in mind that further researches are mandatory to identify the mechanisms and clinical outcomes of SMFs exposure. Thus the concerns that probably every researcher must deal with are:

- (i) Is there really no effect that can be measured?
- (ii) Would there be an effect if we chose a more appropriate model?
- (iii) Can we still miss observability of an effect in a perfect model by superficial execution?

The better optimization of factors such as exposure time, polarity and field strength of the magnet will, for sure, improve the quality of results. In fact, the study of pain performed in animal or experimental models will allow to define the role of all above mentioned factors and determine the efficacy before continuing with expensive clinical research in patient populations [7]. In addition, the inclusion of raw data in specific databases might help to make an easy cross link of results. This scientific approach will clarify whether SMF can be used as useful therapeutic tool, alone or complementary to drugs, made them exploitable for clinicians of third millennium.

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