POWER TOOLS FOR HEALTH

How Pulsed Magnetic Fields (PEMFs) Help You

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Disclaimer:

The information in this book is not intended to replace the relationship between you and your doctor, nor as medical advice. You should regularly consult a health care professional in matters relating to your health, and particularly with any symptoms that may require a medical diagnosis or attention. Since this book focuses almost entirely on how pulsed electromagnetic fields (PEMFs) help the body, there is minimal discussion about other healthcare options. PEMFs may not be the only or best treatment available to you. Please carefully read section 5 of this book and ensure you fully understand all the cautions and contraindications associated with PEMF therapy.

About the Authors

William Pawluk, MD, MSc, is a previously American board-certified family physician with additional training in acupuncture, homeopathy, hypnosis, energy medicine, and bodywork. He has had academic faculty appointments at a number of universities including Johns Hopkins and was the Clinical Director of the University of Maryland's Complementary and Alternative Medicine Program. He co-hosted a weekly health radio show at www.wcbm.com for ten years. In addition, he is an international expert in the medical use of electromagnetic fields with over twenty-five years of experience. He appeared on *The Dr. Oz Show* regarding use of magnetic therapy devices for helping pain. As part of his work with this technology, he has authored books, chapters, and articles, and done numerous TV, radio, podcast and magazine interviews on magnetic field therapies, and conducted research on the use of various kinds of electromagnetic systems on wound healing and other applications. He routinely teaches practitioners about the appropriate use of magnetic therapies. He was formerly Vice President of the North American Academy for Magnetic Therapy. To be able to continue to educate both the public and practitioners and help make this valuable technology available to consumers, he has established an authoritative website www.drpawluk.com, reviewing the science of pulsed electromagnetic field (PEMF) therapy and various PEMF therapy options. He currently practices functional and holistic medicine in Baltimore.

Caitlin Layne is a freelance writer, editor, and web designer who has studied pulsed electromagnetic field (PEMF) therapy for nearly seven years. She has a background in journalism and technical editing from Columbia College Chicago, where she served as copy editor for the nationally award-winning *Columbia Chronicle* newspaper and managing editor for *ECHO Magazine*.

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INTRODUCTION

In 1985, when I was still active in hospital care, there was a one-month period when I became aware that several patients had been admitted for stomach bleeding. One of them actually died.

But why? How did this happen?

It turned out that these were all pain patients taking ibuprofen or aspirin as recommended by their doctors. Stomach bleeding is a known and accepted side effect of these widely-prescribed medications. With no better options to help patients manage their pain, these complications were begrudgingly accepted. I remember thinking, *This is the actual definition of insanity!* Here we were, physicians sworn to protect our patients and above all do no harm, and we were doing the same thing over and over again, hoping for better or different results.

And so I began my journey in search of better alternatives. I stepped well outside of my comfort zone, which until that point remained firmly within the confines of traditionally-accepted medicine. I was a part-time academic family physician managing a multispecialty medical group of thirty conventional practitioners. I looked into tools my peers and I would have previously looked down on, including acupuncture, chiropractic care, osteopathy, and even hypnosis.

I risked ridicule. I faced censure. I received quizzical looks from doctors I had worked with for years. But I could not continue accepting these types of complications as acceptable side effects, and I could not believe that there were no alternatives to such medications.

It was during my study of acupuncture that I was first introduced to the use of magnets for healing and health. I began experimenting with small static magnets myself, seeing no risk of harm in doing so. I continued to be impressed with the results, both on acupuncture points and on tissues directly. I was intrigued. I studied the available scientific literature but found a great deal of it to be in foreign languages. By chance or luck, I met Dr. Jiri Jerabek from the Czech Republic, who had translated and summarized a large body of work done in Eastern Europe. Together we compiled this information into an English-language book.

Most of the studies in the book were based on the use of pulsed electromagnetic fields (PEMFs) as opposed to static magnets. Around the same time as this book was published, nonmedical PEMF devices started becoming available in the US for the first time.

Now, fast-forward over twenty years, and here we are. I am still a practicing physician with a heavy interest in academic research, but I no longer confine myself to the standard practices available within the traditional medical model. I am not a physicist, engineer, biologist, or mathematician. I am a practical, medically and holistically trained physician. My first priority is the person and my interest is in treating the whole person. This means using multiple disciplines to solve a health problem from various angles. Rarely can a single modality solve a problem completely.

Physicians, especially allopathic ones, tend to specialize. The more specialized a doctor is, the more difficult it is for them to tap into complementary modalities. They develop tunnel vision. We like to refer to these specialties as "parlors"—the parlors of neurosurgery, orthopedics, pain management, natural medicine, massage, hypnosis, and many others. Every doctor has a parlor, a specialty. Surgeons want to cut. Pain docs want to prescribe. Chiropractors want to adjust. Good healthcare requires cooperation and communication between parlors and practitioners.

The body is a complex organism, and while it is made up of many moving parts, it is still one interconnected system. Specialists tend to stick to their particular skill set, perspectives, and knowledge base. In the case of medical doctors, they may not suggest or recommend a nutritionist, psychologist, acupuncturist, or other practitioner. On the other hand, it is the philosophy of integrative and holistic medical practitioners to treat the whole person—body, mind, and spirit—and above all, to advocate for self-reliant self-care.

While a great deal of this book focuses on specific health conditions for which PEMFs have been studied, I want to be clear that I believe the first goal of healthcare should be prevention. True prevention requires that we access a wide range of information and consider problems from multiple angles.

In his book, *Ubiquity: Why Catastrophes Happen,* Mark Buchanan, a physicist and author skilled at using lay concepts to explain dense and obscure topics, developed an analogy to explain complexity theory and critical state. This analogy, about a pile of sand, has applications in everything from the butterfly effect to economics and investing. But I would like to use the sand pile analogy to describe the delicate balance that exists in our bodies and drive home my point about the importance of prevention in healthcare.

Buchanan asks you to imagine creating a pile of sand. You are at the beach, shoveling more and more sand onto your mountain. As the pile grows, you notice that some scoops cause small avalanches. Some take out an entire side of the pile, shrinking it significantly. But why? What causes one scoop to raise the mountain while another halves it? The answer, thanks to a 1987 experiment done by physicists Per Bak, Chao Tang, and Kurt Weisenfeld, lies in chaos theory and "fingers of instability."

Buchanan writes,

> To find out why [such unpredictability] should show up in their sand pile game, Bak and colleagues next played a trick with their computer. Imagine peering down on the pile from above, and coloring it in according to its

> steepness. Where it is relatively flat and stable, color it green; where steep and, in avalanche terms, "ready to go," color it red. What do you see? They found that at the outset the pile looked mostly green, but that, as the pile grew, the green became infiltrated with ever more red. With more grains, the scattering of red danger spots grew until a dense skeleton of instability ran through the pile. Here then was a clue to its peculiar behavior: a grain falling on a red spot can, by domino-like action, cause sliding at other nearby red spots. If the red network was sparse, and all trouble spots were well-isolated one from the other, then a single grain could have only limited repercussions. But when the red spots come to riddle the pile, the consequences of the next grain become fiendishly unpredictable. It might trigger only a few tumblings, or it might instead set off a cataclysmic chain reaction involving millions. The sand pile seemed to have configured itself into a hypersensitive and peculiarly unstable condition in which the next falling grain could trigger a response of any size whatsoever.

This is a critical state, a point at which a small change triggers a significant one. In health, it is the tipping point where your itchy nose becomes a full-blown head cold or where one wrong step causes your strained ACL to tear completely. We need to keep our bodies from accumulating red spots. This requires that we access as many health care parlors as possible. PEMF therapy, though a very real option for treating a multitude of conditions, is not a panacea. Nothing will make up for poor nutrition, for example. Likewise, the healthiest person alive may still fall and break a bone.

Everyday use of a whole-body PEMF system creates a dynamic, resilient cellular environment and can cut down on our bodies' "red spots." One of the most obvious reasons our bodies wear down over time is because of the cumulative effects of stress. Stress reactions are immediate but recovery takes hours or even days. PEMF therapy offsets these effects before they make the body more susceptible to disease. In addition to stress, the natural aging process constantly threatens our foundation. Cellular turnover slows as we age. Eventually, cell division happens more slowly and less efficiently until cells die faster than they replicate. Cell communication and metabolism slow, energy production wanes, and immune functions diminish. Daily use of PEMF therapy restores neurotransmitters and brain function, increases blood oxygen levels, improves circulation, balances blood pressure, promotes ATP production, and helps to activate the cellular antioxidant defenses throughout the body.

Nutrition and supplements are a huge part of health maintenance, and absolutely critical in terms of being able to heal a wound or combat a disease process. PEMFs cannot add anything to your body. If you have low potassium levels, you need extra potassium. If your sodium levels are too low, you need extra sodium. PEMF therapy will not give you sodium or potassium. However, PEMF therapy will help your body make the most of the sodium and potassium it has access to, restoring health more quickly and efficiently. Eating a nutrient-rich diet and making a point of taking high-quality supplements when necessary is essential to our overall health. Exercise and an active lifestyle also play an important role in keeping cells as healthy as possible. Movement of the body generates electric currents in joints, which helps to preserve the existing cartilage, tendons, and ligaments.

We use the term "power tools" to describe PEMF therapy because it both literally and metaphorically provides the energy we need to put all the pieces of our health together. PEMF devices treat the body on all levels. A PEMF system does not care what you perceive to be wrong with your body, and will provide stimulation to you whether you have a broken bone, failing heart, or struggle with anxiety. Magnetic stimulation treats at all levels—spiritual, physics processes, chemistry, and tissue. It treats with no regard to whether the disease state is energetic, physiologic, pathophysiologic, or pathologic. Magnetic therapy philosophy is holistic philosophy. By treating the entire person, it works to stabilize the entire sand pile.

Part of thinking holistically is acknowledging that the path to true healing comes from treating the root cause of a condition. Let's say you are standing in front of a wall, repeatedly banging your head against it. You have a headache. Perhaps you should take some aspirin to alleviate your headache. Or maybe a chiropractic adjustment would help ease your throbbing head. Maybe you should have an MRI to determine if there is an underlying cause for your discomfort. Or maybe you should just stop banging your head against that wall!

Treating symptoms without discovering and targeting their root cause is at best inefficient and at worst dangerous and irresponsible. You may very well need an aspirin, a chiropractic adjustment, and an MRI after all that head banging, but only in conjunction with putting a stop to the cause. We do not advocate *against* symptom management. If you break a bone, get a cast. If you have a gaping wound, get stitches. If you have a headache, an aspirin may be appropriate. However, do these things while simultaneously seeking out the root cause of your symptoms. Gather multiple opinions, and remember you are part of a whole.

I still routinely hear from people that they *believe* that PEMFs work. They need to be reminded that it's not a matter of belief. Almost everything we write about in this book is based on experience and research. Therapeutic use of pulsed electromagnetic field therapy is rooted in both science and history, with thousands of university-level controlled studies with PEMFs having been done on a large variety of health conditions and physical processes. Research continues to be done on the range of mechanisms of PEMF therapy effects in the body. Though PEMFs are not a panacea, they have proved safe and successful both as primary and complementary therapy.

My aim remains to emphasize that there is good science to support the use of PEMFs across a wide spectrum of health conditions and basic cell and tissue functions. To be able to help the most people with the widest range of health conditions, I work diligently to keep up-to-date and be the most informed on what research has been done and what works best.

That is my promise to you. All this is to say that my service and giving out information about PEMFs is not only based on practical experience, hearsay from others, a particular philosophical or specialty approach, or reliance on any specific PEMF device or technology. This body of work will help to demonstrate that although PEMF therapy is not (yet) part of standard medical care, it is founded in valuable science.

Change comes slowly, even with great science. Our hope is that through such solid science and a reservoir of peer-reviewed studies, we can help empower you to take charge of your health. Be your own advocate, and the architect of your own health.

Organization of the book

This book is organized into five sections. It is structured to make sure that enough information is supplied for people of many different levels of interest. You should see that the book is heavily referenced for those who want to dig even deeper to see the validity of how PEMFs help health.

In section 1, we provide information about what magnetic fields are, how they are described, and how they work. You will learn about electric charge, frequencies, intensities, and waveforms, among many other things.

In section 2, we discuss how and why magnetic fields affect the body and its various reactions. This forms the basis for all of the benefits that we see with PEMFs. If you can't see a particular health condition reviewed in section 3, always think back to the basic actions of PEMFs on the body. These are to varying degrees the basis of almost all disease processes. When I think of a disease or health condition, I always consider the physiologic and pathologic changes that are part of that health condition. The manifestations of these changes lead to the description or label of a particular health condition. PEMFs treat the physiologic changes, not the disease itself. One way to think about this is the example of aspirin. It is well known that aspirin helps with pain. How? By reducing inflammation. How does it affect inflammation? That happens because aspirin reduces the chemical prostaglandin, which causes inflammation. And so on. This is the way to think about how PEMFs work to help various health conditions.

In section 3, I describe the effects of PEMFs on more than fifty health conditions supported by scientific research. I went to considerable effort to provide scientific evidence for the effects of many different PEMFs on these different health conditions. I didn't want to say only that PEMFs work for prostate enlargement, as an example. If you have prostate enlargement, you would probably want to know how effective PEMFs are for that condition, and if there is research backing to support any assertion that PEMFs are effective.

Sections 4 and 5 cover practical applications of what you've learned in the book so far. I'm constantly asked by people which PEMF system they should select for their various health needs. There are a bewildering number of PEMF systems to select from, with an equivalent number of assertions made by those who sell them.

In section 4, I provide information on how to think about selecting a PEMF system and describe a number of currently available options that I personally have tested and used.

In section 5, I get to the all-important question of how to use a PEMF device. Their manuals tend to be basic and technical, and don't provide much help in how to use them for specific health conditions. Of necessity, this section cannot be exhaustive in covering each device or health condition.

We have also included an appendix, where we chose to include more detailed PEMF and scientific information that still has a place in an authoritative book like this, but may not be as important or interesting to everyone. What has been included in the main section of the book, particularly section 1, is considered more necessary to have a basic understanding of what PEMFs are and how they work.

There are many references throughout the book, particularly in sections 2 and 3. You will know it's a reference when you see a superscript number, like this [1], within or following a paragraph. The sources are listed in the reference section. Simply look up the superscript number in the reference list to see the author or the source.

SECTION ONE
Magnetic Field Basics

While we will directly address many clinical and biologic studies in detail in later sections, we begin this book with a wide-angle lens, providing a brief background on what magnetic fields are and what terminology is used to describe them. This lays the foundation for why therapeutic magnetic fields interact with the body in all the ways they do.

PART ONE: THE BASICS

Magnetic fields have been used therapeutically since as early as 4000 BCE, long before the reasoning for their benefits was understood. Each era of history saw some further understanding of charge and magnetism, though it was not until the early twentieth century that sophisticated magnetic therapies were being used in healthcare. Today, there is a rapidly growing body of evidence to support magnetic stimulation of the body, particularly with high intensity pulsed electromagnetic fields (PEMFs).

New PEMF systems continue to be developed, including for transcranial magnetic stimulation (TMS) applications. Development of new systems is being made easier in the USA by the recently updated FDA guidelines allowing PEMF systems to be marketed without FDA approval if their primary purpose is the management of wellness.

Before we get into the specifics of PEMF therapy and how and why it works in the body, it's important to first discuss some of the most basic principles of electromagnetism. This information will lay the foundation for a better understanding of the research cited in the later sections of this book.

Magnetics and Evolution

Humans and all living matter have evolved on a planet that is a giant magnet of its own. There are many different magnetic fields here, including the Earth's "static" magnetic field, magnetic rock formations, Schumann resonances, geomagnetic storms, and telluric currents. Each of these contributes in its own important way to the overall magnetic environment in which humans have evolved and thrived. Our dependence on these magnetic fields has been demonstrated in research by shielding the body, depriving it of Earth's magnetic fields.

Of particular significance in the context of therapeutic are the Schumann Resonances (SRs). These are atmospheric PEMFs crucial to human functioning. It is generally accepted that these resonances are an important baseline from which the human brain maintains homeostasis. This range of frequencies has also been shown in various studies to be an important part of how the body heals itself. The seven peak resonances are 7.8 Hz, 14 Hz, 20 Hz, 26 Hz, 33 Hz, 39 Hz and 45 Hz. See Figure 1.0. It is often said that the average or major peak SR is 7.8 Hz. SR frequencies (often separated into the brainwave state bands) can be found in many PEMF devices.

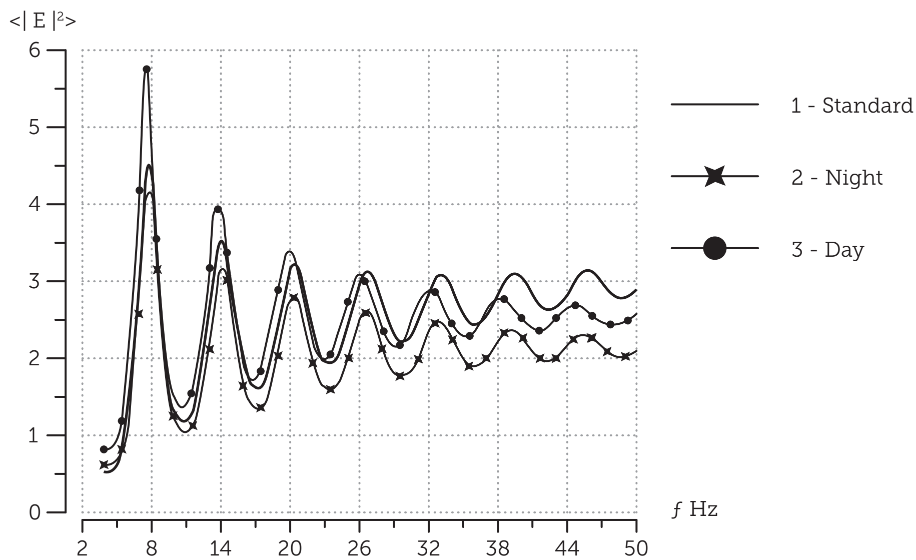

Figure 1.0 The Schumann Resonances

From: Nickolaenko AP, Galuk YP, Hayakawa M. Springerplus. 2016 Feb 1;5:108. Vertical profile of atmospheric conductivity that matches Schumann resonance observations. (http://creativecommons.org/licenses/by/4.0/)

In addition to naturally occurring magnetic fields, the Earth is now also bathed in artificial currents and EMFs created by humans. These include televisions, power lines, microwaves, and cell phones, among many other sources. Especially in densely populated areas, this aura of manmade magnetic fields easily overpowers the Earth's natural magnetic field sources.

We can't escape our basic nature and the forces of nature around us. All the processes that make us functional as human bodies are part of, interact with, and are dependent upon the magnetic fields around us. When we are deficient in electromagnetic energy or there is insufficient electromagnetic energy around us to help us with the health conditions we are dealing with, aging accelerates, illness is more likely, and our ability to recover and repair is decreased. Since the Earth does not always provide us with the energy we need, external local and controllable sources of comparable energy, such as those provided by PEMFs, can be helpful.

Electromagnetic Field Science

It may be helpful to give a basic review of electric and magnetic fields before we get into more detailed discussions about the actions PEMFs have in and on the body. This section will provide a very brief overview of the fundamental science of electromagnetism.

All matter is made up of moving charged particles. Forces exist in the space around these moving (electrically charged) particles. By definition, force is an interaction that can change the motion of an object. The force in these situations is the strength of the interaction that happens with charged particles repelling or attracting each other. These forces are electromagnetic fields (EMFs). They are one of the four fundamental forces of nature.

Electrically charged particles interact with each other. They can either be positive (carried by protons and positive ions) or negative (carried by electrons and negative ions). Electrically charged particles can be formed into collections called objects. Objects form into ions or molecules. All of these are charged as well. Electrically charged positive particles and objects repel other positively charged particles and objects and attract negatively charged particles and objects. Conversely, negatively charged particles and objects repel other negatively charged particles and objects and attract positively charged particles and objects. An electrically charged particle or object can be pushed or pulled by a magnetic field.

An electric field is created by the combination of electric charges resulting from electrically charged particles that exist naturally in an object (static charge) and can also be induced by the pushing and pulling of electrically charged particles by time-varying magnetic fields (induced charge). The magnetic field that exists in the presence of charges combines with the electric field that's present to form an electromagnetic field. Electric and magnetic fields always exist in tandem—one cannot exist without the other. An electromagnetic field (EMF), then, is the simultaneous combination of the electric field and magnetic field.

The bottom line is that magnetic fields are always present when there are electric charges, moving or stationary. Electric charges moving down a wire - as seen with electric current - create a changing or "in motion" magnetic (force) field. Electric current is the flow of electric charges through an object, such as a wire or among molecules in tissue. All current has an accompanying magnetic field perpendicular to the flow of the electric current. The strength and size of the magnetic field depends on the intensity of the flowing charges, that is, the voltage of the electric current.

Even though magnetic fields result from electric charges they have no charge themselves. Magnetic fields' ability to push and pull charges results in the production or induction of current. Faraday's law of induction describes this basic law of electromagnetism and predicts how a magnetic field will interact with electrical charges. This is called electromagnetic induction. The magnitude of the induced current is proportional to the strength (or intensity) of the magnetic field. So, the application of PEMFs to the body induces currents in tissues. The scientific term for this is inductively coupled electrical stimulation, or I.C.E.S. for short. This process applies to all PEMFs.

Magnetic fields can either be static (see the appendix for more information) or time-varying/pulsed. These time-varying magnetic fields result from moving or alternating current (AC) electricity and have a frequency in addition to an intensity.

Electromagnetic fields (EMFs) are created by an electric current or electric field flowing in a conductor, such as a wire. The current flowing in a wire shielded with some kind of covering material still produces an EMF that easily goes through the covering material. The current does not contact the body. In this case the body is exposed only to the magnetic field produced by the current flowing in the shielded wire.

Unshielded electric fields or current can be designed to contact the body and are used therapeutically that way (as with electrostimulation from a transcutaneous electric-nerve stimulator (TENS) unit). A cardiac defibrillator is another example of electric charge being used directly to electrically reset an organ (in this case, the heart). Electric charges are also applied in medicine to burn off warts or other skin lesions, or to cauterize blood vessels. In this book, we will limit the use of the term electric field as current from a wire in direct contact with the body.

Now that we have covered the necessary basics of magnetic science, we can move on to our primary discussion—how PEMF therapy works in the body.

Bioelectromagnetic Fields

To understand how the body interacts with and responds to magnetic fields, we must appreciate how much our bodies themselves are electromagnetic. This brings us to the final example of magnetic fields that are present on this Earth: the body's own internal magnetic fields.

To exist in an electromagnetic world, our bodies have to be an intimate part of it. The extraordinary amount of internal electrical activity that keeps our bodies alive naturally generates its own magnetic fields. Most people assume that this electrical activity is confined to the nervous system, but the vast majority of chemical reactions in the body are accompanied by the movement of charge. When you consider that most of the fluids in the body are actually electrolytes, it is easy to see that the body is like a large battery, producing current and occasionally needing recharging.

Once the connection is made between the magnetic aspects of the human body and its biophysical chemistry, it becomes easier to see the body as a dynamic, ever-changing bioelectric and biomagnetic organism, subject to all the physical laws of electromagnetism. That means that the body not only has a vascular system and a nervous system, but also a less obvious complex electromagnetic system. The biomagnetic fields of the body, though extremely tiny in intensity, have been measured with techniques including magnetoencephalography (MEG) and magnetocardiography (MCG). These measure the magnetic fields produced by the electrical activity in organs of the body and are used today in medicine diagnostically.

The body's electrical activity (and therefore its electromagnetic activity) happens primarily in the cell membrane—the shell of molecules surrounding each individual cell in the body. This membrane is critical to maintaining the cell's structure and to protecting its contents. It also acts as a sort of gatekeeper, opening and closing channels (sometimes called "membrane pumps") through which ions can flow.

The cell membrane itself has a voltage called a "potential" (or membrane potential, or transmembrane potential). Membrane potential refers to the difference in electrical charge between the inside and outside of the cell. The channels in the membrane are opened or closed based on the polarity of the membrane. When the channels are closed, a cell membrane is at its "resting potential" and when it is open, it is at its "action potential." See Figure 1.1.

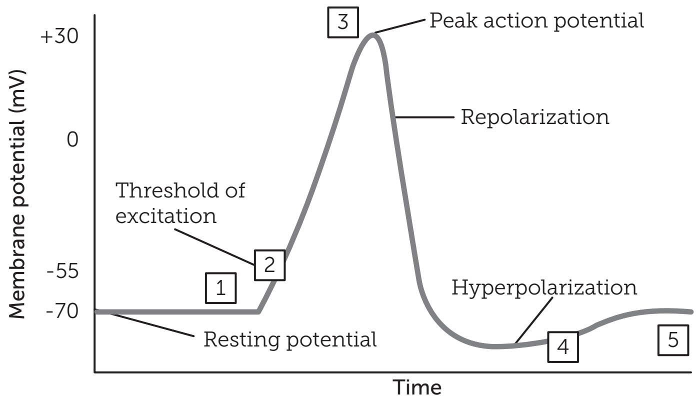

Figure 1.1. Action Potential.

From: http://www.slideshare.net/NewBU/the-action-potential-synapse

Action potential occurs in excitable tissues, such as nerve or muscle fibers, when a changing resting potential reaches a firing threshold. The process of a nerve or muscle cell moving from resting potential to action potential is all or none—it either happens or does not. Membranes cannot be half open or half closed, and there is no in-between state. A nerve stimulus will show several phases, beginning with a rising depolarization, causing a nerve impulse to occur. Then it proceeds to rebuild the charge (repolarization), even to the extent of hyperpolarization.

Besides action potentials, membranes require charge to open their channels. During this process, the electrical potential of the membrane rapidly rises, allowing the channels to open. As they do, ions flow into the cell, causing a further rise in the membrane potential, prompting even more channels to open. This process produces an exchange or movement of charge, another non-nerve form of electric current (and therefore resulting magnetic field) across the cell membrane, and the cycle continues. Once all channels are open, the membrane potential is so great that the polarity of the membrane reverses, and then the channels begin to close. As they do, exit channels are activated. Once the process is complete, all channels close and the membrane returns to its resting potential. This is an ebb and flow cycle of cell energy activity, and is the basis for all organisms being alive.

Charge potentials play different roles depending on cell type, but are generally responsible for cellular communication or to activate cellular processes. Muscle cells, for example, use charge potentials as the first step to achieving action potentials and therefore muscle contraction. Since all potentials are controlled by charge, they can be influenced by magnetic fields.

PART TWO: INTRODUCTION TO PEMF THERAPY

In many ways, PEMF therapy is not so different from electrical stimulation. The primary difference is that PEMF therapy *induces* currents *in* tissues, whereas electrical stimulation *applies* currents *to* tissues. Because PEMF therapy uses magnetic fields as the delivery mechanism for the stimulation (as opposed to an electrical current), it can generate charges much deeper in the body. And, it is safer and much more tolerable.

When we talk about pulsed magnetic fields increasing energy or charge in tissue, we refer to the generation of biologic electric fields by the interaction of the PEMF with the body's own natural charges.

Because PEMFs *induce* charge *in* tissues, the tissues can only produce as much charge as they are physically capable of doing. Tissues cannot be overcharged by PEMFs. On the other hand, electrostimulation can actually burn tissue because it uses externally applied electrical energy. This is, simply put, electrocution. It may be controlled or mild, but it is still electrocution. This is why PEMFs are generally safer than electrical stimulation, especially at higher strengths.

Magnetic fields affect charged particles, so all the elements or processes of the human body that rely on charge to function can be directly affected by magnetic fields. PEMFs have been found to enhance the function of cell membranes, helping to equalize the charges on either side and revitalizing the cell. This is especially true for the sodium/potassium and calcium/magnesium membrane channels. The inflows and outflows of calcium are particularly important in normalizing cell function. The most studied effects of PEMFs are on changing the sodium/potassium and magnesium/calcium ion channels. These actions of PEMFs on the calcium channels in particular appear to create most of the physiologic actions of PEMFs.

Before we get into more detailed information about PEMF therapy, we will briefly outline some of the most commonly used terms associated with the modality. Some of this may seem rudimentary and some of it is complex out of necessity, but all of it will come together in section 2 when we begin to discuss how and why PEMFs affect the body.

PEMF Terms and Descriptions

A huge range of factors goes into the engineering of a PEMF system. The more technical the literature you read, the wider the variety of terms you will encounter. Here we will address the terms that you are most likely to encounter when you read about PEMFs and PEMF systems.

Frequency

All of life is oscillating or in vibration. Light is a vibration. Color is a vibration. Sound is a vibration. Oscillations or vibrations, commonly used terms, are actually frequencies.

Frequency is measured in Hertz (Hz). It is literally referring to how *frequently* (per second) a signal cycle is repeated. A cycle is measured from crest to crest of a single wave. See Figure 1.2.

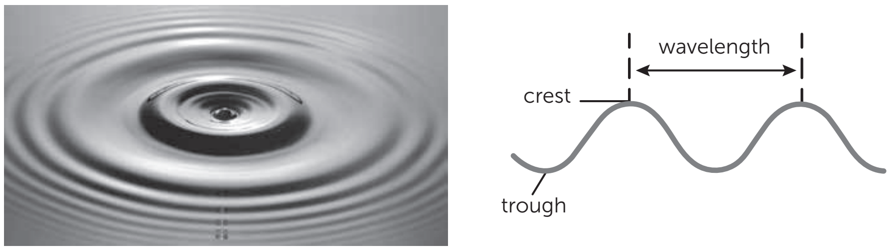

Figure 1.2. Wavelength cycle

One Hertz (1 Hz) is one cycle per second. One hundred Hertz (100 Hz) is one hundred cycles per second. Hertz can also be prefixed, with commonly used multiples being kHz (kilohertz or 10^3 Hz), MHZ (megahertz or 10^6 Hz) and GHz (gigahertz or 10^9 Hz). Most PEMF systems used for health are of extremely low frequency (ELF), that is, typically less than 10,000 Hz or 10 kHz. In fact, the vast majority are under 1 kHz.

Magnetic field systems can produce individual frequencies or combinations of different frequencies. Some devices produce ranges of frequencies, such as 1 – 5 Hz. In other words, the device would provide stimulation at each frequency of 1 through 5 Hz. This is called a frequency sweep.

Every cell has its own frequency and a number of cells with the same frequency create a new frequency, in harmony with the original, in turn forming an organ that also creates a new frequency in harmony with the two preceding ones. Similarly, every atom has a frequency. All the atoms that form a molecule have their own frequency. Molecules then form tissues, which then form organs, and so on up to the whole body.

Somewhat surprisingly, the body produces its own frequency emissions ranging from the Schumann resonances through much of the electromagnetic spectrum (Figure 1.3), including radio waves, microwaves, light, UV, and x-rays.

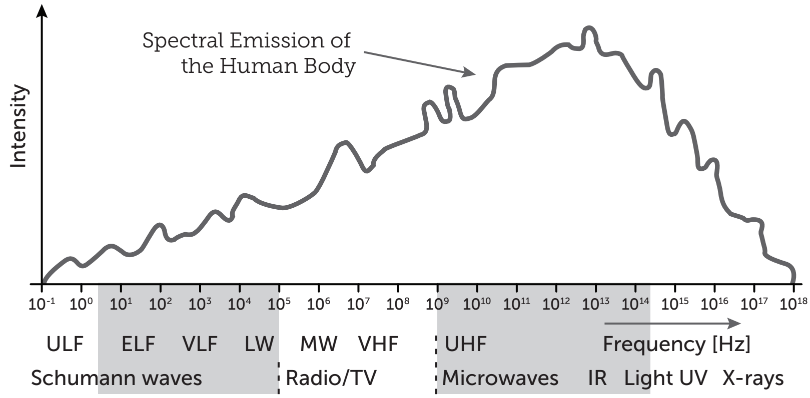

Figure 1.3. Frequency emissions from the human body.
Higher frequencies have higher energy intensity.
From: http://www.faim.org/measurement-of-the-human-biofield-and-other-energetic-instruments

Whether or to what extent these are all produced by the body or simply passing through is not completely known. Nevertheless, the body is itself dealing with a vast array of EMF frequencies. Motions of the muscles of the body, conduction of nerves, the beating of the heart, breathing, and the flow of blood in blood vessels, are all adding additional EMFs to the body due to the charge generated by their activity.

Modulation

Modulation is the manipulation of frequencies into "packets" that themselves create a secondary frequency. Individual frequencies are bundled together, with built-in pauses between bundles. The repetition rate of the bundles provides a secondary "frequency" to the stimulation. Many higher frequency PEMF systems use modulation because of the increased ability to penetrate tissues.

Wavelength

Wavelength refers to the length of the wave itself. This is based on the distance over which the shape of the wave is repeated. See Fig 1.2. This is an important aspect of understanding frequencies in healing magnetic field therapy. The higher the frequency, the shorter the wavelength. Most healing magnetic fields have very long wavelengths. Frequencies under 10 MHz are longer than six feet. The goal for any PEMF frequency is to be able to completely pass through the body, whether it's the length of the body, the width side to side, or front to back. A magnetic frequency wave of 20 Hz is about 9000 miles long. So, again, most healing PEMFs have sufficiently long wavelengths to completely penetrate the entire body.

Waveform

A waveform is the actual physical shape of the wave itself. A huge variety of waveforms exists in nature, in the body, and in PEMF devices. The most common are sinus, saw tooth, and square, though there are rectangular, impulse, triangular, and many others. See Figure 1.4 for illustrations of these waveforms.

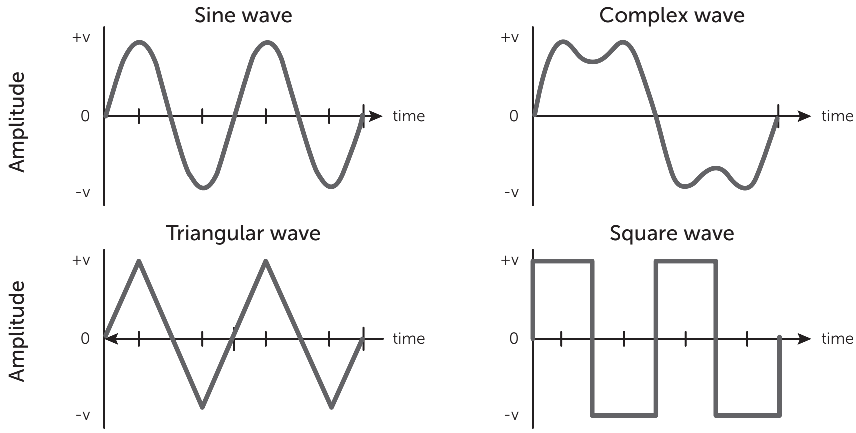

Figure 1.4. Waveforms

In fact, though a square shape may be desired, it's not technically possible to achieve. Square wave signals are actually trapezoidal. The front edge of the signal cannot go straight up as would happen in the depiction of the square wave in Figure 1.4. Instead, it has an angle because it takes time to go from baseline to the top, even if that time is in microseconds. Then there's a period where it is flat or neutral, followed by a decline, which also, from an engineering perspective, has to be angled. Some of the strongest magnetic fields with frequency based healing magnetic field devices have been found with these trapezoid shaped waveforms. When you see the term square wave used to describe a PEMF waveform, know that it is actually a trapezoidal wave.

Therapeutically speaking, what matters most is the amount of time it takes for the wave to reach its peak from the baseline on the front edge of the waveform. This is represented as dB/dT. This means the change (d) in intensity (B) divided by the change (d) in time (T). T is usually measured in milliseconds. As B gets bigger and/or T gets smaller, the total number gets bigger. The bigger the dB/dT, the greater the energy production in the tissues being stimulated. Given the right engineering, this can be maximized with most waveforms. However, dB/dT varies widely among systems and it is rare to get this number from a manufacturer.

From a clinical perspective, all waveforms can produce good results. There is no gold standard or perfect waveform for magnetic field therapy.

It's likely that dB/dT, and therefore magnetic field intensity, is the more important factor for the therapeutic use of PEMFs.

Intensity

Intensity is measured in gauss (G) or Tesla (T). For our purposes, intensity is a measurement of the strength or power of a magnetic field. It's actually more scientifically accurate to use the terms "flux density" or "magnetic induction" when dealing with magnetic fields, but the nonscientific community uses the word intensity when referring to those concepts. Though gauss can be prefixed, it is uncommon. Tesla is often prefixed, with commonly used multiples being μT (microTesla or 10^{-6} T) and mT (milliTesla or 10^{-3} T).

Helpful conversions:
Tesla terms: 1 Tesla = 10,000 gauss or 1 gauss = 0.0001 Tesla
MilliTesla terms: 1 mT (milliTesla) = 10 gauss or 1 gauss = 0.1 mT (milliTesla)
MicroTesla terms: 1 μT (microTesla) = 0.01 gauss or 1 gauss = 100 μT (microTesla)
PicoTesla terms: 1 pT (picoTesla) = 1,000,000 μT (microTesla)

› Inverse Square Rule

The Inverse Square Rule is a basic law of physics that refers to the intensity (in this case, of a magnetic field) being inversely proportional to the square of the distance from the source of the field. Put simply, the intensity of an electromagnetic field decreases rapidly as you move away from its source. This is true regardless of the waveform or wavelength of the electromagnetic field, whether it's color, light, sound, radiation, or heat. All decrease in intensity as you move away from the source of the signal. The degree of reduction is based on the inverse square rule.

Figures 1.5 and 1.6 (below) represent this rule.

In Figure 1.5, the intensity of the magnetic field is represented on the vertical axis and measured in mT, ranging from 1 mT (10 gauss) to 100 mT (1,000 gauss). The distance from the surface of the applicator is represented on the horizontal axis and measured in centimeters, from 1 cm to 13 cm. This figure shows that at about 8 cm away from the applicator, all the magnetic field intensities are at or below 1 mT (10 gauss).

In Figure 1.6, at 6 cm away from the applicator, a 100 mT (1,000 gauss) magnetic field has dropped to around 2 mT (20 gauss). This is a 98% drop in the intensity of the magnetic field in this short distance. This same ratio of decrease in intensity applies to all of the different magnetic field strengths in the graphic, extending from 1–100 mT.

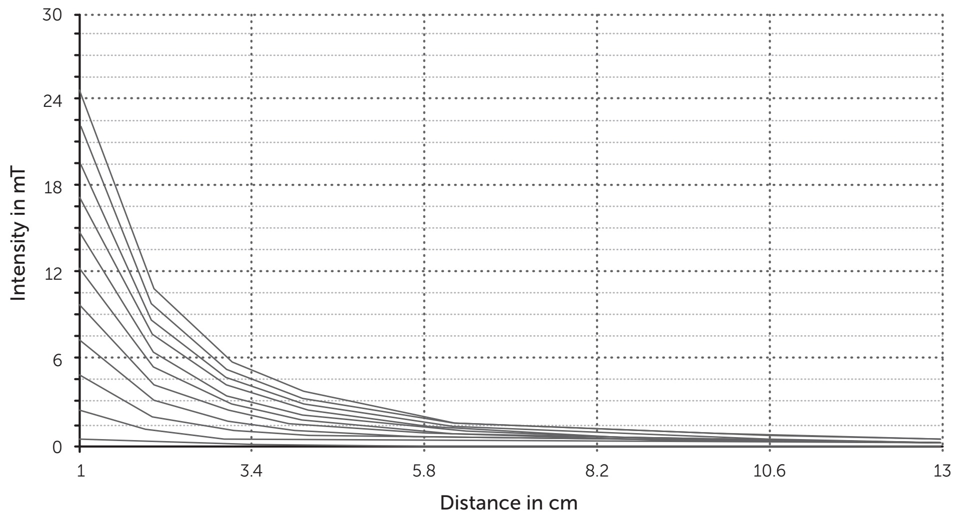

Figure 1.5. Magnetic field intensities versus distance for PEMFs from 1 -100 mT starting at 1 cm away from the applicator (about ½ inch) with intensities from 1 mT (lowest curved line) to 100 mT (topmost curved line).

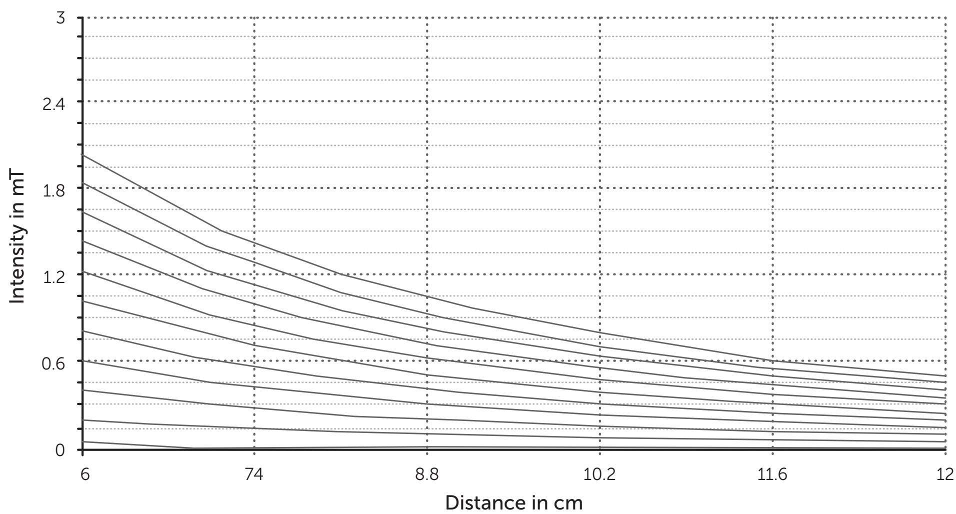

Figure 1.6. Magnetic field intensities versus distance for PEMFs from 1 -100 mT starting at 6 cm away from the applicator (about 2½ inch) with intensities from 1 mT (lowest curved line) to 100 mT (topmost curved line).

The deeper into the body a magnetic field has to go, the greater the reduction in the initial magnetic field intensity will be. This is purely a matter of the characteristics of an electromagnetic field. It does not mean that the field is being consumed or used up by the body. From a practical perspective, it simply means that there is progressively less energy from the PEMF signal available to generate charge as it moves deeper through the body.

If you start with a low intensity magnetic field at the surface of an applicator, then you will end up with an *extremely* low intensity magnetic field on the other side of the body. This is one of the primary reasons why I emphasize maximum magnetic field intensity so much when it comes to healing the body. How well a PEMF works in the body at its minimum intensity will be a matter of debate.

This table describes the intensity of a 100 µT (microTesla) or 1 gauss (0.1 mT) PEMF up to 5 inches or 13 cm away (or into the body) from the surface of the applicator.

Distance		Intensity	
Inches	cm	mT	µT
0	0	0.1	100
0.5	1	0.025	25
1	3	0.0063	6.2
2	5	0.0028	2.8
3	8	0.0012	1.2
4	11	0.0007	0.7
5	13	0.0005	0.5

At 5 inches or 13 cm away from the applicator, there is little magnetic field left. In terms of the Faraday Law (dB/dT), this means the magnetic field is creating almost no charge in the tissues at that point. Lying on your back on a comparable (1 gauss) whole-body magnetic system, then, will produce virtually no magnetic field in the front of the body. Even less so if a body is 10 inches or 23 cm thick.

Research evidence continually and consistently shows that the intensity of a therapeutic magnetic field is important, perhaps more so than any other component[331]. Even the other components of a magnetic field, such as frequency or waveform, rely on the intensity of the PEMF signal at the tissue being stimulated. The field intensity at the target tissue needs to be sufficient to induce charge in that tissue. The lower the magnetic field intensity, the less charge will be induced in the tissue. So, at deeper levels in the body the field intensities will be very low, requiring a higher initial field intensity to produce adequate results. Field intensities may be equated to whispers (low intensity) or shouts (high intensity). Sometimes a whisper is all that is needed for a generally healthy body or mild problem. Often, the body needs to hear "loud shouting" for the job to be done. This is the wakeup call. The rest of the time, a normal conversational loudness will produce the desired results. There is little evidence to support the effectiveness of weaker "whisper" PEMFs acting deep in the body.

If you are lying on an applicator with the goal being whole-body stimulation, then the magnetic field has to be of sufficient intensity to penetrate through to the opposite side of the body. The effects in the body, however, depend on the strength of the generated healing magnetic fields.

› Dosimetry or the "dose" of the magnetic field

Dosimetry is the calculation and evaluation of the dose required by the human body to provide adequate treatment. Originally, the concept of dosimetry was derived from determining the right intensity of ionizing radiation to use in the treatment of various conditions, particularly cancer. PEMF therapy is non-ionizing radiation, but the concepts are equivalent mathematically. In our context, dosimetry looks at the intensity (or dose) of the magnetic field produced by a PEMF system at the tissue (as opposed to the intensity of the magnetic field at the surface of the applicator). We know from the inverse square rule that a magnetic field drops off in intensity depending on the distance the target tissue is away from the source of the signal. In determining the necessary level of intensity, the primary concern is the target tissue, with deeper tissues requiring higher initial intensities to account for this drop-off.

A magnetic field creates a chain of effects in the body and a lot has to happen in the body to get from the initial treatment to a physical response. This is called the clinical dosimetry model, shown in Figure 1.7.

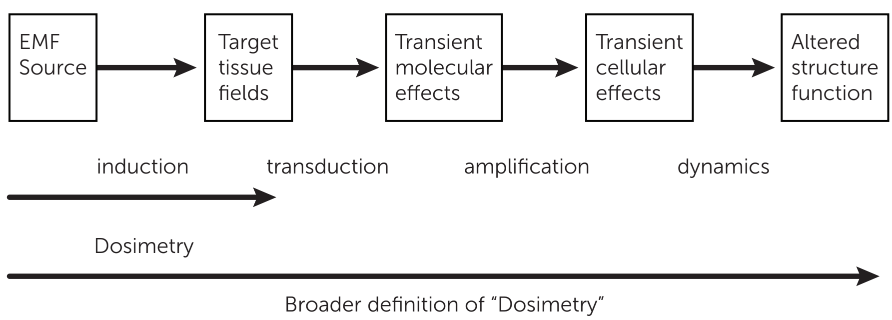

Figure 1.7. Clinical dosimetry Model

From : Bowman J. RF exposures to the general public: lessons from "dosimetry" for ELF – EMF epidemiology. Joint NIOSH/DOE Workshop. EMF exposure assessment and epidemiology: hypotheses, metrics, and measurements. Cincinnati Ohio, September 1994.

The PEMF is applied to the body, creating induction of charge or energy in the target tissues (whether that is a small area of stimulation or a larger area to include one or more organs or even the entire body simultaneously). Any electric fields induced in the tissues are "transduced" by various molecules in the exposed tissues to varying degrees to create molecular effects such as mobilization of calcium ions. Often these molecular effects are transient once the magnetic field is removed and the currents extinguish. Once these molecular effects are in motion, they may be "amplified" by various mechanisms in the target tissue to produce cellular changes.

Amplification can happen through resonance or by the body using the signal and sending it upstream with greater intensity. An example of amplification is illustrated by gently touching a finger to a tabletop. The brain and the sensory nervous system have to amplify this tiny initial touch signal by stimulating more neurons along the peripheral nerves to the spinal cord all the way to the brain. In order for the brain to perceive this touch, the signal needs to be "amplified" all the way to the brain. This amplification allows many more molecules or tissues to be impacted by the original stimulation. This is why even treating only the foot with a PEMF has effects on the rest of the body.

Ultimately, amplification, starting with initial stimulation, leads to physical changes in the tissues. This process may be imagined like water flowing down the hill and getting backed up by a bunch of twigs. A small tap to the twigs causes them to break up and the water then continues to flow freely. Imbalances in the body, which lead to disorders or disease, may be like the twigs blocking the natural flows of energy in the tissues. PEMFs unblock these natural flows, like a gentle tap, allowing the tissues to return to a normal state.

Determining dosage with PEMFs is complex, but it is at least made easier knowing that the body does not hinder the magnetic field. Magnetic field intensity measurements taken at varying distances from the PEMF applicator in free space is essentially equivalent to those found at similar depths in the body.

Coil Configuration

Coil configuration determines the amount and direction of a magnetic field presented to the body. The configuration of the wiring in an applicator determines the size, shape, and configuration of the PEMF fields produced. In the diagram below are several examples of coil configurations with depictions of the magnetic fields they would produce. The coil configurations from most PEMF applicators are relatively simple and are more like those of the ring depicted on the left. See Figure 1.8.

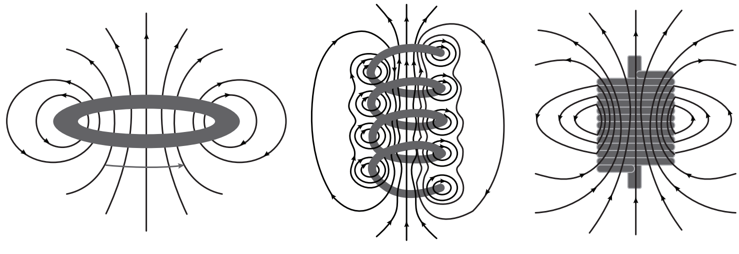

Figure 1.8. Coil current configurations determine magnetic field configurations. Thicker lines are coil current flows and the thin lines are the magnetic fields. The thin lines follow the right-hand rule (see appendix).

Most of the actions of a PEMF system on the body happen when the magnetic field line is perpendicular to the target cells or tissue. Therefore, understanding the relative configuration of the magnetic fields in the PEMF system is important. Below are two examples of commercial PEMF systems. One (Figure 1.9) is a barrel-type system, with the person lying parallel to most of the magnetic field lines.

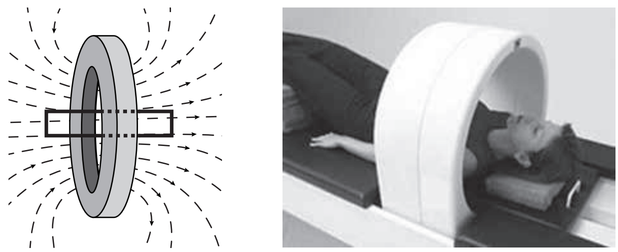

Figure 1.9. Barrel type PEMF system, common in Europe.

The next is an example of a typical whole-body mat (see Figure 1.10).

Figure 1.10. Flat mattress, multi-coil type system.

In this last case, there are many orientations of the field lines because of the multiple coils involved. As a result, it is likely that there are many more tissues having perpendicular field line exposure. A cell membrane perpendicular to a magnetic field line produces the greatest amount of charge when it interacts with the magnetic field. Results from treatment with Figure 1.9 and Figure 1.10 systems are likely different. The coil configuration in the Figure 1.9 system may get better results with body cavity treatments, such as the abdomen or lungs. The system in Figure 1.10 may well be better for longitudinally aligned structures such as the skeleton and extremities. Neither of these configurations is expected to be absolutely better than the other, since tissues and cells have multiple orientations.

Related Concepts

The collection of PEMF terms described above will all be referenced to some degree throughout the rest of this book. In particular, frequency and intensity are factors that all subsequent research will mention. Beyond these basic terms, a handful of concepts are important to further your understanding of how magnetic fields work in the body. Before we present the research on the basic biologic actions of PEMFs (in section 2) and the condition-specific clinical research (in section 3), we will cover these concepts. They include transparency, resonance, and brainwave entrainment.

Transparency

The body is completely transparent to pulsed electromagnetic fields. Low frequency PEMFs go into and through the body without being blocked, slowed down, or used up. All tissues in the body are equally transparent to a PEMF. There is no difference between muscle, bone, brain, blood vessels, or solid organs. PEMFs go through the air and fluids of the body equally. PEMFs affect the body but not the other way around. As the PEMFs pass through the body they stimulate all the components of the body to the degree the different components can interact with the PEMF. The stronger the PEMF, according to Faraday's law, the stronger the effects are in the body, based on the amount of induced charge. PEMFs lose intensity as they pass through the body, not because of their interaction with the body but because of the basic nature of electromagnetic fields. Therefore, the magnetic field intensity next to the magnetic field applicator will be higher than eight or twelve inches away. See the topic above on the inverse square law.

However, very high frequency PEMFs (at or above about 1 MHz) do not pass all the way through the body because of their wavelengths. Because of the high frequency and short wavelengths, they are actually absorbed by the body and can cause tissue heating. Magnetic fields below 1 MHz are not absorbed by the body and do not cause heating or destruction of tissue. Most PEMF systems used for therapeutic purposes are significantly below the 1 MHz level of frequency. That means these extremely low frequency (ELF) PEMFs pass completely through the body without absorption to create their "power tool" stimulation effects for healing.

Resonance

Resonance originates from the field of acoustics, particularly observed in musical instruments. In physics, resonance describes the phenomenon of a vibrating system or external force that drives another system to move, shake, or oscillate at a specific preferred frequency.

Resonance occurs with all types of vibrations or waves: there is mechanical resonance, acoustic resonance, electromagnetic resonance, nuclear magnetic resonance (NMR), and electron spin resonance (ESR). Resonant systems can be used to generate vibrations of a specific frequency (e.g., musical instruments), or pick out specific frequencies from a complex vibration containing many frequencies (e.g., filters). At resonant frequencies, like voices or instruments in tune with each other, small driving forces have the ability to produce larger resonant wave oscillations.

Since all of the tissues of the body, particularly the brain, have their own frequencies and are flexible to varying degrees, outside frequencies applied to the body can cause or "tune" the body's frequencies to be synchronized with the externally applied frequencies. So, a small amount of PEMF energy that is resonant with the molecules or cells of the body produces a much stronger response than when there is no resonance.

The practical application of resonance in healing magnetic fields, particularly in neurology, is called entrainment.

Entrainment

Entrainment refers to the synchronization (resonance) of an existing frequency (such as the brain in a specific brainwave state) to an external frequency stimulus (such as one provided by a PEMF device). Entrainment is a concept first identified by the Dutch physicist Christiaan Huygens in 1665, who discovered the phenomenon during an experiment with pendulum clocks. He set them each in motion and found that when he returned the next day, the sway of their pendulums had all synchronized.

Although there are many types of entrainment, for our purposes we refer primarily to neural or brainwave entrainment. Any stable frequency presented to the body, especially the brain, evokes a brain response. The brain synchronizes its own natural dominant brainwave frequency with that of the external stimulus. This is called brainwave entrainment. This concept is discussed in detail (and with a variety of focuses) in the classic book *Mega Brain* and its follow-up, *Mega Brain Power*, by Michael Hutchison. There are a number of research studies of PEMFs being used to produce brainwave entrainment, but they are beyond the scope of this book.

When an electromagnetic field is presented to the body, the pulses elicit the brain's "frequency following" response, encouraging the brainwaves to align or resonate to the frequency of a given beat. This "frequency following" response of brainwave entrainment can be seen in action with those prone to epilepsy. If a strobe flashes at their seizure frequency, the brain will "entrain" to the flashing light resulting in a seizure. This technique is commonly used in clinical neurology when EEGs are being performed to investigate seizure disorders.

On the positive side, this same mechanism is commonly used to induce many different brainwave states, such as a trance, for enhanced focus, relaxation, meditation, or sleep induction. The brainwave entrainment effectively pushes most of the brain or the entire brain into a certain goal resonant state.

The brain does not operate in just one single frequency; the full spectrum of brainwave frequencies is always running. The dominant frequency determines our mental state, and entrainment temporarily shifts it by boosting one frequency to be louder than the others or by increasing the frequency being stimulated to the extent desired.

SUMMARY

In this section, we saw that magnetic fields in some form have been around since ancient times. As a result of early work, the twentieth and twenty-first centuries have exploded with the potential application of PEMFs for health. We have moved from a strictly chemistry-based concept of the human body, largely fostered by chemists, pharmacologists, and the pharmaceutical industry, and the educational system associated with them, to a more general concept of an electrical and electromagnetic body.

Humans are inseparable from their environments. The earth is one huge magnet, in a sea of magnetic fields, particularly from our nearest high intensity magnetic neighbor, the sun. All biologic structures on the planet have evolved over the eons in this electromagnetic cocoon. Our health and well-being depend on a well-balanced electromagnetic system, both within and outside the body.

Magnetic fields are something of a mystery to the general population and there is a huge variety of concepts present in the whole of magnetic science. Ultimately, you will see that all of these concepts are woven together. This ranges from how wires conducting current produce magnetic fields, the terms used to describe these fields, how these magnetic fields interact with the body to produce energy (charge), how this energy interacts with tissues through resonance and entrainment, and how they depend on the transparency of the body to pulsed magnetic fields. These PEMFs interact with the body's own magnetic fields to produce charge and affect the molecular functions of the tissues.

Treating the body at a chemical level will typically only help at that level or below. However, treating the body at an electromagnetic level will affect the entire body, not only at the electromagnetic level but ultimately into the chemical and tissue levels.

SECTION TWO
How PEMFs Affect the Body

In the first section, we discussed the history of magnetic field therapy, explored how humans evolved in magnetic fields, described our bodies' internal magnetic fields, provided a basic understanding of magnetic science, and defined the elements that go into a therapeutic PEMF system. This section will focus on the basic actions PEMFs have on the body.

Because therapeutic magnetic fields work on such basic level functions in the body, it's best to first have an understanding of their biologic effects before we discuss specific diseases, conditions, and health states. If you understand the basic areas of impact, then you can begin to see the breadth of the possibilities for improving your health with PEMFs. This is why they are called power tools for health.

CLINICAL RATIONALE

Since magnetic fields operate at basic levels in the functions of the body regardless of body and organ systems, they can be used for almost any health condition. All tissues and organs require proper blood circulation, instructions from the nervous system, production of energy, transfer of nutrients, elimination of waste, toxins, and dead cells, reduction of inflammation, defense through the immune system, repair and regeneration, need for mobility, operation of the senses, production and use of hormones, and protection from the environment. PEMFs affect most of these basic functions. Each of these functions affects every cell and tissue in the body to some degree. Whenever we are treating individual health conditions or attempting to improve the overall function of organs, PEMFs work through these basic actions to achieve health benefits.

We have been educated to think in Western society that the focus should be on treating disease. Because of the focus of the FDA and the pharmaceutical industry, we have come to believe that disease is a drug deficiency. That is, every disease has a unique treatment—a pill for every disease. That concept grew out of the era of infections and antibiotics. If you have a staph infection, take an antibiotic. If you break a bone, put a cast on it. However, most disease or injury is not that simple. In fact, in both of these examples, the body would heal itself much better and faster if it were given additional support to speed and improve the healing process.

We need to correct the functions of the body that became disordered and resulted in the disease or injury and to support the body's own ability to heal itself. Every cell in the body is "intelligent" per the seminal book *The Biology of Belief* (Dr. Bruce Lipton). Every cell "knows" exactly what to do to make itself healthy and functional, but they can do their best and still come up short, needing extra energy to finish their job. Supporting the body's own natural capacity for healing is paramount to achieving good or optimal health and recovering from health problems.

There are few true cures in medicine, but there is always some amount or degree of help to be provided. PEMFs help the body in many different ways, (which we will cover in this and the next section) and complement many other health approaches. They can help people to get closer to what could be considered a cure or more complete healing and recover or improve significant levels of function. PEMFs can do this safely, without the toxicity of drugs, medicines, or invasive procedures, conveniently, under your own control, and for relatively low cost.

Your dependence on the conventional medical system could be significantly less. In fact, in cooperation with other supportive measures not recognized by the conventional medical system, this decreased dependence usually results in even better than "normal" health.

Levels of Disease

Problems in the body have degrees of involvement and different tissues are involved in different injuries. In integrative medicine, it is understood and accepted that disease and healing take place at various levels—energetic, physiologic, pathophysiologic, and pathologic. The level at which a disease or injury is present will determine how much regeneration or healing can take place. Problems in the energetic level can be fixed quickly and with little extra cellular energy. Healing at an energetic level requires mostly mindfulness and support. Physiologic problems may take days to improve, and require more cellular energy. The healing process must be more deliberate and focused. Problems with a degree of pathology require absolute intervention.

We can easily illustrate this point by looking at the common cold. When you are first coming down with a cold, you may feel vaguely unwell—you have some brain fog, are slower to get moving, and feel more tired than normal. This is the energetic level. Next, the cold becomes apparent and you have a stuffy or runny nose, your ears feel plugged up, and you may be easily winded. This is the physiologic level. If the cold moves into your chest unresolved, it may turn into bronchitis. You may get an ear infection or sore throat. This is pathophysiologic. If the disease state continues, you may need to be hospitalized for pneumonia, have trouble breathing, or become severely dehydrated. This is the pathologic level.

Of course, not all diseases or injuries move so deliberately from energetic to pathologic. If you slip on ice and break your arm, you've gone from healthy to pathologic in a mere second or two. It may seem in that moment that we are not at all in control of our bodies, but just as there are levels of disease, there are levels of prevention and healing. The levels of prevention are simple: primary, where we aim to prevent a disease or injury before it happens; secondary, where we aim to reduce the impact of a disease or injury that has already happened; and tertiary, where we aim to lessen the burden of an ongoing disease or injury. The levels of healing are much more complex.

Daily use of PEMF is simple primary prevention. It results in constant energetic healing. You may be able to stop that cold from moving beyond the energetic level. If not, then more directed PEMF treatments could work to arrest the disease state at the physiologic level. If there is a level of pathology involved, then likely, a condition has become chronic. Here, PEMFs can both assist with the management of the symptoms, as well as work to reverse the disease state itself. If the illness or injury has reached the pathologic level, PEMFs will still support the body through its healing process, and help to prevent complications or other diseases from progressing simultaneously.

Illness is rarely, if ever, an instantaneous occurrence, and the same is true of healing. Levels of healing often work in the reverse of the levels of disease. You will not, for example, go from pneumonia to runny nose in one day or with one PEMF treatment. In healing (and in life), there is no substitute for time. The more you have invested in prevention, the shorter your healing time will be and the less likely you are to have a condition progress from acute to chronic.

You may not be able to stop yourself from falling on ice or breaking a bone, but primary prevention can help ensure that tissues are as healthy as possible so that in the event of an acute injury, cells are more capable of gearing up for regeneration quickly. The ongoing primary prevention results in stronger tissues that make a clean break as opposed to a jagged one, or are less likely to be easily complicated by infection, as examples. This will translate into shorter recovery times and faster progression through the levels of healing.

When attempting to heal various tissues of the body, or recover and improve their function, the healing ability of the particular tissue has to be considered. I have heard it said that the body is renewed every seven years. This is belied by the fact that all the tissues in the body have their own cycles of natural renewal. Different tissues have different timelines for recovery, given the unique capacity for regeneration of each type of tissue. Corneal cells of the eyes can recover from an injury in as little as twenty-four hours. Gut cells in the intestine can recover within three days. Skin and muscle can regenerate, recover, or heal in one to two weeks. Bone, on the other hand, can take years to heal fully. Ligaments, tendons, and nerves (which have poor blood supply) are extremely slow to recover, if they are ever able to at all. Even given these standard healing timelines, the level of pathology of the disease state is important to consider. The deeper and longer the pathologic process has been present, the longer it will take to recover. In any injury, multiple tissues will be involved, each with a different healing timeline. This complicates the healing process and allows some aspects of the injury to heal faster than others.

Though PEMF therapy can significantly improve the rate of healing and optimize the cell environment making it conducive to recovery, we cannot push a tissue to regenerate beyond its innate capacity. Treatments directed at problems in the energetic level produce dramatic, rapid results. For physiologic-level problems, treatments are more likely to produce noticeable responses after several days. Once there is a degree of pathology involved, the effects of treatments take longer to notice. If a disease state has reached the fully pathologic level, treatment outcomes are unpredictable.

For tissues that do not have the capacity for regeneration, or for health problems that cannot be corrected with PEMF therapy alone, magnetic field therapy is still valuable in reducing pain and swelling, improving circulation, and stimulating whatever regeneration may be possible.

The body has its own wisdom and will respond to treatment in ways that make the most sense to it. We must respect these layers of healing and work positively with them. Patience and acceptance of this natural order will only aid in the healing process.

BASIC BIOLOGIC EFFECTS OF PEMFS

Most of the effects of PEMFs on various disease conditions are mediated through the basic actions of magnetic fields (and electrical charge) on biology. All cellular communication requires an electrical signal, which triggers the release of chemicals. In turn, these chemical reactions cause a change in the neighboring cell. The chain of electrical signal actions continues rapidly until the cell's function has been completed. PEMFs enhance and support this charge activity when it is out of balance so that cells can function more efficiently, but only when they need extra help. A number of studies, discussed below, have shown that appropriate therapeutic PEMFs only affect or improve systems that are compromised, not affecting normal or healthy systems or tissues.

The benefits of this type of electrical charge support are both big and small. From the tiniest molecule or enzyme up to the largest organ system (skin), you can find a process PEMFs either streamline, correct, improve, or don't affect. Therefore, PEMFs have the potential to positively affect an extremely broad range of physiologic and biologic actions. Any negative or non-reaction effects PEMFs have on these processes are usually self-limited and do not result in any significant problems. Cautions, precautions, and contraindications are discussed in section 5.

In general, PEMF therapy is considered extraordinarily safe when used appropriately. It should also be mentioned that there are many gaps in our knowledge about the actions PEMFs have in the body. This is primarily because of funding limitations for this type of research.

PEMFs operate primarily at a physical level, secondarily affecting the body's chemistry. Because of the relationship between magnetic fields and charge, PEMFs are able to have some effect on any molecule in the body that carries a charge. This section will cover some of the basic better-understood actions of PEMFs on cellular processes and organ systems and other approaches to healing the body. We have provided evidence with references for each of these basic actions of PEMFs in keeping with our goal of validating the science behind the technology. This section does not cover individual health conditions (see section 3).

Acupuncture Stimulation

There are tens of thousands of scientific articles about the biologic actions and clinical benefits of acupuncture. In this book, I only cite those of relevance to a discussion about the crossover value of acupuncture and PEMFs.

Many people are uncomfortable with the idea of needles, making PEMF stimulation an excellent alternative to traditional acupuncture. Acupuncture points have electrical characteristics, which means they are susceptible to both electrical and magnetic stimulation [359]. The primary mechanism is that of Qi (or Chi), also called energy flow, with the meridians being the paths that this energy flows through. Acupuncture points lie along the meridians, and have shown corresponding electrical conductivity [500]. Stimulating these acupuncture points with PEMFs can improve the flow of charge, clearing out any blockages.

PEMFs, using the appropriate applicators, can be targeted directly at specific acupuncture points. At the same time as stimulating an acupuncture point, all the tissues in the area of the magnetic field will be affected as well, providing a dual benefit. Acupuncture point stimulation is a more indirect approach to balancing and healing the body. It is not usually a direct cellular approach. If a PEMF is used for other tissue or organ stimulation purposes, any acupuncture points or meridians in the magnetic field will also be stimulated. This will be true whether the stimulation is local or whole body. In other words, when whole-body magnetic field therapy is used, all the acupuncture points and meridians in the body will be stimulated at the same time, creating a simultaneous rebalancing of the meridian system. This creates a major secondary benefit of PEMFs over acupuncture alone. In fact, I know of acupuncturists who combine PEMFs with their acupuncture and claim that their results are even better than usual. There is research to support an improvement in benefit of PEMFs over acupuncture stimulation for muscle recovery after exercise [205].

A direct comparison was done between acupuncture application and PEMFs. A strong experimental study compared the effect on the automatic nervous system of manual acupuncture, laser acupuncture, and PEMF stimulation of a specific acupuncture point. A 15 mm (5/8 inch) diameter PEMF coil of 2 Hz, 460 gauss (46 mT) applied for 20-25 minutes was equal to manual acupuncture at the BL15 acupuncture point in the amount of activation of the parasympathetic nervous system (PNS). PNS stimulation decreases the work of the heart and slows down the heart rate. Laser acupuncture was actually found to activate the sympathetic or stimulatory part of the autonomic nervous system, increasing the work of the heart. This particular acupuncture point has been found to be effective in treating people with coronary heart disease and acute cardiac ischemia. This is one of the only studies I have seen comparing these different methods of treatment directly. It validates the idea that PEMFs can provide similar stimulation to acupuncture points as manual acupuncture [227].

Since there are so many acupuncture points in the body, almost any PEMF stimulation will include acupuncture points and meridians in the magnetic field. Therefore, PEMFs provide the advantage of doing both acupuncture-type stimulation simultaneously with direct cellular stimulation.

Antibacterial, Antifungal, and Antiviral Actions

When doctors want to verify what type of bacteria they are dealing with, they grow them in test tubes or Petri dishes. They expose the bacteria to different antibiotics to find the best drug for each type. This is a standard laboratory test and guides the antibiotic recommendations doctors make. This process has been replicated with PEMFs in place of antibiotics to determine what effects magnetic fields may have on bacterial infections.

The most commonly studied organisms are Candida albicans (yeast infection), Escherichia coli (E.coli), Bacillus subtilis (hay bacillus), Staphylococcus (a normal bacteria that can turn pathogenic in hospitals), Pseudomonas aeruginosa, and Halobacterium halobium inocula or spores.

A wide range of frequencies and intensities has been studied. Bacterial growth inhibition was present in each culture, but was much more dramatic with higher intensity magnetic fields, with effects becoming evident within ten hours after the initial exposure. Longer continuous exposure times (six hours, for example) yielded better results[38]. Studied microorganisms were not killed outright by the magnetic fields, although there was some killing action [438]. The same is true for many antibiotics and antivirals, which only inhibit growth but don't actually kill the organisms. In this sense, PEMFs act like some antibiotics.

Most antibacterial research with PEMFs was conducted in laboratory settings as opposed to in living hosts. A living being employs numerous mechanisms to control growth of bacteria and therefore infection. While this research indicates that appropriate strength magnetic fields slow down the growth of bacteria, the process of controlling infection in a body would be helped even more with appropriate PEMFs designed to stimulate the defense mechanisms of the tissues and bacteria killing cells of the host. Combined use of these two approaches would help to heal infections much more rapidly, without risk to the host [293].

In addition to hindering bacterial growth, research also shows that PEMF exposure improves the function of cells that kill bacteria (phagocytes). One type of phagocyte, the monocyte, had higher levels of stress proteins, leading it to become a better bacterial hunter [4]. Magnetic field stimulation has also been shown to improve the function of the specific type of white blood cell that traps bacteria (neutrophils). These neutrophils create neutrophil extracellular traps (NETs), which act like spider webs to bind pathogens. Studies confirm that the formation of NETs is enhanced by PEMFs and improves the innate immune system [141]. This is yet another example of how PEMFs deal with infections in a number of different ways, even if they don't kill bacteria, viruses, or fungal infections directly.

Blood cell investigations were done to evaluate the ability of the body to engulf (phagocytosis of) yeast cells. Even the first treatment with PEMF enhanced phagocytic activity. Repeated PEMF treatments reduced this activity, probably due to partial exhaustion of the functional capacity of the phagocytic system. PEMF increased the size of granulocytes after twenty treatments [290].

These results confirm that PEMFs affect bacterial growth and the response of the immune system to bacterial challenges, suggesting that PEMFs could be used to help the management of infections. The combination of PEMFs and antibiotics could result in even shorter treatment or exposure times with antibiotics alone [4].

Bacteria infecting the body often leave behind fragments as they break down. These fragments can lead to chronic inflammatory reactions, such as happens in rheumatoid arthritis.

PEMFs have been found to significantly reduce the inflammation caused by these bacterial components and help those tissues to heal and recover [218].

Just as with some bacteria, viruses can also cause chronic inflammation of joints and create inflammatory arthritis. A PEMF applied to herpes virus infected cells did not affect the growth and viability of the cells. However, the viruses developing under PEMF exposure had mainly defective viral particles. This would therefore give the PEMF an opportunity to heal the tissue, while potentially rendering the virus less active [338].

The biological effects of sound frequency magnetic fields (SFMFs) were studied in various cell and virus lines, as well as in a "virus-cell" interaction model. The study employed cell cultures and erythrocytes and viruses of the Western Nile fever, influenza A, paragrippe III, herpes, hepatitis A, and others. The activity of anti-virus defense systems in the cell lines employed was judged from suppression of virus replication in SFMF-treated infected cell samples. The SFMFs studied ranged from 50 Hz - 100 kHz and from 0.1 - 500 μT.

They concluded the following: (1) SFMFs decrease the surface charge of cells, enhance their agglutination properties, increase aggregation capability and cellular resistivity, and decrease the phagocytic index of neutrophils. (2) Exposure of infected cell cultures to SFMF completely suppresses reproduction of the Western Nile virus, paragrippe virus, and hemorrhagic fever virus, and inactivates their ability to infect cells. These effects depend on the field characteristics, duration of incubation of the sample, type of virus and the span of its reproduction in a cell culture. (3) SFMF inhibits the "virus-cell" interaction, and induces production of nonspecific virus defense factors by some cell lines. (4) The threshold of SFMF action on the "virus-cell" system is in the range of 0.2-0.5 μT (2-5 mG) for the frequency band from 50 to 1,000 Hz. (5) The primary target for SFMF effects on the "virus-cell" system is the cell membrane, and all other bioeffects can be regarded as consequences of membrane effects. (6) A hypothesis of "local heating" by SFMF was proposed to explain bioeffects of low-intensity magnetic fields. Even so-called weak fields can produce conformational and structural changes of receptor systems, resulting in their inactivation, disengagement from the membrane, and membrane changes. The author suggested that the inhibitory effects of SFMF on viruses could be used for prevention and treatment of viral infections, but this issue requires further investigation [218].

Nonspecific natural inhibitors of viruses, including interferon, can be detected in fluid, tissues, and cells in vivo and in vitro after induction by biological and chemical substances. Cellular resistance to virus injections in cultures of animal and human cells exposed to MFs and the production and characterization of antivirus substances induced by these exposures were studied. PEMF exposures were uniform 60 Hz of 1 gauss on virus infections. In vitro exposure of cells to the PEMF for at least twenty-four hours induces (1) a state of significant cellular resistance to virus challenge by adenovirus type 5, herpesvirus Type 1, coxsackievirus B3, and vesicular stomatitis virus and (2) the production of substances that markedly suppress virus infections when transferred to unexposed cells. The virus suppressor substances induced by the magnetic field are neither virus- nor species-specific, are not apparently interferon-like, and are important in the regulation of virus replication [487].

There is always a concern that PEMFs may stimulate bacteria to become resistant or mutate. Numerous stimuli may cause bacteria to mutate, including antibiotics, insecticides, or pesticides. These are called mutagenic stimuli. One study examined this specifically and found that PEMF exposure inhibited mutagenic transformation in these bacteria. A PEMF field had no mutagenic effects on the bacterial strains studied. The magnetic field was also not co-mutagenic in combination with a variety of chemical, oxygen, or physical mutagens like UV radiation. So, PEMFs do not appear to increase the risk of bacterial resistance and in fact, at least experimentally, do the opposite [302].

Combining PEMFs with antifungal agents increases the effectiveness of killing the fungi. The combination treatment killed almost 90% of the fungi rapidly, versus only 43% with the medication alone, even after a much longer exposure [312]. Since antifungal therapies can be toxic, PEMF therapies combined with them could allow for much lower dosing with less risk of toxicity. In addition, while systemic therapies are often used for local tissue problems, PEMFs may allow for local tissue treatments, further reducing the risk of toxicity while improving benefit.

Anti-coagulant Effects

PEMF therapy addresses many of the mechanisms that lead to increased blood viscosity and clotting, including the reduction of platelet adhesiveness, reduction of fibrinogen and improvement of fibrinolysis, improving the pliability of red blood cells (allowing them to move through capillaries more easily), and increasing the saline content of the blood, decreasing viscosity. These anticoagulant effects appear to be universal to virtually all types of PEMFs [190].

Anti-Edema Activity

Edema is swelling caused by excess fluid trapped in tissue. Tissues with edema are deprived of oxygen, nutrients, and circulation. PEMF therapy has a positive effect on swelling and edema by improving cellular metabolism through direct actions on the sodium-potassium pump in the cell membrane. Any kind of cell or tissue damage causes edema due to leakage of fluids from the cells and blood vessels. Improving circulation helps to remove this excess fluid and prevent further fluid accumulation. Anti-edema effects happen rapidly after starting the use of PEMFs [190].

In addition to improving blood circulation, PEMFs also have a positive effect on lymphatic vessels, stimulating lymph drainage and reducing production of lymph edema, and therefore simulating the immune system and correcting the edema [190].

Anti-Inflammatory Response

Inflammation is the body's defense reaction to cell injury, regardless of the cause. The goal of acute inflammation is to contain and eliminate the irritant and initiate the process of repair. There are three stages to the acute inflammatory response: Vasodilation (which PEMFs enhance), increased vascular permeability (which PEMFs improve by assisting with action potentials and ion flow), and the transfer and accumulation of white blood cells at the site of injury.

A chronically inflamed tissue is like a swamp—there is little flow of fluids and little drainage. Simply by increasing circulation through vasodilation, you change the swamp environment dramatically. PEMF therapy also increases the production of growth factors that help control inflammation.

Damaged cells have diminished electrical capabilities and therefore lack the necessary action potentials required to perform fundamental cellular functions including oxygen intake and sodium and potassium exchanges. PEMF therapy restores the electrochemical gradient to the cell membrane, restoring a normal electrical potential across cell membranes and therefore normal cell function.

Separately, PEMF therapy can induce the appropriate death of chronic inflammatory T lymphocytes by actions on T cell membranes and key enzymes in cells and tissues with chronic inflammation. PEMFs affect ion flow through specific cell membrane channels that positively affect these enzymes. PEMFs induce death (apoptosis) in activated T cells, thereby reducing chronic inflammation without negatively affecting the acute inflammation necessary for tissue repair [190].

Anti-spasm Activity

This is the mediation or prevention of spasms. Muscle spasms can take place almost anywhere in the body, in either smooth muscles or skeletal muscles. Smooth muscle spasms include those in the GI tract (intestines, stomach, or bladder), muscles controlled by the nervous system (as with multiple sclerosis), and the muscles in arteries (causing chest pain or angina). Skeletal muscle spasms are generally associated with overworked muscles, as commonly happens with athletes or those working in extreme heat. Spasms tend to happen when muscle cells are depleted of energy or electrolytes, causing them to become hyper-excitable.

Because PEMF stimulation has a direct effect on cellular charge, it improves calcium flow in and out of the cell and therefore impacts cell depolarization and action potentials. When nitric oxide is formed in the blood vessel, it diffuses into muscle cells, where it binds to and activates cellular enzymes. This chain of events leads to the cell signaling for muscle relaxation [190].

ATP and Mitochondria

One of the most important functions of PEMFs is enhancing the production and use of ATP, and therefore energy in the tissues of the body. Mitochondria are often called the powerhouses of the cell. This is because they are the major generators of adenosine triphosphate (ATP), which is a key molecule in energy storage and energy transfer in living organisms. All cells need and use ATP. Organs, and the cells in them, that use the most energy, like the brain, heart, and muscles, have the most need of ATP.

ATP needs to be broken down into adenosine diphosphate (ADP) to release the stored energy. This process is called ATP hydrolysis and the enzyme that performs this task is called F_1F_o-ATPase. It is found in the membranes of mitochondria, chlorophyll plants, and bacteria, and is the most abundant protein in any organism. These enzymes move fluids across the membrane.

PEMF stimulation has been shown to improve mitochondrial function and ATP synthesis in a variety of studies.

When F_1F_o-ATPase is exposed to PEMF stimulation greater than 1 gauss, ATP hydrolysis activity is enhanced. Even when researchers deliberately inhibited the enzyme chemically, its hydrolysis activity was still enhanced with the PEMF stimulation. So, in addition to helping with ATP synthesis, PEMFs increase the production of energy from the ATP itself, but only if the stimulation is above a specific intensity threshold [79].

Mitochondrial energy production depends on another enzyme called cytochrome oxidase. This is necessary for oxidative phosphorylation, the process of making ATP. Measurement of the levels of cytochrome oxidase in cells is an indicator of the level of energy production in the cell. PEMF exposure significantly increases the level of cytochrome oxidase energy production above the average level [51, 18].

Phosphorylation is a metabolic activity that helps turn "on" and "off" many enzymes and other cellular energy production processes. The calcium/calmodulin-dependent myosin phosphorylation system—that is, the biochemistry that makes muscles work and relax better—has been extensively studied with both static and pulsed magnetic fields. A 450 gauss (45 mT) static field (measured at the tissue) and a weak 0.2 gauss (20 microTesla) PEMF both accelerate phosphorylation by nearly twofold. This process stimulates the production of ATP in all cells, not just muscle cells. Similar behavior has been seen for nerve cell growth, which increased about twofold with both static and pulsed signals.

Improving mitochondrial energy production has a variety of benefits in the body. One example is a study that found that sperm motility was improved with PEMF exposure because of increased mitochondrial membrane charge. Progressive membrane charge polarization caused by PEMFs results in a continued increase in the levels of both ATP and ADP [181].

One of the main sources of magnetic and electromagnetic effects on biological systems is through a positive effect on free radicals. Free radicals are an especially reactive atom or group of atoms that has one or more unpaired electrons, especially one that is produced in the body by natural biological processes (such as unbound oxygen) or introduced from an outside source (such as tobacco smoke, toxins, or pollutants) and that can damage cells, proteins, and deoxynucleic acid (DNA) by altering their chemical structure. These types of reactions produce increased amounts of ATP and DNA. This mechanism is what allows PEMF therapy to be a medical remedy or technology in transcranial magnetic stimulation, nuclear magnetic control of the ATP synthesis in heart muscle and the killing of cancer cells by suppression of their DNA synthesis [61].

PEMF stimulation elevates energy metabolism-related molecules in all treatments. Genes controlling an enzyme that breaks down glucose for energy were significantly enhanced and the activity of the enzyme itself was increased. Therefore, this is another way that PEMFs enhance energy metabolism and may reduce the need for calories [416].

One of the most important findings in some research is that PEMF signals appear to have therapeutic effects on damaged tissue, but do not seem to affect normal tissue. Under normal conditions, PEMFs interfere only moderately with enzyme activity, but greatly enhance activity when enzymes function under less than optimal conditions. When tissue is damaged and ion leakage results in altered ionic concentrations at cell sites, data show that PEMFs markedly increase the enzymes' activity [51].

Autophagy

Autophagy is the natural destructive mechanism that disassembles unnecessary or dysfunctional cellular components through a regulated process. Autophagy allows for the orderly breakdown and recycling of cell components. Japanese scientist Yoshinori Ohsumi received the 2016 Nobel Prize in Physiology or Medicine for his pioneering work on autophagy.

There is not much research at this point on the effects of PEMFs on autophagy, given how new the science is, but a couple of experimental studies do provide support for its use in helping to maintain healthy cells.

In the autophagy process, the parts of the cell that are to be broken down are exposed to enzymes designated for that purpose. This process takes place both in situations of injury as well as during normal cell function, as cells go through their own life-and-death cycles, allowing the cells to reuse some of their contents. Autophagy degrades damaged organelles, cell membranes, and proteins, and the failure of autophagy is thought to be one of the main reasons for the accumulation of cell damage and aging.

In the context of disease, autophagy is seen as an adaptive response to stress, which promotes survival, whereas in other cases it appears to promote cell death and morbidity. Autophagy may contribute to the beneficial metabolic effects of exercise and is essential in maintaining muscle function during exercise. It appears that there is a decrease in endurance and altered glucose metabolism during acute exercise when stress-induced autophagy is not working.

Autophagy also plays an important role in immunity. Intracellular pathogens, like some bacteria, are targeted for degradation by the same processes as natural autophagy. Autophagy decreases with age and this decrease plays a part in the loss of physical function and various health conditions as humans age, including arthritis and cancer.

Age is a major risk factor for osteoarthritis and a loss of autophagy likely plays a part in its development. Autophagy is a normal cartilage protective process in the joint. Proteins involved in the autophagy process are reduced with age in joint cartilage. Mechanical injury to cartilage cells in the laboratory show reduced autophagy proteins. Autophagy is constantly activated in normal cartilage. It is compromised with age and precedes cartilage cell death and structural damage.

Autophagy plays a role in cancer, both in protecting against it and potentially contributing to its growth. Insufficient autophagy is likely to lead to disordered cell growth and the growth of cancers. Recent research shows that autophagy is more likely to be used by the body as a tumor suppressor. Prolonged autophagy activation leads to a high turnover rate of proteins and organelles. A high rate above the survival threshold may kill cancer cells with a high apoptotic threshold.

Autophagy is also significantly impaired in Alzheimer's disease (AD) and reduced autophagy does not eliminate the proteins that form the plaques that cause it. It appears that the impairment in autophagy precedes the impaired protein processing and dysfunction leading to AD, and the accumulation of beta-amyloid cells, considered its classic cause.

To assess the impact of PEMFs on autophagy, one study looked at effects on neuroblastoma cells obtained from humans. Neuroblastoma cells are often used in research into AD. In these cells, a specific PEMF induced a pro-survival autophagy process that was cell-protective by removing damaged proteins and cell organelles and removing beta-amyloid cells. The same PEMF has previously been found to improve resistance to induced cellular oxidative stress, which is damaging to cells. This study not only demonstrated the potential benefit for PEMFs in protecting against and possibly slowing the progression of AD, but also that it does this through the improvement of autophagy [266].

In another study, authors investigated the effects of a PEMF on mouse embryo fibroblast autophagy. Fibroblast cells exposed to a PEMF were found to cause a significant increase in autophagy markers starting at six hours after exposure [80].

If PEMFs can improve autophagy at a basic level, as they did in these studies, then they are likely to help with many of the conditions of aging and cell breakdown and injury. This is another basic mechanism through which PEMFs help to maintain health and improve poor health conditions.

Circadian Rhythms

Some of the effects of PEMF treatments on cellular processes impact the natural daily cyclical rhythms of the cells, called circadian rhythms. Day and night is one example of such a rhythm. In a circadian rhythm, cellular functions come and go or get stronger and weaker on a regular cyclical daily basis.

Circadian rhythms have a length of around twenty-four hours. The body responds to both external stimuli (like light) and natural internal stimuli. The external stimuli affect the master clocks of the body, and the pituitary and pineal glands. Many of the body's naturally produced rhythms exist without any external stimuli and happen because of natural clocks in the cells and tissues throughout the body. These cellular clocks are controlled by genes that coordinate and regulate themselves through feedback loops. The master clock and cellular clocks work cooperatively. The central clock is "entrained" by light-dark cycles. Cellular clocks can be regulated by the nervous system and the endocrine system, including natural steroid production cycles, daily feeding cycle, and external chemicals like lithium or foam styrene exposure.

The circadian system allows the body to adapt to its internal physical and external environment by controlling processes such as cell growth, cell cycle control, and DNA damage repair. PEMF treatment stimulates biological clock genes. Exposure of the brain or nervous system entrains the body through actions on the master clock. This has been shown experimentally where a PEMF signal entrained clock genes [265].

Circadian rhythms regulate various biological processes on several levels: Subcellular and cellular, tissue and organ (for example, from oscillations in electrical activity of the brain), heartbeats, and the body as a whole. Since an important aspect of PEMF's ability to entrain is by acting on the circadian rhythms of the body, we expect that PEMFs used regularly, particularly to the whole body, will help maintain and optimize the natural health of the body. By affecting and restoring impaired or dysfunctional clock genes, magnetic stimulation may help prevent and reverse obesity, hypertension, type II diabetes, coronary heart disease, and possibly even cancer.

Also, see circadian rhythm disruption and stress below.

Circulation

Vasodilation is the widening of blood vessels. Abnormal or diminished production of nitric oxide (which occurs in various disorders) adversely affects blood flow and other vascular functions. In a healthy cellular environment, blood vessels continually produce nitric oxide. The inner lining of the blood vessel (endothelium) uses nitric oxide to signal the adjacent smooth muscles in the blood vessel wall to relax, causing blood vessels to widen. The subsequent increase in blood flow leads to an immediate decrease in both blood pressure and heart rate. Improving circulation is considered one of the most essential mechanisms of the healing effects of PEMFs, by delivering nutrients, repairing molecules, stimulating growth factors, increasing oxygen, eliminating waste, and many other actions [276].

Collagen, hyaluronic acid, and GAGs

A number of important molecules are present in the skin to maintain its structure properly, particularly as it relates to aging. These include collagen, hyaluronic acid (HA), and glycaminoglycans (GAGs).

Hyaluronic acid is found widely throughout connective, epithelial, and neural tissues. It is a large molecule and one of the chief components of the tissues outside the cell. A 150-pound person has roughly a half an ounce of HA in the body, one-third of which is turned over (degraded and synthesized) every day. The size of HA molecules in cartilage decreases with age, but the amount increases. HA is a major part of the synovial fluid in our joints. HA along with other associated molecules absorb water and are responsible for the ability of cartilage to compress.

HA is also a major component of skin, where it is involved in tissue repair. When skin is exposed to excessive UVB rays, it becomes inflamed (sunburn) and the cells in the skin stop producing as much HA, and increase the rate of its breakdown. HA breakdown products accumulate in the skin after UV exposure. The skin damage seen with aging is often related to the loss or breakdown of HA.

In the early inflammatory phase of wound repair, wounded tissue is abundant in HA, a reflection of increased production. HA acts as a promoter of early inflammation, which is crucial in skin wound healing. HA moderates the inflammatory response, which may contribute to the stabilization of granulation tissue involved in healing tissue. Granulation tissue is the fibrous connective tissue that replaces a clot in healing wounds. It typically grows from the base of a wound and is able to fill wounds of almost any size. HA is abundant in granulation tissue. HA content increases with the presence of retinoic acid (vitamin A). The proposed effects of vitamin A against skin sun damage and aging are likely due to an increase of skin HA content, resulting in increased tissue hydration. Dry, scaly skin such as seen with atopic dermatitis may be treated with skin lotion containing HA, and it is a common ingredient in skincare products.

PEMFs have been shown in humans to increase HA, collagen, elastic fibers, and soluble matrix. Plumping of skin and decrease in prominence of wrinkles are seen, related to increased hydration of the skin. GAGs also increased [138].

Animals with burns and patients with spinal cord injuries and pressure sores appear to heal faster when HA is used along with PEMFs. The use of HA and PEMFs resulted in a 90% reduction in wound area by the thirtieth day of treatment. This is a rapid recovery, especially considering that pressure sores usually require months to heal. Early on in the course of treatment most of the PEMF effects relate to the increased production of HA, while in the latter stages, when HA production has plateaued, the PEMFs trigger increased growth of new tissue. So, in this situation PEMFs have a multilevel role in wound healing [147].

As with HA, collagen is a critical structure for the maintenance of the health and vitality of tissues, but also in the repair of damaged tissue. Collagen is the main structural protein outside the cell in all connective tissues. It is the most abundant protein in mammals, making up between 25% and 35% of the whole-body protein content. Depending upon the degree of mineralization, collagen tissues may be rigid (bone), compliant (tendon), or range from rigid to compliant (cartilage).

Collagen is mostly found in fibrous tissues such as tendons, ligaments, and skin. It is also abundant in corneas, cartilage, bones, blood vessels, the gut, intervertebral discs, and the dentin in teeth. Collagen constitutes one to two percent of muscle tissue, and accounts for 6% of the weight of strong, tendinous muscles. The fibroblast is the most common cell that creates collagen. Fibroblasts are an important constituent of skin that help to form it and maintain it. Collagen also has many medical uses in treating complications of the bones and skin.

Healing tissue needs both strength and elasticity for optimal function. Skin exposed to PEMFs at one week after a wound showed only 18% less strength than normal skin and as much as 18% more elasticity. At three weeks after injury, the skin was found to be 30% stronger with no difference in tissue elasticity. This indicates a process of progression and evolution of healing [239]. Collagen synthesis increased by 46%, accounting for the increased tissue strength.

Along the same lines, rabbits with full-thickness skin wounds stimulated with PEMFs had a 25-30% faster healing rate. Collagen deposition was greater and better in the two-week stimulated group. They had a higher volume of fibroblasts in the wounds. As indicated above, fibroblasts increase collagen production, leading to more rapid healing [12].

Both static and medium strength PEMFs have been found to improve the quality and speed of wound healing, with the best action happening with PEMFs [329]. Electrical stimulation has also been found to improve wound healing, but PEMFs have the advantage of not needing to be in direct contact with the skin, a messy situation with open wounds and bandaging. Another major advantage of PEMFs over electrostimulation is the depth of penetration and the support of all the surrounding structures. Electrostimulation only benefits a wound superficially. PEMFs enhance wound healing by increasing fibroblasts, collagen, and the growth of new blood vessels (angiogenesis) to support the healing process, as well as improving tissue oxygen levels and decreasing swelling (edema). In laboratory experiments with cultured human skin fibroblasts, PEMF exposure resulted in a ten- to thirteen-fold increase in total collagen synthesis [364].

Detoxification

As a culture, we are aware of our external cleanliness. Detoxification (detox for short) refers to internal cleansing. It is a less obvious, but important, part of our daily existence.

We are constantly being exposed to all kinds of chemicals, medications, infectious agents, heavy metals, and so forth. These all have to be removed by the body constantly to maintain optimal health. Detoxification is what your body does naturally to neutralize, transform, or get rid of unwanted materials or toxins.

A large percentage of the molecules made by our bodies every day are for getting rid of waste products. We need hundreds of enzymes, vitamins, and other molecules to help rid the body of unwanted waste products and chemicals. The bulk of the detox work is done by the liver and the intestinal tract. The kidneys, lungs, lymphatic system, and skin are all also involved in this complex detox process [151].

Our liver is the main detox organ. Apart from synthesizing and secreting bile, its primary waste product, the liver acts as a filter for toxins and bacteria in the blood and chemically neutralizes toxins, converting them into substances that go back into the bloodstream, which can then be eliminated by the kidneys [151]. The liver has a large variety of chemical-transforming enzymes that change these molecules through oxidation, reduction, and hydrolysis (Phase I) and then through conjugation (Phase II). This two-phase process handles the vast array of different chemicals in the environment to which we are exposed daily.

Because PEMFs improve inefficient or suboptimal liver and kidney function, they clearly help the body to detoxify. Also, since PEMFs improve the ability of cell membranes to open and rebalance themselves, cellular detox is improved as well. All the things that PEMFs do well contribute to the ability for the body to detox better. These include improving blood and lymph circulation, decreasing inflammation, rebalancing cell energy, helping to restore cell function, improving skin respiration, and repairing damaged cells of tissues involved in detox.

Doing in-depth research specifically on detoxification can be difficult (especially on humans) since there are so many components to the process. So, to find a detox-specific study, we have to look into laboratory animal research.

In one study, mice were exposed to PEMFs to observe hepatic and pulmonary phase I and II drug-metabolizing enzymes. The activity of phase I drug metabolizing enzymes (which are involved in metabolic activation and detoxification of carcinogens) were influenced by this PEMF system. The phase II drug metabolizing enzyme glutathione was increased in the lungs by the PEMF exposure. The results overall suggest that a magnetic field appears to have a positive effect on phase I drug metabolizing enzymes, an effect that was accompanied by an increase in the levels of a strong endogenous antioxidant [427].

Other than the direct impact of the liver on detox, systemic detox also happens, as mentioned above, by improving processing of waste by the kidneys, the G.I. tract, respiratory tract, and the skin. Since PEMF stimulation optimizes cellular function of all cells in the body, compromise in any of these other organs that have detox actions can reduce our overall capacity to detox. Many systemic diseases or conditions compromise the function of various body organs. Therefore, PEMFs help all of these other organs to optimize their function and their role in detox.

Growth factors and nitric oxide

Growth factors are substances (primarily hormones and proteins) that regulate and stimulate various cellular processes. Growth factors are essential for the regeneration and healing of tissues after injury. Stem cell and tissue regeneration experiments rely heavily on the use of growth factors to allow these processes to be successful. Typically, growth factors act as signaling molecules between cells, binding to receptors embedded in the cell membrane of their target cells. PEMF stimulation fine-tunes growth factors in many ways, but one of the best-understood is by increasing nitric oxide production. Calmodulin (CaM) is a messenger protein in the cell that binds calcium. It mediates various biologic processes. Once CaM binds to calcium (a process PEMF therapy increases by supporting the necessary electrical charge activity), the resulting cascade catalyzes the release of nitric oxide, and therefore improves growth factors.

A NASA PEMF neural stem cell stimulation study using a 10 Hz square wave PEMF signal found the increased production of over 160 different growth factors that may facilitate nerve regeneration [142].

Healing and regeneration of tissue

While many other topics in this section relate to the healing effects of PEMFs, it is worth emphasizing healing and tissue regeneration specifically as its own area of PEMF actions. We aspire to heal the cause of a problem, to the extent we can. PEMFs go a long way to do that. Typical conventional treatments infrequently can or do not. We have to be able to balance symptom reduction and healing. Healing tissues usually takes longer, depending on the healing capacity of a given damaged tissue.

Many of the problems PEMFs are used to address involve musculoskeletal and neurologic tissues, which can be stubborn to treat. We cannot push the tissue to regenerate beyond its optimal capacity. However, PEMFs can stimulate damaged tissue to heal beyond what is considered the norm without stimulation. In other words, PEMFs can set new tissue healing norms.

Since magnetic fields interact with and increase natural electrical charges, PEMF therapy can amplify this information transfer. These benefits of PEMF therapy are frequently and, often dramatically, seen with wound healing and tissue regeneration.

PEMF therapy has been used to heal bone, ligaments, and tissues in almost every imaginable situation. Therapeutic magnetic fields accelerate healing through their effects on reduced inflammation, improved circulation, streamlined cellular communication, and growth factors. Magnetic stimulation increases stem cell production, differentiation and maturation, and growth factors.

As mentioned above, PEMF signals have therapeutic effects on damaged tissue but do not seem to affect healthy tissue. This activity of PEMFs primarily on abnormal tissue or functions is another aspect of the appeal of PEMFs for healing [51].

Basic regeneration (that which does not happen because of injury) is part of normal cell function. Cells are always dividing, growing, and eating up their older or injured neighbors (see autophagy above). This does not require any outside stimulation, although it can enhance and ease the process. Injury-induced regeneration and wound healing require significantly more energy and adaptation and, therefore, time.

The body is constantly regenerating itself even without injury; we become completely new bodies about every seven years. This concept is based on the bones recycling completely in seven-year cycles. All organ tissues have their own unique organ repair and regeneration cycles. The cornea of the eye, for example, regenerates every twenty-four hours. Intestinal cells can repair within seventy-two hours. Skin and muscle cells may repair in two to three weeks. Cell turnover slows as we age, but never stops completely, continuing until death.

Some tissues do not renew well, if they renew at all. These tissues (ligaments, tendons, nerves, spinal discs, and brain cells) generally don't have a good blood supply in addition to a low regenerative capacity.

Whether or not it is a response to injury, the process of cell regeneration is the same: A cell's contents must be copied. DNA is made up of two strands, each able to serve as a template for a new strand. DNA synthesis or replication requires existing proteins to split and reassemble. RNA messengers help with the transfer of genetic information from the existing cell to the nucleus of the newly formed cell. This process requires electrical energy or charge and tissue energy or ATP.

Healing of tissue from injury, damage, or dysfunction relies on tissue regeneration or reconstruction. Regeneration is one of the most remarkable of all cellular functions. In some animals, regenerative capabilities are incredible. For example, a deer can regrow up to sixty pounds of antlers in as little as three months, and salamanders can regrow limbs that are as perfect as the originals they've lost. Human regeneration capabilities, though still impressive, are more limited.

The body heals itself in many ways, either somewhat rapidly in response to a disease, a wound, or loss of tissue, or slowly over time, as part of normal functioning. Regeneration refers to the regrowth of lost or damaged tissues. Wound healing refers to the closing up of an acute injury with scar tissue. While we know the skin readily regenerates or heals, other tissues have long been thought to have no regenerative capabilities. But as research and time progresses, we are learning more and more that most all cell types can be stimulated to repair, regenerate, and heal themselves.

Injury-induced regeneration and wound healing require a significant amount of energy. To regenerate, a cell's contents must be copied. DNA synthesis or replication requires existing proteins to split and reassemble. RNA messengers help with the transfer of genetic information from the existing cell to the nucleus of the newly formed cell. Regeneration and wound healing also require a great deal of cellular communication and adaptation to take place.

These processes require electrical energy or charge. Since magnetic fields interact with and increase natural electrical charges and ATP, PEMF therapy can assist with this information transfer.

Heart

The heart is an electrically dynamic organ and therefore susceptible to PEMFs. Magnetic fields have been found to affect cardiac function significantly, in addition to the rest of the body.

Extremely low frequency (ELF) EMFs easily penetrate tissues and cause virtually no sensory reactions [473]. The heart muscle itself, because of its dynamic electrical activity, creates its own endogenous PEMFs that have their own effects on cardiac tissue [360]. The reaction of the cardiovascular system to external PEMFs is complex and includes direct responses of many tissues including, among others, cardiac muscle, the autonomic nervous system, blood vessels, and reflex responses processed by the central nervous system. Studies have shown that the natural PEMFs of the heart become much larger when exposed to external PEMFs [167]. The heart contributes between 5% and 10% of the total electromagnetic field induced in the human body by external electric and magnetic fields.

Cells and tissues can be protected against lethal stress by first exposing them to a sub-lethal dose of a stressor, forcing the production of stress proteins [108]. This concept is known as "preconditioning" and gives protection against oxidative stress caused by ischemia/reperfusion, UV light exposure, heat, chemicals, or electromagnetic field exposure. Rodent heart muscle cells preconditioned by PEMFs for thirty minutes have more effective induction of protective stress proteins than those preconditioned with heat. As little as ten seconds of PEMF exposure produced a detectable response at thirty minutes, lasted for more than three hours, and could be re-stimulated by a second exposure to fields of a different intensity [71]. This raises the strong possibility that using PEMFs before, during, and after cardiac surgery can minimize heart damage from surgery, transplantation, or heart attack in humans.

Experimental studies show that PEMFs can affect the function of the centers of the autonomic nervous system controlling cardiac rhythm. A temporary increase in blood pressure (BP) is seen with clinical exposure to industrial EMFs, but extended exposure causes the systemic pressure to decrease. Microcirculation dilatation occurs, with increased blood flow and an increased permeability of the vascular wall. Even lymphatic vessel flow increases [502]. These changes decrease the workload of the heart, which is especially important when the heart is already damaged, has cardiomyopathy, or undergoes heart failure.

PEMF therapy acts beneficially on the functional state of the nervous and endocrine systems as well as on tissue metabolism. Magnetic stimulation causes the heart rate and BP to decrease and the cardiovascular system becomes less reactive to adrenaline and acetylcholine. The parasympathetic nervous system is activated. Stimulation of the autonomic ganglia along the spine reduces the stress hormones cortisol and aldosterone. This likely explains why it is so common for people with whole-body PEMF exposure to report significant relaxation and the feeling of stress reduction. PEMFs typically cause only a momentary change of the microvascular bed with slowing blood flow. This then changes over to a longer compensatory period of an increased heart rate, rate of blood flow, and filling of the blood vessels [466].

PEMFs have been shown to improve microcirculation in people with ischemic heart disease and vascular diseases of extremities. Magnetic fields improve both lipoproteins and cholesterol levels. In people with low blood pressure, PEMFs improve heart contractions and help normalize bioelectrical function. In most people, PEMFs lower BP by lowering vascular resistance with vasodilatation.

Hypertension is improved, depending on the function of the heart before magnetic treatment. People with normally functioning hearts have improved blood flow. PEMFs normalize heart function and circulation in people with high BP, and at the same time improve circulation. The improvements in blood pressure as well as lipid metabolism and coronary circulation make PEMFs a useful treatment for people with the combination of hypertension and ischemic heart disease.

Early in the course of PEMF treatments, there are changes in ECGs to a lower wave-size pattern, normal rhythm, extra beats, and a decrease in heart rate. With continuing PEMF therapy, these changes disappear and cardiovascular function is improved. This is common with magnetic field therapy. Meanwhile, there may be temporary worsening while repair and rebalancing is happening, with the outcome being more normal function and health. To get better results with PEMF treatments, understanding the underlying cause of the problem and function of the organ is critical for designing the proper protocol to use for an individualized approach. Awareness of the potential for initial de-stabilization minimizes misunderstanding in managing the course of therapy and should be carried out with the assistance of a knowledgeable professional.

There is also much evidence of accelerated tissue healing effects where there has already been tissue damage, either from ischemia or mechanical or surgical trauma. Tissue healing with PEMFs appears to be accelerated by about one third to one half the usual time and results in fewer tissue complications, such as infections and poor or aggressive scar formation. In addition to stress protein effects mentioned above, PEMFs increase free radical scavenging and accelerating RNA/DNA production as part of laying down new repair tissue. This means that if cardiac surgery were required, EMFs would help tissues be less traumatized and speed recovery afterwards.

Cardiac vascular and peripheral vascular blockages depend on the development of "soft" and "hard" plaque formation. These plaques and their actions on platelet dynamics can cause vascular obstructions, occlusions, or thromboses, leading to cardiac ischemia (angina) or heart attacks. This is the basis for several drug therapies aimed at reducing platelet adhesiveness, including daily aspirin and warfarin, to name a few. PEMFs have similar strong effects in reducing platelet function and other clotting factors and likely act synergistically and additively with these drugs. The primary actions studied have been on ADP-dependent platelet adhesion, reduction in plaque-forming thrombin, and increased breakdown of plaque (thrombolysis) [190].

Good results are not always seen. In one small series, patients were treated with PEMFs for arrhythmias caused by ischemic heart disease after heart attacks and cardiomyopathy. This study used a sinusoidal EMF for ten sessions per day, alternating placement between the sternum for fifteen minutes and "palm/wrist" area for five to seven minutes. PEMFs did not normalize heart rhythm. One woman had an attack of paroxysmal tachycardia. Six patients reported unpleasant sensations ("sickness at heart" and headache) during or after PEMF therapy, occurring most often with cardiomyopathy. A sinusoidal EMF may even increase BP in males, regardless of length of exposure. This speaks again to the need for professional monitoring for people with cardiac situations like arrhythmias and cardiomyopathy when initiating PEMF therapy [190].

On the whole, PEMF therapies have been found to be beneficial in cardiac and cardiovascular conditions. Their benefits significantly outweigh risks when used properly and with appropriate support.

Immunology

The body's immune response to disease, especially infection, requires nitric oxide for a variety of reasons, not least of which mirror its role in circulation and lymphatic drainage. PEMFs assist with this on a basic level by way of increased nitric oxide production. This helps lay the foundation for a healthy immune system and is part of why PEMF therapy is so important for prevention.

PEMFs affect white blood cells (WBCs) in similar ways as red blood cells. In addition to those effects, PEMF stimulation can assist with "rolling adhesion." As described above, part of the body's natural inflammatory response is vascular permeability, which allows white blood cells (leukocytes) to move through tissues and collect at the site of injury or disease. During rolling adhesion, the WBCs bind to the inner wall of the vessel and slowly roll along its surface, inducing chemical changes in the surface of the vessel. These changes result in the WBC migrating through the vessel wall and into the target tissue [275]. The basic actions PEMFs have on transmembrane potentials and ion flow improve this process by increasing the adhesion properties of WBCs, and by improving the overall permeability of the vessel walls themselves.

Free radicals are known to interfere with cellular communication and mitochondrial function, damaging the immune system. PEMFs support cellular metabolism, making the body better able to adapt to the presence of free radicals [190].

Nerves and Nerve Conductivity

Studies conducted on bone and soft tissue healing using PEMFs in the 1970s found that nerve function improved as a byproduct. After this, researchers began to study PEMF therapy on nerve regeneration directly. Much of the early research was done on animals or in a laboratory.

In the laboratory, it was found that even low-intensity PEMF stimulation produced a 50% enhancement in the growth of new nerves, called nerve sprouting. In living animals, a slightly higher intensity PEMF signal produced a 22% increase in the rate of nerve regeneration [342]. Other research found that nerve growth factor (NGF), which is lost after major nerve injury, increased in the first seventy-two hours following the injury using a PEMF signal [246].

The conduction of currents through nerves follows the same principles as any electrical current. That means that nerves not only produce charge that creates actions in tissues such as affecting muscles that open or close blood vessels, generate muscle actions, or carrying sensations, but also produce their own tiny but dynamic magnetic fields that affect all the surrounding tissues. This is especially important in the brain, where the different regions constantly talk to each other through nerve conduction and the magnetic field effects produced by neural activity.

Charge movement through nerves involves both action potentials (see section 1) and activity involving synapses. These are called action potential currents and post-synaptic currents. Synaptic currents follow a much slower recharging process and usually involve several thousand adjacent nerve processes [367]. PEMFs affect both of these types of currents or nerve activity.

Damage or injury to nerve fibers causes nerve (neuropathic) pain. The damage to nerves can be due to trauma, infection, metabolic changes, burns, radiation, autoimmune reactions, or toxicity. So, any treatment that improves the cause of, or reaction to, the nerve damage will improve nerve function. Inflamed or irritated sensory nerves tend to be hyperactive. PEMFs often help to resolve the underlying cause of the nerve problem and quiet the overactive nerves.

Slowing down nerve firing was shown in research for myelinated nerves [183]. Nerve traffic decreased to zero after five minutes in a relatively high intensity magnetic field and after ten minutes in a lower intensity field. It is thought this is caused by the displacement of calcium ions across the nerve cell membrane. This is another example of how stronger PEMFs produce faster results.

High intensity PEMFs rely heavily on activation of neurons by the high intensity magnetic fields. The number of neurons stimulated depends on the intensity of the stimulus. These high intensity stimuli have a net result of disruption of any abnormal pattern of neuronal activity occurring in the brain at the time of the stimulus. Simultaneously there is activation of current in many nerve cells that release multiple neurotransmitters. The release of the neurotransmitters then causes their own beneficial actions in the brain [186].

Chronic pain often occurs from aberrant small neural networks with self-perpetuated neurogenic inflammation. It is thought that high intensity pulsed magnetic stimulation (HIPMS) noninvasively depolarizes neurons, reduces nerve inflammation, and facilitates recovery following injury [119]. HIPMS, intensity up to 1.17 T (11,700 gauss), was used to study recovery after injury in patients with post-traumatic/post-operative low-back pain, reflex sympathetic dystrophy (RSD), neuropathy, thoracic outlet syndrome, and endometriosis. The outcome VAS pain scale difference was 0.4-5.2 with sham treatments vs 0-0.5 for active treatments.

I have frequently seen people get miraculous, sudden, and complete relief of pain after only one treatment of even low intensity PEMFs. In this case, it is most likely that there are these reverberating small neural networks causing the pain from an old injury. One PEMF treatment may be sufficient in these circumstances to offload the circuit eliminating the pain. Unless the pain returns, further treatments are rarely necessary.

Oxygen

Low oxygen levels cause cell injury, with the degrees and lengths of time tissues are oxygen-deficient determining the degree of damage. The vast majority of cellular functions depend on an adequate supply of oxygen.

PEMFs can significantly increase oxygen levels in tissues by improving circulation, helping the body transfer oxygen from the air into the lungs and blood, affecting the ability of hemoglobin to carry oxygen, and helping the oxygen in hemoglobin to transfer into the tissues.

One study focused on the effect magnetic fields have on the gas-transport function of blood during oxygen deprivation. They found that magnetic field therapy changed the shape of the hemoglobin molecule from a form that was less reactive to oxygen to a form that was more reactive, positively influencing the gas-transport function.

Another study was done on patients with terminal emphysema. These patients received PEMF therapy (just thirty minutes per day for seven days) in addition to their standard medical care. The addition of the magnetic therapy improved blood oxygen levels by as much as 21%, and all patients reported greater stamina. It's likely that these results would have been even more dramatic if the treatments were done earlier in the disease state and for longer times, since the oxygen exchange mechanisms in the body would be better overall.

One of the earlier demonstrations of the benefit of PEMFs in improving oxygenation was done in Germany in the early 1990s using a large PEMF plate. They found that PEMF effects could be increased during periods of high muscle activity, after drinking alcohol, while sleeping, or after inhaling CO_2. Hyperventilation and large meals would reduce the magnitude of the effects. In their studies, they found that blood volume increased, oxygen levels increased, and pH became more alkaline [477].

I coordinated a study looking at the use of two different PEMF systems in increasing tissue oxygen levels using pulse oximetry in pain patients in an acupuncture practice. We compared two low intensity PEMF systems and a non-treatment relaxation control group. System A had a maximum field intensity of 24 μT (microTesla) while system B had a maximum intensity of 40 μT. Exposure was for twenty minutes for each group. The control group had an oxygen saturation level of 96%. The B group started with an oxygen saturation of 96% and ended with a saturation of 97%. For system A, the pretreatment oxygen saturation was 96% and ended the same. The changes in oxygen saturation for the system B group was statistically significant. A 1% peripheral tissue oxygen saturation change in someone without pulmonary disease is practically significant. The conclusion of this limited study was that some PEMF systems can create a useful increase in oxygen saturation in the tissues, particularly for stronger PEMF systems.

Pain

Pain management is one of the most common applications for PEMFs. Whether the pain is acute or chronic, inflammatory or vascular, musculoskeletal, or in the nervous system, PEMFs will act in basic ways to help address both pain perception (pain blocking) and the cause of the pain itself (pain reduction) [332].

Pain mechanisms are extremely complex, but on the most basic level involve a signal being transferred to a receptor and causing a change in cellular behavior. Our goal is always to prevent cellular injury in the first place, which is why daily treatment with PEMF therapy is essential. But with acute injuries, or for those people who have found magnetic field therapy after an injury or disease condition has already taken hold of the body, the goal changes from prevention to injury resolution and pain management.

The body normally does its own pain blocking in response to pain signals through an increase in levels of serotonin, dopamine, endorphin, and encephalins along with a decrease in cortisol and noradrenaline.

The primary mechanisms for pain in response to cell injury are edema, apoptosis or necrosis, diminished circulation, decreased cellular metabolism, and impaired cellular repair processes. As we established in the previous section, PEMF therapy addresses each of these mechanisms in very basic and measurable ways.

Psychological and Cognitive Function

PEMF stimulation impacts psychological and cognitive function both directly and indirectly. Indirect benefits are especially significant when other symptoms are present. For example, if you're experiencing chronic pain, you're more likely also to experience some depression or anxiety. So, when PEMF therapy addresses your pain, it will also improve your psychological function. Another indirect benefit is from improved sleep. Sleep disturbances can affect daytime functioning, psychologically and cognitively. Since PEMFs at desired brainwave frequencies (below 7 Hz) and higher intensities can improve sleep, PEMFs can improve psychological and cognitive daytime function through better sleep.

Direct benefits result from magnetic fields' actions on the brain and nervous system. Whether these actions are because of changes to the brainwave levels or actions on the brain cells themselves, the effects are measurable. Through entrainment, PEMFs can quickly shift dominant brainwaves from beta (hyper alertness and anxiety) to alpha (relaxed) or theta (dreamy), and even down into delta (deep sleep). Modern neuroscience teaches us that our brainwave levels create or at least affect our overall states of mind.

Since different parts of the brain function at different frequencies, stimulation at a given frequency will either simulate or depress brainwave frequencies to match the simulation frequency (see "Entrainment" in section 1). PEMF exposure in the alpha and beta rhythms will likely have a positive effect on long-term memory, making us better able to see relationships between ideas and memories, and enhancing other cognitive processes. Even a single session of theta frequency (5-8 Hz) stimulation to the brain affects numerous measures of cognitive function [177].

Even weak PEMFs appear to help cognitive function, including short and long-term memory, word finding, attention, and concentration [389]. Recollection seems to improve more dramatically with higher intensity stimulation. Studies in mild to moderate Alzheimer's disease patients found higher intensity PEMF stimulation improved cognitive function. In fact, PEMFs alone were better than PEMFs and medications together [238]. Results from single courses of treatment were not as effective as repetitive treatments over longer periods. Also, significant cognitive benefits are not consistent with low intensity PEMFs, since many external influences and internal emotional states can affect cognitive function. Higher intensity PEMFs will get the best results.

Other people that benefit from lower frequency (alpha, theta, delta) PEMFs include those with stress-induced anxiety (in which patients have been shown to respond significantly even from a single session), day surgery patients, healthy individuals, ADH children with behavior problems (up to 70% benefit), and women suffering with premenstrual symptoms.

In terms of specific mental/cognitive functions:

- verbal skills - theta/alpha/low beta stimulation increases grade scores in ADHD children.
- attention disorders - alpha stimulation in ADHD children improves inattention, impulsivity, processing speed and freedom from distractibility.
- memory - 10 Hz stimulation results in the best recall in healthy adults and healthy elderly.
- intelligence - beta stimulation of college students with academic difficulties improves GPA scores.

We routinely hear from people using PEMFs for the first time that they feel relaxed and pleasant. A sensation of congeniality is especially common with PEMF treatment directly to the head with frequencies at 10 Hz or below.

While PEMFs are not the same as counseling or resolving personal and interpersonal issues by working through them, they can at least help to change the state of the brain, making it more receptive to finding new solutions. Some psychologists use PEMF stimulation prior to doing their counseling sessions and report that their patients/clients have much better working sessions and are better able to resolve emotional and cognitive blocks.

Red Blood Cells

Red blood cells are the primary transporters of oxygen to tissues. The sheer number of red blood cells (erythrocytes) we carry and produce is astounding; we produce upwards of two million per second, and they make up 70% of all the cells in our body.

Red blood cells (RBCs) are unique from other cells because they have no nucleus, allowing more room for hemoglobin. Because they contain no mitochondria, they do not use any of the oxygen they carry. This also means they contain no DNA, and so are not capable of much, if any, repair or regeneration. RBCs are formed in the bone marrow and last for about 110 days before they are broken down and reabsorbed by the body. Through all the basic mechanisms it affects, PEMF therapy will facilitate the formation, function, and reabsorption of RBCs.

RBC membranes are made up of lipids and proteins that allow for maximum flexibility as the cells travel through the circulatory system. One of the major functions of RBCs is to carry oxygen into the tissues. The majority of oxygen transfer happens as red blood cells travel through the microcirculatory system, made up primarily of capillaries. Capillaries are so incredibly small that red blood cells often must contort themselves, almost folding in half, to squeeze their way through.

There is a phenomenon known as the "rouleaux effect" that makes this process difficult or impossible. A rouleaux formation is a stack of red blood cells stuck together. It closely resembles a stack of coins and is therefore commonly referred to as "coining." Because of the disc-like shape of RBCs, they are somewhat predisposed to this type of clumping. Capillaries can only accept a single RBC at a time, so healthy circulation requires that coining or rouleaux should be prevented from happening as much as possible.

Because PEMF therapy facilitates a balanced cellular membrane charge, it has a direct effect on RBC activity. Properly charged red blood cells will repel from one another. Aside from preventing rouleaux, this separation of RBCs allows for a greater available surface area for oxygen and nutrients to be absorbed and exchanged.

Magnetic fields appear to enhance the release of oxygen from hemoglobin, with only ten to thirty minutes of exposure increasing the rate of oxygen release for several minutes to several hours [298].

Skin

The skin is the largest organ in the body in surface area. Its primary job is to keep the outside out and the inside in. There are three layers of skin. The epidermis is the outermost layer and provides a barrier between us and the outside world. The dermis is the middle layer, made up of connective tissue. The deepest layer is the hypodermis, made up of connective tissue and fat.

Skin cells in the deeper layers of the skin are three dimensional and cube-like. As dermis cells migrate to the epidermis layer, they lose their nucleus and start to become flat, layering themselves on top of each other. Fats between the flattened epidermal skin cells bind the now-flattened epidermal cells and protect them and therefore the dermis from the external environment—air, sun, wind, temperature, and water.

The skin contains a variety of structures including nerves, blood vessels, hair follicles, sweat glands, oil glands, and lymph vessels. So even though the skin's primary job is to protect the contents of the body from the environment, it also has to allow for temperature regulation through sweating and blood vessel dilation to allow for evaporation and radiation of the body's own heat, plus it allows for the release of toxins in perspiration.

The skin is the only organ besides the lungs that is directly exposed to atmospheric oxygen. Oxygen is directly consumed from the atmosphere in all three layers of skin. The dermis has a rich supply of blood vessels, so oxygen demand is partially satisfied by oxygen carried in the blood. The epidermis has no blood supply, but is exposed directly to the atmosphere. Environmental external oxygen, nitrogen, and carbon dioxide in the atmosphere can diffuse into the epidermis in small amounts.

In humans, only the cells in the outermost 0.25–0.40 mm of the skin are exclusively supplied by external oxygen, although this amount relative to total body respiration is negligible. Therefore, any stimulation that increases blood supply to the skin, such as PEMFs, also improves respiration. Magnetic therapy can increase the respiratory rate of regenerating skin by as much as 70%, preventing skin breakdown.

Magnetic fields inhibit a process called lipid peroxide oxidation, which destabilizes cellular membrane charge and inhibits respiratory enzymes. Lipid peroxide oxidation, which is the process of breaking down fats in the tissues, generates damaging free radicals in the tissues. This is considered one of the key processes for aging of the skin [340].

PEMFs have been used successfully in the treatment of eczema and psoriasis. The benefits are through a reduction in the number of mast cells (a type of white blood cell that causes allergic symptoms) in the skin, with magnetic fields decreasing the number of mast cells in skin by twofold [501].

Skin has a measurable electrical current, with the average charge potential around -23 mV. This electrical charge varies depending on the part of the body being tested, with the hands and feet having the largest potentials, up to -50 mV in the hands, -39 mV in the feet and the back and the arms being -15 to -21 mV. Skin wounds have larger voltages at the edges of the wounds. As part of the healing process, skin cells migrate in response to the level and direction of charge in the tissue. Since electrical charges interact so dynamically and directly with magnetic fields, PEMFs have a direct effect on skin wound healing rates and the healing rates may vary depending on the location of the skin wound. Wounds in the hands and feet will heal faster than the skin in other parts of the body [127].

The general actions of PEMFs will also have a variety of benefits to skin, including improving circulation; reducing edema and inflammation; resolving infections and the impact of insect bites; stimulating tissue regeneration, resulting in the healing of scars, cuts and wounds, by increasing collagen production; improving cellular nutritional status; and much more.

Whenever you're treating any part of the body with PEMFs, the skin is of course also getting treatment. While aging is a normal process, it is due to the breakdown of various repair processes. Regular use of PEMFs will keep the skin younger-looking by slowing down the natural aging breakdown of repair processes. Although a study has not been performed on this directly, clinical experience and feedback from people using PEMF therapy suggests their skin feels and looks younger. This is an exciting area to explore in future studies.

Stem cell stimulation

Stem cells are those able to become (differentiate into) specialized cells and can divide to produce more stem cells. In humans, the two main types of stem cells are embryonic (found in the developing fetus) and adult (found in various tissues). Adult stem cells act as the body's repair system, replenishing damaged tissues. They are found in bone marrow, adipose tissue, and blood and in the umbilical cord immediately after birth.

We now have the technology to artificially stimulate adult stem cells into specialized cell types with characteristics consistent with cells of various tissues such as muscles or nerves. Undifferentiated stem cells in the blood have to be turned into differentiated stem cells in the target tissue or organ. Adult stem cells have less differentiation capacity than fetal/embryonic stem cells, so stem cell therapies don't always work well without additional external stimulation, such as with PEMFs.

One of the goals of PEMF therapies is to help stem cells differentiate themselves into specific tissues to help with regeneration and healing. This can be used as a therapeutic modality to address an injury or disease state, but it can also be used as a health maintenance modality. By encouraging existing stem cells to maintain their regeneration capabilities, you ensure they are available to differentiate or reproduce at the first sign of degradation. It's much more efficient to stimulate stem cells to differentiate into the cell type of the tissue they already exist within as opposed to trying to get a stem cell to differentiate into a different type of tissue. Every tissue has its own supply of stem cells available and ready to do the necessary regeneration and repair of tissues as they are injured or die off naturally.

The goal with PEMF therapy is to be able to stimulate stem cells that are already present in tissues to keep those tissues healthy. It takes less energy to maintain health constantly than to repair or regenerate tissues after injury. Either way, health maintenance or repair/regeneration using PEMFs has been found to be possible and effective.

There is a significant amount of evidence that PEMFs affect stem cells. PEMFs increase RNA building blocks of neuronal progenitor embryonic stem cells [220]. Human bone marrow stem cells (hB-MSCs) can differentiate into nerve cells and PEMFs induce this differentiation [83, 325]. Proteins turned on through PEMF stimulation may help as a therapeutic option for treating neurodegenerative diseases [204]. PEMF stimulation increases the amount of viable stem cells by 40 – 59% and results in up to 60% higher cell densities. The PEMF exposed hB-MSCs have the ability to differentiate into multiple types of cells. PEMFs also differentiated neural stem cells and neurons [237].

NASA studied the use of 10 Hz PEMF stimulation on the growth of nerve stem cells. With their particular 10 Hz signal, NASA discovered about a 400% increase in neural stem cells and this signal turned on about 160 growth and regeneration genes [142].

In line with the NASA research, PEMF stimulation of Schwann cells was studied. Schwann cells are a variety of nerve-associated cells that keep peripheral nerve fibers (both myelinated and unmyelinated) alive. PEMF stimulation produced high regeneration ability. A PEMF has an additive effect on human dental pulp stem cells. The stimulated Schwann-like cell improved nerve regeneration after transplantation into a body. Therefore, PEMFs improved peripheral nerve regeneration [172].

Human soft tissue mesenchymal stem cells (MSCs) derived from different sources have been extensively used in building bone tissue. MSCs are typically obtained from bone marrow, blood, or fatty tissue. Compared with MSCs obtained from bone marrow (BMSCs), those from fatty tissue (ASCs) are easier to obtain and available in larger amounts. ASCs have less ability to turn into bone-building (osteogenic) cells than hB-MSCs. PEMFs induce bone cell development by increasing various different factors in both BMSCs and ASCs. PEMFs may be even be considered a tool to improve one's own stem cells obtained to enhance regeneration [318].

PEMFs are known to affect cartilage tissue. Human mesenchymal stem cells (hMSCs) are likely an alternative approach for cartilage repair. PEMF stimulation of hMSCs increases collagen type II and glycosaminoglycan (GAG)/DNA content. PEMFs could be a good way to stimulate and maintain growth of cartilage from either implanted or naturally present hMSCs [272].

In a different twist, PEMF stimulation of BMSCs appears to enhance the development of bone cells, but also it appears to inhibit the development of fat cells. PEMF promoted bone formation from the stem cells and at the same time inhibited fat cell formation. This finding has interesting implications for people using whole-body PEMFs routinely, whether for the prevention of growing fat cells or incidentally during use for other reasons. Unfortunately, this research does not provide support for the ability of PEMFs to help people lose fat cells that have already developed. So, it may have more preventive value than therapeutic value regarding development of fat cells [498]. Whether this is a handicap to people trying to gain fat is unknown and should be studied further.

Human skin is considered the biggest reservoir of stem cells. Normal wound healing requires the proliferation and differentiation of new skin cells from skin stem cells. In fact, epidermal stem cells can be used to repair various damaged tissues, not just the skin itself. The accelerated growth of human epidermal stem cells (hESCs) induced by PEMF may be one of the factors contributing to accelerated healing of skin wounds. This same stimulated tissue may also provide easy access to a larger pool of epidermal cells for harvesting for non-skin purposes [506].

Low frequency PEMF significantly enhances the proliferation of hESCs in culture. Exposure to a PEMF significantly increased the percentage of cells at an early growth phase. The cell cycle proceeds in three phases, the G0/G1 phase, S phase, and G2/M phase. In general, the proportion of S-phase cells is considered to represent the proliferative potential of a cell population. The amount of hESCs in the S-phase increased with PEMFs, enhancing the proportion of cells synthesizing DNA and increasing cell growth [506].

In a laboratory study, cell proliferation and osteogenic differentiation was evaluated in human bone marrow stem cells (hBMSCs). Results showed no significant cell damaging effects on the hBMSCs even with high intensity PEMF treatment (1 Tesla, thirty pulses per day). hBMSC proliferation was enhanced. Bone cell differentiation of hBMSCs was significantly increased in the high intensity PEMF-treated groups. Deposition of bone minerals increased after treatment in PEMF-treated groups compared to the control group. In conclusion, HPEMF also accelerates bone-forming differentiation of cultured hBMSCs and enhances bone repair, growth of new blood vessels, and cell growth in necrotic bone in mice [129].

To further support the above research, hBMSC cells with PEMF stimulation begin differentiation earlier than untreated stem cells. PEMF stimulation is able to increase the bone building cell differentiation potential of adult mesenchymal cells [120].

It is accepted that tendons and ligaments regenerate very slowly if at all. Stimulating the stem cells in these tissues would go a long way to healing damage. Human tendon stem cells were exposed to a one-hour treatment with a 5-15 gauss, 10 - 30 Hz rectangular PEMF signal. This PEMF had no damaging or stimulating effects on the stem cells in cell viability, proliferation, and migration. However, they did improve some stem cell markers, preserving these stem cells to be available for regenerative repair work. Without the stimulation, these types of stem cells would simply die off [353].

So, PEMF stimulation of stem cells not only helps for health maintenance, but it also helps with tissue healing, and in the future we will see a lot more use of stem cells to heal various parts of the body. It appears that PEMFs can help with increased stem cell harvest, increased differentiation, better preservation of the tissues into which the stem cells are being implanted, and likely will increase the ability of those stem cells to be successful.

Stress

PEMFs help with stress in three basic ways. One is to reduce the brain's reaction to it. The second is to help the body to eliminate the neurotransmitters and hormones produced by stressful fight-flight reactions. The third is to defend the cells and tissues of the body from the physical changes induced by stress chemicals and hormones.

In terms of reducing the brain's reaction or reactivity to stress, PEMF therapy acts positively on the functional state of the nervous and endocrine systems as well as on tissue metabolism. The heart rate and blood pressure decrease and the cardiovascular system are less reactive to adrenaline and acetylcholine. The relaxation part of the nervous system (parasympathetic) is activated. Stimulation of the spine reduces production of the stress hormones cortisol and aldosterone [466].

PEMF stimulation of the kidneys accelerates the excretion of produced stress hormones. The same thing happens with the hypothalamus in the brain, which has a central role in controlling the brain's responses to stress.

In many individuals, the brain is in a heightened state of expectancy for stress. Stimulating the brain in these situations would be expected to decrease the stress response, whether perceived or real. Often individuals suffering from posttraumatic stress disorder (PTSD) are in a chronic state of hyper-responsiveness to even small stimuli. Repetitive TMS (rTMS) of the right forehead reduces core symptoms (re-experiencing and avoidance) and markedly improves anxiety symptoms, primarily at 10 Hz [88]. As expected, high intensity PEMFs tend to entrain brainwaves and brain cells more rapidly, more effectively disrupting their negative symptom-producing patterns.

Treatment of PTSD with 20 Hz rTMS of either right or left forehead for ten daily sessions over two weeks significantly decreased PTSD symptoms [52]. TMS on the right side induced a larger effect. Mood improves better after left rTMS and anxiety improves better after right rTMS. Improvements were long lasting, even at three-months. Stimulation at 1 Hz doesn't appear to be as effective. Since lower intensity PEMFs may not produce as long-lasting results as high intensity PEMFs, they may still be expected to be effective if used over longer periods.

Anxiety is another condition predisposing individuals to exaggerated responsiveness to stressors. Alpha brainwaves appear to be lacking in these individuals. Alpha entrainment is effective in helping people with anxiety [166]. Treated individuals had positive results with reduction of multiple measures of psychological symptoms including anxiety when compared to prior to entrainment therapy.

Stress clearly causes significant disruptions in normal brain rhythms. Research in Germany found that 10 Hz PEMF stabilized circadian rhythms [484]. Use of this frequency can restore jet lag and other sleep disturbances. Circadian rhythms control the hormone balance of the body and when they are out of alignment or not in their proper phase, many problems begin to show up in the body. Stress is a clear example of how circadian rhythms and brainwave frequency patterns can become disrupted. So, 10 Hz PEMF can be useful for reducing many of the physical effects of stress, circadian disruption, and tissue regeneration.

Water

There are two aspects to considering PEMFs and water. One is the internal water of our bodies. The other is the intake of magnetically treated water.

The water naturally in the human body is a solution, a kind of soup, of electrolytes, proteins, fats, and starch. It is a catalyst in chemical changes from simple to complex, and provides the medium for the electrical conduction required for ionization of cells and cellular mobility. Since water is the medium through which all electrochemical activity in the body takes place, its ability to respond to an electromagnetic field is a major aspect of the actions of PEMFs in the body and critical in the body's health maintenance and healing process. Research shows that magnetic fields are capable of changing the properties of any solution with charge, and so have a direct effect on the water in our bodies [23]. See the topic in the appendix for a more expanded discussion, if interested.

When cells are studied under an MRI (which replicates a powerful PEMF treatment), water is observed to act differently from when it is not exposed to a magnetic field. Molecules are re-formed in smaller clusters in a linear arrangement. The molecules are lined up and move in and out of the cells easily. In contrast, when water is photographed after being removed from MRI exposure, molecules are randomly ordered and cluster with neighboring water molecules to form large, molecular clusters. Interestingly, when cancer cells are studied under

MRI influence, its water molecules are also organized and calm, in contrast to their aggressive, violent movement without MRI exposure.

There is evidence that MF-treated pharmaceutical solutions are affected by the MF treatment. Their actions are altered, positively or negatively by these fields—that is, enhanced or reduced effects on the solutions [190].

I have read unpublished reports that Eastern Europeans and Chinese since the eighties have found magnetically-treated water may help to dissolve kidney stones and gallstones. Since calcific stones in the body are often associated with nano-bacteria, MF-treated water may help to work gradually at degrading the stones through a process of erosion, akin to the wearing action of water on rocks in nature.

Heart muscle contractility is also apparently affected by PEMFs and acts similarly to hydrogen peroxide. This may be one of the ways, besides nitric oxide, that PEMFs cause muscles to relax. In addition, the ability of oxygen to dissolve in water has been demonstrated by magnetic fields [24].

It has certainly been established since the eighties that magnetic fields can change various physical, chemical, and obvious properties of solutions including surface tension, electrical properties, and the ability of substances to dissolve in magnetic field exposed solutions. Calcium compounds demonstrate long-lasting changes in conductivity on exposure to magnetic fields. Subsequently, when these magnetically exposed solutions were applied to nerve cells, they caused both physiological and biochemical changes. Even outside the body, a brief magnetic field exposure can create changes in fluid conductivity for at least two and half hours after the exposure. Water-salt interactions may well underlie biological magnetic field sensitivity. The solutions altered by PEMFs can produce changes in cell membranes and metabolism [26].

Magnetically restructured water produces a synergistic effect on the insecticidal activity of endosulfan in solution. The results imply that magnetically restructured water could play a significant role in managing different crop pests and human and animal diseases, allowing less than the recommended concentrations of insecticides, antibiotics, fungicides, and other pesticides to be used. [426].

Growth of algae, a form of bacteria, in solution exposed directly or indirectly to a magnetic field were significantly affected by magnetic field exposure. Indirect exposure was done by exposing the solution the algae were to be grown in first and then the algae introduced into the treated solution. The results showed that the magnetic field influenced “structural chemistry” of the water to produce “live water” structures, that is, different water structures can influence bacterial nutrient uptake, enzyme activities, and the orientation of precursor biomolecules in the liquid crystalline phase during growth. This means that biochemical processes in organisms are affected both directly and indirectly. The degree of these effects increased with increasing duration of exposure [426].

Water treated with magnetic fields first will affect whatever grows or lives in that water subsequently, including cellular molecules, making the water “live.” Even growth of fungal spores is decreased by up to 83% if the water is pretreated with magnetic fields [351, 352].

There is some research to suggest treating drinking water with PEMFs will positively alter its molecular composition, making it more readily absorbed by the body and having positive therapeutic effects (see appendix).

Water exposed to 0.1 T and 0.25 T magnetic fields appears to increase activation of chick pancreas digestive and salivary enzymes, enhancing the breakdown of the substances these enzymes work on, and making this happen faster. Pretreatment of drinking water before eating would have the effect of improving digestion [133].

Magnetically treated water (MTW) has been used for therapeutic purposes at a health resort for several years. Drinking magnetized water and taking magnetized water baths produced favorable results in patients with hypertension, gastrointestinal, and skin diseases. General health improved, and decreased fatigue and improved sleep. They also studied whether there may be a direct bactericidal effect of MTW. Bactericidal effects of MTW were confirmed by experiments with mineral water. The maximum gross concentration of bacteria decreased from 60/ml in untreated samples to 40/ml, 8/ml, and 2/ml at field intensities of 50, 115, and 140 mT, respectively [283].

At the same health resort, detailed analysis was done of the health of patients treated with and without MTW. Those receiving MTW had a decrease in heart rate, improved cerebral blood vessel tone, and a decrease in systolic blood pressure [279].

Proliferation rate of some fungi, especially of human digestion supportive Saccharomyces cerevisiae, appear to decrease when grown on culture media prepared with MTW. The rate of growth on bread did not change when the bread was made with MTW and flour. However, treatment of water and flour by a magnetic field prior to mixing them greatly stimulated proliferation of Saccharomyces in the dough; the content of the yeast cells increased up to five times compared to untreated samples. It's unknown what creates these differences in response [462].

Also, magnetic field therapy of the water in an oral irrigator appears to significantly decrease formation of supragingival calculus and its accompanying plaque. The probable mechanism for the effect of magnetically treated water involves calcium (Ca++) ion. The magnetically affected ions reduce the attachment of plaque and calculus to the gingiva [479]. This effect may be similar to that seen in the use of magnetic fields in industrial water storage tanks to reduce slaking, or clogging of the storage tanks with calcium deposits.

SUMMARY

In this section, we provided evidence-based information on over twenty-five different ways that PEMFs act on basic functions in the body. The conditions that are present in the body will determine which of these basic actions the magnetic fields will affect. Every time a PEMF is applied, these physiologic actions are occurring, whether or not they are felt or seen. Many of these actions happen at a molecular level and take time to become obvious at a functional or symptom level.

Physicians are trained to seek the underlying causes involved in the development and manifestation of disease, and the mechanisms involved in the therapies they use. With these understandings, it is easier to estimate the potential benefits and risks of a therapy. A normal research progression would begin with a concept, move to laboratory experimentation, to animal testing, and finally to human study. This does not always happen and is not always possible. Even when it is, the findings at any level prior to the human study may have limited applicability because of the complexities involved at each level of research. The true value of a therapeutic approach only becomes obvious when it finally starts to be used more widely in humans.

Most therapies become accepted when they have been shown to address a given condition's underlying cause. However, any condition's mechanisms may be complex and varied, while the treatment only addresses a single one and therefore only achieves partial benefit. Additionally, the mechanism at hand may be used by the body across a whole host of functions, all of which can become compromised by the therapy. This is one of the many reasons why it is not uncommon for pharmaceuticals to be withdrawn from the market after five to seven years of approved use—unintended consequences or unexpected side effects.

PEMF therapy has been researched for decades and the physiologic reasons for its benefits are numerous. By addressing these basic actions separately from specific health conditions, we hope to have shown their supportive benefits in relation to the underlying causes of most health conditions. We also hope to have shown the immense benefits possible in relation to basic health maintenance and prevention.

Not all disease mechanisms are known. PEMFs may well help conditions for which conventional approaches are only modestly effective. One of the most frustrating situations clinicians face is the inability to provide a concrete diagnosis for a patient. Time may sometimes reveal the underlying condition or cause, but not always. In these instances, PEMFs may be able to provide some relief because of their actions on basic bodily functions.

The actions listed in this section are by no means all that are possible. We have only discussed those that have robust scientific support. This science is expanding all the time, and it is likely that not only will we eventually better understand the current actions PEMFs affect, but will identify additional actions as more research is completed.

PEMF therapies have been shown to be generally safe (see Cautions, Precautions, and Contraindications in section 5). Using PEMFs to help with problems that are functional and symptomatic without being diagnosed may go a long way to resolving or improving these issues, without the need to use therapies that may be more invasive or toxic and possibly ineffective. In this situation, you would be relying on the basic actions of PEMFs in the body to improve health and well-being.

SECTION THREE
Helping Health Conditions with PEMFs

There have been more than two thousand university level double-blind medical studies done on the effectiveness of pulsed electromagnetic field therapy for specific health conditions, and tens of thousands on the more general actions of magnetic fields on cells and tissue. Translating the results of these studies into practical use in a home or clinical setting is difficult and requires technical and medical expertise. Most of the devices used in clinical research are not commercially available and most studies are done using systems that were created by the research team for the study itself.

On one hand, this is ideal. It means that the research was done without commercial interest. On the other, it is frustrating for a consumer, and regulatory authorities, because decision-making is easier from brand-specific studies.

Further complicating the research done on PEMFs is the fact that, practically speaking, they should usually be considered in a complementary role with a regimen including healthy eating, physical therapy, or even pharmaceutical use. Because PEMF therapy works on such a basic level in the body, it has many actions. And, a good part of the time these actions add together to create a complete tissue and health response. This makes it difficult to pinpoint a PEMF-induced change in a single biological or chemical process as solely responsible for an improvement in a symptom or disease state. There is actually less known about how many pharmaceuticals act than there is known about magnetic field actions on biology. It is because of these wide-ranging actions of PEMFs that they can affect a vast array of medical conditions.

ACUTE VS CHRONIC CONDITIONS

An acute disease has a rapid onset or short course, and a chronic disease has one that is persistent, long lasting, or comes with time. Conditions are usually not considered chronic until they have been present for at least three months. The line between acute and chronic usually lives somewhere between the physiologic and pathophysiologic levels of disease. The healing process is often not linear. It may meander, take a step backwards, or become stuck. When the healing process becomes stuck, the condition is most vulnerable to becoming chronic. A fracture or a wound that won't heal or heals very slowly are good examples.

Using PEMF therapy in the acute phase can help prevent it from becoming chronic. This is true for many chronic conditions but especially true for pain. Cellular communication begins with a cell signal impulse and ends with a change in cellular behavior. PEMF therapy can help to ensure that the result of this biologic communication—a change in cellular or tissue behavior—is constructive not destructive. The most common place for an injury to become stuck is in the acute inflammatory phase.

Inflammation is the body's initial response to a harmful stimulus. It is a cascade of physiologic processes initiated to repair cellular damage in tissues with good blood supply. In the acute stage, inflammation is necessary and beneficial to restore normal function. When the inflammatory response becomes exaggerated or deficient persistently, the once-beneficial and protective response becomes destructive. In other words, the body seeks to develop the best level of function it can find given the dysfunction present. Treating inflammation requires finding a balance between supporting the acute inflammatory stage and preventing progression to chronicity.

In chronic inflammatory diseases, cells are constantly compromised. Regular PEMF stimulation can induce the appropriate death of T lymphocytes when they have overstayed their welcome.

Chronic conditions also result when natural and smooth flows of ions in and out of cells become impeded. In this case, cells will end up building up an excessive amount of charge on the outside of the cell membrane indicating insufficient energy inside the cell. The lack of energy and nutrients inside the cell then creates the effect of a chronically sick or dysfunctional cell or cells and tissue. PEMFs have a direct effect on ion flow through specific cell membrane channels that affect key cellular enzymes. So, by improving ion flow through the membrane channels of a cell with PEMFs, sick or dysfunctional cells are able to be restored partially or completely. This is another way that PEMFs restore chronic health conditions.

CLINICAL APPLICATIONS FOR SPECIFIC HEALTH CONDITIONS

Armed with a basic understanding of how PEMFs affect cells and how they act on biology as described in section 2, it is now useful to present evidence to support the effectiveness of PEMFs for various health conditions. Below I describe how PEMFS can help with over fifty health conditions. PEMFs may be able to help many more conditions by understanding the basic actions of PEMFs on the body. These conditions have been chosen because there is research evidence to support the value of PEMFs for each of them. Be on the lookout for new research that is constantly emerging, beyond the scope of these particular conditions.

Addiction

Repetitive transcranial magnetic stimulation (rTMS) is a noninvasive method of brain stimulation used to treat a variety of neuropsychiatric disorders, but is still in the early stages of study as addiction treatment. At the time of writing, there have been nineteen unique human studies using rTMS to manipulate drug craving or use, treating a total of 316 adult patients. Nine studies involved tobacco, six alcohol, three cocaine, and one methamphetamine. The majority of studies used "higher" brain frequency stimulation (5-20 Hz) expected to stimulate neuronal activity, to the top left upper part of the forehead. All studies showed decreased substance use, with the average decrease being 53%. Since this research is still in early stages, optimal treatment protocols are still being worked on. rTMS treatment of addiction is not yet considered standard treatment, and is not covered by insurance or Medicare, though results appear promising [143].

rTMS could be working in helping with addiction through PEMF's effects on dopamine. Dopamine is a brain neurotransmitter—a chemical released by neurons (nerve cells) to send signals to other nerve cells. The brain includes several distinct dopamine pathways, one of which plays a major role in behavior affected by rewards. Rewards can include food or addictive substances. Most types of reward increase the level of dopamine in the brain, and many addictive drugs increase dopamine, but they also can cause dopamine imbalance. Other brain dopamine pathways are involved in movement (motor) control and in controlling the release of various hormones. For example, dopamine deficiency can lead to Parkinson's disease, restless leg syndrome, and even ADHD in some cases. Many drugs are used to mimic dopamine, called dopaminergics. However, dopamine does not easily cross the blood brain barrier, even if given intravenously. Unfortunately, many of these drugs have strong side effects. This is another situation where alternative approaches, such as magnetic stimulation, could be useful.

The effects of rTMS on brain dopamine concentrations were studied in eight healthy humans. They received positron emission tomography (PET) scans before and after rTMS at 10 Hz. Prefrontal cortex rTMS releases natural dopamine on the stimulated side of the brain. As a result, rTMS may be useful in in movement, learning, and motivation disorders, and therefore probably useful in illnesses such as Parkinson's disease and drug addiction [437].

It is reasonable to assume that home-based PEMF systems may be able to provide similar benefit, even though few home systems reach an intensity level comparable to rTMS. In this situation, PEMFs would be applied daily for thirty to sixty minutes to the prefrontal cortex (upper forehead) and the insula (just behind/above each ear). Pinpoint placement is not critical since the magnetic field is not pinpoint. Being in the approximate area should be sufficient.

Adhesions, abdominal

Abdominal adhesions, which cause intestinal obstructions, lead to major health care costs and misery, and result from almost any kind of abdominal surgeries, abdominal inflammation, or infection. These often require hospitalizations, intestinal decompression tubes, and even surgery to break down the adhesions to reverse the obstructions. Unfortunately, even with corrective surgery for breakdown (lysis) of the adhesions, the adhesions often recur. This results in a cycle of multiple hospitalizations over a person's lifetime for the adhesion problem. Developing new techniques, such as PEMFs, for preventing adhesions is necessary. One study evaluated a group of eighteen children with intestinal obstruction due to adhesions (aged three to twelve years) who had been treated for lymphosarcoma involving the small bowel. In all cases, initial surgical operation for the lymphoma was followed by cycles of chemotherapy. Intestinal obstruction developed one or several months after the operation. In other words, the chemotherapy accelerates and worsens the usual development of adhesions following abdominal surgery, because the natural repair and healing processes in the abdomen are compromised. The children received 15-20 minutes of PEMF treatment per day. Even though complete elimination of pains and return to normal of bowel function were achieved after 2-4 PEMF treatments, the treatment course was extended to 10-12 days. Even long-term follow-up found no relapses of adhesion-related intestinal obstruction during a 0.5-6 year follow-up period, suggesting a long-term benefit of initial PEMF therapy [206].

In an ideal world, anybody having abdominal surgery should have PEMF therapy as soon as possible after the surgery, for up to two weeks after that to decrease the risk of developing adhesions. Because conventional hospital-based medicine, as of this writing, does not yet recognize PEMF therapy for almost any indication, it will be highly unlikely to be able to place a PEMF system in a hospital setting. Therefore, the next best recourse would be for individuals to begin to do their own PEMF therapy in the home setting after abdominal surgery, during the healing process, for at least several months. In this situation, not only will there be a benefit from reducing the risk of adhesions, but also a major benefit in reducing the healing time of the abdominal wound in general.

Alkaline Balance

The pH of our blood is maintained in a tight neutral range, which is slightly more alkaline than pure water. If the pH falls below the optimal level, 7.4, the result is acidosis. If the pH rises above the optimal range, the result is alkalosis. Though very different, both are dangerous if the change is persistent or more than minimal. This is why the body is so extraordinarily aggressive in maintaining pH. It does this as a priority over other self-preservation functions. Most of the metabolic processes in the body depend on a steady state of the blood pH in the neutral zone. If the pH of the blood becomes too acid or alkaline, metabolic functions will not be normal. Acidity is a much more common problem than alkalinity. That is why there is so much written about alkaline balance. In other words, there is a greater and more common need to restore alkaline balance and limit acidity.

Restoring unbalanced acidity has two major components, systemic and local.

Systemic acidity is, in my mind, a less relevant concern than local. By virtue of their healthy actions on all solid organs, PEMFs help the metabolic functioning of the organ being treated. A malfunctioning or sub-optimally-functioning kidney, for example, cannot do appropriate electrolyte adjustments to rebalance pH. Using supplements that help with redox balancing can be useful. No matter what, when a body is exposed to PEMFs on a regular basis (particularly with full-body systems or local applications which treat the kidneys), kidneys will be continually balanced and function optimally.

Local acidity is where PEMFs may be of the most help. Inflammation, infections, toxicities, degeneration, trauma, and other causes of cell injury, create local acidity in either tissues or specific organs. The body will do its best to restore natural function to these tissues, resulting in balanced local pH. Local tissue pH changes are often not well identified by the central pH sensing mechanisms of the body, unless they are severe and spill over into the systemic circulation. Therefore, mild local acidity is more likely to result in or from chronic health conditions. So, the goal is not to just restore pH, because that will not necessarily remove the cause of the local pH imbalance. The goal is to remove the cause of the imbalance itself, which then restores local pH. This is where PEMFs are most effective. As discussed in the previous section, the many basic actions of PEMFs on the body (including improved blood supply, reduced inflammation, tissue regeneration and repair, reduced edema, antioxidant support) will help tissues to become healthier faster, and restore viability and optimal function.

The more local tissues all over the body are balanced and healthy, the more systemic balance will occur. Significant magnitudes of local tissue acidity or imbalance will obviously affect the whole body. A splinter in a toe will create limited local inflammation and acidity, but will likely not significantly affect the entire body or change the serum pH. However, if the splinter becomes a rampant infection involving the entire foot, then the pH of the whole body could be impacted. If the infection continued to spread, it could create sepsis, affecting the pH of the entire body seriously, becoming a life-and-death situation.

For most people, regular use of PEMFs can help the body maintain a better state of local tissue alkaline balance through the reduction of inflammation and improved circulation. By combining multiple areas of tissues being rebalanced simultaneously with a whole-body PEMF system, the whole-body benefits. If the body is failing and becoming aggressively acidic (as with diabetic ketoacidosis, sepsis, or cardiac arrest, for example), the use of PEMFs is likely to more rapidly restore balance when used alongside traditional medical rescue therapies.

Anxiety, Panic, and PTSD Disorders

Anxiety is a normal adaptive response to stress that allows coping with adverse situations. However, when anxiety becomes excessive or disproportional in relation to the situation that evokes it or when there is no special reason for it, such as irrational dread of routine stimuli, it becomes a disabling disorder and is considered abnormal. Anxiety disorders comprise the most frequent psychiatric or psychologic disorders and can range from relatively benign feelings of nervousness to extreme expressions of terror and fear, that is, panic.

In the United States, the lifetime presence of anxiety disorders is about 29%.

Anxiety disorders include separation anxiety, selective mutism, specific phobias, social anxiety (social phobia), panic disorder, agoraphobia, generalized anxiety disorder (GAD), substance/medication-induced anxiety, and anxiety due to another medical condition.

Anxiety can be disabling and although the available methods of treatment are safe and effective (that is, medications, psychotherapy, and cognitive behavioral therapy), about 25% of people do not respond [256]. With advances in the understanding of the neurobiology involved in anxiety disorders, new treatments are being considered, including PEMFs.

Many patients with anxiety disorders experience physical symptoms related to anxiety and subsequently visit their primary care providers. Despite how common anxiety disorders are, they often go under recognized and undertreated clinical problems.

Some believe that there is an imbalance between the hemispheres of the brain or a deficit of limbic and brain cortex control. This could mean that anxiety, considered a "withdrawing from a situation" related emotion, is located in the right hemisphere, whereas emotions related to "being able to approach," such as joy or happiness, are based in the left hemisphere. There is increased right hemisphere activity in anxiety disorders.

Panic disorder (PD) is a more severe form of anxiety. PD is seen with recurrent and unexpected attacks of sudden onset and short duration (ten to fifteen minutes). A panic attack may be followed for up to one month by persistent worry regarding another panic attack. It may consist of symptoms such as feelings of shortness of breath, hyperventilation, palpitations, chest pain, sweating, chills, nausea, trembling, fear of dying or losing control, numbness, and a feeling of detachment or unreality. Neuroimaging has verified specific abnormalities in panic disorder.

In generalized anxiety disorder (GAD), brain scanning shows that limbic or frontal brain regions are activated in people with a high degree of hesitation in reacting to stressful stimuli. Less anxious individuals do not show the same activations. rTMS given to people with GAD over the right upper forehead for fifteen minutes significantly reduces anxiety.

A quantitative electroencephalogram (QEEG) gives a glimpse into the underlying electrical patterns of the brain that can cause or result from various neurochemical changes in the brain. Neurofeedback relies on QEEG measurements and the latest developments in neuroscience. Neurofeedback causes changes in EEG patterns that result in improvement of cognitive, psychological, and emotional symptoms and conditions. There is a large body of neuroscience research to support this approach to managing behavioral health conditions, including anxiety [346].

Current interventions for anxiety disorders leave much to be desired. Psychological interventions are still the keystone to non-medication management of anxiety disorders. There are a couple of drawbacks to these approaches, primarily, their relative effectiveness and that people resist doing treatment. Cognitive behavioral therapy (CBT) plus medication has a 70% benefit but CBT alone is only 14 to 28% effective [299]. Various psychological interventions alone range from 8%-to 38% effectiveness. Individual CBT compared with psychological placebo is 44%. As a comparison, SSRIs and SNRIs are 56 % better than placebo pills [273].

The most common medical approach to managing anxiety is with the use of medications. Medication treatments for GAD currently licensed in the United Kingdom were ranked; duloxetine was ranked first for response (third across all treatments, 3%); escitalopram was ranked first for remission (second across all treatments, 27%); and pregabalin was ranked first for tolerability (second across all treatments, 8%) [30]. A 3% response rate is clearly not that effective. Therefore, medication treatment of anxiety is not a panacea and is associated with significant long-term risks, not the least of which is drug dependency, dementia, and memory decline [363]. In addition, one of the most effective medications for anxiety is extraordinarily expensive for its value in improving quality of life [271]. These cost and risk concerns for only partial benefits indicate the need for other approaches.

With advances in the understanding of the neurobiology of anxiety disorders, new treatment options are being considered, including PEMFs. QEEG research has found six or seven typical patterns in anxiety that can be targeted for treatment. These include imbalance in the frontal lobes in alpha frequencies (8-13 Hz), excessive beta frequencies (>13 Hz) in many parts of the brain, and possibly high alpha frequencies (>11.5 Hz). Based on these findings, neurofeedback practitioners recommend treating both frontal lobes with either lower alpha or alpha at the sides of the head [346]. Some call this alpha training.

While neurofeedback is applied in a practitioner's office and in a different approach compared to PEMF stimulation, there is evidence that both cause changes to the underlying brain EEG patterns. Neurofeedback does this indirectly and PEMF stimulation does this directly. PEMF stimulation does it through entrainment of brainwave oscillations. Many other forms of entrainment have been tested and used, particularly electrical stimulation and visual auditory stimulation. The value of PEMFs over these other forms of entrainment is that they could do the same kind of entrainment stimulation but penetrate deeper into the brain and have the opportunity to be able to heal the underlying brain tissue causes of the problem.

Oscillatory brain activity within the EEG alpha band affects many brain functions, including memory processing and attention [36]. Brain cells responsible for perception, cognition, and action have distinct vibrational patterns. Increase in resting alpha activity at the back of the brain denotes a state of relaxed wakefulness [43].

Even very weak 0.01 gauss (1 μT) PEMF at <1 Hz applied across both sides of the head causes the EEG frequency to change to the applied PEMF frequency. These cause brain entrainment or "synchronization" [335]. One of the more obvious results of ELF MF stimulation is an increase in EEG alpha (8–13 Hz) activity [43].

Alpha waves have been measured in human brains by EEG or magnetoencephalography (MEG). TMS tuned to the alpha (α) frequency (α-TMS), entrains alpha-oscillations in the brain area stimulated, increasing the area entrained progressively with the duration of exposure. The greater the underlying amount of alpha in the brain before starting stimulation, the faster the entrainment. The electromagnetic force that is generated during rhythmic TMS can cause local entrainment of natural brain oscillations. These can look similar to the types of brain rhythms seen naturally during mental tasks. The result is that TMS action on brain activity can generate frequency-specific behavioral changes [457].

In addition, research in Germany [483] found that 10 Hz (alpha) entrainment stabilized circadian rhythms. Stress and anxiety are clear examples of what happens when circadian rhythms and brainwave frequency patterns become disrupted. Sleep disturbances caused by circadian disruption are common in anxiety. So, 10 Hz stimulation can be useful for reducing many of the physical effects of stress by balancing circadian disruption.

Intense magnetic field stimulation has also been reported to affect neurotransmitter function. Daily exposure to 10 Hz fields at 1.8–3.8 mT increases production of dopamine and 5- hydroxytryptamine (5-HTP) in the forebrain of rats. In addition to entrainment, alpha frequencies also increase significant amounts of neurotransmitter production [424].

The evidence for the value of PEMF use in anxiety disorders comes from animal studies and human studies using both high intensity PEMF stimulation (rTMS) and lower intensity PEMF stimulation.

Animal studies

A specific pulsed low-frequency magnetic field 100 microT peak intensity was studied in a mouse experiment of anxiety. The mice had a reduction of "anxiety-like" behaviors, seen in the first fifteen minutes of exposure. When compared to a relatively low dose of a classical anxiety medication, benzodiazepine, behavior was similarly improved by a frequency magnetic field [84, 85]. Rats also had similar results in reducing anxiety levels [197]. At low frequencies (4 and 6 Hz), rats had significantly decreased emotionally negative reactions of anxiety and fear by 370% and 450%, respectively. By contrast, PEMF at the beta frequency of 20 Hz rats had emotionally negative reactions of anxiety and fear significantly increased by 200% [411]. This is consistent with what is seen in QEEG studies in humans.

rTMS in rats selectively bred for high (HAB) and low (LAB) anxiety-related behavior found that rTMS of frontal brain areas induces profound reductions in acute stress coping strategies and hormonal system reactions to stress. This only happened in rats that normally have high anxiety and not in low anxiety rats. The results seen in high anxiety-bred rats were similar to antidepressant drug treatment [200]. This would mean that individuals with normally low anxiety levels would be the least likely to benefit from PEMF brain stimulation.

While data evaluating for possible origins of GAD and panic disorder have been obtained using imaging studies, tissue studies in animals have found other results. Low intensity PEMFs positively affect brain 5-hydroxytryptamine (5HT) receptors whether at 0.1-2 mT (1-20 G) or at magnetic field intensities from the 0.1- 1 mT range, with about 50% of the effect happening at 5 gauss. This means that PEMFs lead to physiological changes in the central nervous system, particularly in mood disorders where the 5HT system plays a major role. This may explain the benefits seen with higher intensity PEMF stimulation used to treat depressive disorders [270].

Human studies - low intensity PEMFs

Most alpha brain stimulation research is conducted by stimulating the brain directly. However, stimulating other parts of the body may have an indirect action on the brain as well. PEMF applied separately to the right or left hand increased in alpha EEG brain activity in healthy individuals in 77%. The smallest EEG changes were seen in those who were self-reliant and showed little indication of strain and anxiety. The greatest changes happened in those showing anxiety, constraint, and less adaptiveness. This is similar to the results in HAB rats above. Other PEMF research also reveals that healthy cells, tissues, or individuals show little response to PEMFs [410].

On the other hand, very low intensity PEMF in healthy women applied simultaneously to two brain areas at the top of the sides of the head for only nine minutes at various frequencies close to alpha, 10 Hz and 14 Hz, and 18 Hz (low beta) caused EEG changes. Stimulation with 10 Hz significantly decreases beta (15-25 Hz), sensorimotor rhythm (13-15 Hz), and theta (4-8 Hz) by 12-27% after exposure. The study indicates that PEMF stimulation to the top of the head at 10 Hz alpha decreases higher frequencies making it especially useful in the treatment of anxiety [8].

Many people with other medical conditions can experience significant anxiety. A sixty-two-year-old male who was diagnosed with Parkinson's disease at age fifty-one had typical symptoms. He experienced sleep disturbances and continuous anxiety. Treatment was with a very low intensity PEMF for six minutes (two minutes over each temple area and two minutes over the top of his head). Immediately following PEMF stimulation, he reported decreased anxiety, complete disappearance of muscle aches, marked elevations in mood and level of energy, increased appetite, and generalized feeling of wellbeing. He also experienced marked improvements in his ability to move his muscles. The effects of this single treatment lasted about three days. Because of this treatment success, he began similar magnetic field treatments at home nightly using a portable device [392].

Some of the PEMF effects in helping anxiety may be due to coincidental stimulation of the acupuncture points underlying the magnetic applicator. As early as 1990, PEMFs have been used in the local treatment of so-called biologically active points (BAPs, acupuncture points, or "acupoints"). They called this "magnetic puncture" (MP). In addition to coincidental stimulation of acupuncture points, small and focused magnetic applicators can be applied directly to very small acupuncture points. This approach was used in men with duodenal ulcers, known to be caused by anxiety and stress. BAPs used for general adaptation were exposed for one minute. Pain and dyspepsia were controlled in three days and ulcer healing took eighteen days, nine days faster than a medication only group. Combining MP and medication therapy actually took longer to control pain and dyspepsia (nine days and six days, respectively) and healing time was the same. MP therapy controlled anxiety. The authors stated that correction of anxiety related autonomic nervous system dysfunction and improvement of its control by the central nervous system were the mechanism of the therapeutic effect of MP [216].

Low Energy Emission Therapy (LEET) delivers therapeutic low levels of electromagnetic energy. Electrical devices like the LEET deliver both an electrical and a magnetic field. It is impossible to segregate which component is producing the results, since it is believed that electrostimulation produces very similar results biologically as PEMFs. What happens with the LEET is also likely to happen with PEMFs, although PEMF therapy reaches deeper tissues than the electrical field can alone.

LEET is applied in the mouth by an electrically conducting mouthpiece. The LEET device is battery-powered, emitting a carrier frequency of 27.12 MHz, modulated at frequencies between 0.5 and 300 Hz. Healthy volunteers received fifteen minutes of either active or inactive LEET. EEGs during the fifteen-minute period following LEET treatment showed decreased time to fall asleep and reach deeper sleep than placebo and improved feelings of relaxation. LEET was also tested on individuals with chronic anxiety. They received a fifteen-minute treatment in the morning and a thirty-minute treatment in the evening every day for six weeks. Anxiety improved by more than 50% in 61% of the individuals at the end of the first week and in 90% by the end of the third week [326].

Like LEET, cranial electrostimulation (CES) may be considered a form of electromagnetic stimulation. CES uses electroconductive gel or water saturated electrodes placed on the skin on the surface of the scalp. Unlike the comparable TENS devices, it can be used across the brain. Because it involves conducting electricity, it also produces a magnetic field. One group conducted a meta-analysis of randomized, controlled studies to evaluate the efficacy of CES for selected psychological and physiological conditions. CES has been used as an alternative therapy for the treatment of insomnia, anxiety, and depression and a variety of other conditions and symptoms worldwide. Eight studies used CES to treat anxiety, two to treat brain dysfunction, two to treat headaches, and two to treat insomnia. Analysis for treating anxiety showed CES to be significantly more effective than sham treatment [207].

CES was also tested for its ability to relieve anxiety in hospitalized psychiatric patients. They received either active CES or placebo stimulation. Stimulation was at 100 Hz for thirty minutes for five sessions on consecutive days. They were retested six to nine days following the last treatment. The active CES group showed significantly less anxiety than the control group [374].

A more complicated group with anxiety is chemically dependent. Hospitalized patients were evaluated in a double-blind study for the effectiveness of CES. About 60% were alcohol abusers and 40% were single or poly-drug abusers. CES was at 100 Hz through electrodes placed just behind the earlobes. Fifteen thirty-minute treatment/sham treatment sessions were given to each person, once a day for three weeks, excluding weekends. Sham-treated people had minimal improvement. Those treated with CES had significantly reduced anxiety levels compared to their initial level on every anxiety measure. Even this challenging treatment group, commonly resistant to most forms of therapy, benefited from electromagnetic therapy [405].

From my own medical practice experience, I had a patient recently who was extraordinarily anxious and had a hard time participating in the office visit discussion. She was wringing her hands and her feet were constantly fidgeting. She clearly looked very anxious. Her chronic daily anxiety was the primary reason for her visit. Because of her anxiety, she couldn't follow everything I was saying and brought a friend with her to the visit to keep track of the information she was being given for how to help her anxiety and other health issues. Given her visible distress, she needed help immediately to be able to continue the visit. I placed a portable battery-operated coil at the base of her neck at maximum intensity (about 300 gauss) and 7.83 Hz. As the visit progressed, her friend and I both clearly saw a huge reduction in her level of anxiety. When she agreed that she felt less anxious, I asked her what her level of anxiety was before she started the PEMF treatment. She said it was eight out of ten, with ten being the worst she could imagine. At that point, she said her anxiety level dropped to four out of ten. That was a 50% reduction in anxiety in barely twenty minutes. She admitted that it felt just like taking a medication that she also used regularly for her anxiety. She was clearly delighted with the rapid benefits without dependence on a medication. Normally, she would have a hard time withdrawing from this medication if she began using it regularly.

For me, this patient's experience was validation—visibly and practically—that medium intensity PEMFs, at theta frequencies, work well to reduce anxiety. This was not only a dramatic clinical experience with a patient, but, as shown above, the value of PEMFs for anxiety is validated by research. Though this is anecdotal, it is in line with previously cited research and provides another example of how promising the use of PEMFs for anxiety can be.

Human studies - high intensity

Some studies show benefit using rTMS in the treatment of GAD. rTMS applied to the right side of the head at low frequency was found to be effective in relieving depression and panic symptoms, and additionally reduced brain irritability (cortical excitability) [114].

Anxiety can occur in people with other psychiatric disorders. Reducing their anxiety can often have an impact on the underlying condition as well. A study, in which 1 Hz, 1 T (10,000 gauss) rTMS was given to schizophrenic and major depression patients for ten days, reported that the depressed patients appeared to show improvements in mood and the schizophrenic patients showed some decrease in their degree of anxiety and restlessness [478].

In individuals with major depression, taken off their usual medications, rTMS made them feel more relaxed or calmer after treatment, but this effect disappeared by the morning after treatment [448].

High frequency 20 Hz (HF rTMS), as an add-on anti-depressive treatment, was used in individuals with medication-resistant depression and anxiety. They continued their regular medication. Patients were divided into two groups to receive HF rTMS or placebo treatment for two weeks with two weeks of follow-up in a randomized double-blind design. Next, rTMS was offered for two weeks to patients who failed to improve or who were in the placebo group. Each received ten sessions of HF rTMS treatment on consecutive days. They were all assessed by the Hamilton Anxiety Rating Scale (HARS) at baseline and after weeks one, two, and four. Real HF rTMS caused a significantly greater decrease in HARS scores in both groups from the first week. This amounted to a thirty-four-fold, eighteen-fold, and ten-fold improvement between the scores, respectively. While anxiety and depression often go together, the depression is often associated with lower frequency EEG oscillations and would respond to higher frequency stimulation. Improving the depression will therefore improve the anxiety [134].

It should also be pointed out that rTMS used at 20 Hz in healthy individuals does not appear to cause or increase the risk of mood changes, including, sadness, anxiety, happiness, tiredness, or pain/discomfort [296].

A pregnant woman with clinical depression was successfully treated with rTMS during week nineteen of her pregnancy. She reported experiencing an acute panic attack with being in open spaces (agoraphobia) while recovering from bronchitis. Her symptoms rapidly worsened over the course of several days to include depressed and anxious mood, severe restlessness and insomnia, constant anxiety about the health of her baby, obsessive feelings about her lack of appetite, and fear about being hospitalized for her bronchitis. At the time of evaluation, she was unable to sit still, was constantly pacing and clenching her fists, had difficulty maintaining focus, and could maintain a conversation only with difficulty. An extensive medical and obstetrical workup ruled out any medical cause for her symptoms. She refused antidepressant medications because of their unknown effect on her fetus and decided to try one session per week of active counseling. She had only minimal improvement after two weeks, and decided to enroll in an rTMS study.

At week twenty-two of pregnancy, she received active low frequency rTMS once a day for five days over a nine-day period at 5-Hz, for twenty minutes each time. rTMS produced no changes in her blood pressure, oxygen saturation, or heart rate. After the second week treatment session, she was tapered off rTMS over the course of five sessions (total of fourteen days of treatment over three weeks). She tolerated the treatment well and repeatedly experienced a calming effect around twelve minutes into the first treatment session and reported being "relaxed and tired." On day six of stimulation, this relaxed effect occurred around three minutes into the session. Anxiety returned to normal. She also showed improvement in her agoraphobia. For example, on her first weekend of treatment, she went shopping with a friend and attended an engagement party. After nine days of treatment, she attended a job meeting out of town without any recurrence of her anxieties. Her mood became bright, conversation more elaborate, and she was minimally preoccupied with her body. Periodic follow-up evaluations indicated that she remained in remission. She delivered a healthy (3.4 kg) baby boy at term. rTMS may be considered in circumstances such as this because it involves no fetal exposure to anesthesia, used with ECT, or to medications [300].

PTSD

Post-traumatic stress disorder (PTSD) is a type of anxiety disorder. In the strictest sense, it is considered the psychological and emotional effects following experiencing or observing trauma. In the broadest sense, PTSD results from symptoms arising from any negative psychological event or events. It is characterized by symptoms that appear suddenly, cause psychological withdrawal, and hyperarousal that may result in significant social or occupational dysfunction. It is estimated that 8% of the United States population experience PTSD in their lifetime and it is estimated that the resulting impaired ability to work costs in excess of $3 billion per year in lost productivity. There is no definitive medical treatment for core PTSD symptoms. Although medications and psychotherapy have been shown to help reduce symptoms and treat comorbid anxiety and depressive symptoms, in one third of individuals there is no improvement in symptoms.

Relatively few studies have investigated the effects of TMS on anxiety disorders, and even fewer in PTSD. One session of single-pulse TMS applied over the top of the head for fifteen minutes produced a significant improvement that lasted twenty-four hours; however, the symptoms had returned to baseline by seven days after treatment. PTSD and depression show different brain changes on imaging studies [243].

Individuals with accidents, combat reactions, and assault, experiencing their trauma about six years earlier on average, have been described. A majority were being treated with medications. In addition, they received a single TMS treatment with thirty stimuli, maximum output of 25,000 gauss (2.5 T) over the top of the head. Results were assessed at two hours before treatment (baseline), twenty-four hours, one week, and twenty-eight days after treatment. All individuals showed significant improvements in symptoms during the first twenty-four hours after TMS, which gradually returned to baseline levels. Psychological withdrawal symptoms, which are core PTSD symptoms, were significantly decreased for up to seven days after TMS. Anxiety and physical preoccupation were significantly decreased after twenty-four hours and the decrease in the physical preoccupation persisted for twenty-eight days. Even with a single TMS treatment, PTSD symptoms improved markedly. Multiple courses of treatment would be expected to produce more enduring results [155]. Combining TMS with counseling or other common therapeutic approaches would be expected to produce even faster and better results.

Another paper described two people with PTSD in whom rTMS appeared to normalize the hypermetabolic areas of the brain around their limbic system. One was a twenty-nine-year-old woman with a twelve-year history stemming from traumatic events when she was between eight and twelve. Her symptoms included depressed mood, cognitive dysfunction with poor attention skills, irritability, chronic fatigue, decreased appetite, abnormal sleep patterns, frequent sense of not feeling herself, unpleasant memories that would intrude on other thoughts, and occasional suicidal thoughts. The other was a forty-two-year-old woman with PTSD for 2.5 years associated with a shooting incident. Her symptoms included flashbacks, sleep disturbances, exaggerated startle responses, panic attacks, depression, and irritability.

Both women had been treated with a variety of medications with only minimal improvement. One Hz rTMS was for twenty minutes per day, seventeen treatments three times per week for the first two weeks, and then increased to five times weekly. Improvement in symptoms was more pronounced during the second half of the four-week treatment period. Frequency of PTSD symptoms was significantly decreased and her personal sense of cognitive clarity improved. The benefits of rTMS slowly reduced and PTSD symptoms gradually returned to baseline one month after the last rTMS session. The forty-two-year-old woman was treated with thirty sessions of right frontal 1-Hz rTMS given twenty minutes daily, 3-4 times per week for three weeks then increased to 4-5 times per week for another three weeks. During treatment, she had significant symptomatic improvement. She felt greatest improvement in symptoms when treatments were more given more frequently. Her symptoms returned to baseline one month after rTMS ended. In both women, regional brain metabolic rates (which were hyper-excited) were measured before and within twenty-four hours after the final rTMS treatment by PET scans. rTMS decreased overall brain metabolism toward normal. The most prominent decreases were seen over the right hemisphere [274].

Low-frequency TMS (1 Hz) is typically inhibitory, and high frequency TMS (frequency above 10 Hz) is excitatory to underlying brain tissue. A review paper of five randomized clinical trials studying 118 individuals found that active TMS was significantly superior to sham TMS for treatment of core PTSD symptoms [459].

In PTSD, EEG studies have shown reduction in alpha in the right hemisphere in PTSD patients compared to control groups while they are exposed to trauma-related pictures. These findings have been corroborated by SPECT studies that have shown brain blood flow to the right hemisphere is increased in PTSD when they hear trauma-related sounds. Trauma-related stimuli during visual memory tests in combat veterans without PTSD and combat veterans with PTSD are different. There is greater activation in the right frontal brain compared to the control group. PTSD patients may require more effort to ignore emotionally distracting stimuli [459]

Since PTSD is such a challenging condition to treat, PEMFs may be helpful either alone or with other therapies. At the very least, PEMFs may be able to reduce the irritability and hyper-excitability of the brain allowing other therapies to be able to be more effective.

PEMF treatment for anxiety may be interfered with by environmental EMFs in some circumstances, producing less effective results. See the appendix on environmental EMFs.

The bottom line is that PEMFs, including high intensity PEMFs, can be helpful in the treatment of anxiety disorders, including PTSD. The value of PEMFs is that there is a great potential for ongoing PEMF therapies in the home setting to provide enduring and long-lasting benefits with continued treatment. This can be done with short-term home treatments or potentially with longer times of use portable PEMF systems applying alpha stimulation. These approaches would appear to produce the most benefit. Nevertheless, since anxiety disorders are complex, combination approaches may well be necessary to produce the best results and long-term use may be necessary. Another benefit of portable, battery-operated systems is the ability to do treatment throughout the night to enhance sleep, which has its own positive benefits for the management of anxiety disorders.

Arthritis (Osteoarthritis)

Osteoarthritis (OA) is the most frequently occurring rheumatic disease caused by metabolic changes in joint cartilage cells (chondrocytes). PEMF therapy has proven to be effective for the management of this condition.

Osteoarthritis (OA) affects about forty million people in the USA. Joints are complex structures including bone, muscle, ligaments, tendons, and blood, nerve, and lymphatic supply. Joint cartilage is a connective tissue that is not able to repair itself well because it does not have a good blood, nerve, or lymphatic supply, and cartilage cells do not replace themselves easily. For these reasons, high-energy, acute, or continual trauma, and extensive stress on the joint, lead to the development of OA.

It typically takes years for osteoarthritis (OA) to develop, and that is why it is most common in the elderly. Changes in the fundamental structures of the joint tissues, that is, the "extracellular matrix," and the presence of inflammation play a key role in OA by inducing an imbalance between tissue growth and tissue breakdown, favoring breakdown. Connective tissue cells also play a role in OA because they secrete a wide range of inflammatory molecules.

Currently in conventional medicine, therapies for OA are aimed at improving quality of life and reducing pain and swelling, but not disease progression. Their primary tools are medications or procedures. Unfortunately, both of these have drawbacks, with limited effectiveness in OA, because of the degree of underlying impairment of joint cells in the presence of an extensive tissue breakdown environment.

The best approach would be to prevent progression of the OA process at the earliest stages. The later the stage and the more severe the problem, the more challenging it is to treat no matter what you do, short of joint replacement. We already know that people with chronic joint pains will use large amounts of nonsteroidal anti-inflammatories (NSAIDs), such as aspirin and ibuprofen, chronically, often resulting in gastrointestinal bleeding. This complication or side effect of NSAIDs unfortunately causes at least sixteen thousand deaths per year in the US alone [425]. This is an unacceptable consequence of a poor chronic treatment option in OA, further emphasizing the need for a different way of looking at the treatment of OA.

As a result, new, safe, non-toxic, and noninvasive alternative therapies are necessary. PEMF stimulation of tissue is a relatively new approach to treating OA, emphasizing stimulation of tissue repair. Most studies to date have shown that PEMFs are effective in treating pain and improving function in OA, typically, most obvious at about eight weeks following treatment, and with virtually no toxicity or side effects.

Previous research both on living and nonliving tissue shows significant benefits of PEMFs OA. Various researchers have found positive effects of PEMFs in cartilage cells and tissue cells with field intensities between fifteen and thirty gauss (1.5 and 3 mT), often using a 75 Hz signal. In these studies, PEMF stimulation increases cell growth and extracellular matrix (ECM) production. ECM molecules include collagen II, glycosaminoglycans (GAGs), and proteoglycans (PGs), IL-1b and IGF-1. PEMFs inhibit inflammation producing prostaglandin E2 (PG-E2), helping to reduce inflammation, and increase joint capsule cells. Breakdown of the joint capsule by the presence of inflammation and a reduction in support molecules is critically important in the development of OA. In addition, local joint tissue stem cells and collagen synthesis increased with PEMFs. Increased proteoglycans provide more lubrication to joints. Stem cells help to repair and regenerate tissues.

Collagen forms the basic structure of the soft tissues of the body, including joints. All of these molecules are necessary to maintain joint health. One study showed positive results between a PEMF of 5-20 gauss used for one to twenty-four hours and PG production, regardless of frequencies between 2 - 110 Hz, as soon as four to twenty-four hours after stimulation. On the other hand, another study showed no benefit from 16.7 Hz PEMF stimulation.

In one study, isolated human OA cartilage cells were cultured in the laboratory under standard conditions or stimulated with IL-1beta or IGF-1 to mimic the imbalance between cartilage formation and breakdown processes seen in OA cartilage in the body. The cells were exposed for a specific time to 100-Hz electromagnetic PEMFs and to Therapeutic Application of Musically Modulated Electromagnetic Fields (TAMMEF), which are characterized by variable frequencies, intensities, and waveforms. The researchers tested the metabolism of the cartilage cells. The exposure of the cells to both systems enhanced cell proliferation, did not generate oxidative stress (reactive oxygen species), did not cause changes in mitochondrial cell charges, and did not induce the death of the cells. Based on this they concluded that both PEMF and TAMMEF systems can be recommended for OA therapy and represent a valid non-pharmacological approach to the treatment of OA [465].

An important consideration in looking at the above results is that it is not always certain what the value is to humans from studying nonliving tissue/molecular laboratory tests. Studying living tissue is more relevant directly to human needs.

A new study has surfaced, which I consider one of the most important studies on OA I have seen in years. We can finally see that there is much more happening with PEMF therapy in OA than simply improving function and reducing pain. Reducing pain and improving function are important, but unless the underlying changes in the tissues that are part of the OA process are actually affected directly, then the underlying problem continues to progress and more aggressive measures will need to be taken years later, including joint replacement.

A groundbreaking new study was done in guinea pigs [468]. Guinea pigs develop arthritis quickly, often severe at about two years of age, with evidence of arthritis beginning between three to six months of age. Guinea pigs are already considered old at about twenty-one months. They have a much shorter lifespan and as a result are often used to study the development of arthritis in humans. The arthritic changes in guinea pigs are pathologically similar to humans, so whatever happens in guinea pigs is believed to be possible in humans, but over longer periods.

This study shows that the fundamental underlying process of progression of arthritis can be slowed, stopped, or reversed, even in the presence of fairly severe arthritis. The guinea pigs were studied in three groups, with two groups using 75 Hz or 37 Hz at a peak intensity of 15 gauss, and treated for six hours a day for three months, and another group with no PEMF (sham). At their deaths, the joints were examined for various components of joint health and breakdown.

The sham group showed increased cartilage surface degeneration compared to the two PEMF groups. In other words, their arthritis got significantly worse in the short three months of the study. On the other hand, in the PEMF groups, cartilage thickness was significantly greater. The PEMF group also had much lower evidence of cartilage damage and degeneration. Bone thickness under the joint capsule typically increases significantly in OA. This is why the whole joint area becomes much enlarged compared to normal. PEMF treatment with both frequencies significantly reduced bone thickness in almost all areas of the knee compared to the sham group. Both PEMF treatments were able to counteract OA progression by acting on both cartilage and the underlying bone. Both frequencies maintain cartilage structure, PG content, cell appearance, and general cell integrity compared to the sham group. Both PEMFs significantly reduced cartilage surface irregularities and resulted in greater cartilage thickness, with 75 Hz being better than 37 Hz.

Even in those animals already at the later stages of OA, PEMFs were still effective at counteracting the progression of OA, especially in cartilage breakdown and less on cartilage thickness, compared to earlier stages of OA. Other aspects of the study showed that the beneficial PEMF effects were not much different between 75 Hz and 37 Hz for most cartilage components even with more severe OA.

Since guinea pig metabolism is so rapid, approximately forty times faster than a human, regeneration was seen quickly. It is hard to see regeneration in human OA because of the length of time treatment would be needed to see these results. This guinea pig research gives added optimism that regeneration of arthritis is indeed possible with regular long-term PEMF use. Clearly, long-term research on humans would be required.

In the general PEMF scientific literature on the treatment of OA, there are no specific indications about the length of exposure, duration, and how long PEMF should be applied. In the laboratory setting, the same PEMF reactions were seen after four, nine, and twenty-four hours of stimulation of cartilage. In a live tissue study, a cartilage response was seen when seven to nine hours per day of treatment were used at 60 Hz. In other studies, PEMFs at 75 Hz, 15 gauss for six hours per day had better clinical outcomes, with decreased use of NSAIDs and reduced knee pain. Daily exposure times longer than six hours may not necessarily increase cartilage preservation, and are generally harder to adhere to. Other studies found an increase in the natural growth factors and a decrease in the inflammatory markers in the joint fluid after PEMF treatment, helping to preserve joint health.

While the results of this study seem to favor 75 Hz over 37 Hz, other research indicates that it is unknown whether other signals can produce similar results in reducing the progression of arthritis. Not even this study compared other frequencies to the ones selected. For those individuals wanting to replicate the most beneficial frequencies in this study, self-treatment would require the choice of a device that allows the specific frequencies to be selected. My own experience with arthritis and joint inflammation is that even though a signal may not be 75 Hz or 37 Hz, it could still be useful for arthritis treatment.

As the above study showed, the best results were obtained with many hours a day of daily use. The downside of using frequency specific PEMF devices for OA is that they require electrical current as their energy source. On the other hand, there are battery-operated devices that, while they do not have the same signal, do allow use throughout the day during activity, or throughout the night, by being battery operated. While the study stopped at three months, I believe that most people with arthritis will need to continue therapy for the rest of their lives in order to reduce or prevent progression of their arthritis. Whether the arthritic process can be reversed is still subject to further research.

The above research shows us that PEMF therapies may be an important tool for the treatment of arthritis. Most adults will develop arthritis during their lifetimes, with it becoming progressively worse as the person ages. Many people already have evidence of arthritis in their fifties, often in their sixties, and definitely beyond that. This is one of the reasons that joint replacements have become so common. The use of PEMFs, even with mild arthritis, will improve symptoms and function and decrease progression, probably allowing the person to avoid procedures and eventually joint replacement. What has to be accepted by anybody with arthritis is that treatment will have to be lifelong, whether the arthritis is mild or severe.

Back pain

Up to 85% of adults will experience back pain, including low back pain, at some point in their lives. As many as 10% of those who develop low back pain still have it three months after it starts, which makes it a chronic condition. Back pain is the second most common neurological ailment in the United States—only headache is more common.

Low back pain may reflect nerve or muscle irritation or bone lesions. Most low back pain follows injury or trauma to the back, but pain may also be caused by degenerative conditions such as arthritis or disc disease, osteoporosis or other bone diseases, viral infections, irritation to joints and discs, or congenital abnormalities in the spine. Additionally, scar tissue created when the injured back heals itself does not have the strength or flexibility of normal tissue.

Buildup of scar tissue from repeated injuries eventually weakens the back and can lead to more serious injury.

The lack of visible changes to spinal discs at surgery may give the perception of the lack of a disc problem. However, when discs are looked at under a microscope, tiny changes can be seen, often starting as early as the second decade of life. This shows that oxidative stress, tissue inflammation, or poorly nourished tissue due to decreased circulation is present earlier in life than expected and possibly the cause of the problems seen later in life.

A huge variety of conditions may lead to back pain. Among them are:

- Bulging disc (also called protruding, herniated, or ruptured disc)
- Sciatica
- Spinal degeneration from disc wear and tear can lead to a narrowing of the spinal canal
- Spinal stenosis
- Osteoporosis
- Skeletal irregularities
- Fibromyalgia
- Spondylitis
- Lumbar spine stenosis
- Radiculopathy (a set of conditions in which one or more nerves are affected and do not work properly)

Typical treatments of back pain include analgesics, ice or heat, bed rest, exercise or yoga, medications, manipulations including chiropractic work, acupuncture, steroids, and surgical approaches. When there are so many approaches to treating back pain, it usually means that they are all ineffective to some degree. Clearly, there are times when surgery is the absolutely right thing to do, but it should always be the last resort. Surgery unfortunately has complications and consequences that are irreversible, including failed back syndrome. The only clear indication for surgery is for tumors, cysts, or cancer. A relative indication is major nerve compression. Decompressing a nerve with clear objective evidence of the nerve being pressed on by a disc or the arthritis of spinal stenosis is important to be able to obtain recovery of the nerve as fast as possible.

Almost all current back pain treatment approaches have been found to be variably successful, inconvenient, painful in themselves, expensive, or invasive. Many of them are more likely to be useful for acute back pain but not as useful for chronic back pain. For chronic back pain, they would need to continue to be applied over long periods. Spinal stenosis and arthritis of the back are not conditions that are physically reversed easily. Usually they will persist for the rest of a person's life and typically are progressive. So, many treatments for low back are simply buying time and reducing symptoms temporarily. Long-term solutions, such as PEMFs, that are safe, non-toxic, noninvasive, and convenient should be considered.

In addition, imaging studies may show abnormalities in the back but the source of the pain is actually somewhere else. It is common with back surgery to have the surgery fail because the actual cause of the pain is not resolved with the surgery. This is also another reason for failed back syndrome and it suggests consideration of PEMFs for conservative management as a first resort, not a last resort.

There have been many studies on PEMF therapy for back pain.

Two randomized studies looked at patients with either signs or symptoms of lumbar nerve compression (radiculopathy) at L5/S1 or whiplash syndrome. One hundred patients with lumbar radiculopathy and ninety-two with the whiplash syndrome were studied. Both groups (magnetic field treatment and controls) received standard medication. Group 1 had low intensity PEMF therapy twice a day, for two weeks. The average time to pain relief and painless walking was eight days in the PEMF group, and twelve days in controls. In whiplash, pain was measured on a ten-point scale. The before/after result averages were as follows: Pain in the head 4.6/2.1 in magnetic field treatment, and 4.2/3.5 in controls. For neck pain 6.3/1.9 as opposed to controls 5.3/4.6, and pain in the shoulder/arm with PEMFs 2.4/0.8 as opposed to controls 2.8/2.2. So, PEMFs have a considerable and significant potential for reducing pain in cases of lumbar radiculopathy and the whiplash syndrome [456].

In another randomized controlled clinical trial, researchers evaluated the effect of a PEMF system in the management of patients with disc-related lumbar radiculopathy. The study included forty patients with lumbar disc prolapse who were randomly assigned to either a PEMF group or a control group that received placebo treatment. Both groups were evaluated at baseline and after three weeks by using the commonly used visual analogue pain scale (VAS) (0-10), and objective electrical sensory tests (SSEPs) and a questionnaire using a Modified Oswestry Low Back Pain Disability scale (OSW).

Results were compared before and after treatment. PEMF produced better results for the OSW, personal care, lifting, walking, sitting, standing, sleeping, social life, and employment. PEMFs also produced better results in physical signs of sensation, an indicator of nerve damage, sensory testing. So, they found that PEMF therapy is an effective method for the conservative treatment of lumbar radiculopathy caused by lumbar disc prolapse. In addition to improvement of clinically observed nerve entrapment symptoms, PEMF therapy was effective in reducing physical nerve root compression as evidenced by improvement or recovery of objective tissue electrical sensory tests after treatment [317].

Patients with lumbar osteoarthritis who were treated with 35-40 mT PEMFs found relief between 90-95% of the time. PEMF therapy also improved results from other rehabilitation therapies and improved related neurologic symptoms [288]. Even PEMF of only 5 to 15 gauss used at the site of pain and related trigger points dramatically improved patients' pain [356]. Some patients remained pain free six months after treatment.

While PEMFs can be especially dramatic in acute back pain, they are actually most often used for chronic back pain. Those patients who had PEMF systems for other reasons and used them for any acute back pain got over their back pain much faster.

Failed back syndrome, as mentioned above, is a somewhat disastrous consequence of back surgery, and largely unpredictable. I have had a number of patients who had failed backs with nothing else for medicine or surgery to offer, except addictive painkillers. Failed backs, that is, continuing or worse back pain resulting from the surgery itself, can be a disaster and much more disabling than the original condition. Most of these patients become disabled because of their back problems. They often have had multiple procedures to their backs. In this situation, PEMF therapy is a rescue treatment and can make a huge difference in their ability to function. While PEMFs may not be able to eliminate the pain because of the degree of damage to the back, a severe pain may become a tolerable mild pain.

As a final consideration, there appears to be a correlation between heavy cigarette smoking and chronic back pain. Researchers tested two questions: (1) whether cigarette smoking reduces intervertebral disk pH, and (2) whether PEMFs might be capable of blocking this reduction in pH induced by cigarette smoke. Rabbits were exposed to cigarette smoke in the presence or absence of PEMFs. Rabbits were exposed to smoke for two weeks (twenty cigarettes), four weeks (forty-four cigarettes), or six weeks (sixty-four cigarettes). In anesthetized rabbits, intervertebral disk pH was measured. These experiments demonstrated a significant induction of acidic pH in the intervertebral disk fluid in the cigarette-exposed rabbits, regardless of duration of smoke exposure. In a second experiment, two groups of smoke-exposed rabbits were tested with PEMFs. Group 1 rabbits were exposed to two cigarettes per day with simultaneous exposure to PEMFs. Group 2 rabbits were exposed to two cigarettes per day, and after that were exposed to PEMF for four hours per day. Group 3 rabbits were not exposed to smoke, but were exposed to PEMFs for four hours per day. All three groups were treated for two weeks. PEMFs prevented smoke-induced acidification of the disks compared to animals not treated with PEMFs. The pH improvement effect was more pronounced in the smoke-exposed animals receiving four hours of daily PEMF treatment, about the same as animals without smoke exposure. This study not only demonstrates the harmful effects of smoking on disc health but also has implications for smoking humans who need to have bone graft fusions of their vertebrae. These results also dramatically demonstrate that PEMFs are likely to counteract the negative effects of smoking on bone and discs [164].

Some of the most gratifying work I've done with PEMFs has been in people with back pain. I had one patient who was told that his back-disc problem was not operable. He normally had an almost one-hour commute each way to work every day. By the time he got to his job, he would be in excruciating pain. I recommended a portable PEMF system with the coils placed on his lower back. He had a dramatic benefit in the first hour from use, while sitting in my office, and I spoke to him several weeks after he started using the therapy for several hours a day, including during his commute, and he said that he was able to drive with virtually no pain. He was also able to sit at his work desk for hours at a time without significant pain. He didn't need surgery.

In my experience the treatment of back pain with PEMFs, especially with higher intensity systems, is one of the most common and one of the most gratifying conditions to treat, even when conventional medical and surgical approaches have failed. The evidence cited above supports this value.

Bladder Conditions

Enuresis, nocturnal

Enuresis, or bedwetting, is a common childhood condition, although the problem may also persist into adulthood in some cases [303]. There is similarity between urinary symptoms in childhood, such as nocturnal enuresis (NE) and overactive bladder (OAB) symptoms, and OAB in adulthood [379].

Normally, mammals urinate less frequently during sleep than when awake. This is affected by three factors: decreased arousal (wakefulness or alertness levels) in the brain, decreased urine production in the kidneys, and increased functional bladder capacity (FBC) during sleep. People with enuresis and nighttime urination show impairment in these three factors.

Many children and adults with enuresis wet their beds not because their bladders are full, but because they suffer from nighttime bladder over-activity [100]. There is great overlap between nighttime enuresis and urgency or urge incontinence.

There is increasing evidence that these mechanisms can be attributed to an underlying brainstem disturbance. There are four neuronal networks spreading their communications to many areas of the brain, and all relate closely to arousal and sleep function. Among the four networks, the "fight/flight" noradrenaline network, originating from the locus ceruleus (LC), is the system most typically responsible for arousal. The LC is activated by the stimulation of a filling or full bladder while the person is in deep sleep. The LC overlaps both functionally and anatomically with the brainstem micturition center, which coordinates the reflex to urinate, called the micturition reflex. The LC and the micturition center are located next to each other in the brainstem.

Growing evidence suggests that basic or primary enuresis is a maturational disorder of the central nervous system with a lack of arousal and inhibition of the micturition reflex. Those with nocturnal enuresis are characterized by abnormally increased excitability and reduced inhibitory processing in the part of the brain controlling muscle movement. This could also contribute to the development of nocturnal enuresis [202].

Common treatments include pharmaceuticals (Desmopressin, antidepressants, anticholinergics), advice regarding fluid intake and regular voiding habits, and enuresis alarms. Less common but still somewhat accepted treatments include acupuncture, biofeedback, and electrical stimulation [57].

Electrical stimulation has been used for more than a century as an alternative therapy for adult urinary syndromes, such as urinary incontinence (UI), urgency, frequency, and urinary retention. There are many forms of electrical stimulation, including interferential (IF) current via transcutaneous application, frequency-specific electrostimulation, and sacral nerve stimulation (neuromodulation) [99, 406].

Though most electrostimulation has shown value in treatment-resistant cases, it remains an invasive and potentially uncomfortable option [115, 194]. For this reason, PEMF therapy may be a better option.

Magnetic stimulation, initially a treatment for adult UI, has also been shown to be a relatively simple and effective mode of neuromodulation in various types of voiding dysfunction and produces results comparable with those from invasive sacral nerve stimulation (SNS). Magnetic stimulation is believed to have the same underlying effect as SNS in that it generates an electrical field in tissue that results in nerve stimulation (considered neuromodulation). Unlike direct electrical stimulation, which decreases in intensity in deeper tissues due to resistance in the tissues, and has to be applied through an electrified needle to reach deeper structures, a magnetic field penetrates tissues without alteration and without having to have a needle inserted into the body. Therefore, a greater effect can be achieved with a PEMF on tissues at a greater depth and with little to no discomfort at the point of application.

This ability of PEMFs to stimulate tissues at depth is especially important to improve all the muscle and nerve tissues of the bladder directly, which are the cause of OAB. Electrostimulation works indirectly by only affecting the spinal nerve function controlling the bladder. Magnetic stimulation accomplishes both tasks, for a more complete solution.

PEMF therapy is thus a more acceptable and valuable form of electrical therapy, especially for children, because it is painless, noninvasive, and free of side effects. It is also convenient because the magnetic fields pass completely through clothing, and do not cause children the distress of having to undress to attach electrodes at every stimulation session. In addition, electrostimulation is usually uncomfortable, with a prickling or stinging sensation. Therefore, I believe that PEMF stimulation for children is more appropriate and effective than SNS and other forms of "electrical" stimulation.

Transcranial magnetic therapy (TcMT) was studied in children with nocturnal enuresis (NE). Children (age six to fourteen years) were divided into two groups, with a control group receiving sham/placebo treatment and basic therapy. Basic therapy was a standard anticholinergic medication. The study group received basic therapy in combination with active TcMT. The results showed that TcMT improves the clinical effect in NE patients two-fold over what is seen with pharmacologic treatment alone [321].

A group of fifty-five children, including boys and girls, with NE refractory to various other treatments, had high intensity PEMF applied under the pelvis for ten minutes, a two-minute rest period, and a second ten-minute treatment, once a week for four weeks. Of them, 64% had a decrease in their NE by more than 50%, about half of the time after seven treatment sessions. The frequency of NE went from five to two episodes per week. The mean bladder capacity increased almost twofold [198].

Frequent nighttime urination is a common distress with OAB. Portable PEMF stimulation was tried in young females with NE and incontinence. The young females (6-14 years old) were randomly assigned to either active magnetic stimulation or sham stimulation. They wore portable stimulators continuously day and night for two months. In the active treatment group, the number of weekly NE episodes decreased significantly compared to sham, from 3.1 to 1.3 per week. Three girls from the active group were completely dry and four were significantly improved. Also, in the PEMF group there was a significant increase in bladder volume at the time of a strong desire to void as well as an increase in bladder volume at that void. The increase in volume indicates that the bladder can be stretched more before the urge to urinate is perceived [64].

In a different study, a portable PEMF device was used in women with mixed incontinence and objective measures of bladder dysfunction. After two months of wearing a portable magnetic stimulator (applied continuously over the pubic bone day and night), they had significant decreases in voiding frequency, nighttime urination and pad use. Of this group, 78% reported improvement in symptoms after magnetic stimulation with an average success rate of 42% versus the sham group at 23% [66]. The results would no doubt have been even better had the study been continued longer in those who did not respond in the first two months. This is normally what would have been done if this had only been a clinical setting.

Another group of children was treated with a 25 Hz, 25 mT coil applied to the pelvic area for ten minutes at a time for ten treatments. Of these children, 69% had either no enuresis or it was greatly reduced. They also had x-ray evidence of improvement in bladder capacity and the capacity to empty the bladder [190].

Urinary incontinence and overactive bladder

Urinary incontinence (UI) and overactive bladder (OAB) are extraordinarily common conditions in both men and women. In women past menopause, UI is often combined or mixed with stress incontinence and makes management more complicated. Medical management of urinary incontinence and overactive bladder still leaves a lot to be desired. It includes medication, surgery, invasive neuromodulation, and cognitive behavioral therapy. No gold standard therapies clearly stand above all others. As a result, there is a constant search for other approaches to dealing with this problem, safely and noninvasively. PEMFs appear to have a role in the management of UI and OAB.

UI and OAB are complicated. The most recent science on OAB indicates that this condition in particular involves muscles and nerves in the bladder, nerves in the spinal cord and most likely even involves the brain. Inflammation is an important background and underlying aspect of UI and OAB. Therefore, managing inflammation becomes an important part of the solution to this problem. As has been previously stated, one of the most important roles of PEMFs is to decrease inflammation. Since there is both muscle and nerve involvement, again, PEMFs have been well established to decrease muscle irritability and over activity, as well as the over excitability of nerves.

In my review of the science, it's clear that high intensity PEMFs (HI-PEMFs) do improve OAB and UI significantly, including positively changing the underlying causes of the incontinence in the bladder tissue itself. At the same time, research is showing that even very low intensity magnetic fields, worn throughout the day for upwards of two months at a time also produce improvement. Some of the studies at the lower intensities used 10 Hz and 18.5 Hz, both producing positive results. Higher intensity PEMF systems are typically limited to much lower frequencies, or repetition rates, usually less than 10 Hz. But from all of this research, there is still no certainty as to which frequency or intensity works best.

Neuromodulation has revolutionized the management of OAB and is now well established as a safe and effective treatment for those who don't respond to conservative medication treatments. Most of this involves uncomfortable and surgically implanted electrical stimulation. PEMFs have been discovered to have similar actions without the discomfort, cost, or harm. Neuromodulation also happens with PEMFs, since these magnetic fields reach deep into the body and pelvis non-invasively. Therapeutic electric fields do not go deep into the body. This is why electrical stimulation usually has to be done right on the nerve or muscle being stimulated. That's also why the stimulators typically have to be surgically implanted.

In addition to doing neuromodulation, PEMFs also work on muscle directly, addressing the theory that OAB derives from problems with the muscles of the bladder itself and pelvis. In Kegel exercises the goal is to stimulate weakened or stretched pelvic muscles to contract to reduce stress incontinence. This is caused by the lack of muscle strength in the pelvic muscles, affected by the stretching of the tissues during labor. The pelvic muscles maintain the position of the bladder in relation to the urethra. When this position is disrupted, stress incontinence happens. Kegel exercises frequently fail, for many reasons. As noted above, stress incontinence can also be associated with urge incontinence, partly due to bladder muscle irritability. High intensity PEMFs can strengthen pelvic muscles but also work on the irritable bladder muscles to relax. Lower intensity PEMFs can also help bladder and pelvic muscles to relax.

An early clinical trial in a small number of women found that magnetic stimulation of the pelvic floor muscles may be effective for urge incontinence [446]. Patients with urge incontinence who failed pelvic floor muscle training were given high intensity ten-week PEMF treatments with a continuous 10 Hz chair device at about 1100 gauss. They had a number of tests conducted at the end of the ten-week cycle of treatments. This group was compared to another group receiving sham treatments. Magnetic stimulation was found to be effective in reducing urge incontinence on both physical and subjective measures.

In another study by the same group, using 20 Hz, fifteen-minute (with one-minute on and thirty-second off cycles) stimulation twice a week for five weeks, women with stress incontinence and another group with urge incontinence were treated with high intensity PEMF stimulation. In that study, 86% of patients with stress incontinence and 75% with urge incontinence were improved.

The ability of the urethra to control pressure from the bladder to urinate is important in reducing incontinence, to allow some degree of voluntary control by being able to delay the urge to urinate if needed. In earlier work done by the same Japanese group, they studied the use of a magnetic coil underneath the pelvis in the area from the anus to the pubic bone, called the perineum. They confirmed that urethral pressure increased, suggesting that magnetic stimulation can be effective as a UI therapy. In other words, the women studied were able to tolerate pressure from the urge to urinate longer without having to urinate [182].

Another study reported on the ability of PEMFs to control urethral pressure. An active PEMF treatment group received high intensity functional PEMF stimulation. The stimulating intensity was gradually increased to the tolerable limit. This common approach is used in the office setting, since individual tolerances tend to vary. A fifteen-minute, 20 Hz single session was carried out using an on-off cycle of PEMF stimulation. In the active PEMF treatment group, the maximum urethral closure pressure increased significantly after stimulation, allowing better voluntary urethral urinary control. In the sham group, no changes were seen. All women tolerated the functional continuous magnetic stimulation well, and none experienced any adverse effect [496].

In a much larger study to evaluate the efficacy and safety of magnetic stimulation for the treatment of UI in women with OAB, a larger group of women with UI were randomized to active stimulation or sham stimulation. An armchair-type magnetic stimulator was used for a twenty-five-minute magnetic stimulation twice a week for six weeks, 560 mT (5600 gauss) peak at 10 Hz. The sham device was kept at a maximum intensity of 20% at 1 Hz. The number of leaks per week, number of voids/urgency per twenty-four hours, mean and maximum voided volume, and the quality of life assessment were measured. The active treatment group experienced about half the number of leaks per week and number of urgency sensations per twenty-four hours and a large increase in the amount of urine voided. Even the sham group experienced some benefit because they were still getting PEMF stimulation, albeit at a 20% intensity. This suggests that even some lower intensity systems may produce a lower level of benefit. As for safety, except for rare episodic, treatment-related diarrhea and constipation, no patients experienced any significant device-related adverse event, despite the high magnetic field intensity [493].

As the above study found, few adverse events are typically found with PEMF stimulation, even with high intensity PEMFs. To verify this, another group evaluated whether there were any obvious tissue or cycle changes in rats receiving much lower intensity continuous stimulation to their genital organs (uterus and ovaries). Rats are much more sensitive to PEMFs than humans, and tend to show adverse effects results sooner than would be seen in humans. The rats underwent thirty-six sessions of twenty-five-minute PEMF stimulation with 10 Hz at a maximum output level of 560 mT (5600 gauss) once per day, five days per week. No adverse effects of long-term PEMF stimulation were noted. So, these results are reassuring to the potential risks to humans of frequent treatment to pelvic organs with PEMFs to improve OAB and UI [401].

PEMFs also have varying abilities to penetrate deep into the body or act on specific nerves or tissues. The deeper in the body the tissue is that needs stimulating the stronger the magnetic field often needs to be. High intensity PEMFs are usually required to activate sacral nerves. rMS can achieve this. High intensity 15 Hz repetitive peripheral magnetic stimulation (rMS)—as opposed to rTMS, which is transcranial magnetic stimulation—was evaluated in women with stress incontinence. rMS of the sacral nerve roots (S2-S4) was applied for fifteen minutes, three days a week for two weeks (six times in all). At one week after treatment ended, the active stimulation group showed improvement in health perception, social limitation, sleep/energy performance, and incontinence severity. These results were not seen in the sham stimulation group. Also, these results were no longer seen at one month after the end of treatment. So, rMS of the sacral roots has a short-term benefit on the quality of life of patients. This is also true as well for electrical stimulation. And, these results are comparable to those seen in short-term treatment programs for pain management using rMS, suggesting that longer-term courses of treatment are necessary [264].

While the above research group did not find significant physical changes with short-term high intensity magnetic stimulation, another group [131] found that with only thirty minutes of treatment with rMS to sacral nerve roots, the number of leaks and amount of urine loss on a pad test significantly decreased with only one treatment session. They also found that there was a 74% improvement in quality of life, which is often reported to be diminished with OAB.

A group of Japanese researchers has worked for years on developing techniques of using magnetic stimulation as part of neuromodulation. They devised a continuous magnetic stimulator allowing longer-term, in office magnetic stimulation, using a magnetic chair type device. They wanted to see if continuous magnetic stimulation would result in strengthening the closure of the urethra when under pressure and inhibition of bladder contractions in dogs. The stimulating coil was placed underneath the pelvis to stimulate the pudendal nerve at 10 Hz. Urethral pressure was increased by more than double and bladder contractions were inhibited [496]. In effect, OAB was improved.

Many of the above studies were high intensity, neuromodulation-type PEMF approaches. Lower intensity PEMF treatments appear effective too. In one research study, investigators used a portable magnetic therapy device worn in a garment over the bladder continuously all day. Women with UI receiving active device treatment were compared to a group of women who used a non-active sham device. The treatment device had a pulsating magnetic field of 10 microTesla and 10 Hz, worn day and night for two months. Compared with the sham device, the number of pads used was significantly lower, as was the pad weight, and a significant improvement in the power and duration of pelvic floor muscle contractions. Active magnetic stimulation produced a 56% improvement in UI symptoms compared with 26% improvement in the sham group. This form of magnetic stimulation is efficient and safe, can be used at home, and because of its small size, wearing the device is not annoying for patients [66, 67].

A portable PEMF device with 18.5 Hz was used to treat women with mixed urge and stress incontinence, who also had objective measures of bladder function. The active treatment group was compared to a sham control group. The device was applied day and night continuously for two months. After two months of magnetic stimulation, there were significant decreases in voiding frequency, nighttime urination, and pad use. First sensation of bladder filling and maximum bladder capacity increased significantly before and after stimulation only in the active stimulation group. Seventy-eight percent reported improvement in symptoms after magnetic stimulation with an average success rate 42% versus a success rate in the sham group of 23% [65].

The same group looked at the use of this same type of PEMF stimulation in young females with enuresis, or nighttime bedwetting. This also applies to women with UI, because frequent nighttime urination is a common distress with OAB. Females, mean age eleven years, range six to fourteen years, were randomly assigned to either active 18.5 Hz magnetic stimulation or sham stimulation. As above, they wore their stimulators continuously day and night for two months. In the active treatment group, the number of weekly enuresis episodes decreased significantly compared to sham, from 3.1 to 1.3 per week. Three girls from the active group were completely dry and four were significantly improved. Also, in the PEMF group there was a significant increase in bladder volume at the time of a strong desire to void as well as an increase in bladder volume at that void [64].

PEMFs can be helpful in women struggling with urinary incontinence. Lower intensity, home-based PEMF therapy is likely to be successful without the risks associated with medication and may well reduce the risk and need for more invasive treatment approaches. They are easy to use and have no risk. Lower intensity PEMFs should be considered first before the need to use higher intensity PEMF systems, which are typically done in doctors' offices.

Bone Healing and Repair

Electromagnetic stimulation is a safe and effective way of enhancing bone formation. One of the first medical and regulatory accepted uses for PEMF therapy was in the treatment of nonunion fractures. PEMF therapy is useful in the treatment of acute injuries like breaks or fractures (whether fresh, delayed, stress, or nonunion fractures), incorporation of bone grafts, and for the prevention and treatment of more chronic bone conditions including osteoporosis and osteopenia. Even with proper use of nutrition, hormones, and supplements, additional energy is necessary to create new bone structures effectively.

PEMF therapy accelerates the ECM formation and stimulates tissue healing while enhancing deposition of calcium phosphate crystal seeds in bone. PEMF therapy induces electric currents or charge in tissues, which improve the permeability of the cell membrane, increasing bone formation and bone density simultaneously.

PEMFs have been used extensively as a non-invasive treatment for fractures and the enhancement of spinal fusions. Common PEMF configurations include medium or low intensity, low-frequency magnetic pulses, or pulse bursts applied with a coil over the target area. In animals, PEMFs show enhanced early fracture healing, generation of cartilage, and reactive bone formation. Even in laboratory studies with bone cells, PEMFs are seen to enhance the proliferation and maturation of bone building cells (osteoblasts) and thus the formation of new bone. To rebuild bone in a fracture also requires the old bone to be broken down and removed. The body molecules that breakdown bone (osteoclasts) are increased by PEMFs. So, PEMFs not only stimulate the bone building molecules (osteoblasts), but also help with the remodeling molecules (osteoclasts). These effects are as good or better, and safer, than medications used for this purpose. Typically, the medications do not affect both functions (osteoblasts and osteoclasts). As a result, medications often will leave the bone even weaker in the long run, as is often reported by oral surgeons in instances of fractures of the jaw.

Surgical incisions in bone and the presence of implants cause acute and at times chronic inflammation [11]. During inflammation, scavenger macrophage cells release reactive oxygen species (ROS), such as nitric oxide (NO) and superoxides. Inflammation is known to hinder bone repair. On the other hand, moderate amounts of NO can stimulate bone breakdown whereas high concentrations of NO suppress bone breakdown and reduce the number of osteoclasts [248]. As demonstrated in the previous section, PEMF therapy has been shown to improve both inflammation and the production of NO.

Low frequency PEMFs change calcium ion concentration in cells and stimulate DNA production. The calcium ions inside cells regulate NO production and increase it. NO in bone cells has been linked to their development and growth into mature bone cells. Osteoblasts themselves are capable of generating NO once stimulated by inflammatory molecules or PEMFs. Osteoblasts need moderate amounts of NO to maintain their numbers. These effects of PEMFs are important for the management of osteopenia or osteoporosis, fractures and other bone problems [248].

New bone formation (osteogenesis) is a complex series of events involving the differentiation of soft tissue (mesenchymal) stem cells and gene expression in bone marrow undifferentiated soft tissue (mesenchymal) stem cells (BMMSCs) during new bone formation to generate new bone. Exposure of BMMSCs to PEMFs increased the number of stem cells by 30% compared to untreated cells. PEMFs significantly increased osteogenesis-related genes by 2.7-fold. These results indicate that PEMFs enhance early stem cell proliferation and as a result accelerate osteogenesis [443, 444].

A unique study was done to compare the effects of different waveforms of PEMFs (sinusoidal, triangular, square, and saw tooth), all set at 50 Hz and 1.8 mT on increasing the number of new bone cells (proliferation), turning them from immature to mature cells (differentiation) and the deposition of the minerals necessary for the hardness of bone (mineralization). These were studied in rats' skull osteoblasts. Square wave PEMFs stimulated osteoblast proliferation but sinusoidal EMFs inhibited it. Sinusoidal and triangular EMFs produced significantly greater differentiation - indicated by the production of alkaline phosphatase (ALP), calcium deposition, mineralized areas, and gene growth factors, as compared to square and saw tooth PEMFs. Triangular PEMFs were better than sinusoidal EMFs on most indices. These results indicated that while square EMFs promoted proliferation and had no effect on the differentiation of osteoblasts, sinusoidal EMFs inhibited proliferation but enhanced bone cell differentiation. Triangular EMFs did not affect cell proliferation but induced the strongest osteogenic activity among the four waveforms of EMFs. Thus, in this study the effects of EMFs on proliferation and differentiation of osteoblasts in the laboratory were dependent on their waveforms [506, 507]. Whether the same differences with different signals would be seen in the clinical setting is unknown.

Externally applied PEMFs can induce oscillating magnetic fields in tissue, compensating for the mechanical deficits of bone injury or dysfunction. Experiments were done using PEMF therapy on samples of human bone removed during hip joint operations and placed in a bone preservation bath saturated with calcium phosphate. Within twenty-four hours, the PEMF stimulated bone samples showed a highly significant increase in calcium uptake (approximately 70% higher than untreated samples). X-rays showed a significant increase in density of the stimulated bone tissue. To further this research, in the veterinary setting, beagles had screw and plate implantations into their lower jaws. PEMF treatment resulted in bone that was superior to the control group in mechanical strength and tissue biopsy [215].

Fractures provide us with a clear example of how bone heals itself. Fractures of the lower jaw are more challenging to treat than in other parts of the body because of the complicated structures involved. After a fracture, the jaws often have to be wired to restrict movement, similar to what a cast would do with longer bone fractures. Eighty-seven patients with jaw bone fractures had PEMFs four to five days after usual care produced good results. They had five to ten exposures ten to fifteen minutes long. The PEMFs produced a marked decrease in swelling and pain, and bone measurements showed enhanced bone regeneration [282].

Stress fractures are a common injury in athletes. They are most commonly seen in the lower extremities, especially with running. Stress fractures result from repetitive, cyclic loading of bone that overwhelms the reparative ability of the skeletal system. Typical treatment options include rest and stopping the activity. Some stress fractures are at risk for complications of healing, including non-union. Women are more likely to have stress fractures. They are often related to eating disorders, amenorrhea, and osteoporosis, called the female athlete triad. PEMFs in this situation can be helpful in both treatment and prevention [358].

Foot fractures are also very common and are somewhat prone to failure if not handled properly. Surgery is the most common approach to control these fractures. Patients with a fifth toe (metatarsal) delayed or nonunion foot fracture, with no progressive signs of healing for a minimum of three months were studied in a randomized, double-blind trial. Each person had a biopsy of the fracture site and fitted with a PEMF device. Three weeks later, they underwent surgery with a repeat biopsy, alignment of the fracture and implantation of hardware into the area of the fracture nonunion. They were followed at two- to four-week intervals with serial x-rays and graded by the amount of healing. All fractures healed, with an average time to complete x-ray union at fifteen weeks for the inactive group and nine weeks for the active PEMF groups. In other words, the PEMF group healed their fractures in almost half the time than normal. The biopsies showed that there were significant increases in healing growth factors. These PEMF-stimulated growth factors aided in faster recovery of these nonunion fractures [439]. While PEMFs have been used successfully for repairing small bone fractures (<1 cm), for the repair of larger fractures (>1 cm) they do not have good results, when used alone. Tissue-engineered artificial bone grafts placed in the bone defects to induce host bone tissue ingrowth are often required to achieve adequate faster bone repair.

One animal study evaluated the effects of a one-time PEMF treatment (1 Tesla, thirty pulses per day) on new bone formation and regeneration of blood supply (revascularization) with an almost dead bone graft. Results showed that high intensity PEMF treatments at both seven days and twenty-five days after surgery increased new bone formation around the dead bone and increased new blood vessel formation. This PEMF enhances bone repair, new blood vessel growth, and cell growth even in dead bone. The clinical advantage of this PEMF is the short daily application and the shorter treatment course. Therefore, high intensity PEMF may be used to treat fractures and the early stages of bone death, even with few treatments [129].

Since most conventional medical management of bone lesions is either passive or surgical and results in a heavy burden of disability and cost to our society for recovery, a natural approach to enhancing and accelerating bone healing is needed. If the time to recovery can be shortened by even half, as some research shows, the savings in suffering and costs to our society can be reduced dramatically. PEMFs are neither passive nor surgical, and can be used safely either alone or alongside other therapies to be greatly beneficial.

Bruising

A bruise is simply a collection of blood that exists outside of a blood vessel (hematoma) caused by some type of trauma. The blood from a bruise collects in the spaces between cells. They are unsightly, tender, limit function, and retard healing. The body has to decrease the swelling, the space that is occupied by the blood, the inflammation and heal the underlying injury. PEMFs reduce bruising by inhibiting inflammation, improving circulation. PEMF therapy can be especially helpful for post-surgical bruising. Plastic surgeons have known about the use of PEMFs for healing postoperative wounds and bruising. Almost any PEMF system applied as early as possible after a bruise develops will help to accelerate the healing of the bruise. Often there is as much is a 70 to 80% reduction in a bruise within twenty-four hours. In sports injuries, ice is typically used to reduce bruising, but the depth of penetration of ice is shallow and will not work well in deep bruising. In addition, ice will tend to slow down the healing process. Therefore, PEMFs are a much better solution not only for the bruising, but also to accelerate the healing of the underlying injured tissue.

Cancer

Cancer is the second most common cause of death in North America behind heart disease. At this time, few cancers are curable and there is a constant search for new treatments. Most conventional therapies for most cancers are best for the early stages of presentation. In the later stages, 3 and 4, most medical therapies fail and only, often at great cost, extend life by a matter of only months. So, there is a huge need to find therapies that can help and ease the burden of suffering with better management of cancer, whether or not they may cure.

PEMFs have been studied to a moderate extent in the setting of cancer. I will say right at the outset that PEMFs are not expected to cure cancer. Cancer is not a contraindication to the use of PEMFs. However, the sickest individuals who are the most depleted by their cancer therapies are going to be the most vulnerable to excessive PEMF stimulation. Current evidence appears to suggest that PEMFs can be an appropriate complementary and integrative approach to use in the management of cancer, along with behavioral management, nutrition, and lifestyle.

I have treated many patients with PEMF therapies while they have been undergoing the many other therapies that medicine has to offer as well as complementary approaches. Generally, PEMFs help to sustain people through their cancer treatment process to allow less discomfort, more effectiveness of the therapy of their choice, and a better quality of life.

Below I present a number of studies that have been done on PEMFs, whether in animals or humans. The amount of scientific literature on the effects of PEMFs in cancer is extensive and it is not possible to devote enough space in this book to the topic. I will summarize only some of the more relevant studies.

Human studies are usually based on preceding animal and laboratory studies and guide subsequent human therapy development. The substantial number of animal and laboratory studies serves as a rich resource of information for us on how cancer behaves and how various therapies may be used. Laboratory studies give us basic information on cell function, which may be common to all cells in most species, and therefore apply to human cell function. Animal studies, across many different species, cannot be used as absolute evidence of probable effectiveness in humans, because animal physiology and cancers in animals are commonly different from that in humans, but there are many similarities. Confidence in the value of a particular therapeutic process is gained from showing benefit from the laboratory table, through to the animal level, and then through to the human level.

Cancer – Animal and laboratory studies

Because the focus of this book is on what is of value to you, a human, I will not go into detail on what is already known from research in the laboratory and in animals about the effects of PEMFs on cancer. This is a summary of the results from numerous laboratory and animal studies:

Basic mechanisms

- influence free radical recombination processes that activate p 53 gene dependent survival mechanisms
- lack of adverse responses in normal cells and tissues
- affect early tumor growth as well as advanced tumors
- affect metastatic processes
- angiogenesis inhibition
- long-term exposure to ELF-EMFs reduced proliferation of several cancer cell types associated with increased mitochondrial activity, increased energy demand
- increase mitochondrial activity leads to early death of breast cancer cells
- do not appear to act as a promoter or DNA-damaging agent for human breast cancer cells
- decrease the proliferative activity of myeloma cells by 42%
- increase mitochondrial activity and causes changes in the structure of breast cancer cells

- decrease the rate of proliferation of HeLa cells by 15%; the HeLa cell is from an immortal cervical cancer cell line
- exposure for twenty minutes causes two-fold increase in SOD antioxidant activity; forty minutes causes even more of an increase of SOD activity but only in lymphocytes
- either alone or in combination with radiation, decreased growth and reduced vascularity of tumors
- increases sensitivity of some types of cancer cells to radiation
- co-exposure of breast cancer cells to PEMFs and seven chemo agents caused further decreases in mitochondrial activity, from to 6.0% to 39.5% of the control for an average of 39% reduction over chemo agents alone

Animal studies

- static MF enhances chemotherapy in mice
- inhibit tumor growth in mice
- 40-50% tumor growth inhibition of human colon cancer in mice
- inhibit pre-neoplastic lesions chemically induced in rat liver
- MF treatment significantly increases survival time (31%)
- inhibition of spread and growth of lung metastases in mice with human breast tumor
- mice with breast cancer had a significant reduction in the growth of tumors
- human breast cancer cells unlikely to induce breast cancer
- in mouse colon cancer, increase survival and inhibits tumor growth
- in mouse breast cancer reduced tumor growth and vascularity and increased tumor cell death
- in endometrial, ovarian and prostate cancers reduced cisplatin toxicity
- endometrial and prostate (endocrine) cancers are more sensitive than ovarian

Even the laboratory and animal studies show that PEMFs frequently inhibit tumor growth, work cooperatively with chemotherapy to enhance the effects of chemotherapy and help across many kinds of cancer.

Cancer and nitric oxide

Nitric oxide (NO) is a free radical gas made from L-Arginine by nitric oxide synthase (NOS) and mainly acts as a signaling and cell-killing molecule. There are three forms of NOS: neural NOS (nNOS), inducible NOS (iNOS), and endothelial NOS (eNOS). eNOS mainly exists in endothelial cells in all blood vessels. eNOS-derived NO is important role in the regulation of vasodilation and vascular permeability. This is one of the key effects of PEMFs in the body in general, not just in the context of cancer.

Research is conflicting regarding how much NO is produced by PEMFs in the body. High levels of NO are required to be toxic to tumors. This is one of the reasons I rarely recommend PEMFs as a primary or sole method to help in the management of cancer.

However, when NO is combined with chemotherapy and immunotherapy it has been shown to reverse the resistance of tumor cells to these therapies. This is the probable mechanism behind PEMFs being able to improve the benefits seen with chemotherapy and radiation [56]. In addition, NO has been shown to be a potent sensitizer of cells to radiation [409]. Because PEMFs can be applied locally in the same area that radiation would be applied, any NO generated by the PEMF would be focused to the tumor without causing systemic effects. Too much NO generated in the body may cause blood pressures to fall and headaches, as seen with nitrates/nitroglycerin therapy for cardiac angina. Locally focused treatment decreases this risk [413]. In fact, nitroglycerin treatment has been added to chemotherapy and radiation therapy for locally advanced non-small cell lung cancer [17] and prostate cancer [420] with improvement of survival.

Human studies (general)

In one study, a whole-body PEMF system was used in the treatment of 151 cancer patient—45% with stomach cancer, 21% lung cancer, 25% breast cancer, 5% Hodgkin's disease (lymphogranuloma), and 4% melanoma. The whole-body was treated with a medium intensity PEMF system for fifteen cycles of twenty minutes each. PEMF therapy was always supplemented with other care, including major surgery. In fifty-two patients, PEMF therapy was performed before operation; fifty of those noted pain relief and improvement in their general health and appetite. In forty-seven patients, PEMF therapy was provided on the third day after surgery. It alleviated complications of the postoperative period and decreased pain and weakness. Of these forty-seven patients, nineteen had arm lymphedema following mastectomy for breast cancer and were treated with a combination of PEMF therapy and compression therapy. These therapies decreased or entirely eliminated the lymphedema. Another thirty-one patients had surgery for stomach cancer and the use of PEMFs following surgery improved their rehabilitation and decreased stomach acid problems. Weight improved by 0.7-4 kg as did white blood counts and a significant increase in immune function. During follow-up, metastases were seen in only two patients at three months and nine months after the operation. Whole-body PEMF therapy had a favorable effect on the general state of cancer patients, sped up repair in the postoperative period, and improved immune status [249].

Advanced techniques of magnetic field therapy of tumors ("TAMMAT") was launched in 1992. TAMMAT PEMF devices generate virtually uniform rotating, ELF magnetic fields. Their frequency range includes the bands of major physiological rhythms (cardiogram, encephalogram, rate of firing of neurons, and muscles). TAMMAT treatments are done in an outpatient setting, fifteen to twenty-five minutes of exposure daily for three to four weeks. Preliminary data showed PEMFs to be an effective aid for malignancies at stages up to T2-T3. Promising results were obtained for cancer of breast, lungs, intestines, oral cavity, and some others. PEMF therapy was employed either alone or in combination with traditional techniques.

In the latter case, it reduced or eliminated the adverse side effects of radiation therapy and chemotherapy. In T4 stage tumors, PEMF exposures reduced pain, temporarily slowed tumor growth, and increased life span [213].

A weak PEMF, the Modulated Electromagnetic Generator (GEMM), has been shown to have anticancer activity. A typical GEMM treatment lasts twenty minutes and uses rectangular pulses. During the first half of a treatment session, a static or variable 50 Hz magnetic field, a pulsed electric field, and a PEMF are all used simultaneously. In the second half, the static or variable magnetic field is not applied. This is not unlike an MRI, which combines static and high frequency PEMFs. The characteristics of the fields used will depend on the type of tumor, grade, mass, and location. The anticancer activity of the GEMM has been evaluated in a laboratory setting and demonstrates that this type of stimulation has an ability to activate or change the motion of electrical charges. They apparently increase ATP production or activation. A cancer cell would, therefore, enter into reproduction due to excess ATP. GEMM, as is seen with other PEMFs, acts on the mitochondrial membrane. Undifferentiated cancer cells stop producing ATP because of the high resistance induced on the mitochondrial membrane, they alter reproduction, and continue in a quiet state. Normal cells are not influenced by PEMF treatment, as their mitochondrial sensors are not altered. GEMM PEMFs can be used for therapeutic purposes across a range of different conditions, including anticancer treatment. As an example of the latter, eleven cancer patients were described who were treated with the GEMM. A typical example was that of a forty-nine-year-old female with infiltrating ductal carcinoma of the breast. Following surgery and chemotherapy, metastases were found in the axilla. A month of GEMM treatment caused the metastases to regress. Subsequent X-ray examination showed no evidence of cancer [144].

Specific Cancers

There are a number of studies evaluating the use of PEMFs with specific cancers.

› Breast cancer

Below are summaries from various studies on the use of PEMFs for breast cancer, including early and later stage breast cancers, showing result when combined with surgery, radiation, and chemotherapy.

Radiation therapy is toxic to cancer cells but it's also toxic to healthy cells. So, for PEMFs to be useful as a treatment of breast cancer they need to be toxic to breast cancer cells but not to healthy breast cells. A study was done using human breast cancer cells and normal cells in a laboratory culture with exposure to a PEMF between 20 and 50 Hz, intensity between 2 mT (20 gauss) and 5 mT (50 gauss) for thirty to ninety minutes per day for up to three days. There was a discrete optimal window of vulnerability of the breast cancer cells to PEMFs of 20 Hz, 3 mT (30 gauss) for sixty minutes per day. The amount of breast cancer cell damage increased progressively over the three days of consecutive exposures. PEMFs at 50 Hz did not appear to affect the survival of the breast cancer cells. PEMF stimulation was not damaging to normal cells, and, in fact, slightly enhanced normal cell function. While the above frequencies, intensities, and time were the most effective, other exposure times (ninety minutes) and 2 mT and 5 mT were still effective for killing cultured breast cancer cells [95]. This study leads to some optimism that PEMFs may actually be used to treat breast cancer cells directly. Let's not forget, however, that this study was done outside the body and it is unknown what would happen inside the body with a cancer present.

Electric stimulation fields have both an electric and magnetic aspect to them. That means that potentially less invasive PEMFs may be able to accomplish similar results as seen with electric therapy. Very short pulse-length electric fields of 4 Hz, which didn't create heating to destroy tissue, were tested in superficial breast cancer growths. Two weeks after treatment, the growth of treated tumors was inhibited by 79%. MRI was used to assess the physical changes in the tumors. Various growth factors, including the development of new blood vessels (angiogenesis), were strongly suppressed. As a control, normal skin was treated the same way as the tumors and showed no permanent changes. PEMFs generating similar intensity local electrical changes, even deeper in the breast, could have similar results [489].

It has been shown in studies that increasing intracellular calcium reduces cancer cell survival, in particular in triple negative breast cancer [499]. A commonly reported result of PEMF exposure is elevation of intracellular calcium level [163]. This was studied using 3 mT PEMFs at 20 Hz, sixty minutes per day. Non-malignant cells were unaffected, even fortified, by the PEMFs [95]. Based on this research, using PEMFs, and the fact that the greatest damage is done in breast cancer cells, it may be ultimately feasible to selectively remove cancer cells from someone without damaging normal tissues. The lack of response of normal cells to PEMFs suggests that the internal calcium control mechanisms of normal cells are capable of balancing, or even exploiting, small increases in cellular calcium concentrations. At least some breast cancer cells, especially triple negative types, do not appear to be able to withstand even modest changes in cellular calcium levels.

As an example, a forty-eight-year-old woman had a prior history of cancer of the right breast with spread to the axillary lymph nodes. She was treated with resection of the tumor, radiation, and chemotherapy. Ten months after she completed chemotherapy, she was discovered to have a recurrent stage IIIB tumor in the opposite breast. Because she had a low white blood count, she was not a candidate for further chemotherapy or radiation. Instead, she had PEMF therapy treating the whole body for sixty minutes at a time. After thirty treatments with the PEMF, the tumor in the breast decreased considerably; after sixty exposures, one of the metastatic nodes disappeared while others became soft and reduced in size. After 110 PEMF treatments, there was complete regression of the tumor and metastases. More than twelve years after PEMF therapy, the patient was reported in good health. While this is a single case, it is illustrative of the potential for PEMF therapy. It should also be noted that extended treatments are likely to be needed to produce the best results. In this case, it took 110 hours, or about fifteen weeks of daily therapy [29]. This woman's story is a good example of how ongoing home-based PEMF therapy is needed for the best results.

Seventy-three women with stages II and III operable breast cancer received PEMF therapy and radiation prior to surgical removal of the tumor. PEMF therapy was for five days, thirty to sixty minutes per day, to the whole body. Each PEMF treatment was immediately followed by radiation of the breast and regional metastatic areas. Mastectomy was performed twenty-four to seventy-two hours after the last exposure. In the control group, three were operated on without any preliminary treatment, and the rest received the same course of radiation therapy as described above, but without PEMF therapy. Two weeks after surgery, women with stage III disease received an additional course of PEMF and radiation therapy (therapy group), or radiation therapy only (control group). Subsequently, women could be ordered add-on (adjuvant) hormone and chemotherapy treatment. It was found that PEMF therapy reduced the negative effects of radiation therapy on cellular immunity, recovered the lymphocyte count faster, and returned the production of hormones to normal. PEMF treated women did not see the same degree of drop of lymphocyte counts as would be normally seen with radiation. The oxidative stress typically caused by surgery was prevented by PEMF therapy by almost threefold. Women were followed for twelve to thirty months after surgery. Metastases were found in 12% of the women treated with the magnetic field, and in 19% of the women treated without it. In women with initial stages IIB and III cancers, within one year after surgery, metastases appeared in 8% of those with PEMF and 22% of non-PEMF, respectively. The authors concluded that treatment with PEMFs was well tolerated, did not have any adverse side effects, normalized immune and hormonal functions, and decreased the probability of metastasis [284].

In another study, a PEMF system was used in twenty women with breast cancer, stages II or III. The PEMF was used sixty minutes a day. Samples of tumor tissue were obtained during surgery and were processed and stained using conventional techniques, then analyzed. Analysis revealed that PEMF induced significantly abnormal changes in the cancer cells in 100%. These pronounced alterations often caused cell death, which in turn caused formation of dead areas in the cancer tissue, and cancer cells in such areas were replaced by normal scar tissue. On the whole, the tumors slowed in their development or regression. The authors thought that PEMFs affect the nucleus of malignant cells, decreasing their ability to proliferate [128].

Women with locally spread breast cancer, stage III (stage T3, N1 - N3) and no metastases (M0) all had standard therapy in sequence including (a) preoperative radiation of the breast and adjacent areas, combined with chemotherapy, (b) radical resection the breast, and (c) postoperative adjuvant chemotherapy. In the time before the first phase of treatment, that is, before radiation, one group had multiple exposures of medium strength PEMF therapy added and one group did not. Follow-up was done looking for x-ray changes in the primary tumor and regional lymph nodes, and then later, biopsy changes in the primary tumor tissue. The PEMF treated women did not have any side effects. X-ray response in the PEMF group was seen in 87% and 82% in those without PEMF. There was less regional cancer spread in the PEMF group than those without, 97% improved versus only 52% without PEMF. In the PEMF group, 42% had total regression of the tumor and 46% had partial tumor regression. Regression or reduction of regional metastasis was seen in 90%. Even the biopsies after surgery found more tumor destruction in 56% with versus 48% without PEMF therapy. So, the use of PEMFs in stage III breast cancer patients, along with radiation and chemotherapy preoperatively, produced considerably better results [375].

Postoperative lymph or surgical fluid drainage problems after radical mastectomy are usual and can delay recovery and discharge from the hospital. This outcome of mastectomy is caused by the removal of the axillary lymph nodes so that the normal amount of lymph in the breast accumulates without the ability to adequately drain itself through the axillary lymph nodes. After basic recovery from the surgery, many women have to go home with drains so that the fluid does not accumulate so much that healing can't happen. This outcome was studied in a group of 106 women who were grouped in either usual care or usual care plus PEMF therapy. Eighty-seven patients had metastasis to the regional lymph nodes. Preoperatively, all the patients received radiation to the breast and the adjacent axillary lymph node area combined with chemotherapy. In addition to mastectomy, all patients had their regional lymph nodes removed. Postoperatively, the daily accumulation of lymph or fluid could reach the level of 200-600 ml. When the level of post-operative drainage was sufficiently stable, PEMF therapy was begun. This included five to twelve PEMF therapy sessions for forty to sixty minutes. The average duration of lymph or fluid drainage in the control group was thirteen days, versus eight days in the PEMF group. The twenty-four-hour lymph drainage in the PEMF group decreased from 200-300 ml to 50 ml or even absolutely stopped within two weeks. In eight women who had 600 ml of lymph drainage, after five to six PEMF treatments the drainage stopped completely. Therefore, PEMF therapy can be useful in the recovery of women postoperatively who have had radical mastectomies or partial mastectomies with extensive removal of lymph nodes, allowing quicker recovery and discharge from care [232]. Probably even better outcomes would be obtained in women who start PEMF therapy before their surgery, continue it right after surgery, and then at home until complete recovery is obtained. Continued treatment long-term would also be helpful to reduce the likelihood of recurrences or the development of new lesions in the opposite breast.

› Head, neck, oropharyngeal cancers

Therapies for cancers of the head and neck, that is, oropharyngeal cancers, involving surgery and radiation are among the most disfiguring and functionally disabling. As a result, PEMF therapies could be beneficial in this setting. One of the questions regarding these therapies is, what can be done prior to radiation or surgery to reduce the complications and side effects? The goal of PEMF therapies is to reduce tumor size prior to surgical resection in an effort to prolong survival and improve function. Previous studies have shown that the survival rate of patients with stage 2 and 3 oral cancers depended on the initial size of the tumor.

In this setting, therapy consisted of giving antioxidants supplemented by PEMFs for seven weeks before surgery. This approach was tested in two people with squamous cell cancer of the tongue. In both, the tongue developed a softer consistency and became more mobile after three weeks of treatment. Speech improved and pain was controlled after only a few days. Surgery was less invasive and only required minimal resection of the tongue tip together with neck surgery. Biopsies of the surgical tissues found no tumor cells. After this initial experience, another eleven people with stage 3 tumors have the same protocol followed by radiation and chemotherapy. The PEMF treatment improved their tolerance for radiation and chemotherapy. Skin and mucous membrane changes, common after radiation, were minimal in the PEMF treated people [354].

Additionally, PEMFs were used successfully in the treatment of people with cancer of the larynx who had acute and chronic laryngitis, postoperative inflammation of the larynx and trachea, or radiation damage of the cartilage of the larynx. Clinical improvement was seen in 65%. PEMFs showed marked anti-inflammatory effects with cancer of the larynx using moderately high intensity PEMF therapy prior to radiation therapy. They decreased post radiation edema of the larynx [323].

› Liver cancer

Conventional treatment options for patients with advanced liver cancer, that is, hepatocellular carcinoma (HCC), are limited. Commonly survival at Stage C without treatment is between four and eight months and at Stage D it is less than four months. The survival of people who have failed conventional approaches is even more dismal. There is evidence that the growth of primary liver cancer cells may be altered by low level unique frequency design PEMFs [508]. Advanced cancer was defined as not eligible for surgical resection or had disease progression after surgical or other local or regional therapies, or had disease progression after chemotherapy or sorafenib. Forty-one people with advanced cancer were treated with ongoing three per day in office oral (not over the liver) treatments, sixty minutes each, until disease progression or death. Imaging studies were done for monitoring every eight weeks to see if there was impact on reducing cancer progression and survival over six months. Treatment was well tolerated and there were no significant toxicities. In all, 34% had stable disease for more than six months. Median survival without progression of the cancer was 4.4 months and median overall survival was seven months. Treatment is safe, well tolerated, and shows evidence of antitumor effects in patients with advanced HCC [94].

› Lung cancer

Lung cancer tumor tissue from twenty patients was evaluated for biochemical and physical changes using deep electron microscopy. All had PEMFs preoperatively to reduce tumor resistance to standard therapy. PEMFs produced nonspecific adaptation reactions, resulting in desirable physical changes to the cancer cells indicative of a marked antitumor effect of the PEMFs. These changes were best seen after twenty to thirty sessions. Highly differentiated (mature) adenocarcinomas were the most sensitive to PEMF action [316].

› Stage IV Cancers

Medical therapies in advanced cancer situations are largely experimental, do not cure, have poor results, and can even exaggerate morbidity before death. If life can be extended comfortably, this could be an important benefit of PEMFs.

As can be expected with any therapy for cancer, not everyone can benefit, especially with late stage cancers. The same is true for PEMFs. One report described seventy-four people with advanced malignancies who could not be treated by conventional approaches or who had progressive disease without symptoms and aggressive conventional treatments were not reasonable. As a last resort, they were treated with PEMFs at home for one hour, three times daily, for at least three months and longer if possible. Twenty-eight had metastatic bone cancer, twenty-five pelvic tumors, seventeen pulmonary tumors, and four brain tumors. All were followed by x-ray, CT, MRI, clinical evaluations, and self-rated quality of life. About 16% stopped using the PEMF during the first six weeks because of practical issues involving immobility, stimulator positioning, how time-consuming treatment was, and the depression that occurred because PEMF treatment was a constant reminder of their disease. Another 25% had therapies stopped because of rapid progression of cancer. Nobody showed a clear benefit of the PEMF on a tumor or an unequivocal tumor response, such as partial remission. Lasting pain relief, explained only from the PEMF therapy, was reported by three patients with severe pain from growing tumor masses. While these results are disappointing, they are expected given the late stage of the cancers evaluated. It is also possible that these results may be more specific to this particular PEMF system. Other systems, particularly of higher intensity, may produce better results in late stage cancers. I have seen reduction of cancer pain many times in my patients using PEMFs. In one notable case of a doctor's wife, she was able to reduce her daily narcotic use dramatically [402].

One hundred thirty-seven patients with advanced malignant tumors of various kinds had sinusoidal PEMF therapy at 7 Hz, 4000 G (400 mT), for two hours a day for thirty to fifty days. Sixty percent had benefit. Twenty-eight had a complete response and fifty-four a partial response. The median overall survival was twelve months. The one-year, two-year, and three-year survival rates were 47.0%, 11.8%, 3.4%, respectively. Complications were minimal. There were no treatment related deaths. So, the type of PEMF used in this study seems to have improved the quality of life of these individuals and probably in many cases prolonged survival at least somewhat. This relatively high intensity PEMF appeared to provide a significant benefit for these unfortunate people [165].

There is always a question of whether PEMFs are safe to use in people with advanced cancers. Often these individuals have many different health problems happening at the same time, making them vulnerable to any therapy. A group of researchers who had done previous preliminary studies in mice found that medium intensity PEMFs had antitumor benefit. In fact, in this prior research, cancer inhibition with PEMFs was significantly greater than that seen with chemotherapy. As a result of their previous animal research success, they studied eleven people with advanced cancer that was already heavily pretreated. PEMF stimulation was to the neck, chest, and abdominal areas, five days a week, for four weeks using two different treatment schedules—twenty minutes daily and seventy minutes daily. They concluded that PEMFs can be safely administrated without acute negative side effects in patients with advanced cancer [368].

Stage IV ovarian cancer was evaluated in a small controlled study on women with inoperable ovarian tumors. PEMF therapy consisted of treatments twenty minutes daily for two weeks. They also received standard chemotherapy. Five patients served as controls and only received chemotherapy. Another five received chemotherapy and PEMF therapy. The results showed that the women who had PEMF treatment had no complaints of nausea, weakness, and loss of appetite in contrast with the control group where these typical side effects of chemotherapy were pronounced. White blood cell counts can drop severely, depending on the chemotherapy used. This poses a dangerous risk of severe, potentially life-threatening infections. The PEMF-treated women had increases in their white blood counts and sedimentation rate, which returned to normal two weeks later. The control group showed no positive results on these tests. There was no difference in tumor size between the PEMF and control groups on MRT and ultrasound [145].

I have personally used PEMFs along with other therapies in patients with stage IV cancers. One had lung cancer and the other had colorectal cancer. Both survived more than four years with no evidence of progression of their tumors and were considerably more comfortable with fewer symptoms. Their life expectancy otherwise was less than two years. Not everyone with this stage of cancer can expect the same results.

While there aren't any commercially available PEMFs exactly the same as those used in the Han study above, there are available PEMF systems of comparable intensity with a similar frequency. However, these types of high intensity devices are expensive and need to be used for extended periods of time, several hours per day, daily, even for months, if not the rest of the person's life. It is not known if treatment extended beyond the thirty to fifty days used in that study would have produced even better results. Nonetheless, the results are impressive, despite the limited length of time the treatment was used. Since high intensity PEMF treatments are often applied in doctors' offices, treatment durations are probably too short. Even if available PEMFs are not exactly comparable to those used in this study, other available devices have the potential to produce similar results, by being used daily over more extended periods. In the end, it is likely there would be no significant harm, from what this study shows, in trying. In my clinical experience, patients using PEMFs on an ongoing basis, in the home setting, long-term, with or without conventional therapies, do better and are much more comfortable.

Other cancer-related topics

› Chemotherapy complications

Bones from which tumor has been removed are often left with large defects. Surgeons usually will try to fill these bone defects with bone from other sources or grafted from cadavers. Bone grafts have a slow healing rate and take a long time to have a complete repair. The use of chemotherapy during this time of healing interferes with the healing process even more. PEMFs decrease the healing time from nine months in the postoperative chemotherapy situation to 6.7 months. Chemotherapy mostly affects all rapidly regenerating tissues, the case with acute bone healing, and includes healing delays in all tissue, including postop wound healing [69].

Complications from chemotherapy are extraordinarily common and often severe. Conventional medical therapies for cancer often leave much to be desired. One group presented the results of use of PEMFs for treatment of two kinds of cancer chemotherapy complications in adults and children. Research on use of PEMFs in children is rare. Local injuries of the skin underlying tissues and veins frequently develop after IV chemo injections or chemo agents leaking outside the blood vessel wall (extravasations). They have phlebitis (inflammation of a vein) or thrombophlebitis (vein inflammation with associated thrombosis (clot formation), clots in veins without inflammation of the wall, infiltrations of the chemo agents into the surrounding skin outside the blood vessel, ulcers, hardening of the blood vessels) and tissue breakdown (necrosis). Individuals with these complications were divided into two treatment subgroups, one with conventional care and the other with PEMF therapy. Conventional care consisted of local application of medicines and compresses. PEMF therapy was given once a day for fifteen minutes, with a different device protocol for adults versus children. Magnetic applicators were placed over the chemotherapy drug injection site or along the injured vein. Evaluations were done after two weeks.

In those with phlebitis, about 60% of the traditional care patients had improvement, though vein hardening persisted for three to four months. In the PEMF group, the phlebitis was cured in twelve to fourteen days in all cases. In those with vein clotting, complete vein occlusion from inflammation in the clot happened in two of the standard therapy group, and in none of the PEMF patients. Infiltrations and hardened veins gave rise to ulcers in 67% in the standard therapy group, whereas PEMF therapy completely eliminated these problems in twelve to thirty days. Ulcers and areas of dead tissue in the standard care group healed slowly, with the average wound surface area decreasing by 1% per day. A further 30% needed surgical care. In the PEMF group, the average daily reduction of the wound surface area was 3%, and wounds were healed in 100% of patients in a month at most. In the PEMF-treated children, healing of these chemo related wounds happened faster than it did in adults, in spite of the children having worse injuries to begin with [206].

› Brain radiation therapy

Patients about to undergo radiation therapy, particularly to the brain, are usually warned away from PEMFs because of the lack of knowledge regarding their possible negative interaction and the concern that PEMFs may decrease the benefits from radiation therapy. A pilot study was done to see whether PEMF stimulation would work when combined with radiotherapy for inoperable metastatic brain cancer. They did several sessions of cobalt radiation to the brain forty-eight hours apart. Immediately after each cobalt treatment, each one had the brain stimulated with PEMFs for twelve hours. Return evaluations were thirty days after the second PEMF treatment. Thirteen patients had follow-up evaluations. In ten, the source of the tumor was the lung, in the remaining three, the primary tumor was a seminoma, a breast cancer, and a melanoma. Four had more than one metastasis. Comparison of pre- and post-treatment CT scans showed progression of the metastases in one, no change in two, partial remission in eight, and complete remission in two. The authors thought that the overall brain treatment results seemed to be slightly better in the treated group when compared with a previous group treated with cobalt radiation only. There were no negative side effects. The authors noted that exposure to PEMF has been shown in previous studies to increase the damage caused by radiation in mice, with similar effects reported for PEMF combined with chemotherapy using cyclophosphamide and mitomycin C. [265]. Therefore, this study indicates that PEMFs may be combined with radiation to the brain for brain metastases to improve outcomes.

› Radiation damage

Radiation therapy for cancer can be devastating to the tissues in the path of the radiation field and to tissues around the area being specifically targeted. There is evidence to suggest that PEMF exposures prior to radiation may actually increase the sensitivity of the tissues to radiation therapy. PEMF exposures to the tissues away from the target tissue being radiated may help to preserve their normal function and less damage is likely to occur.

Radiation done to the breast for breast cancer not only radiates the breast itself but also the muscles and bones of the underlying chest wall, the lining of the lung (pleura), and even the lung itself. If it's applied to the left breast area, the heart may also be affected creating inflammation and scarring. Plus, the lining of the heart, called the pericardium, may also become inflamed and scarred creating additional problems. The skin overlying the breast may become inflamed and irritated, even potentially creating ulcers. Treating the area of the breast being radiated with PEMFs before radiation begins would help to decrease the damage to all the surrounding tissue not involved in the cancer process.

The same issue applies to pelvic radiation, including seeds for the prostate. People with prostate or pelvic radiation often develop inflammation of the rectum, vagina, vulva, urethra, and bladder, not to mention the skin. These are challenging problems to treat once they've occurred and almost never resolve completely. In Eastern Europe, patients with radiation for gynecologic tumors had blood and mucus in the stool, blood in the urine, ulcerations, and signs of inflammation and sloughing mucous membranes. High intensity static magnets were used in the pelvic area for thirty minutes at a time for ten treatments. After three to four magnetic field applications, all the patients had less pain, less blood and mucus, reduced evidence of inflammation in blood testing and on examination, and less swelling and redness of the tissues. While PEMFs were not specifically studied, similar results would be expected to occur [190].

The evidence at this point does not support the use of PEMFs during radiation itself. Treatment with PEMFs after radiation is finished can help the non-cancerous normal tissues recover faster with less damage.

› Pre-cancer

The search for treatment of early tissue changes that commonly result in the development of cancer is still progressing. There are many examples of this in medicine, including, but not limited to, chronic esophagitis (Barrett's esophagus), leukoplakia in the mouth, and cervical dysplasia. For the most part, existing methods of local and symptomatic treatment are not sufficiently effective and do not lead to permanent cure. Inflammation is almost always present in precancerous lesions.

PEMFs were studied in the treatment of premalignant pathology of the stomach in eighteen individuals with a chronic peptic ulcer involving abnormal precancerous tissue development at the second or third stage. Whole-body exposure was used for twenty minutes, fifteen to twenty times. Endoscopy after treatment revealed complete ulcer healing in 60%, partial healing in 18%, and no changes in 22%. Even in the group with no improvement, PEMF exposures had a pronounced pain reduction effect. The abnormal tissue regressed in 43%, reverting to the first stage. The PEMF increased the total number of inflammation reducing T-lymphocytes (from 58% to 65%). These data show that PEMFs have an immunomodulating effect on stomach lesions. It's quite probable that if PEMF therapy was extended beyond twenty treatment sessions, results would be even better in the slower healing patients, and those with more extensive pathological changes [211].

› Millimeterwave or microwave resonance therapy

While most of our emphasis is on extremely low frequency PEMFs, the Eastern Europeans have done a considerable amount of work with high-frequency millimeter wave (MMW) or microwave resonance therapy (MRT), primarily applied to acupuncture points, not to involved tissues directly. This is yet another example of the many different approaches that can be taken to stimulate acupuncture points, including ELF PEMFs. In one study, 149 individuals with various cancers were treated with MRT: large intestine, stomach cancer, breast cancer, other malignant tumors, and colon polyps. MRTs were applied to selected acupuncture points. A number of accompanying conditions (duodenal and gastric erosions and ulcers, chronic pulmonary and other gastrointestinal disorders) improved during the preoperative period. MRT decreased the risk of operation in 88%. MRT was also useful for reducing early postoperative complications (hemorrhage, gastric atony syndrome) in 68%. MRT used at the same time as radiation and chemotherapy significantly reduced the toxic effects in 75%. Stage IV cancer patients had improvement in pain, toxicity, and fatigue and weakness syndromes in 67%. MRT did not stimulate tumors and was well tolerated. Thus, MRT like ELF PEMFs can be successfully used in patients with malignancies and pre-malignant conditions and increase the efficacy of conventional therapies [281].

The role of PEMFs in the management of cancer is evolving and more research is needed on basic mechanisms and benefits in animal and human studies. The above review shows that PEMF therapy used alone or in combination with traditional techniques reduced or eliminated adverse side effects of radiation therapy and chemotherapy. In advanced tumors, PEMF exposures reduced pain, temporarily slowed tumor growth, and increased life span. There is some evidence to suggest that PEMFs may be able to enhance the effects of radiation therapy and chemotherapy. At this point, there do not appear to be any major risks in the use of PEMFs in the comprehensive management of cancer.

Chronic Fatigue Syndrome (CFS)

Clinical CFS is a general name for a debilitating illness, the cause of which is still unknown. It is characterized by incapacitating fatigue of at least six months duration, neurological problems, and a constellation of symptoms that can resemble other disorders such as mononucleosis, multiple sclerosis, fibromyalgia, AIDS-related complex, Lyme disease, post-polio syndrome, and autoimmune diseases such as lupus. Research studies suggest that CFS results from a dysfunction of the immune system, involving a disruption of fundamental mechanisms of central nervous system (CNS) function such as the sleep-wake cycle and the hypothalamic-pituitary-adrenal axis. One study found that a significant proportion of CFS patients had abnormal brain scans and subtle changes in the levels of circulating neuroendocrine hormones. Other studies have found electrolyte disturbances, permanent biochemical changes in mitochondrial function, and disturbances in insulin and T3-thyroid hormone functions.

There is some evidence that environmental levels of 50/60-Hz EMFs may act as a stressor with the potential to cause hormone disruption and changes at the cellular level. Much of this evidence was presented in a draft report from an expert committee of the US National Council on Radiation Protection and Measurements (NCRP), which was completed in 1995 but never officially published for reasons characterized by the authors as "intense industry opposition to its findings." [259] We discuss the differences between this type of non-therapeutic EMF exposure and therapeutic PEMFs in the appendix of this book.

CFS is associated with damaged or diseased cells that present an abnormally low trans-membrane potential—as much as 80% lower than a healthy cell. This diminished cellular metabolism can be swiftly addressed with PEMF therapies.

Structural and functional abnormalities of the upper forehead part of the brain (prefrontal cortex) seem to correlate with fatigue in people with chronic fatigue syndrome. High-frequency rTMS applied to the forehead of people with CFS two times per day over three days was evaluated. They had 150 minutes or 15,000 pulses over six treatment sessions. In most, treatment resulted in an improvement of fatigue. They had a 20% drop in a visual pain scale in the first hour after the first rTMS, but within twenty-four hours after the first treatment, the fatigue returned to the initial level. After three days of treatment, the average score dropped 40% and remained there for one week. Two weeks after treatment fatigue level began to return. Therefore, high-frequency rTMS over the forehead for short periods can be a potentially useful short-term, acute therapy for CFS. These results seem to support that regular, longer-term use of PEMFs, perhaps even in the home setting, may produce more sustainable, better results [196].

EEGs in patients with CFS had increased amounts of delta, theta, and alpha waves compared with controls. This suggests that brain beta activity in CFS is significantly reduced or inhibited, more in the right frontal and left occipital regions. [490] While there is no specific research in CFS to support this, these EEG changes indicate that brain oscillation patterns seen in CFS can be improved using beta frequency PEMFs. A locally applied beta-frequency PEMF stimulation would be expected to improve symptoms of CFS, particularly when applied daily over extended periods.

While the primary manifestations of chronic fatigue may be initiated by the brain, and may explain the benefits seen with rTMS, this is not necessarily treating the underlying cause or causes. These individuals frequently have other health conditions, such as fibromyalgia, including pain, that also need to be managed. Dysregulation or dysfunctions in other parts of the body may place a drain on the energy resources of the body including the brain. Keeping the whole body healthy should be one of the goals in managing this condition. As a result, daily, long-term, whole-body PEMF treatment should be considered to achieve the best and most enduring results, in addition to other treatment modalities, such as nutrition, lifestyle, and psychological support.

Concussion and traumatic brain injury (TBI)

There is a persistent perception in the medical community that a damaged brain does not heal, at the worst, or not well in most circumstances. As a result, innovative therapeutic approaches that address the damaged tissue of the brain directly are desperately needed.

The classic categories of mild, moderate, or severe TBI are based on the acute clinical presentation and are not a good predictor of long-term outcomes. Moreover, the long-held notion that mild forms of TBI recover rapidly and without consequence is not supported by more recent science. TBI leads to neurophysiological changes, changes in brain cell polarity, and premature brain cell death. These consequences occur in sequence and can progress quickly or gradually over a long period, often without obvious symptoms.

Even mild traumatic brain injury (mTBI) - more commonly called concussion- is a complex clinical phenomenon complicated by the overlap between the lingering symptoms of mTBI and more long-term disorders, including posttraumatic stress disorder (PTSD), post-concussive syndrome (PCS), and chronic traumatic encephalopathy (CTE). They can all exist separately or together, and the symptoms of one can look similar to the symptoms of another, making the diagnosis more challenging. mTBI is poorly diagnosed and underreported. Doctors rarely ask about this possibility, which can occur from an accident such as one banging one's head on a cabinet.

When a concussion or mild TBI (mTBI) happens, the brain nerve axon takes the brunt of the damage. Axons are normally somewhat limber, but they become frail when exposed to rapid distortion such as with a brain injury. A frail or damaged axon becomes inflamed. When normal communication from other normal neurons tries to take place with a damaged axon, even more damage occurs because the axon cannot handle the natural chemical or electrical stimulation. This leads to a chain of events where multiple neurons are involved in the breakdown. This is microscopic damage to brain neurons and is not visible on standard diagnostic medical imaging or testing. It causes functional changes for the individual, whether temporary or more permanent, but unfortunately, standard medical testing cannot detect it directly.

Following concussion, symptoms such as dizziness, nausea, reduced attention, amnesia, and headache tend to develop shortly after the injury but usually resolve within a week or two. Concussion that is severe enough can also lead to loss of consciousness, the most common criterion for diagnosing TBI. Despite the transient nature of the clinical symptoms, more sophisticated, specialized diagnostic brain function assessments show that the disturbances from concussion can take over a month to return to baseline. Tissue (neuro-pathological) evaluation shows that concussion-induced impairments may persist for years, if not permanently.

About 15% of those having had an mTBI will develop lingering, persistent symptoms consistent with post-concussive syndrome (PCS). Depression and PCS commonly show up similarly. People with PCS also describe frequent headaches, dizziness, irritability, and anxiety. To be formally diagnosed with PCS, a person must exhibit these symptoms for at least three months after the initial injury.

PCS is different from CTE in that the symptoms of PCS tend to appear to resolve years before the onset of CTE. Yet, these individuals often display ongoing personality changes, exaggerations in mood, or reduced levels of cognitive function including impairment in memory and decision-making (executive function). CTE should be considered in the differential diagnosis of a young adult with repetitive head impact exposure and persistent mood and behavioral symptoms.

Repetitive mTBI, or repetitive concussion, can cause CTE, a recently recognized neurodegenerative disease. CTE is characterized by protein deposits accumulating in brain tissues and can only be diagnosed pathologically by sampling a piece of the brain tissue, which is typically done after someone dies. This is how the NFL football player Junior Seau, who committed suicide, was discovered to be suffering from CTE. Part of the reason CTE is so difficult to diagnose is because symptoms only tend to appear eight to ten years after the repetitive mTBIs themselves, and imaging studies along the way were negative.

Each of these conditions - single TBI, repetitive mTBIs, PCS, and CTE - share common neuropsychological impairments, including memory loss, delayed problem solving, slowed reaction time, fatigue, and impulsivity. Such complexity can lead to misdirected and ineffective treatment efforts and can hamper the ability to assess treatment response accurately.

Much in the same way that our bodies rely on our bones for structural support, individual cells, including brain cells, need a cellular skeleton. One of the major components of the cellular skeleton is the microtubule. Microtubules are stabilized by proteins called tau proteins. Tau proteins are most abundant in neurons, and a few exist in other cell types. When tau proteins become defective and stop stabilizing the microtubules, this leads to local brain cell degeneration and diminishes the ability of the brain cell axon to transport information. As the process progresses it leads to brain cell death [255]. Tau protein deposition is a hallmark of Alzheimer's, and is a common long-term occurrence of TBIs.

Small areas of brain injury and spots of micro-bleeding, caused by any brain trauma, lead to the deposition of abnormal tau proteins in the brain tissue. Acute TBI-related nerve cell injury, loss of microscopic nerve cell blood supply, and breach of the blood brain barrier, result in an inflammatory cascade and activation of defense mechanisms deep in the brain. These are all likely to be among the bases of mTBI causing PCS and CTE. They all serve as a basis for the potential actions of PEMFs in helping brain injury.

Early, frequent, and continuing effective deep brain intervention is often necessary even with apparently innocuous concussions/TBIs and minor bumps to the head and head injuries. The brain is the most difficult organ in the body to recover structure or function in without outside stimulation and support from supplements and nutrition. Reversing the physiologic changes seen with concussion and mTBI are the main targets for considering PEMF therapy.

PEMFs applied to the head, with or without TBI, have been shown to have significant effects on nerve function. PEMFs improve brain neuro-transmitter levels, monoamine function (such as dopamine, noradrenaline, and serotonin) [503], circulation [34], reaction time [50], increase stem cells and growth gene factors [142], and movement of charge from neuronal membranes [336]. It is estimated that even a very weak PEMF signal applied to the head will stimulate the function of about 25 billion neurons.

PEMFs have been proven to produce rapid mood elevation in depressed patients with bipolar disorder and other depressive disorders [365]. rTMS is a robust, high intensity, FDA-approved PEMF treatment for Major Depressive Disorder, and is also being studied in many other neurological applications as a painless method to stimulate the brain. More painful, and often invasive, methods to stimulate the brain are various kinds of electrostimulation [324]. PEMF directed at the brain enhances neuroplasticity, and entrains and resets brain cell resonance and communication between the thalamus, cortex, and other brain regions. It normalizes regulation and facilitates recovery of natural cerebral rhythms. Through these mechanisms, it restores normal brain function [235]. TMS can also be administered at a low to medium magnetic field strength to affect multiple brain areas simultaneously.

Relative to TBI specifically, there are a number of studies using a range of different types of PEMF signals, from low intensity to very high intensity, with success. Even a weak PEMF across the temples once a week for five weeks can significantly reduce depression and phobias in TBI patients [28].

One study explored whether PEMF signals could alter the course of inflammation in TBI. The inflammatory chemical mediator, cytokine IL-1β, is increased in the brain tissue of rats having experimental bruising or penetrating head injuries. IL-1β levels in cerebrospinal fluid (CSF) were proportional to injury severity in a bruise injury. PEMF treatment applied continuously reduced IL-1β levels by up to ten-fold in CSF within six hours after blunt injury, and significantly suppressed IL-1β within seventeen to twenty-four hours after penetrating injury. This study clearly showed reduction of inflammation following head injury by a PEMF signal [355]. This experimental study is extraordinarily important in showing how important early intervention with PEMF brain stimulation is after even a milder bruise to the brain. The longer inflammation persists after even a mild injury the more damage is done to nerve tissues, which may become ultimately unrecoverable. This makes one think that anybody playing contact sports where a brain bruise could happen, regardless of how severe somebody thinks it might be, should be doing PEMF treatments daily to their brains.

Post-concussive/TBI headache is one of the most common symptoms following the injury. PEMF treatments as short as thirty minutes improved headaches following concussion. People with established diagnoses of mTBI with headache had average post-rTMS headache intensity reduced by 53%. The average headache episodes per week were reduced by 79%, with some patients reporting complete resolution of severe headache episodes [156].

rTMS has shown improvement with PTSD [88], pain [291], and integration of function between regions in the brain [341], along with improvement in related behavior and depression [191]. One study found a 27% reduction in a depression score [233]. rTMS can also improve cognitive function in Alzheimer's disease, a long-term consequence of TBI [238]. rTMS improves brain activity in brain networks connected to each other by improving cerebral blood flow (CBF) and therefore the supply of nutrients to brain nerve cells, not only at the stimulation site but, most importantly, in regions farther away but functionally connected with this site. Improving CBF can facilitate healing of brain tissues and improving brain function [234].

I have recently completed a pilot study using a medium intensity 10 Hz PEMF device applied to the head (front to back or side to side), two hours a day for three months, to a group of ten individuals with concussion/TBI. In some cases, the injuries were more than ten years old. Everybody noticed benefits. An objective measure of brain function was used to gather information before and after treatment and showed clear improvements over baseline scores as well as important clinical and functional benefits. Almost everybody reported clearer cognitive functioning, better memory, and more focus. These changes were noticeable enough, to the point of friends, family, and colleagues commenting on them. When PEMFs are suggested for the treatment of TBI, or for that matter, aimed at the brain for any reason, concern about safety and risk of brain harm is automatically raised. There is much evidence to suggest that there is minimal risk, with a large upside potential as seen from the science review above.

The safety and risk of PEMF stimulation to the brain have been assessed in a number of studies, which we discuss in more detail in section 5 of this book. Despite intense TMS or rTMS treatment programs, no significant side effects were seen. One patient received seventy treatment sessions over twelve months, or 420,000 high intensity magnetic field pulses, with no side effects. One seventy-five-year-old patient received 130 sessions over twenty-six months with a total number of 156,000 stimuli, while seven patients received sixty sessions over twelve months with a total number of 72,000 stimuli [371]. In another study, healthy men were given 12,960 high intensity rTMS magnetic pulses a day for up to three days in one week. This equals 38,880 magnetic pulses over one week, one of the largest exposures of rTMS to date. Despite this intense treatment regimen, no significant side effects were seen [10].

Even in the setting of other, underlying brain diseases, PEMFs appear to be safe. In relapsing remitting multiple sclerosis combined with TBI, no patient showed evidence of relapse during follow-up of at least eight months. The authors concluded that magnetic brain stimulation was easy to perform, painless, and safe [180].

Some people also express a concern that PEMFs might promote brain cancer or seizures, given the presumed relationship of environmental EMFs with brain cancer. In fact, PEMFs appear to reduce the risk of seizures [319] and do not promote brain glioma tumor growth [378].

Newborn brains are often considered especially vulnerable to PEMFs and the risk of harm. Human experiments to assess for the risk of harm to the brain are not allowed. When high intensity magnetic fields were applied to newborn rat brains, not only was there no evidence of harm, but they found that eight out of nine brain areas examined actually became thicker, suggesting improved brain cortex development [110].

The bottom line with regard to concussion and mild TBIs is that the long-term effects of one or more concussions are poorly recognized and as yet there are no effective conventional medical therapies to restore brain function. PEMFs reach into and through the whole brain safely and easily without any evidence of harm. Based on a small pilot study in adults, even medium intensity ELF PEMFs appear to offer significant benefits to recovering brain function after concussion/mild TBI. In addition, these PEMFs can help many other symptoms and aspects of the lingering effects of concussion/TBI without the risks associated with drug therapies.

Dental Issues

PEMFs are used by some dentists to help keep dental prosthetics in place and even in orthodontia to help to straighten teeth. Various studies have shown the value of the use of magnets and PEMFs for the treatment of periodontal disease [117, 443]. Magnetic field therapy has also been used to treat dental infections and abscesses. Magnetic field therapy can help to ease dental or jaw pain, caused by dental caries or abscesses. However, routine dental care should still be used, as well as antibiotics as indicated. Even fractures of the jaw have been found to heal faster. This is especially important since these individuals often have their jaws wired shut and can only take in fluids for their nutrition. The magnetic field therapies in these situations accelerate healing as well as reduce pain and discomfort, as they do for almost any other smaller bone fractures in the body.

Depression

Depression is common, with a lifetime rate of over 20% in the USA. It is estimated to be the leading cause of disability in developed countries worldwide by the World Health Organization. In depressed patients who do see improvement with treatment, relapse rates are 37-70% in the first year. Many are treatment-resistant, that is, failing to improve after three or more treatment trials. There are few effective conventional options left for those who are treatment-resistant.

Current antidepressant therapies for treatment-resistant depression include drugs, ECT (convulsive therapy), or rTMS (high intensity transcranial magnetic stimulation). ECT requires anesthesia. rTMS is expensive and often not covered by insurance. Both can have little immediate benefit and ECT and rTMS often have to be applied many times. Some high-intensity rTMS PEMF devices have been approved by authorities around the world, including the FDA.

Drugs typically need four to six weeks to be clinically meaningful. ECT has failure rates of 65% or higher, requiring two to three treatments per week for three to four weeks for full effect. These time lags leave people vulnerable to the disabling symptoms of depression, including higher risk of suicide in the first few weeks of therapy.

There are many problems with the use of SSRIs for depression, not least of which is that SSRIs do not work right away. Because they may take anywhere from two to eight weeks to take effect, they cannot be acting specifically or only at the brain synapse level. They may have to recruit a large number of synapses to finally have a positive benefit. Also, about 30% of patients with depression are resistant to antidepressant drugs, despite escalating doses and multiple drugs.

It is these problems at a minimum with current standard therapies that have driven the search for treatments that will produce rapid results, which will hopefully translate into long-lasting results too. It would also be helpful to have treatments that can be applied in the home daily, not just periodically in a doctor's office, clinic, or hospital.

PEMFs have been shown to have a dramatic effect on anxiety and depression in both chronic and acute forms. Though there is substantial research on the benefits of this therapy for mood disorders, the mechanisms of action are somewhat unclear.

Conventional drug treatments for major depressive disorder (MDD) act at different layered levels of complexity, ranging from the individual nerve cell connection (synapse) to the brain as a whole. However, recent science suggests that antidepressant medications synchronize the frequencies of brain electrical activity in the connected networks of brain cells, starting from the base, at the individual brain cell, and ending with collections of cells (networks)—bottom-up. Brain and nerve modifying treatments such as rTMS are thought to do the same thing, but they change synapses and brain activity from the network level down to the synapse level (top down).

Brain development and learning processes rely on the synchronization of vibrations (oscillations) of the various networks in brain activity, in specific frequency bands, and may be important in how antidepressant treatments work. The ability of the brain to adjust itself to insults or new demands is called neuroplasticity. Synchronization of oscillations among nerve cells and networks likely helps neuroplasticity whether driven by medication or neuromodulatory treatment with PEMFs.

Medication and PEMF treatments have related effects on the rate and pattern of brain neuron firing, another common factor making these treatments effective for depression. How low intensity PEMF stimulation works to relieve mood issues is unclear. The mode of action is believed to be different from the higher intensity PEMF systems applied externally and deep brain electrical stimulation (an invasive procedure). These systems likely cause brain neurons to be dramatically less active or excitable, exhausting, or inhibiting them. Lower intensity systems likely provide benefit more by causing neurons to vibrate at the frequency of the PEMF. This stimulation affects the electrical activity of neurons, that then change the neuronal networks, and then change the areas of the brain that control mood [235].

PEMF fields also appear to affect the glucose metabolism of regions of the brain that are involved in depression and anxiety and the release of various neurotransmitters, including BDNF. These regional changes have been mapped in the brain extensively by neuroscientists and have been found by neurofeedback practitioners to change even with very weak PEMFs.

A well-done study was conducted at Harvard Medical School using a low intensity PEMF device (*Rohan*). The FDA considers the device to be a nonsignificant risk to the brain. They used a 1000 Hz (1 KHz), square/trapezoidal wave signal at 20 gauss (2 mT) maximum field intensity to see if depression can be helped faster than conventional treatments. Previously it was found that magnetic resonance spectroscopic imaging (MRSI) studies caused people with bipolar depression (BPD) to have rapid improvement of their symptoms. In this double-blind, sham-controlled study there was greater than 10% significant improvement in mood with only one twenty-minute treatment in forty-one patients with BPD and twenty-two with major depressive disorder (MDD). All the patients were on stable medication for at least six weeks before PEMF treatment and were having a current depression episode. Other findings that really intrigued me were obvious improvements in guilt, ability to work, life interest and some aspects of anxiety. Since anxiety very frequently accompanies depression, this 1000 Hz signal likely helps both depression and anxiety. In other words, based on these results, this PEMF signal is likely to be helpful across a range of forms of depression, and rapidly.

A low-intensity transcranial PEMF (T-PEMF) was used in combination with antidepressants in patients with treatment-resistant depression. This was a sham-controlled double-blind study comparing five weeks of active or sham T-PEMF in patients with treatment-resistant major depression. The antidepressant treatment, to which patients had been resistant, was unchanged four weeks before and during the study period. Study participants were assessed weekly. The 9 gauss (0.9 mT) 50 Hz, square wave T-PEMF was delivered as a helmet containing seven separate rotating coils located over the skull that generated an electrical field in brain tissue, much weaker than those generated by rTMS. The active T-PEMF group had a significantly better outcome than sham T-PEMF, with an onset of action within the first weeks of therapy. The reduction on a Depression Rating Scale was 62% [268]. A related home study with the same device found that depression was gone in 73% after eight weeks of once a day treatment, but at five weeks, only 27% had their depression resolved [40, 436]. Among those treated, 52% were still in remission two years later. Those who were not in remission became so with an additional course of treatment. It is not yet known if even more extended treatment times at the beginning would produce even better results. Many people who don't respond to treatment may have other problems such as alcohol or drug dependence, severe physical disorders and other psychosocial problems that need to be treated before attempting T-PEMF treatment [40]. Side effects were few and mild.

Even lower intensity PEMF therapy than reported above has also been found to improve scores on the widely accepted Hamilton Rating Scale for depression. After the magnetic therapy, there were obvious and sometimes even dramatic improvements in guilt, ability to work, and life interest.

Not all people who have depression following a TBI respond completely to antidepressant drugs. Several individuals who had TBIs and showed mild to moderate brain impairment received thirty minutes of weak (1 μT) PEMFs across the temples once a week for five weeks. Depression improved significantly and phobias decreased, while physical symptoms and other complaints were not changed [28].

Moderately high intensity TMS at an alpha frequency (sTMS) may also help depression. Rotating cylindrical static magnets will produce a sinusoidal magnetic field. An array of three separate magnets placed at three locations along the midline over the scalp from above the eyebrows to the top part of the head, will affect the frontal area of the brain. Forty-six people with major depressive disorder (MDD) were treated in a randomized, sham controlled, double-blind study. Most received antidepressant medications at the same time. There were three treatment groups: 1) active sTMS with a fixed alpha frequency; 2) active sTMS with a random frequency varying between 8 Hz and 13 Hz; and, 3) sham sTMS. Twenty half-hour sTMS sessions were given five days per week for four weeks. The magnetic field intensity was 6430 gauss (643 mT). The intensity of the magnetic field energy produced (dB/dT) is about 1% that of a standard rTMS system. Those receiving either fixed or random frequency active sTMS had significantly greater reduction in depression severity compared to sham (49% vs. 19%). There was no difference between fixed and random groups. No significant side effects were reported. These results suggest that sTMS may be an effective treatment for MDD [191]. They also suggest that this single alpha frequency, PEMF system, not as high in intensity as rTMS, can still produce significant benefits in the treatment of MDD.

High intensity PEMF therapy is thought to have a sort of reset effect on the brain. It is thought that those with depression, including Major Depressive Disorder (MDD), have areas of the brain that are underactive along with an imbalance of the brain's neurotransmitters. It is thought that PEMF therapy's direct effects on brain signal pathways is at least partly responsible for the benefits seen on the depressed or anxious brain [234]. A large amount of research is currently being conducted on the use of rTMS in depression, particularly treatment resistant depression. Treatment resistant depression means that people had failed medical therapy with antidepressants or other medications. More often than not, these are more severely depressed individuals.

In an extensive review of the randomized controlled studies already published using rTMS for treatment resistant depression, rTMS compared to sham treatment showed a significant improvement in depression scores [169]. The results may not have been as strong as desired to be clinically useful. Those who received rTMS had a 220% greater likelihood of benefiting from rTMS than sham. ECT showed a bigger response. It is because of the challenges of using ECT that rTMS was developed. The hope was that it would be good enough to replace ECT for many people who had treatment resistant depression, and it appears that rTMS may in fact be useful in a lot of treatment resistant patients, with ECT reserved for those who see no benefit at all. However, follow-up studies did not show that the benefits of these short-term treatments lasted and were limited by the nature of these studies.

That means that many of these patients had to end up going through multiple courses of treatments to sustain the benefits. This result continues to lean to the potential benefit of long-term home treatments with PEMFs, particularly for those with milder forms of depression. At this time, I would not recommend long-term treatment in the home setting without adequate psychiatric supervision for those with depression who do not respond to medication, that is, treatment resistant depression.

Magnetic field therapy may also have an effect on depression through the improvement of REM sleep, which has been shown to play an important role in the development of depression. Some PEMF therapies (particularly high intensity treatments) delay the first REM sleep cycle and prolong the duration of sleep, improving circadian, and ultradian biological rhythms, which in turn have anti-depressive actions [89].

Diabetes

There are two major types of diabetes. Type I diabetes can occur at any age but is often diagnosed in children, and people with it produce little or no insulin. The cause is still unknown, but likely involves damage to the pancreas, and often due to viruses or autoimmune assault. Type II adult onset diabetes is the most common.

In normal digestion, glucose enters the bloodstream after being broken down from the food we eat. The pancreas produces insulin, which moves glucose from the bloodstream into muscle, fat, and liver cells, where it is used for energy. In a diabetic person, the pancreas either does not make enough insulin, cells do not respond to the insulin correctly, or both. Therefore, glucose isn't moved into muscle, fat, and liver.

A major negative part of the diabetic process is that the circulation of tissues is among the primary targets of high blood sugar levels and high levels of glycation end products. The end products of high sugar levels (called advanced glycation end products, or AGEs) deposit in all soft tissues of the body—bone, nerves, joints, ligaments, and skin included. These AGEs never leave the tissues once they are deposited; they will be a silent scourge for diabetics for their entire lives. Because of AGEs, tissues become robbed of circulation. Diabetics are always at a higher risk for poor circulation. This can be due to damage to the tiny blood vessels in the body (microcirculation) or due to plaque buildup in the larger blood vessels in the body. Both of these types of circulation damage make the blood vessels unable to deliver a sufficient amount of blood to cells.

Once circulation becomes compromised in the body, it begins to affect all organs and tissues to varying degrees. The most common problems seen in diabetics are retinopathy, cataracts and macular degeneration, due to damage in the nerves and microcirculation in the eye, heart, kidneys, and brain, and atherosclerosis (which affects the larger blood vessels the body—macrocirculation). Atherosclerosis causes heart attacks, peripheral arterial disease (PAD), carotid artery disease, and more. Neuropathy (damage to the nerves throughout the body, especially in the gut and feet), Alzheimer's disease, kidney failure, advanced arthritis, and impaired healing of the tissues makes affected tissues more prone to infection and slower recovery, as often caused by microcirculation changes as they are macrocirculation changes. Below are some study results that illustrate the value of PEMFs on the various health issues commonly seen in diabetes.

The use of PEMFs to improve circulation in diabetics is supported by two studies. One showed that PEMFs significantly increased blood flow in cutaneous microcirculation, as measured by transcutaneous partial pressure of oxygen in the feet of people with diabetic foot problems [480]. In the other study, for both the healthy and diabetes groups, a single session of PEMFs (0.5 mT, 12 Hz, for thirty minutes) produced significantly greater increase in peripheral blood flow velocity in the dorsal foot, as compared to sham PEMFs [442].

Diabetics are more to infections and their infections progress more rapidly and are often stubborn to treat. Seventy-two diabetic patients in one study had infected wounds from diabetic vascular disease, skin infections, spreading diffuse inflammatory process with formation of purulent exudate, and other disorders. They all had standard therapy. In forty-two patients, the wound was also exposed to a 50-Hz sine-modulated magnetic field intensity ranged from 20 to 35 mT (200 to 350 G), fifteen minutes daily, for ten to twenty days. In the PEMF and control groups, pain stopped after four versus five days of therapy, edema disappeared after 8.8 versus 10.4, and wound healing started by the seventeenth and twenty-third days, respectively. Metabolic and immune laboratory tests returned to normal in PEMF patients. Magnetic reduced the average hospital stay by six days compared to conventional therapy only [217].

Diabetes can cause a number of problems with the eyes, including retinopathy and ophthalmopathy. Ninety-seven patients with diabetes mellitus and diabetic retinopathy and sixty-four with ophthalmopathy from hyperthyroidism were studied. Treatment was with a 50-Hz device at 10-mT applied over the closed eyelid daily for ten to twenty sessions lasting seven to ten minutes. Improvement in microcirculation of conjunctiva and retina of was seen in 74%, restoring blood flow in the conjunctiva and retina, disappearance of edema, and reduction of hemorrhages. Visual acuity improved in 44% and stabilized in the rest. Stabilization is also a win. In those with ophthalmopathies, "positive effects" were seen in 92% as seen by decrease or disappearance of subjective complaints, edema of tissues around the eye socket, conjunctivae, lid lag, bulging of the eye (exophthalmos), and by an increase in the amount of eye movement [97].

One of the major management problems of peripheral diabetic disease is the development of Charcot foot (see the situation presented in the wound topic below of a diabetic foot). In Charcot foot, weakness of the muscles of the foot leads to nerve function changes of the foot bones, breakdown of these bones and spontaneous fractures, with a characteristic absence of pain. Conventional treatment, which consists of limitation of weight bearing, decreases swelling and inflammation but often does not improve the structural deformity, especially the multiple fractures often found in Charcot joints. Three patients were studied. The foot was immobilized in a cast during treatment. Foot measurements and x-rays were used. A commercially available PEMF system, typically used for healing non-union fractures, was applied for eight to twelve hours per day over three to four months. Each person had clinical healing of the Charcot joint. Increased sensation was noted in one person. In another person, where both feet were involved, the PEMF treatment was successful after conventional therapy had failed. The authors concluded that further study was warranted since the use of PEMF may be a more effective and efficient means of treating Charcot foot [47].

After studying diabetic neuropathy experimentally, the authors undertook clinical trials in humans. Forty-one people with diabetes mellitus (types I and II) and intense symptoms of non-proliferative (twenty-three persons) and proliferative (eighteen persons) retinopathy were treated. All had sinusoidal PEMFs, 40 Hz, at 10 mT, twelve minutes daily, for twenty-one days. Those with non-proliferative retinopathy had inhibition of progression of lesions and significant improvement of visual acuity. The benefit was thought to be due to antiedema, anti-inflammatory, and anticoagulant action of the magnetic field and to the improvement of the general health of eyeball tissues as result of the circulation benefit of the PEMF [423].

In a diabetic neuropathy study, thirty-one people with diabetes mellitus (type I and II), with stable diabetes, and suffering from intense symptoms of neuropathy were evaluated. They had twenty treatments to a sinusoidal PEMF, 40 Hz, 15 mT, done every day for twelve minutes. They had a distinct improvement with improving pain, paresthesias, improved muscle strength in 85% and vibration sensation. These results were significantly better compared to the control group [87].

In addition to these studies, my co-author Dr. Jerabek, when I was on a visit to see him in the Czech Republic, described a woman who was recommended to have a foot amputated due to massive infection from neuropathy complications. After three months of daily medium intensity PEMF therapy, she was able to save her foot. The neuropathy in that treated foot actually improved as well. Interestingly, the other foot, which was not treated with PEMFs, had no improvement in the neuropathy. She should use PEMFs for the rest of her life to save her feet from further harm. I even had a patient with diabetes who recovered from gangrene in both of his lower extremities, and was able to avoid amputation.

Because of the major action of PEMFs on numerous body processes, covered throughout the book, and the fact that diabetes affects so many of the same body functions and tissues, PEMFs are ideal in helping people with diabetes heal their affected tissues, neuropathy, and vascular, eye, and brain changes. After over forty years of medical practice, I know of no other therapeutic system that can affect so many aspects of a disease condition. As a result, over the years, I've concluded that every diabetic should own a whole-body PEMF system, for prevention if nothing else. The sooner one starts, the better. Obviously, properly managing the diabetic process and the causes is the most important. However, until this happens completely, with the reversal of the metabolic condition, it is helpful to stabilize and repair any damage already done with PEMFs.

Erectile dysfunction

Erectile dysfunction (ED) is a common condition experienced by more than 39 million men in the USA and has many contributing factors. Male sexual arousal is a complex process that involves the brain, hormones, emotions, nerves, muscles, and blood vessels. Erectile dysfunction can result from a problem with any of these. Likewise, stress and mental health concerns can cause or worsen erectile dysfunction. Sometimes a combination of physical and psychological issues causes erectile dysfunction. For instance, a minor physical condition that slows sexual response might cause anxiety about maintaining an erection. The resulting anxiety can lead to or worsen erectile dysfunction. In many cases, erectile dysfunction is caused by something physical.

Common causes include heart disease, clogged blood vessels (atherosclerosis), high cholesterol, high blood pressure, diabetes, obesity, metabolic syndrome, Parkinson's disease, multiple sclerosis, some prescription medications, tobacco use, Peyronie's disease, alcoholism and other forms of substance abuse, sleep disorders, treatments for prostate cancer or enlarged prostate, or surgeries or injuries that affect the pelvic area or spinal cord. There are also multiple psychological causes of erectile dysfunction. As men get older, erections can take longer to develop and not be as firm. Testosterone deficiency is also a common contributor (see the testosterone topic below).

PEMFs may be able to help with ED by addressing a number of the underlying factors or health conditions, reviewed in this section of the book. In addition, PEMFs may be able to help ED by direct stimulation of the pelvic nerves controlling erectile function or to the pelvic blood vessels to provide adequate blood supply to erectile tissues.

Weak magnetic fields have been used in male sexual dysfunction for decades in Eastern Europe. Erectile dysfunction (ED), premature ejaculation, and decreased libido were studied in 201 males wearing one of three types of active or one type of sham magnetic stimulators for three weeks. The PEMFs were extremely low intensity—10-15 μT (0.1 to 0.15 gauss). Testing results in the active versus sham groups showed restored sexual function in 31-38% vs 15%; sexual function improved in 39-47% vs 18%, and did not change in seventeen—30% vs 60%. These data clearly established a favorable effect of PEMFs. In addition, magnetic treatment significantly improved general health on a scale from one to ten, from 2.4 before treatment to 8.9 after. In the placebo group, changes were virtually absent at 2.2 and 3.6, respectively. Enhanced penile blood flow was the mechanism of the benefit. Magnetic stimulation was therapeutically effective in 70-85% [146].

Vacuum therapy is often recommended in the treatment of ED. The effectiveness vacuum therapy (VT) alone and in combination with a PEMF was compared in two similar groups of men with ED. Local VT was performed by a VT device for ten to twelve minutes, twelve to fifteen procedures per treatment course. PEMF, 6 Hz, 30 mT (300 G), was applied to the penile area simultaneously with VT; the duration and the number of the procedures were the same. After the VT only course, sexual function was restored in 51%, improved in 24% (75% total), and did not change in another 24%. After the combined VT+PEMF therapy, the results were 71%, 17% (88% total), and 12%, respectively. Blood flow increased from 3.2 cm/sec. to 5.3 cm/sec. after the VT course, and from 2.8 to 8.6 cm/sec after combined VT+PMF course. It's clear that that VT+PEMF therapy is more effective than VT alone. VT+PEMF method is most strongly recommended for men with the erectile form of impotence, when there is no prostatitis [199].

One hundred forty-three men with erectile dysfunction (ED) and abdominal obesity received transcranial magnetic stimulation (TMS) of 45 mT at alpha frequencies. The majority were also obese with waist circumference over 40 inches (102 cm). After treatment, they had improved lipid metabolism, erectile function, lower blood pressures, and sedative action. The testosterone increased by 27% compared with the pre-treatment values while the number of study participants complaining of erectile dysfunction decreased by 31% [343].

While PEMFs appear to improve ED in several ways with use of PEMFs to the pelvic area, men who are interested in maintaining fertility may ask about the effects of PEMFs on sperm. Occupational MF exposures have found no risk to fertility [250]. Likewise, PEMF treatment to the prostate in dogs did not affect semen quality, even with high intensity PEMF stimulation.

Eye conditions

The eye is extraordinarily sensitive to PEMFs. It is composed mostly of fibrous connective tissue, thin epithelial cells, blood supply, and nerve type cells. Because of the arrangements of the tissues of the eyes, they are very responsive to PEMF stimulation. Considering the fact that eye tissues usually heal rapidly, PEMF therapy can enhance that healing and is a useful tool from both an effectiveness and safety perspective. Even extremely high intensity PEMFs are routinely used on and around the head with no adverse reactions reported to the eyes.

Macular degeneration was treated with a PEMF system in 177 patients (283 eyes). The treatment had a positive influence on the pathologic process in the eye, with stability of the benefit after treatment. In 152 eyes, visual acuity remained unchanged in 54%, improved in 46%. Stability was confirmed objectively. In 72 eyes, the results of treatment were followed for six years, confirming the effectiveness of this method of treatment. Long-term observations have found the need to repeat the course of treatment every three to five months every year to prevent progression of the damage. This study confirms the need for longer-term treatment for chronic eye conditions to get sustainable results [429].

It would be helpful to know the possible mechanisms for improvement seen in retinal function after PEMF therapy. The effectiveness of PEMF therapy is not the same in all patients. The benefits from PEMF treatment for fifteen to thirty minutes usually last only for eight to ten days, consistent with the time to renew rod pigments in the retina. In addition, visual examination of the back of the eye after PEMF treatment reveals dilatation of capillaries, leading to the conclusion that the favorable effect of PEMF therapy was from improvement of microcirculation. They found that retinal circulation gradually increased from arterioles to capillaries and venules. That means that the conditions for retinal rod pigment restoration in the central area of the retina are less favorable than in its peripheral areas, therefore central retinal recovery will require a greater number of PEMF stimulation sessions [417].

Since the general circulation and pumping of the heart affects circulation through the whole body, it is important to balance and restore the overall circulation, not just the circulation of the eyes. Also, glaucoma and macular generation, both affected by circulation, tends to be more common in people as they age. So, central general circulation, diastolic and pumping functions of the heart, reactivity of the heart muscle, microcirculation and biological age of the cardiovascular system were studied in sixty-six elderly patients with hypertension and ischemic heart disease. The patients received systemic magnetic therapy, which produced a protective effect against aging as shown by improved microcirculation, heart muscle function, and central circulation [2].

Indirectly, actions of PEMFs on the eye are due to repair and reduction of inflammation in the eye in general, as well as specifically in glaucoma. Fifteen patients with surface infections of the cornea due to a foreign body in one eye were treated with PEMF (50 gauss, 50 Hz) for nine minutes and the topical antibiotic gentamycin applied before and after removal of the foreign bodies. This treatment promoted suppression of the inflammatory reaction of the eye and accelerated corneal tissue regeneration. This study establishes that PEMFs can accelerate healing of not only inflammation but also eye tissue damage [470].

Cataracts

A cataract is an eye condition that can eventually affect vision and is usually part of the aging process. It is a clouding of the normally transparent lens inside the eye. The lens is positioned behind the colored part of your eye (the iris) and is responsible for focusing light that passes into your eye before it gets to the retina. The lens is made up of proteins that can clump together as we age, causing a cataract. The cataract scatters the light as it passes through the lens, reducing your vision.

While aging is the most common factor for cataract formation, their development is accelerated by diseases like diabetes and hypertension, and by environmental factors like toxins, radiation, and UV light, as well as lifestyle factors like smoking (which as much as triples the rate of cataract development) or UV exposure (like being in the sun without sunglasses). Some medications, such as corticosteroids, can induce cataract development.

While there is little research using PEMFs directly in the setting of cataracts, the underlying mechanisms of the development of cataracts fall within the scope of actions of PEMFs. PEMFs would reduce the oxidative stress on the lens and the eye, reduce the formation of layering of fibers that create a denser lens, improve the appropriate concentrations of natural fats, and improve circulation to the tissues.

So, using low to medium intensity PEMFs on a regular basis in the home could be expected to help with reducing the progression and development of cataract. As with many other applications of PEMFs, the longer one waits to begin PEMF therapies, the less successful the resulting effects will be. That is because these tissues will end up being too resistant to change and reversal of underlying damage. The best time to start PEMF therapies is early in the cataract development process. All that would be necessary is fifteen to thirty minutes every day. Even using a whole-body PEMF system for health maintenance or other health reasons would benefit the eyes if the head is lying on it, since the PEMF signal goes right through the head and into the eyes. Extra time and attention need not be focused on preventing cataract formation with separate cataract prevention treatment time.

In addition to working at delaying or stopping the progression of the formation of cataracts, PEMFs can also be used to help people recover faster from their surgery and have a lower risk of complications. One group studied the effects of low-intensity laser and alternating PEMFs on the course of postoperative recovery after cataract extraction and implantation of an intraocular lens (IOL) in patients with edema reactions. Edema reactions can cause significant delays in healing and recovery and increase risk of other complications. Patients were observed for up to six months after starting treatment. The postoperative course was more benign and recovery happened sooner in patients getting the combined laser and PEMF therapy compared to controls [261]. PEMFs alone would likely create similar results.

Glaucoma

The most recent science about the cause of glaucoma diseases points to inflammation blocking the flow of fluid out of the eye channels. This inflammation exists long before measurable changes in pressure or vision are noted. A secondary cause is the induction of the undesirable form of nitric oxide, that is, iNOS. PEMF therapy, as explained in the previous section of this book, has basic effects on both inflammation and nitric oxide production and regulation. PEMF therapy will also improve circulation to the retina and stimulating repair of any nerve damage in the retina. As with most conditions, more dramatic results are to be expected when magnetic field therapy is begun early in the disease process.

Much of the research on the use of magnetic fields in eye disorders has come from Eastern Europe. In one study, courses of PEMF therapy with rotating magnets, 33 mT (330 gauss), at 1.0-1.5 Hz, were given to individuals with primary open-angle glaucoma for ten minutes over ten sessions. Untreated eyes of the same people were controls. Examinations were before and four to five months after PEMF. Vision acuity improved by 0.16 diopters, on average, in 97% of the treated people who had vision acuity below 1.0 diopter before treatment. By way of comparison, mild myopia (shortsightedness) could have a loss of 1.00 to 3.00 diopters, while over the counter reading glasses will be rated at +1.00 to +3.00 diopters. PEMF brought about an improvement of contrast sensitivity by at least seven of a possible twelve levels in 85% of twenty-six eyes assessed. After PEMFs, visual field deficits decreased by at least 10% in 72% of eyes versus controls and decreased by 22% vs. the initial value overall for those treated. The results were stable even after four to five months after treatment. Controls showed no improvement over the entire follow-up time [49].

In a different study, another device, in this case a "traveling" PEMF device, was used to treat primary open-angle glaucoma (POAG). In a traveling magnetic field device, each coil is turned on sequentially in a series repeatedly. That creates a wave or stream-like action in the tissues, thought to be more activating. The PEMF was applied in patients to the cervical spine.

Vascular flow and pressure parameters were analyzed along with visual evoked potentials, visual fields, and visual acuity. They found that PEMF therapy produces better clinical results in patients with stage I and II POAG compared with conventional medication (using viscosity-reducing Trental tablets) [471].

Another group studied the influence of PEMF on the flow of fluid of the eye in POAG. They used a rectangular pulse form at 50 Hz, 8.0-8.5 mT (80-85 gauss) intensity for seven minutes at a time for a total of ten sessions. One hundred fifty patients (283 eyes) were evaluated. Latent, initial, and advanced glaucoma all benefited from the use of PEMFs. There was an increase in the amount and flow of fluid through the outflow canals of the front part of the eye (anterior chamber). In the latent (not yet established) stage of glaucoma, outflow became normal in 25% of cases. At the initial and advanced stages 18% and 16.0% of cases, respectively, became normal. The authors concluded that they could recommend this method of treatment of open-angle glaucoma. As with many studies, the total treatment time is limited and even better results would be expected over longer treatment times [461].

While most of our emphasis has been on the use of PEMFs, based on the studies found, I also reviewed a study on the effect of a constant magnetic field (about 200 gauss) on the fluid flow parameters of the eye. PEMFs are normally expected to produce similar results for static magnets, assuming comparable tissue intensities. This works for PEMFs emulating static magnets but not the other way around. This study was in twenty healthy controls and twenty-nine patients with glaucoma. A ring magnet was applied vertically to the external corner of the orbit so that the longitudinal optical axis of the eye was within the center of the magnetic field. Exposure was three, five, or ten minutes. The magnet field caused a decrease of the intraocular pressure (IOP) and decreased the rate of tear secretion. The changes were more pronounced after a five-minute exposure, while a ten-minute exposure did not cause significant changes in the fluid flow properties of the eye. From this study, we do not know how frequently these exposures should happen and what the long-term benefits would be expected to be. Nevertheless, there appears to be benefit from even using static magnets of the right circular configuration [469].

Fibromyalgia

Fibromyalgia (FM) is a pain disorder of unknown cause that brings amplified pain and psychological distress. It has a diverse set of disturbances, mainly involving autonomic, neuroendocrine, and neuropsychologic systems, alongside symptoms such as sleep disturbance, fatigue, pain, daily function impairment, and often stress. There are few clear peripheral abnormalities. FM is a central nervous system disorder, since individuals with FM have abnormalities within central brain structures that normally deal with pain sensations, leading to a hypersensitivity to pain. In FM, people do not process the body's natural pain relievers efficiently, which may be due to a dysfunction in their natural painkilling mechanisms [440]. Women have been found to be a little more sensitive to experimental pain in general but much more so when pressure is used to induce pain. Affected women appear to be more vulnerable to the development of chronic musculoskeletal pain. A natural weaker pain inhibitory control system in the spinal cord and brain in women might be the reason for both enhanced pain perception and the risk of developing chronic pain [366]. FM sufferers are impaired in their ability to activate natural pain inhibition. Chronic pain conditions that are more common in females, including FM, have altered CNS processing of pain signals as at least one factor [154]. These central neurological aspects that contribute to pain perception in FM, create the challenge of treating this complex condition.

Current treatments for FM include medical, self-management, and alternative interventions. Treatment remains inadequate to reliably resolve persistent symptoms and improve functional limitations and quality of life in most patients. Antidepressants and non-pharmacologic interventions (mainly exercise, occupational therapy, and psychological strategies) have shown moderate efficacy. Between 60%-90% of the patients with FM in the United States have used one or more complementary or alternative treatments for their condition, indicating the need for finding other effective interventions. PEMFs can frequently be very helpful as another option.

In one study [445], fifty-six women with FM, aged eighteen to sixty years, were randomly assigned to either PEMF or sham therapy, thirty minutes per session, twice a day for three weeks. They were tested for general fibromyalgia status, pain, perception of benefit, depression, and general function. Outcomes after active treatment ended at four weeks showed significant improvements in test scores, and were maintained at the twelve-week evaluations. The sham group also showed improvement at this time on all outcome measures except the specific fibromyalgia questionnaire at four weeks. At twelve weeks, the benefits disappeared except for depression and general function. So, low-frequency PEMF therapy can improve at least some general FM symptoms and pain.

A low intensity PEMF (400 μT) in a portable device fitted to the head was found to help FM. In a randomized, double-blind, sham-controlled clinical trial [454], individuals with either chronic generalized pain from fibromyalgia or another group with chronic localized musculoskeletal or inflammatory pain were exposed twice daily for forty-minute treatments over seven days. A visual pain scale was used to assess effectiveness. Those with FM had better results with PEMF compared to sham treatment. The same level of benefit was not seen in the non-FM group. In this group with other causes of chronic pain, either longer periods of exposure were necessary or other approaches needed to be considered. It would be expected that a higher intensity PEMF system will produce better results with the same intensity and duration of treatment and even better results with longer treatment times.

PEMF or sham exposure treatments were used in another study and levels of pain and anxiety were evaluated [419]. The study was double blind, randomized, and placebo-controlled with a thirty-minute magnetic field exposure (intensity less than or equal to 400 μT; < 3 kHz). There was a significant before and after benefit in reduction of pain for the FM patients with PEMFs.

Since humans live within the constant huge magnetic field of the Earth, it is not known to what extent the planet's magnetic field effects pain perception or pain management. This is complicated further by the ambient artificial EMFs all around us. People with FM are especially sensitive to these ambient fields. To account for these external EMFs, a FM study was done in a Faraday cage, which blocked out external magnetic fields, including the Earth's magnetic field.

This double blind, sham-controlled clinical trial was done in females (twenty-two to fifty years old) with FM. The active stimulation group had an 8 Hz square wave PEMF of 43 nT (0.00043 gauss) at 1 cm away from the applicator. Thirty-three small PEMF coils were placed in an EEG cap. Treatment sessions were once a week for eight weeks and lasted twenty minutes each time. Pressure pain thresholds before and after stimulation were determined using a pain meter (algometer) during each of the eight weekly sessions. Blood serotonin levels were measured and the women completed questionnaires to monitor changes in symptoms. Measures included pain thresholds, ability to perform daily activities, perceived chronic pain, and sleep quality. While improvement in pain thresholds was found after the first stimulation session, improvement in the other three measures occurred after the sixth week. After week eight, there was an increase of 28% in pain thresholds compared to a worsening of the pain threshold by 10% change in the sham group. The perceived pain after eight sessions was 39% less compared to only 8% less in the sham group. There were also significant improvements in the ability to perform daily activities and sleep quality. There were less significant improvements in fatigue, anxiety, depression, severity of headaches, and level of serotonin. No adverse side effects were reported in any of the patients. This study makes clear that even low-intensity magnetic stimulation may offer a safe and effective treatment for chronic pain and other symptoms associated with FM [257]. Given the magnitude of the benefits seen in this study, one has to wonder about the negative effects of ambient EMFs on the pain suffered by women with fibromyalgia. It's also possible that these ambient EMFs may interact with the Earth's magnetic field in a negative way to amplify the pain normally present even more.

Two randomized controlled trials have been conducted with static magnetic fields for treatment of pain due to fibromyalgia. Both studies documented an absence of adverse side effects from prolonged whole-body static field magnetic pad exposures. Both found statistically significant and clinically relevant reductions in pain scores. The magnetic intensity at the skin surface differed substantially, 3-6 G (0.3-0.6 mT) in one study [6] with the magnetic pads placed under a standard mattress. The other study used 200-600 gauss magnets [90] and patients slept directly on the pads. The spacing of the magnets was also different in both studies. Similar clinical outcomes in these studies are remarkable considering a hundred-fold difference in magnetic field strength. Colbert suggests that the static magnetic field could act on electrically unstable points (such as acupuncture points) to alter the polarity of the resting tissue potential and trigger a cascade of biochemical responses. Magnetic field intensity was reported in the Alfano study [6] at various distances above the mattress because the authors felt that distribution in the whole "zone of body exposure," rather than just at the skin surface, is important. Their results show substantial treatment effectiveness in the six-month evaluation.

The women sleeping on the experimental mattress pad [90] experienced a decrease in total muscle pain of 12%; improved physical functioning of 30%; an average pain score decrease of 38%; and improvement in sleep of 37%. The control group had a 1% decrease in total muscle pain score; 3% decrease in physical functioning; 8% decrease in pain score, and 6% improvement in sleep.

It certainly appears that field intensity with static magnetic fields can be important in achieving adequate results, with higher field intensities likely producing better results. On the other hand, these fibromyalgia studies also indicate that magnetic field density, that is, the number of magnetic fields applied to the whole-body simultaneously may be a significant factor as well, and may be the preferred approach given that it's often not clear where the actual versus assumed pain generators are. Since FM has a major central nervous system component, a large amount of peripheral stimulation of acupuncture points and meridians will without question affect brain structures and functions. So, it is not likely that these magnetic pads are actually changing the peripheral terrain as much as they are actually affecting the nerve traffic to the brain. On top of that, these individuals most likely had their heads on these magnetic pads and were therefore stimulating their brains as well. As I have stated before, it is highly likely that PEMFs would have similar results to static magnetic fields. Therefore, these static magnetic field treatment results lend support to the general conclusion that magnetic fields can help with FM symptoms.

Since FM is a complex, chronic condition for which there is no adequate treatment, magnetic field therapy, whether with high or low intensity PEMF or static magnetic whole-body mattress pads, appears to be a safe and effective alternative or complementary therapy. It is also likely that medium to higher intensity PEMFs applied to the head at home long-term would be even more effective since pain changes in the brain likely lead to this chronic debilitating condition.

Heart Conditions

Many heart conditions come about because of chronic conditions or diseases. Disease mechanisms include inflammation, spasm of blood vessels, thrombosis, and stenosis, among other secondary or indirect causes.

Some of the most basic actions of PEMFs on the body are involved when dealing with heart conditions. A PEMF stimulus increases nitric oxide production, which improves calcium ion movement. These processes alone play a large role in the improvements PEMFs have on the heart. Other PEMF actions include positive responses of cardiac muscle, the autonomic nervous system, blood vessels and blood viscosity, vasodilation, and microcirculation, among others. The heart is dynamic, electrically and as a tissue type, and responds readily to an electromagnetic stimulus.

Some PEMF treatments may cause a temporary increase in blood pressure, though extended exposure almost universally lowers blood pressure over time. Microcirculation dilatation occurs, with increased blood flow in the capillary bed and precapillary small arterial blood vessels and increased ability of the vascular wall to allow movement of molecules. Even lymphatic vessel flow increases. Circulation changes produced by PEMFs depend on the functional state of brain regulation centers, especially the hypothalamus.

Atrial fibrillation (AF) is the most common heart rhythm disturbance, or arrhythmia. It is diagnosed on EKG as a rapid or irregular atrial heart rate. It can present acutely with a sudden onset of symptomatic rapid irregular heart rate or may show up only as a non-symptomatic irregular heart rate. A great deal of evidence has accumulated that AF is frequently triggered from disturbed local tissues in the heart or tissues of blood vessels leading from the heart. Degenerative tissue changes have been found in about one-third of local arrhythmia producing tissues. Knowing that these tissues have degenerative changes provides an opportunity to prevent or reverse the degeneration using non-invasive non-drug approaches.

Rapid heart rates can occur from nervous system stimulation (neural basis) or from within the heart tissue itself (myocardial basis). Neural stimulation comes mostly from stress responses, that can't be adequately naturally dampened or managed. Myocardial sources are from inflammation, infection, internal heart conditions, and so on. Both neural and myocardial based forms of AF can occur separately or coexist.

Medications and invasive procedures are used to manage either form of AF. Medications are used to control the heart rate and the irregular rhythm. Anticoagulants are also used to reduce the risk of stroke from clots forming in the atria. The use of these medications is considered lifelong. Destructive procedures of the heart include ablation (destruction) of local tissue firing sites. The long-term implications of any invasive procedure are not yet known. As it is, the long-term success of a single catheter ablation procedure for AF, with a follow-up period of five or six years, has ranged from 29% to 55%. Ablation may well cause other problems with heart function later in life. Let's not forget that any of these therapeutic approaches do not typically address the underlying cause of AF. Alternative approaches are desperately needed that provide symptomatic benefit as well as reverse or improve the underlying heart changes causing the fibrillation.

PEMFs appear to be able to help not only with the AF rhythm disturbance itself but also help improve existing tissue changes causing the AF and prevent additional structural tissue changes (remodeling). In the early stages of AF, PEMF therapy helps reduce the abnormal electrical conduction of the atria and the atrial reactions to excess nervous system stimulation (stress) from outside the heart. The heart tissue itself has normal nerve cell type of tissue, which is intrinsic, allowing the heart tissue to respond to nervous system stimuli external to the heart. In AF, these reactions are exaggerated due to the underlying physical changes of heart and inflammation.

PEMFs have been found to be useful in helping with the management of AF. In one experimental study in dogs, they found that PEMF stimulation of the chest for only five minutes reduces the heart rate by 29% versus the control dogs. Electrical stimulation was used to induce atrial hyperactivity, and with even a very low intensity PEMF, the amount of voltage needed to induce atrial hyperactivity increased. In other words, the degree of sensitivity of the heart tissue to stress was reduced. In one situation in dogs in which atrial electrical pacing induced AF, the low intensity PEMF suppressed the AF for up to three to four hours after only thirty-five minutes of PEMF stimulation across the chest. In fact, PEMF stimulation was comparable to rate and rhythm blocking medication in its effect in reducing atrial hyperactivity [404].

In a human study, twenty-two patients with extra ventricular beats (VPCs/PVCs or VPBs), AF, and tachycardia, were treated with a medium intensity, low frequency PEMF applied alternatingly to the sternum (fifteen minutes) and wrist (five to seven minutes) over ten treatment sessions. Combined with medications, the PEMF therapy resulted in recovery of rhythm in 60% of the patients. It's possible that better results will be seen with more extended treatment. PEMF therapy should be considered a long-term approach to managing the problem and patients may need to be monitored on medications, which could be gradually reduced, once there is evidence that the person is improving [208].

Anecdotally, I have several patients with AF who use a PEMF system with a field intensity of about 200 gauss worn over the heart for an average of four hours a day. On follow-up visits, all patients said they could feel a difference relative to how often their heart skipped beats. In one case, after about one month of the PEMF treatments, improvement was such that the patient was able to begin reducing his medication.

Managing AF is a complex process and needs to be integrated with PEMFs over extended periods until gradually the heart has a chance to remodel itself to a state with little to no fibrosis and inflammation. Heart specific supplements (see *The Sinatra Solution: Metabolic Cardiology* by Dr. Stephen T Sinatra, M.D. and James C Roberts, M.D.) can be additionally helpful along with PEMF therapy. Anyone hoping to treat their A fib with PEMFs with the goal of reducing or stopping medication should do so only under medical supervision.

Magnetic field therapy reduces conduction abnormalities while simultaneously targeting remodeling of the autonomic tissues of the heart, and fibrosis, and inflammation of those same tissues.

As with other conditions, there are preventive benefits to using PEMF therapy with the heart. Decreased vascular resistance means the blood vessels are more open. This decreases the workload of the heart, reducing strain on the heart muscles, which if applied over long periods leads to decreased cardiac wear and tear.

By way of example, fifty patients were treated following heart attacks (myocardial infarctions). PEMF treatment was to the lower neck and upper spine behind the heart with a medium intensity 50 Hz field for fifteen minutes every other day for twelve exposures. Before treatment, testing on both the active treatment and the sham treatment groups showed similar heart workloads. After the end of the course of treatment, there was a 22% improvement in workload capacity in the actively treated group. Also, 57% versus 37% of the active versus sham groups had a reduction in the frequency of angina (chest pain) episodes. Nitroglycerin use was eliminated in twenty-seven people treated versus thirteen controls. Other research showed improved elimination of fluid in cardiac patients treated with magnetic fields that led to a reduction in the amount of circulating blood and thus to reduction in size of the liver and blood pressure. In other patients after myocardial infarction, sinusoidal magnetic fields produced functional and subjective improvement in 66% of the cardiac patients. In yet another group of fifty-one people with ischemic heart disease, 92% had improvement with decreased sympathetic tone, reduced use of medications, improved workload, and decreased stress hormones. A higher field intensity was better than low intensity treatment in this study [190].

Many individuals end up getting cardiac surgery for their heart problems. My experience has been that recovery following cardiac surgery also appears to be better and faster. These individuals appear to have less surgical wound pain, use less pain medication, start being more active sooner, have less irritation of the nerves in the chest wall, and sleep better.

Hepatitis, Viral

Conventional medical treatments for viral hepatitis are often inadequate, but more recent therapies for hepatitis C appear to be effective. The long-term consequences of these therapies are yet unknown. Most antiviral therapies only stop the active growth of existing infections, but do not eliminate the viruses that are left behind in the tissues, which are dormant and can be reactivated later in life. In addition, even if the antivirals work to slow down the growth of the infectious process, they do nothing to help the liver to recover from the damage left behind by the viral infection. So, PEMF therapies can be helpful to not only help the body to deal with the virus, but also to help the liver recover and hopefully regenerate (See below on liver regeneration).

A study was done treating viral hepatitis patients with PEMFs. These patients had severe viral hepatitis with pre-coma or coma. Steroids are used often in this situation to decrease the amount of inflammation present. Unfortunately, sometimes steroids can actually cause the viruses to grow even more. The patients in this study were treated with PEMFs along with steroids. While survival from this level of severity of illness is highly unlikely, 56% were clinically cured by this therapy. Five patients who did not respond to this therapy subsequently were exposed again to magnetic fields (45-55 mT, 2 x 20 minutes per day for one week, then twenty minutes per day for another eight to ten days. Three patients had pre-coma and two were comatose. Against all odds, these five patients were cured clinically. The time to obtain recovery was ten to fifteen days shorter than in the ten other patients who did not receive PEMF therapy. Many liver function tests returned to normal by the end of the magnetic field treatment [178]. This study supports the possibility for PEMFs to help with severe liver inflammation, even viral infection, whether alone or with other therapies. I personally would not recommend relying solely on PEMFs in the setting of severe hepatitis. PEMF therapy alone can be used with good results in milder cases of hepatitis, to limit the amount of liver damage caused by the viruses. The combination of viral therapy, steroids, and PEMFs is likely to be synergistic.

Intestinal Function

The intestinal tract is one of the most complex organs in the body. It comprises the mouth, esophagus, stomach, small bowel, large bowel, and anorectal area. The tissues of the intestinal tract comprise most of the tissue types of the body, especially muscle, soft tissue, blood vessels, nerves, veins, lymphatics, secretory tissues, and valves, as a short list. The intestinal tract is the largest absorptive and excretory organ of the body. It has more nerve cells in it than the brain, numbering in the trillions. The largest percentage of the immune system is housed in its walls. It is home to more non-human organisms than the whole body itself has cells. This is the microbiome, a collection of bacteria and other microorganisms that are cooperative with body functions and are critically important to digestion, metabolism, detoxification, waste removal, food processing, and immune function.

Any way that PEMFs affect other tissues of the body, they will affect the intestinal tract similarly. Some examples include relieving cramping of abdominal contractions, regulating bowel function whether to slow it down or speed it up, healing bowel wall damage, improving circulation to the bowel itself, reducing inflammation, and balancing stomach acid production.

Research in Eastern Europe on 151 patients who had gastrointestinal conditions for upwards of ten years found PEMF therapy to be extremely effective. The participants of the study not only had subjective and clinical improvements but also had lower stomach acid levels. In those with ulcers, gastric or duodenal, ulcer size was actually reduced. They actually measured the contractions of stomach and duodenal muscles and found that muscles that were hyperactive or underactive all became normal. The normal rhythm patterns of the contractions of the muscles returned. They even saw improved circulation of the tiny blood vessels in the stomach. By treating the stomach, they also found improved circulation in the liver. Other laboratory tests found levels of immune markers (gamma and alpha globulins), histamine, and serotonin all improved. If they were high, they returned to normal. If the lab markers were low, they also returned to normal. Another important finding is that stimulation of the abdomen with PEMFs increased the removal out of the body of stress hormones. Stimulation of the upper abdomen for gastric and duodenal ulcers provides benefits to other organs in the abdomen in the area of the magnetic field. In addition, since these conditions are all typically associated with stress, either as a cause or as a result, the increased removal of stress hormones helps to decrease stress levels [190].

Joint replacements and implanted prosthetics

The last three decades have witnessed a marked increase in total joint replacement procedures with excellent results. Joint replacements are being done in progressively younger people. The age at which a prosthesis is considered is critical to deciding the timing of a joint replacement. Healing that has to occur after these replacements is complicated.

During the healing process, bone cells first develop or proliferate, then mature, and finally deposit minerals. In the active growth phase, osteoblasts have elevated production of extracellular matrix (ECM) genes such as type I collagen (COL1). When cells enter the maturation phase, cell growth slows down and the expression of matrix formation proteins such as COL1 and alkaline phosphatase (ALP) increase. The last stage involves adding minerals (mineralization) to the area of the injured bone.

Joint replacement prosthetic implants need to be integrated into the pre-existing bone. Implants are believed to cause faster osteoblast proliferation that can better promote osteointegration because they produce more extracellular proteins, such as COL1. Because of increased collagen synthesis in the ECM, the bone cells produce elevated alkaline phosphatase (ALP) activity. Higher ALP activity eventually leads to more mineral deposition and superior bone repair.

Surgeons doing an original joint replacement or implant often have to wait until a person is older to do the procedure because of the possibility that in ten to fifteen years the procedure will have to be redone. Revisions (also called re-dos) are usually more surgically complicated and challenging, with an increased risk of breakdown and complications.

The reason for this is that the prosthetic in a joint replacement becomes loose over time. In other words, it becomes less firmly seated within the bone. Loosening, whether due to loss of blood supply (avascular) or infection (septic), remains the main complication of joint replacement and is the cause of more than 70% of hip revisions and 40% of knee revisions. In 74%, loosening of implanted prostheses occurs following the primary operation and smaller numbers following the second and third implantations. Two-thirds of the loosenings were due to avascular or aseptic (noninfectious) conditions. Survival of cement-less hip replacements is as low as 75% in young patients after ten years. Significant bone loss is seen in up to 14% of individuals during the first three months after the initial total hip replacement. Pain is a common finding after loosening occurs, on average twelve months after implantation or with another peak at seven years. On average patients suffered pain from loosening for about seventeen months, before revision surgery.

Revision prostheses have poorer outcomes compared with primary joint replacement because the quality of the bone tissue where the new prosthesis is to be implanted is poor, with loss of bone mass and osteoporosis of the surrounding bone. Breakdown of bone around the implant, bone loss, poor natural bone healing capability, and local inflammation are the main problems in reconstructive hip surgery and reduce the lifespan of revision implants. Inflammation produces enzymes that degrade tissue at the bone implant interface [96].

Multiple new approaches have been researched to improve the bone-implant interface. Some of these include other types of implant surfaces, locally applied osteoporosis medications (bisphosphonates), and locally applied growth factors, platelet rich plasma, and stem cells. However, costs, safety issues, complexity of administration, optimal dosing, other factors, and lack of long-term studies limit these options.

PEMFs have been studied for the ability of various materials to integrate with bone. Almost all the studies have shown that PEMF stimulation can be applied locally and can significantly enhance the integration of implant materials, including titanium, stainless steel, and ceramic implants. Even nails or rods implanted long before into the bone marrow of large bones for fractures, such as the femur, which became movable or unstable, improved and were integrated better into the bone. Most PEMFs, except for very high intensity fields, do not react with bone or metallic implants negatively. Using PEMFs at very high intensities should happen with caution.

I had a similar personal experience with a titanium dental implant, which integrated better into my own bone graft because I was using PEMF stimulation (often being my own guinea pig). Even the dental surgeon was pleased, surprised, and amazed. He had apparently only seen this one other time in seventeen years of practice doing implants.

There are three possible strategies for dealing with preservation of a joint replacement, considering the role of PEMFs: Prevention, dealing with loosening, and improving outcomes when revision surgery is needed. Prevention will be dealt with last.

To prevent loosening: A new strategy is needed that can enhance the success of the implantation procedure by increasing bone formation around the prosthesis, or osteo-integration, and lowering local inflammation, especially in un-cemented implants. PEMF stimulation is ideal for this. The effectiveness of PEMFs in enhancing endogenous bone repair and reducing inflammatory processes has been shown in multiple studies, thereby enhancing the long-term effectiveness of this type of surgery. Higher than usual osteoblast for proliferation is stimulated by PEMFs and determines the rate of new bone formation.

In the scenario of loosening of prostheses already present, the intention is to try to reduce the need for revision. In one study, 132 patients had PEMF therapy for advanced loosening of their prostheses. Treatment was forty minutes two to three times per day for twenty weeks. Follow-up extended for over five years. A revision procedure was no longer deemed necessary in 70% of the patients [215].

In an extension of this research, and by far the biggest series to date [18], PEMF therapy was performed in more than a thousand patients with loosened artificial hip joints. The PEMF signal was 30 gauss with a frequency range between 2 and 20 Hz. The treatment ended when patients were free from pain and complaints for up to six months. Treatments for 334 patients with 348 arthroplasties were applied within a controlled study. Treatment was successful in 70% of the patients. Also, 76% used crutches before treatment and this was reduced to 48% afterwards. In more than 65% of the patients, further surgery could be avoided within a follow-up of ten years. Normally the treatment took just sixteen weeks. Another 54% of the patients suffered from chronic pain before the PEMF treatment, reduced down to 6.5% afterwards. Before PEMF treatment 36% used analgesics and after treatment only 2%.

Based on this research, PEMFs are best considered for patients at an early stage of aseptic prosthetic loosening [18]. A double-blind trial of PEMFs for loosened cemented hip prostheses was conducted. All thirty-seven patients completed six months of treatment (either active or control units). Success was determined clinically by a Harris hip score. Ten of the nineteen active PEMF treatments were successes (53%), whereas only two of the eighteen controls (11%) had a positive placebo effect, a significant and clinically relevant result. A 60% relapse rate among the active successes was seen at fourteen months after stimulation, and despite maintenance therapy of one hour per day, the relapse rate increased to 90% at three years. These data suggest that for loosened cemented hip prostheses, use of PEMFs is a treatment option only to delay revision hip surgery [201]. It's quite likely that longer daily treatment times would have produced better results, as seen with the next study.

PEMF treatment was used in twenty-four patients with hip replacement loosening. At the end of treatment, six months and one year later, pain and hip movements improved significantly. Both bone scans and ultrasound improved significantly, but plain X-rays didn't. The decreased pain and improved function suggest that PEMF is effective in improving symptoms of patients with loosened hip replacement, supported by objective improvements in bone scan and ultrasound. Minimal improvement, however, can be expected in patients with severe pain due to gross loosening [212]. PEMFs in this circumstance would only be expected to help with pain management.

In another study, forty-five patients with a painful hip prosthesis had a 75 Hz, 2 mT PEMF stimulator for sixty days, at a minimum of six hours per day, and for a minimum of 360 hours total treatment time. Of those, 76% had good or excellent results. The more PEMF treatment done, the better the results were, with 80% of those who used it for more than thirty days reporting good results. However, of those who used it for more than sixty days with at least 360 hours of exposure (for an average of six hours per day), 92% had good results. There appears to be a total dose-related cumulative effect. No side effects of this much stimulation were seen [362].

A forty-four-year-old patient had disastrous bone dissolution (osteolytic) changes that developed around the distal end of a femur prosthesis. These changes appeared to reverse with the use of anti-inflammatory medication and PEMF stimulation. Most of the time osteolysis shows progressive change at an unpredictable rate. Incredibly, reversal of osteolytic change has never been previously documented, without surgical intervention [434].

Joint revision: Since joint revisions are such a frustrating situation for most patients and doctors, a randomized, double-blind study was done to assess the value of PEMFs in this situation. Thirty patients undergoing hip revision were treated for six hours per day up to ninety days after revision. Symptom improvement was higher in those undergoing active PEMF stimulation compared to placebo. Bone density measurements (DXA) above 3.5% were considered responders. Some of the bone healing zones were not different between the two groups both postoperatively and at ninety days into the investigation. In two of these zones, corresponding to the interior of the bone, they found six responders (40%) in both of these interior areas in the control group, while in the PEMF stimulated group they found between 66% and 93% responders. This study showed that PEMF treatment aids clinical recovery and bone restoration [96].

Another group of thirty patients undergoing hip revision with a replacement prosthesis was treated for six hours per day with a 75 Hz, 2 mT PEMF from the seventh through ninetieth days after revision in a double-blind study. PEMF-treated individuals were functionally better. Postoperative bone mineral density (BMD) was 66–93% versus 40% in controls, or more than double the improvement, even at ninety days after surgery. In addition, the PEMF group had a reduction in pain of 77% compared to 40% in the control, even as far out as ninety days after the procedure. The treatment was not associated with any negative side effects; nevertheless, it must be noted that the use of the PEMF stimulation at the hip required considerable patient commitment. Still, this important study showed that PEMF treatment aids clinical recovery and bone restoration [96].

Prevention: Since inflammation is caused by bone implants of any kind and hinders bone repair, it is important to know whether PEMF could stimulate bone repair under conditions of inflammation. Conditions of bone repair were studied in experiments simulating implant placement. On day seven, a PEMF-exposed bone culture released more nitric oxide (NO) than the control. PEMFs resulted in a significant increase in NO release. PEMF-induced NO production in macrophages takes on an oscillating pattern and peaks at seven days. The survival of osteoblasts in a control group decreased from days zero to seven. The PEMF-exposed osteoblasts had significantly higher survival on day seven. Osteoblasts stimulated by PEMF began to synthesize internal NO and probably developed their own protective mechanisms such as intracellular detoxifying actions and heat-shock proteins to prevent NO from damaging themselves. NO subsequently promoted osteoblastic activities such as growth, viability, and collagen expression.

Since joint replacements and other implanted hardware, such as screws and plates, cause inflammation in the bone into which they are implanted, it makes sense to consider PEMFs even before surgery is considered. Prior to surgery PEMFs would stimulate the bone to prepare it for the surgical process. If the tissues are optimized prior to surgery, they would be expected to recover faster and the prosthesis would be placed into bone that is healthier. Many of these patients already have predisposition to problems by virtue of having osteopenia or osteoporosis. Since PEMFs clearly help with loosened prosthetics and in revision surgery, they would be likely to help to maintain the life span of a prosthesis, by keeping inflammation at a lower level.

Having a joint replacement is a major event in a person's life. It cannot be taken lightly especially when considering the complication rate and the rate at which these prosthetic replacements can break down. Not only is there the suffering that happens as a result, but also the risks of disability and recovery time of having revision surgery. The research on the use of PEMFs is compelling.

I would strongly recommend anybody considering joint replacement to begin using PEMFs before the replacement to condition and prepare the tissues to be as healthy as possible so they can be better able to recover faster after surgery. In addition, continued use and frequent use after the implantation would provide a much greater guarantee that the prosthesis would last longer and reduce the risk of many of the complications and suffering that happen after these procedures. This is not something that can be done in a doctor's office, but has to be done daily in the home setting.

The challenge is that individuals with joint replacements usually experience considerably less pain and discomfort because of their surgery and are happy with their results with little understanding of the downstream consequences of the surgical procedures. Unfortunately, most surgeons are not aware of this PEMF research, and individuals are not offered or recommended PEMFs to help them maintain the benefits of their surgery.

Keloids

The scars that form from the healing of wounds may be normal or abnormal. Abnormal scars can be hyperactive (hypertrophic) or form keloids. Keloids are abnormally high and irregularly shaped masses of scar tissue, believed to be due to an over production of collagen during connective tissue repair following tissue injury.

Keloids are firm, rubbery lesions or shiny, fibrous nodules, and can vary from pink to the color of the patient's flesh or red to dark brown in color. Keloid scarring is common in young people between the ages of ten to twenty. Studies have shown that those with darker complexions are at a higher risk of keloid scarring due to skin trauma. Keloid scars are seen fifteen times more frequently in people of African descent than in people of European descent. They occur in 15 – 20% of individuals with African, Asian, or Latino ancestry, significantly less in those of a Caucasian background, and there are no reported cases in people who are albinos. Keloids tend to have a genetic component, which means one is more likely to have keloids if one or both of their parents have them.

Keloids should not be confused with hypertrophic scars, which are raised scars that do not grow beyond the boundaries of the original wound. Keloids usually occur at the site of an injury, but can also rarely appear spontaneously. They can occur at the site of a piercing (ear lobes are one of the most common presentations today) and even from something as simple as a pimple or scratch. They can occur because of severe acne or chickenpox scarring, infection at a wound site, repeated trauma to an area, excessive skin tension during wound suturing, or a foreign body in a wound. Keloid scars can grow, if they appear at a younger age, because the body is still growing.

The best treatment is prevention in people with a known predisposition. Treatment of a keloid scar is age dependent. Surgical excision is currently still the most common treatment for a significant amount of keloid lesions. However, when used as the solitary form of treatment there is a high recurrence rate of 70–100%. Excision has also been known to cause a larger lesion to form when it recurs. While not always successful alone, surgical excision when combined with other therapies dramatically decreases the recurrence rate. When keloids occur, the most effective treatment is superficial external beam radiation therapy (SRT), which can achieve cure rates of up to 90%. However, radiation therapy can also create new problems with collateral tissue destruction, no matter what protections are taken.

In laboratory research, PEMF exposure inhibited the proliferation of keloid-forming fibroblast cells by 10–30%, a statistically significant decrease by day ten. Proliferation of normal fibroblasts was not altered by the PEMF. In the absence of PEMF exposure, the level of collagen synthesis was more exaggerated in keloid fibroblasts than in normal fibroblasts [301].

This study suggests the possibility that PEMF treatment to the injury at the time of any skin injury in anybody predisposed to keloids, whether by family history or personal history, heals better and faster and helps to prevent keloid development.

It is not known how well PEMFs will do with existing keloids. Except for anecdotal reports there is no risk in trying PEMFs since it's known that PEMFs heal skin well.

Liver Regeneration

Regeneration of organs following partial removal of an organ, such as the liver, for example, in trauma, surgery for cancer, or partial liver donation is of significant interest. At this time, conventional medical practice has nothing to offer to accelerate regeneration. Accelerating regeneration becomes important to reduce the risk of complications, recover organ function, and improve the general health of an individual. Of all the solid organs in the body, the liver has the greatest capacity for regeneration after surgery or damage. A somewhat limited capacity for regeneration has been the general experience of humanity. PEMFs change all that. Tissue regeneration of many tissues in the body with PEMFs is a real possibility. More on this in the wound care discussion below.

Regeneration of rat liver after partial liver removal has been used as an approach to study controlled growth in a living creature. PEMF therapy was compared to sham therapy in a group of rats who had 60 to 70% of the liver removed. These rats were treated for thirty minutes every twelve hours. The PEMF signal used was 50 Hz, 6 mT alternating every four treatment-sessions with 400 Hz, 0.6 mT. Analysis of the remaining liver was done at baseline, one, three, five, and seven days after surgery. They measured the weight of the liver and total protein, lipid and sugar (glycogen) content. On the first day after surgery, the control animals had glycogen levels 20% of their baseline values versus 42% for the PEMF group, indicative of the energy reserves of the tissue. Lipid content, a less desirable source of energy, increased thirteen-fold in control animals the day after surgery and returned to normal by seven days. The PEMF group had only a six-fold increase in lipid content and reached normal in five days. PEMF treated rats had a much more rapid gain in the weight of the liver and protein content in the first three days than controls, although both groups reached the same values at the end of the regeneration. Clearly, liver regeneration following partial liver resection is improved by treatment with PEMFs [301].

How well this would apply to humans remains an open question, because rats are smaller and have much faster metabolism and therefore faster regenerative capability. If this were to be done in humans following liver resection, the magnetic fields used would have to be scaled to the size of the human liver to be certain the same magnetic field intensity is provided throughout the volume of the remaining liver.

Lyme disease

Lyme disease is caused by the transmission of bacteria and viruses by the deer tick. Tick borne diseases are found throughout the world. The bacterial infection caused by the tick bite in the case of Lyme disease is a corkscrew type organism, called a spirochete. These are hardy, reproduce rapidly, and can persist.

Lyme disease infection, called borreliosis, is a major health challenge. The Lyme tick is tiny and hard to see, and is frequently not ever seen before infection sets in. A classic sign of Lyme infection is the so-called target or bull's-eye skin lesion. Many people who have Lyme disease never see a bull's-eye lesion.

Lyme disease can be associated with a vast array of health problems. This depends on where the infection settles into the body. It can affect the brain, muscles and joints, the lungs, heart, the intestinal tract, and so on. The most common reactions are in the brain, muscles, joints, and the heart. Most of the time it is treated with antibiotics once the initial diagnosis is made. Some people need IV antibiotics to handle the infection. There is much controversy between non-conventional medicine and Lyme specialists on the best management of Lyme infection. Many people are treated shortly after a bullseye rash and never seem to have a problem again. Many other people show up with chronic, severe, ill-defined conditions, which upon testing, often months to years later, reveals past Lyme exposure.

Lyme disease often becomes chronic. I often tell my patients that there are four aspects to Lyme disease. Number one is the actual active infection with the spirochete, especially that seen after a typical bulls-eye rash. The second is the presence of the hidden, other morphological cell forms, hidden in the cell (intracellular forms of the organism). These tend to be chronic aspects of the infection, which can reactivate into a recurrence of symptoms. The third aspect of the infection is an (auto-)immune reaction. This is also likely to be manifested in chronic long-term health conditions, not unlike rheumatoid arthritis or other connective tissue disorders. The fourth aspect is the actual damage caused by the infection in the various tissues in which it settles. Acute Lyme infections, like any other infections, can settle in various tissues or organs of the body and create variable amounts damage, inflammation, or scarring. The results of this damage can cause chronic symptoms.

Obviously, Lyme disease needs to be treated with appropriate antibiotics, nutritional support, supplements, and other therapeutic modalities, such as chiropractic and acupuncture. Some people may even need long-term IV antibiotics.

In the acute phase of the Lyme infection, antibiotics will usually suffice, if carried on for a sufficiently long enough time. In the chronic phases, it is difficult to completely eradicate the infection or its consequences. This is where PEMFs come in.

Because PEMFs help with reducing inflammation, improving circulation, reducing pain, and in general improving the value of other treatments, they should be part of any treatment program in anyone with chronic Lyme-related health problems.

A common problem with Lyme disease is chronic pain. Many patients with Lyme disease become dependent on narcotics for their pain management. Unfortunately, narcotics can also be immunosuppressive and may in the long run be more harmful to the individual, besides the risk of addiction. PEMFs not only help with pain but also help to address the underlying causes of the pain in the body. PEMF therapy used at home on a daily basis is necessary to manage the pain of Lyme disease. Occasional treatments in a doctor's office will not do the job for somebody with chronic daily pain. At the very least, these occasional treatments will only provide temporary relief. The major value of PEMFs is that they can be purchased and used in the home setting at one's convenience.

One of the most important aspects of the use of PEMFs for Lyme disease management is to be able to uncover or expose the forms of the Lyme organism that hide out in the cell, hidden from detection by the natural immune system. Antibiotics have not been found useful for attacking these hidden forms. PEMFs help to open cell membrane channels, allowing nutrients, supplements and antibiotics better access to the inside of the cell and also helping the cell to eliminate waste better. By balancing the energy of the cell membrane, the cell will be healthier and more resistant to the hidden forms of the Lyme disease in the cell.

Lyme disease in the brain, called neuro-borreliosis, is especially challenging to treat. Many medical treatments and nutritional approaches do not access the hidden Lyme organisms in brain tissue, due to not being able to get through the blood-brain barrier. PEMFs have been shown to increase the circulation in the brain, allowing better access of treatments, supplements, herbs, and nutrients into the interior of the brain's nerve cells.

Because of the longer-term damage done by Lyme infection, ongoing daily home use of PEMFs, likely for a person's lifetime, may be necessary to achieve the best results. It's possible that programmable PEMFs may be able to disrupt the Lyme organisms using resonance theory. I honestly cannot tell you that PEMFs will cure Lyme disease. I should also say that, when Lyme disease becomes chronic, there is less hope of complete cure with any treatment, largely due to the autoimmune and chronic damage caused by the infection. Healing that damage becomes paramount to achieve reduction of symptoms. In addition, the chronic use of multiple oral or intravenous antibiotics will clearly leave the body suffering from them as well. Using PEMFs along with antibiotics should make a difference in helping the antibiotics to be even more effective and in decreasing the negative aspects of the antibiotics.

Migraine

Migraine is a disorder with recurrent headaches that are moderate to severe. Globally, approximately 15% of people are affected. Typically, the headaches involve half of the head, are pulsating, and last from two to seventy-two hours. They may also include nausea, vomiting, and sensitivity to light, sound, or smell.

Migraines are believed to be due to environmental and genetic factors. Two to three times more women than men have them. They involve the nerves and blood vessels of the brain. Initial treatment is usually with simple pain medication such as ibuprofen and acetaminophen (paracetamol) for the headache, medication for the nausea, and the avoidance of triggers. Specific medications such as triptans or ergotamines may be used in those for whom simple pain medications are not effective. Even medications are only partially successful and can have significant side effects. At this point, there is no cure for migraines. Alternative approaches to management are clearly needed. PEMF self-treatment could easily fill this gap.

A double blind, placebo-controlled PEMF study was done in forty-two people. High frequency PEMF was applied to the inner thighs one hour per day, five days per week, for two weeks. During the first month of follow-up, 73% of those receiving actual exposure reported decreased headaches (45% good decrease, 14% excellent decrease) compared to half of those receiving the placebo (15% worse, 20% good, 0% excellent). Ten of twenty-two with actual exposure had the option to get two additional weeks of exposure after the initial one-month follow-up. All showed decreased headache activity (50% good, 38% excellent), a further improvement over baseline. Eight in the placebo group were also crossed over to receive an additional two weeks of exposure. In addition, 76% showed decreased headache activity (38% good, 38% excellent). This type of PEMF approach for at least three weeks is an effective, short-term intervention for migraine, but not tension headaches [415].

Another group reported results of a trial for chronic headaches with fifteen treatments at 12 Hz and 5 mT (50 G) PEMF. Migraine patients typically had two or more attacks per month, each lasting three days. PEMF stimulation was only applied on days they were headache free. All participants had decreases in the number of attacks after PEMF therapy. One was symptom free for one year after treatment. Most reported the headaches lasted for a shorter period, but severity was not changed. In two, PEMF during an attack didn't help. The study authors thought PEMFs are an effective preventive treatment for migraine, indicating the need for owning a home-based system for daily use [140].

Another group looked at the thresholds for eliciting phosphenes by transcranial magnetic stimulation (TMS) in migraineurs and the ability to trigger headaches visually with and without aura. A phosphene is the experience of seeing light without light actually entering the eye. The visual aura of migraine is thought to be phosphene-related. Phosphenes can be directly induced by mechanical, electrical, or magnetic stimulation of the retina or visual cortex as well as by random firing of cells in the visual system. The results showed that the threshold for seeing visual effects on stimulation is lower than in healthy controls. The migraine patients in the study were susceptible to visually triggered headaches [20].

In another migraine study PEMF therapy was given at 2-5 Hz and 3-4 mT (30-40 G) to the head once daily for 10-15 minutes for thirty days while reclining. Improvement was 66% versus 23% in the placebo group. The frequency and intensity of attacks decreased [226].

Ninety patients with headaches, resistant to medications or acupuncture, were treated with PEMF twenty minutes daily for fifteen days. PEMF stimulation was most effective against tension headaches with 88% reporting excellent or good, results. PEMFs had excellent or good results with common migraines and cervical migraines in sixty and 68% [347].

Patients who suffered from headaches and failed to respond to acupuncture and other therapies, who applied PEMFs for at least twenty minutes per day had at least a 50% reduction in the frequency or intensity of the headaches and a reduction in dependency on medication

[456]. In a somewhat surprising study, it appears that even PEMF therapy away from the head may be able to help migraines. Somewhat surprisingly, PEMF therapy to the inner thigh, femoral artery area, can decrease headache activity. Short courses of therapy produced only about a 73% result in pain reduction versus a longer course of therapy, providing relief of about 90% [415]. It is unknown what the combination of treating the head and peripherally would do, but may be expected to be even more effective.

Patients with headache treated with a PEMF for fifteen days, after failing acupuncture and medications, get effective relief of migraine, tension, and cervical headaches at about one month after treatment [347]. They have at least a 50% reduction in frequency or intensity of the headaches and reduction in need for pain medicines.

One author reviewed the case of a migraine patient successfully treated with a PEMF. A forty-two-year-old female suffered from recurrent migraine attacks since the age of twenty-seven. Sham PEMF treatment had no relief. She had an extremely low intensity (7.5 pT) magnetic field at 2-7 Hz for seven minutes over the top of her head. Headache symptoms began resolving 45-60 minutes later. She experienced increasing sleepiness and heaviness in the head. Next morning, she was free of headache and reported having had a good night's sleep and being full of energy [382].

The stimulation threshold required to obtain TMS benefits has been found to increase during the time between episodes of headache in patients with aura symptoms. Similar changes have not been found in those having migraines without aura. Aura is likely caused by an interval of blood vessel constriction, which can alter the brain's bioelectric function of the hemisphere in which the aura-related changes occur. Migraine with aura has decreased brain blood supply, while migraine without aura does not. Ten women with menstrual migraines without aura had TMS on the second or third day of menstruation. A second TMS was delivered on the fourteenth day from the onset of menses. TMS of 1.9 T did not stop the headaches. However, they showed a significant increase in the threshold for exciting the brain in both hemispheres. This means the brain would be less likely to produce a headache. So, this higher intensity stimulation, only used twice, can be preventive [46].

Eighty-two people with a variety of headaches (migraine, migraine combined with tension, tension, cluster, weather-related, post-traumatic, or other) were evaluated in a double-blind, placebo-controlled study with four weeks of PEMF therapy (16 Hz at 5 microTesla). Of those, 76% with active treatment had clear or very clear relief of complaints. Of those on placebo, only one (2.5%) felt some relief; 8% slight relief and 2% had significant worsening of symptoms. No side effects were noted [333].

Several other studies found significant benefits from PEMFs for migraines. A series of twenty daily treatments, 10 Hz, for fifteen minutes was given to fifty migraine patients. Sixty percent had reduced frequency and intensity of attacks with reduced drug use over a three to four month period [290]. In another case series, 50-60% also reported a favorable effect of PEMF therapy with migraine headache [485]. A PEMF of 96 gauss (9.6 mT), 12 Hz applied to the head for one hour alleviated migraines [156].

rTMS has been compared to botulinum toxin-A injection for the treatment of migraine. Both treatments were equally effective. rTMS did not produce sustainable benefits even after twelve rTMS sessions. However, botulinum injections carry their own risk and have to be repeated regularly. A better, side effect free, non-invasive solution would be home-based daily PEMF therapy [414].

The above results indicate that PEMFs of various kinds have both preventative and therapeutic value in the management of migraines. As with other therapies for migraine, early treatment in the course of a migraine episode is likely to produce the best outcomes. In addition, regular use of PEMFs between migraine episodes is likely to reduce the frequency and severity of episodes, if not eliminate them altogether.

Multiple sclerosis

Multiple sclerosis (MS) is a chronic, complex, and often disabling disease of the central nervous system (CNS) with a variable clinical course. There are two basic forms of MS—relapsing/remitting and progressive. There is significant overlap between these two forms. Patients with MS have inflammation, destruction of the myelin sheath covering nerves in the brain and spinal cord (demyelination), scarring of brain tissue, nerve cell degeneration, and dysfunction resulting from immune system imbalances. Inflammation causing demyelination predominates in the relapsing/remitting phase of MS and is seen as recurrent episodes of worsening and improvement (exacerbation and remission). Neurodegeneration, leading to extensive brain nerve cell (neuronal) damage, occurs at the same time as inflammation in progressive stages of the disease.

While many causes have been evaluated, an important study at Vanderbilt has demonstrated that the brains of MS patients who passed away showed a high (70+%) level of chlamydia pneumoniae (CPn) infection. This form of chlamydia (CPn) is distinguished from the sexually transmitted disease form, C-trachomatis, in that it is mostly acquired through upper respiratory infections. CPn finds its way to the blood vessels in the brain, creating the demyelinating lesions [431]. This means that using PEMFs as a potential antibacterial, anti-inflammatory, and general brain tissue regenerative treatment method adds to all the other known benefits of PEMFs when it comes to managing MS.

Research suggests that PEMFs, although not creating a cure (and there is no known cure for MS), can alleviate many of the major symptoms, including spasticity, fatigue, cognitive function, mood changes, and other impaired physiologic functions. Even though MS starts in the brain and spinal cord, it ultimately affects the functioning of the whole body. Because PEMFs act at such basic cellular and physiologic levels throughout the whole body, including the brain and spinal cord, they become a valuable tool to improve function and enhance the quality of life of individuals with MS.

Although the specific mechanisms by which PEMFs alleviate MS symptoms are not completely defined many possibilities exist. For example, through influencing the flow of ions through membrane protein channels, electromagnetic fields may enhance signal conduction in dysfunctional neurons. In another example, magnetic fields alter neuro- and immunochemistry, both of which are affected by MS.

Electromagnetic fields influence the levels of various MS-altered hormones. External microwave level EMFs, such as cell phones and Wi-Fi, have been suggested as a key player in the cause of the disease, because these EMFs affect the brain's all-important, magnetically and light-sensitive pineal gland, which secretes hormones (e.g., melatonin). Melatonin subsequently affects the entire body [382].

The occurrence, cause, clinical manifestations, and disease course of MS can all be correlated, at least to some extent, with the pineal gland. For example, most individuals with MS have calcified (i.e., dysfunctional) pineal glands. If MS demyelination is a secondary consequence of pineal dysfunction, research efforts should focus on therapeutic interventions, such as PEMF therapy, that enhance pineal function [504].

PEMFs can alleviate MS symptoms such as fatigue, bladder control, and spasticity, as well as improve quality of life [161]. A double-blind study found that PEMFs improve disease activity in MS, including bladder control, cognitive function, fatigue level, mobility, spasticity, and vision. In thirty-eight people with more advanced MS, PEMF stimulation effects on spasticity were evaluated and showed that they could improve ease of daily activities and clinical spasticity [306].

Regarding fatigue, commonly seen in MS, it has been proposed that depletion of neurotransmitter levels in damaged neurons may contribute significantly to the development of fatigue and showed that even a picoTesla PEMF improved fatigue. These results suggested that replenishment of neurotransmitter levels in neurons damaged by demyelination in the brainstem by periodic picoTesla PEMFs may lead to more effective impulse conduction and thus to improvement in fatigue [385].

Another possibly related way PEMFs might improve MS fatigue is electrophysiological. During a language task and after visual stimulation, PEMFs increased the amount of brain alpha activity [361]. Another study showed significant positive differences in theta and beta band activity between subjects exposed to real and sham 3 Hz magnetic fields [174]. High theta and low beta activity can lead to fatigue.

Forty-five MS patients had active PEMF treatments and twenty were given sham treatment. The head and lumbosacral region were treated to the PEMF, twelve minutes a day for twenty-two consecutive days at 10 Hz, 10 mT, with semi-triangular and triangular waveforms. They also had standard medication and physical therapies. Treatment cycles were repeated every six to eight weeks. There was a significant decrease of muscular tension and spasticity, increased force of muscle contractions, improved gait, and decreased intensity of intentional tremor and abnormal eye movements (nystagmus) as well as improvement of mental state and concentration. Positive therapeutic results were seen in 31-73% of the patients depending on their clinical symptoms. PEMFs make coordinated therapy of MS more efficient [421].

Transcranial applications of picoTesla PEMFs produce rapid and sustained improvement of symptoms in patients with chronic progressive or secondary progressive MS, and make electrophysiologic responses more normal. There were recurrent episodes of uncontrollable yawning and body stretching, identical to those observed upon awakening from sleep. This behavioral activity has been seen exclusively in young females, who are still fully ambulatory with a relapsing/remitting course of MS. This is actually a favorable therapeutic response to magnetic stimulation. It is likely due to the production of adrenocorticotropic hormone (ACTH) stimulated by the PEMFs. Intracerebral administration of ACTH in experimental animals elicits yawning/stretching. A surge in plasma ACTH levels at night and just prior to awakening is also found in humans with yawning and stretching. In addition, ACTH is sometimes used to treat MS due to its immune modifying effects [398].

A forty-year-old woman with cerebral palsy (CP) and MS had symptoms of spastic paraplegia, loss of trunk control, marked weakness of the upper limbs with loss of fine and gross motor hand functions, severe fatigue, cognitive deficits, mental depression, and autonomic dysfunction with neurogenic bladder and bowel incontinence. These began at age eighteen with weakness of the right leg and fatigue with long distance walking. Over the ensuing years, she experienced steady deterioration of functions. She became wheelchair dependent and it was anticipated that within two years she would become quadriplegic. She began treatment with picoTesla PEMFs transcranially weekly. With PEMF treatments over the next year, she had improvement in mental functions, return of strength in the upper extremities, and recovery of trunk control. During the second year, she experienced the return of more hip functions and recovery of motor functions began in her legs. For the first time in years, she could initiate movement of her ankles and actively straighten her legs voluntarily. Over the next year, she started to show signs of beginning to walk again. With enough function restored in her legs, she began learning to walk with a walker and was able to stand unassisted and maintain balance for a few minutes. She also regained about 80% of the functions in her upper limbs and hands. Most remarkably, there was no further progression of the disease during the four-year course of PEMF therapy. This patient's clinical recovery cannot be explained as a spontaneous remission. The doctor suggested that the regular use of the PEMFs affected the neurobiological and immunological mechanisms underlying the pathology seen in CP MS. Despite the obvious benefits of PEMF in this setting, regenerative changes in the brain require a long course of treatment, possibly forever [391].

During his extensive experience in treating MS with PEMFs, Dr. Sandyk also saw the resolution of sleep paralysis and double vision, reversal of problems with speech, improved bladder and swallowing function, and other evidence of improvement of nerve functions [390]. The best results occurred in people who had the longest courses of care. Interestingly, the extent of demyelinating plaques on MRI did not correlate with the rate and extent of recovery in response to PEMFs. Dysfunction of brain cell connections more likely contribute to the development of MS symptoms than the process of demyelination, considered almost a side product of the disease. PEMFs almost certainly can show improvement in function before they show improvements in physical damage. This lag in the benefit versus anatomic proof is frequently seen in other conditions, such as arthritis, for which PEMFs are helpful.

One study evaluated twenty people in a double-blind controlled fashion using an 80 gauss PEMF device for twenty-minute treatments applied to either the head, trunk, or thighs. All those treated had improvements in circulation. After one month of receiving sham treatments, people in the placebo group of the double-blind study began receiving active treatments and were termed a "crossover" treatment group. Double-blind results showed "well improved" or "improved" status for seven of ten PEMF-treated patients, and only two of ten of the placebo group. Later, eight of ten of the crossover group of former placebo patients became "well improved" or "improved" [161].

In a separate study by the same group, participants were given fifteen daily treatments or sham treatments in a reclining or sitting position by placing a coil on the upper and lower spine areas, then on the lower extremities. The applied PEMF was a 300 Hz sine wave, 2-50 Hz and intensity 50-70 gauss. Another 104 patients were treated in an open series involving one or more groups of treatments, each grouping separated by three or more months, for up to five treatment series over a period of eighteen months. In the open series, 80% were "well improved" or "improved." Regardless of which treatment group the participants were in, everyday life was made easier; general weakness improved, walking longer distances or stepping on stairs became possible, and bladder incontinence improved in 52% patients with urinary incontinence. A notable effect of the PEMF was the reduction of spasticity and pain [161].

Another physician, using the same method as above, treated 126 MS patients, mainly with spasticity. Of those, 50-60% reported a favorable effect of the therapy with their spasticity, vascular headache, and spinal pain [485].

Ten patients with MS were treated using a similar system. Treatments consisted of twenty daily exposures of low frequency (10 Hz) PEMF for fifteen minutes. Clinically, 30% of these MS patients had immediate subjective improvement [290].

Over a three-year period, ninety-seven MS patients were treated; seven of those had MS with associated disorders. Most were treated while in the hospital. They received 177 courses of PEMF therapy using a medium intensity PEMF device (10 or 50 Hz at 70 gauss). A typical course consisted of ten to twenty-five treatments given daily, six days per week. Health status improved, worsened, or remained unchanged. No benefit was seen in 21%. In 6%, the condition deteriorated or treatment was interrupted for some reason, and 73% showed some improvement. Some 78% of female MS patients and 58% of males reported improvement after their treatment series. Urinary incontinence improved in 5%. In several patients, muscle spasticity decreased to such a degree that the dose of muscle relaxants could be reduced or even discontinued. Most of the other MS patients reported increases in muscle strength. No adverse side effects of the treatments were seen. No precise data were available on how long the benefits lasted, but a few patients reported benefits lasting for three to seven months after treatments were stopped [453].

Another study was done using a low to medium intensity PEMF system on seventy-six people with a long-term history of MS (nine years and mean age of thirty-eight). They were divided into two groups: active and non-treated control. Active treatment consisted of sinusoidal PEMFs, 1-10 mT (10-100 gauss), 20-50 Hz. Function was assessed initially and after twenty-one days of stimulation. The level of movement impairment was the same in both groups. Quality of life was found to be significantly better from PEMFs. Mental state improved the most significantly with alleviation of depression, elimination of anxiety, improved emotional control, as well as decrease in muscle tone, altered sensations, and pain. No side effects were seen. PEMF therapy may supplement symptomatic treatment of people with multiple sclerosis [59].

High intensity PEMFs (HI-PEMFs), using rTMS, have been studied in MS too. With HI-PEMFs over the scalp, currents can be induced within the brain to excite the motor cortex, even to the extent that the brain stimulation would cause hand muscles to contract. Spinal neurons controlling extremity muscles are induced to fire by sending impulses over fast conducting spinal nerve fibers [285].

In a double-blind placebo-controlled PEMF study, thirty-eight people with MS had a coil placed in the midline of the back, with the bottom part of the coil placed over the eighth thoracic vertebra. The active group had intermittent HI-PEMF stimulation for twenty-five minutes and the other group had sham stimulation, twice daily for seven consecutive days. The clinical state improved by 18% and was unchanged in the sham group. Ease of daily activities improved by 22%. Clinical spasticity improved in treated patients and improved less or worsened with sham stimulation. The stretch reflex increased by 27% and did not change in the sham group. In the treatment group, 50% improved their self-score, 70% the clinical score and 50% their stretch reflex. In the placebo group, improvements were 59% in their self-score, 59% clinical scores, and 29% the stretch reflex. The effects lasted at the same level for twenty-four hours. Eight days after the end of treatment, the stretch reflex remained improved by 27% in the treatment group as compared to baseline, indicating improved spasticity. After sixteen days, no statistically significant effect of treatment could be detected. This study supports the idea that HI-PEMF has an antispastic effect in multiple sclerosis. The results are similar to the success seen with drug therapy. Many MS sufferers who have spasticity cannot tolerate or refuse medication treatment because of side effects. HI-PEMF is well tolerated with no significant side effects. Transient dizziness was the primary side effect, likely due to blood pressure changes. HI-PEMF appears to be more tolerable than electrical stimulation since there is no induced pain or muscle contractions [306].

Spasticity in MS was also studied in a group of nineteen patients with relapsing-remitting MS and lower limb spasticity. They used 5 Hz or 1 Hz HI-PEMF in a single session over the part of the brain controlling leg muscle movements. The ankle stretch reflex improved. Single treatment sessions did not induce any effect on spasticity but were better when HI-PEMF was repeated over a two-week period. Clinical improvement lasted at least seven days after treatment with a two-week protocol. No effect was found after a two-week sham stimulation [76].

Using rTMS of 5-Hz over the motor cortex in people with multiple sclerosis with cerebellar symptoms appears to improve hand dexterity but does not change dexterity in healthy subjects [209].

Bladder dysfunction is common in people with MS. HI-PEMF over the motor cortex for five consecutive days improved the voiding phase of the urination cycle, suggesting that enhancing spinal nerve function can improve bladder function in MS patients [77].

While there is plenty of evidence to suggest that PEMFs may be very helpful in MS for a wide range of symptoms and functional limitations, including fatigue, there is at least one study demonstrating a lack of benefit for fatigue in MS. In that study, fifty MS participants with primary fatigue were evaluated in a randomized double-blind cross-over trial at a rehabilitation center. They were randomized into two groups, a magnetic field group and sham therapy group, and evaluated with a fatigue impact scale, fatigue severity scale, VAS, and ten-meter walking test. Each group received both sham therapy and magnetic field therapy for twenty-four minutes per session, three times per week, for eight weeks, then a no treatment period of five months before being treated with the opposite therapy. They had a statistically significant improvement in physical scores using the active PEMF therapy. However, there were no significant benefits for fatigue, despite improvement in physical function [98].

This study points to the need for additional research to better understand the nature of the fatigue seen in MS. Research designs are complicated and need to consider the nature of the intervention, how it is applied, the particular physiologic nature of the participants, and many other factors. While physical functioning was improved in this study, fatigue measures were not. Further research needs to separate out the parameters that differentiate the contradictory results from the various studies.

Overall, it can be seen that PEMFs can help with not only the clinical symptoms of MS but also disease progression. They are not a panacea. Unfortunately, there is as yet no cure for it. Also, there have been no longer-term studies comparing the benefits from disease modifying agents versus PEMFs. Disease modifying agents may be most effective in reducing the frequency and severity of flare-ups, but they show little benefit in helping with function or symptoms. So, even in the setting of the use of disease modifying agents, PEMFs add another element to address other aspects of the condition and assist with the overall clinical picture.

Neuromyelitis optica (NMO)

I include a discussion of this condition here because it is so much like MS. A common presentation of MS is optic neuritis. Neuromyelitis optica (NMO) is an uncommon disease syndrome of the central nervous system that affects the optic nerves and spinal cord. NMO is a relapsing-remitting disease, like MS. During a relapse, new damage to the optic nerves and/or spinal cord can lead to accumulating disability. Unlike MS, there is no progressive phase of this disease. Therefore, preventing attacks is critical to a good long-term outcome.

Individuals with NMO develop optic neuritis, or inflammation of the optic nerve, which causes pain in the eye, vision loss, and transverse myelitis (TM). TM is inflammation of the spinal cord, causing weakness, numbness, and sometimes paralysis of the arms and legs, sensory disturbances, and loss of bladder and bowel control. NMO leads to loss of myelin, a fatty substance that surrounds nerve fibers and helps nerve signals move from cell to cell. NMO can also damage nerve fibers and leave areas of broken-down tissue. In NMO, immune system cells and antibodies attack and destroy myelin cells in the optic nerves and the spinal cord. Unlike MS, it is typically more severe and acute.

As with many other conditions, PEMFs are not likely to cure the condition but appear to be useful in a supportive role to decrease complications and support the tissues. PEMFs would act to reduce inflammation, improve the capacity of the cells to absorb nutrients and supplements, facilitate the function of damaged nerves, and possibly even potentially help recover nerve cell damage. Because NMO and MS are similar in several ways clinically, the benefits seen with PEMFs in MS patients may be reasonably expected with NMO. PEMFs help MS patients with optic neuritis [389].

Obesity

The causes of obesity are complex. PEMFs are not normally thought of as helping this problem because it is normally considered a matter of metabolism, exercise, and nutrition.

European regulators recently approved TMS for smoking cessation. TMS works by stimulating the reward centers of the brain, and since one aspect of obesity can be a food addiction, the reward pathway in the brain is the same as in other addictions. TMS has the potential to be a groundbreaking alternative for helping with obesity. To date, there are a few options to treat obesity, including lifestyle modification, drugs, devices such as gastric balloons, and bariatric surgery.

When people with obesity are given pictures of their favorite foods, the reward system areas of their brain light up, but dopamine release is blunted compared with the response in normal-weight patients, so they tend to overeat. The researchers hypothesized that treating patients with deep repetitive TMS would induce satiety and weight loss.

A nine-week study of sixteen obese patients who received transcranial magnetic stimulation (TMS) or a sham treatment suggests that TMS may help obese patients reduce cravings and shed pounds. They enrolled sixteen patients with a mean body mass index (BMI) of thirty-four and randomized them to receive high-frequency (18-Hz) TMS (treatment group, eight patients); low-frequency (1-Hz) TMS (control group, three patients); or sham treatment (five patients). Low frequency (1-Hz) TMS suppresses cortical excitability, whereas high frequency (> 3 Hz) enhances it. So the 18-Hz group was expected to have enhanced dopamine release in response to food cues. At baseline, after five weeks of treatment, and one month later, participants filled in a food-craving questionnaire, had weight recorded, and had blood drawn to determine metabolic parameters.

The TMS and sham sessions were given three times a week for five weeks. Before the TMS or sham sessions, participants were shown images of their favorite foods (cues). They received TMS that targeted the forward parts and the sides of the brain just above the ears or sham treatment.

All individuals received advice from a nutritionist and a physical-activity trainer every two weeks.

At five weeks, the patients who had received the high-frequency TMS had lost about ten pounds (4.5 kg) and food cravings were reduced by 34%, which was significantly greater than the changes in the sham group. They continued to lose weight, and a month later, had lost 3.2% of their initial weight.

With the lifestyle-alone intervention, the sham control group still lost 1.8% of their baseline weight.

At five weeks, the high-frequency TMS group also had significant reductions in blood glucose, cholesterol, and the stress hormone cortisol and a significant increase in epinephrine compared with their baseline values. These changes were not seen in the other participants. The individuals receiving active treatment were incredibly happy with their results [251].

An underlying cause of obesity may be impaired gut bacteria (microbiota) composition, an imbalance in the complex mix of beneficial and harmful microorganisms that inhabit the digestive tract. Impaired gut microbiota can alter the brain's signals for appetite and satiety, or fullness. In their study, funded by the Italian Ministry of Health, they recruited three men and eleven women, ages 22-65, with obesity and body mass index (BMI) of 30-45 kg/m2.

They randomly assigned the study subjects to two groups for five weeks to receive fifteen sessions—three times per week—of either TMS or a sham stimulation. The research team also measured blood levels of glucose (sugar), insulin, pituitary gland hormones, and neurotransmitters such as norepinephrine. Pituitary hormones play a key role in regulating appetite, and recent research shows that norepinephrine and other neurotransmitters affect microbiota composition. After five weeks of treatment, those subjects receiving TMS lost more than 3% body weight and more than 4% fat more than controls.

Results of the stool analysis after five weeks, TMS-treated subjects had greatly increased quantities of several beneficial bacterial species with anti-inflammatory properties, such as are found in healthy people. The control group had no clinically relevant alterations in their microbiota. They also discovered that changes in the abundance of other bacterial species improved metabolic and hormonal tests, including glucose, insulin, several pituitary hormones, and norepinephrine. Thus, TMS had a positive benefit on both weight loss and change in microbiota composition.

This research shows the innovative ability of TMS to have anti-obesity effects not only through stimulation of the brain reward center but also through alteration of the gut-brain axis.

While this study was done in a professional setting, home-based TMS treatment would be expected to produce similar results and be more sustainable with ongoing treatments to not only achieve the desired weight loss but also to maintain the weight loss. Since TMS stimulates the same brain-reward center that is involved in other addictive behaviors (such as smoking or gambling), in theory, people who receive TMS treatments for obesity might also see a decrease in their other addictive habits.

PEMFs may also be able to help with reducing fat cell size. By decreasing fat cell size, waist circumference, for example, may be able to be decreased. A new medical device was developed for this approach that uses alternatively low frequency PEMFs and controlled micro-pressure over a minimum of twelve treatment sessions.

Two studies were done: a double-blind randomized study performed on twenty-eight patients with a waistline over 88 cm/35 inches for women and over 102 cm/40 inches for men for a period of six weeks. After treatment, they found significant reduction of waistline of more than 6 cm after twelve sessions. Biological assessments performed before and after treatments showed both a highly significant reduction of liver enzymes and stimulation of insensitive muscle contractions. This treatment approach was found to be efficient with patients not committed to any weight loss program [42].

Production of fat (adipogenesis) consists of two related steps, the development of soft tissue mesenchymal stem cells (MSCs) into pre-fat cells, and the differentiation of pre-fat cells into mature fat cells (*Bowers)*. Because the number of pre-fat cells and mature fat cells has been shown to be different between lean and obese human adults [451], variations in the differentiation process in early stages of adipose tissue development are important in obesity. However, the regulation of adipogenesis is complex and includes alteration of the sensitivity to hormones and the expression of genes in response to various stimuli including lipid influences.

It was reported that obese mice lose their weight and fat when treated with 0.5 T PEMFs. 7.5 Hz, 0.4 T PEMFs have an inhibitory effect on obesity. Stem cells, including MSCs, are multi-potent cells capable of differentiating into different tissue types, including fatty tissue. Specifically, 7.5 Hz PEMFs at an intensity of 0.4 T (4,000 gauss) may inhibit differentiation of stem cells into fatty cells when exposed two hours per day for fifteen days. The inhibitory effect of this PEMF on obesity may be from inhibition of differentiation of MSCs into fat cells. Therefore, this type of PEMF signal may be a potential approach for the treatment of obesity [113].

Pubertal females, with different levels of obesity and healthy non-obese females, were examined. Those with obesity were divided into a study group (SG) and a control group (CG). Healthy females were a control group. SGs received bilateral temporal TMS (45 mT, alpha frequencies) for 10-15 daily sessions. After six months of treatment, SG and CG showed average reductions in BMI by 5.9 and 2.5 kg/m2, respectively. Lipids became normal in 70% [54].

In another study by the same group, eighty-four girls of pubertal age saw an average reduction of body weight by 9 kg after three months [55].

Therefore, PEMFs likely have an innovative and emerging role in the management of obesity.

Osteopenia and osteoporosis

Attention is paid to osteopenia and osteoporosis because of the serious disabling risk of fractures as these conditions progress, especially fractures to the hips and spine. However, there is a significant increase in fractures anywhere in the body from relatively minor trauma.

A discussion about the treatment of osteoporosis or osteopenia is not complete without considering PEMF stimulation of the bones. PEMFs penetrate bones without any blockage or absorption, meaning they can stimulate the entire volume of the bone in ways that beat almost any other approach. Nutrition, hormones, and supplements saturate the bones and provide the "bricks and mortar" to build new bone. When these are deficient, it is harder to build new bone. Even all used together, they still require additional energy to effectively create new bone structures or enhance existing weakened bone. PEMFs provide this energy to have the bones more effectively use these building blocks.

Current methods of measuring osteopenia or osteoporosis can be misleading. They typically only assess specific and limited local areas, typically, the wrist, the heel, or spine, and hip. If the wrist and the heel show osteoporosis, it is highly likely the rest of the skeleton has similar loss of bone. These are quick and easy areas to measure bone loss. The spine and hips are measured because fractures in these areas can be devastating. Still, discrepancies in bone loss are often seen between the spine and hips, or even multiple levels of the spine. So, if osteopenia or osteoporosis are seen in any part of the skeleton, it can be assumed that the whole skeleton is involved to varying degrees.

Testing is only done typically every two to three years, because bone density changes are slow, except for extreme causes such as spinal cord injury, high dose steroid use, radiation, chemotherapy, immobility, and weightlessness. Most treatments for osteoporosis—whether medication, injections, or PEMFs—can take years to show benefits. I often tell patients that PEMF treatment for two years is a positive result even if no further bone loss takes place. The value of medications in the treatment of osteoporosis in two years is commonly less than a 1-2% improvement in bone density, if at all, depending on the underlying causes or bone density at the start of treatment.

Although the benefits of conventional medical therapies for osteopenia or osteoporosis have small incremental improvements, they also have significant risks. These may include gastrointestinal problems, at the worst esophageal or gastric cancers, or over the slightly longer term the risk of other types of fractures because of the unnatural bone changes that result from their use. Even the newest immunotherapy for osteoporosis has similar risks to the older oral therapies. This is why it's so important to consider other safer, non-toxic alternatives to current standard therapies. This is where PEMFs come in.

Evidence for the use of PEMFs in osteopenia/osteoporosis comes from a number of sources. This includes evidence from human and animal experimental studies specific for osteopenia/osteoporosis. On the other hand, there is an even greater amount of evidence on the effects of PEMFs on bone healing and bone formation (osteogenesis), less specific to osteoporosis itself. Taken together from all the sources of effects of PEMFs on bone, the evidence is reasonably strong support for the value of PEMFs for osteopenia/ osteoporosis.

Yale University School of Medicine studied the use of PEMFs in arthritis, but also found that they could be useful in the treatment of other bone disorders, including osteoporosis [460]. Researchers who helped develop an FDA-approved bone-healing device showed that PEMFs had a profound effect on a large variety of biological systems, especially bone [37, 339].

An orthopedic research team at Brown University found many therapeutic effects of electric and magnetic fields in the repair of connective tissue (bone is considered a connective tissue). The most widely studied applications are for bone repair and acceleration of the healing of fresh fractures, delayed- and non-unions, incorporation of bone grafts, osteoporosis, and osteonecrosis. PEMFs even improve repair of cartilage and soft fibrous tissues. Basically, PEMFs accelerate extracellular matrix synthesis and tissue healing. PEMFs repair bone and enhance bone tissue formation, through enhancement of the natural formation and deposition of calcium phosphate crystal seeds in the bone [1]. Even Loma Linda University in California research found that PEMFs increase bone cell growth [124].

The Department of Orthopedics at the State University of New York, Stony Brook, looked at PEMFs in preventing osteoporosis from lack of use of bones. Non-use of bones could result in a 13% loss of bone as compared with exercised bones over as little as a two-month period. Even one hour per day of PEMFs induced bone formation. The bone formation response was caused by a decrease in breakdown of the hard outside and inside surfaces of bone and stimulation of both outside and inside new-bone formation. These data tell us that short daily periods of exposure to appropriate PEMFs positively influence the cells responsible for bone remodeling [372].

A randomized, active-controlled clinical trial was conducted to examine the effect of PEMFs on women with postmenopausal osteoporosis (PMO) in southwest China. Forty-four participants were randomly assigned to receive alendronate (a common conventional osteoporosis medicine) or one course (consisting of 8 Hz, 3.8 mT, forty minutes per treatment, one treatment session per day, six treatment sessions per week, for thirty times) of PEMF treatment. There was no significant treatment difference between the two groups in the BMD of the lumbar spine, left upper femur bone, total lower-extremity manual muscle test, and balance. Vitamin D concentrations were also comparable. These results suggested that a course of PEMF treatment with specific parameters was as effective as alendronate in treating PMO in a twenty-four-week study [245]. If PEMFs could show these benefits in twenty-four weeks, what would it do over two years?

At the University of Hawaii, PEMFs were studied in the treatment of post-menopausal (osteoporosis-prone) forearms. Wrist fractures in older women are very common. Evaluations were done during and after treatment of ten hours a day for twelve weeks. BMD increased significantly in the immediate area of the PEMF field during exposure and decreased during the following thirty-six weeks after PEMF stimulation stopped. BMD benefits appeared to last only for a short time after three months of stimulation. More evidence that PEMFs need to be applied for long periods, especially, as long as the reasons for the osteopenia/osteoporosis are still present. The same researchers looked at BMDs in the opposite untreated arm of post-menopausal women, as a natural, same-person comparison. A similar but weaker response occurred in the opposite arm, suggesting a "cross-talk" effect on the non-treated forearms. This confirmed that properly applied PEMFs for whole-body use could prevent and treat of osteoporosis throughout the body [449].

PEMFs were studied in osteoporosis around the knee in individuals with chronic spinal cord injury. As mentioned above, lack of movement of any part of the body can create osteoporosis. Spinal cord injury itself accelerates the problem. Even with a spinal cord injury more than two years old, osteoporosis can be improved. When bone mineral density (BMD) is compared before treatment with three, six, and twelve months after treatment, improvement in bone density is found. At three months of treatment, BMD increased in the stimulated knees by 5% and declined in the untreated knees by 6%. At six months after treatment ended, BMD returned to near baseline values, and at twelve months, both knees had lost bone at a similar rate to 2% below baseline for the stimulated knee and 3.6% below baseline for the untreated knee. The biggest changes were seen in bone close to the area of treatment. The stimulation appeared useful in impeding osteoporosis for the period of the stimulation. This indicates that treatment of osteoporosis is needed long-term, if not lifelong. It also indicates PEMF therapy should not just be directed at a single bone location, but is best if the whole-body is treated [135].

PEMFs were studied in patients with limb lengthening surgery. Limb lengthening is needed most often in children who have major differences in the lengths of their extremities, whether due to birth trauma or accidents, to name two. It is painful and takes up to a year or more to complete, with these children in hospital or long-term nursing care settings. It is therefore extremely helpful to try to shorten the time it takes and the amount of discomfort they have. This situation was evaluated where limbs were lengthened comparing active PEMF coils and inactive coils. Bone loss in the segments of bone beyond the lengthening sites was seen in both groups but was greater in the group with inactive coils, between 23% and 33% after one and two months, respectively. Those treated with active PEMF coils had only 10% bone loss at two months. Differences were greater at twelve months after surgery, with growth reduced by 54% and 13%, respectively in the two groups. So, in this situation, PEMF stimulation had a dramatic effect on preventing bone loss. Increased bone loss delays the recovery of these already unfortunate children [121]. In addition, PEMFs would be able to decrease the pain and discomfort they have from the bone lengthening procedures themselves, and reduce the risk of complications from infection and other tissue breakdown.

PEMFs appear to be helpful for people with osteopenia or osteoporosis but cannot be relied upon as a sole treatment. I strongly recommend that they start to be used when osteopenia is diagnosed, before it progresses to the more severe osteoporosis. It is still recommended for osteoporosis, but PEMF treatment needs to be more aggressive since bone density takes years to improve. PEMFs need to be combined with adequate nutrition, supplements, exercise, and proper hormone balancing or replacement. I have many patients who have demonstrated positive impacts on their bones using these combinations of treatment, and without the need to resort to the high-risk drugs used for osteopenia/osteoporosis.

Pain management

Current conventional medical approaches to pain management often leave much to be desired and involve heavy medications, procedures, surgeries, and physical therapy. Rarely will conventional doctors refer patients to alternative modalities like acupuncture, massage, mind-body medicine or chiropractic therapy, let alone PEMFs. There are a staggering number of people in pain in this country and around the globe. In the US alone, 17% of people aged fifteen or older suffer from chronic pain to such a point that it interferes with their daily life. At any given moment, one in four adults is suffering from some form of pain.

A lot of the time, pain management involves painkillers or medications to blunt the perception of pain. I call this "numbing and dumbing." The most common medications used for pain management are anti-inflammatories, which are best used for acute problems. More than 16,000 North Americans per year with arthritis alone die from gastric bleeding from non-steroidal anti-inflammatories (NSAIDs) like aspirin and ibuprofen, and these deaths are only in those with arthritis [425]. The number could be easily doubled when all the conditions are considered for which NSAIDs are used. Thousands of others have permanent kidney damage from the NSAIDs, requiring dialysis.

In January 2014, the FDA finally began to address this pain medication risk issue, urging physicians to warn patients of the risks of long-term or high-dose acetaminophen (found in Vicodin, Percocet, and OTC medication like Tylenol) that often lead to life-threatening liver damage.

People who have failed to find relief from other modalities, or are looking for other alternative approaches, will often find relief using PEMFs. Animal studies show that PEMFs reduce the pain receptors in the brain. In some research, PEMFs were found to be equivalent to 10 mg of morphine—all of this aside from the natural healing responses PEMFs trigger in the body [455].

I frequently recommend magnetic therapies for people in chronic pain (usually before anything else) so that they can avoid addiction issues, complications, and side effects. PEMFs usually provide a reliable degree of pain relief, through convenient treatments done at home. PEMFs have been proven in numerous studies to affect various aspects of the pain process [332]. In my experience, almost everyone benefits from PEMF therapy and they can frequently avoid procedures and decrease or avoid the use of medications. Treatment of chronic pain at home provides the most reliable long-term benefit. Most treatments in practitioners' offices tend to produce only short-term benefits for chronic pain conditions. Just because the pain is gone, doesn't mean the problem is gone. Left alone and not properly treated, it will tend to come back.

Chronic pain is often perpetuated by abnormal, small nerve networks stuck in a rut of constant inflammation. PEMF stimulation (especially with high intensities) quiets down nerves and facilitates recovery from injury and inflammation. Even patients suffering from stubborn or systemic sources of pain have found pain relief using magnetic therapies [119].

Musculoskeletal disorders make up the vast majority of pain sources commonly treated with PEMFs. These include arthritis, tendinitis, sprains and strains, fractures, post-op pain, osteoporosis, wounds, neuralgias, neuropathies, hip disorders, muscle spasms, spinal cord injury, trauma, burns, neuromas, heel spurs, phantom pain, carpal tunnel syndrome, headaches, tennis elbow, reflex sympathetic dystrophy (RSD, now known as complex regional pain syndrome), and so on.

The tissue inflammation that accompanies the majority of traumatic and chronic injuries is essential to the healing process. However, sometimes the body over-responds, and the resulting tissue swelling (edema) itself causes pain and delays healing. For soft tissue and musculoskeletal injuries and for postsurgical, post-traumatic chronic wounds, edema reduction must take place in order to accelerate healing and reduce associated pain.

PEMFs work to reduce pain by changing the local tissue environment from which the pain starts. Double-blind clinical studies have shown this with chronic wound repair, acute ankle sprains, and whiplash injuries [190]. Similar studies have been done for neck pain.

A number of studies have also been done on the use of PEMFs for back pain. (See the back pain topic in this section.) Just over 15% of the entire US population complains of chronic lower back pain. In the back- pain studies, findings suggest that it is best to apply PEMFs on a consistent basis over an extended period to achieve the best results, and 95% of individuals find relief. Benefit was found for patients suffering from herniated discs, spondylosis, radiculopathy (spinal nerve compression), sciatica, spinal stenosis, and arthritis. People who have tried other modalities and failed to find relief will often find relief from PEMFs. Higher intensity PEMFs are often necessary in the more severe or chronic back pain situations, and pain reduction happens rapidly. One of the main reasons I recommend PEMFs for back pain is because they go deep into the body to heal the tissues. In fact, a back pain study using a static magnetic pad found no value for back pain. This is because it was too shallow in its actions and was not used correctly [91].

In diabetic neuropathy, PEMFs used every day for at least twelve minutes improve pain, paresthesias and vibration sensation, and increase muscular strength in 85% of patients compared to controls [87].

Post-herpetic neuralgia, which is often medically resistant to treatment and can be extraordinarily debilitating, has been found in research to benefit from PEMF therapy. Some patients respond in as little as thirty days, while others take upwards of ninety days or more to find relief. Often, this situation requires a high intensity PEMF to provide the benefit. Used properly, PEMF therapy is effective in 80% of these individuals. In no cases was the pain made worse. Both local and whole-body treatments could be used, although individuals with local therapy appear to benefit better, probably because local treatments tend to be from higher intensity PEMFs [219].

Research has shown that PEMFs work for many other pain related conditions, including:

- abdominal pain
- angina
- bruises
- burns
- bursitis
- carpal tunnel syndrome
- cervical disc and arthritis
- dental pain
- fibrocystic breast disease
- fibromyalgia
- fractures
- heel spur/ plantar fasciitis
- intermittent claudication
- ischemia
- muscle spasms and tears
- nerve entrapment
- nerve pain
- neuroma
- painful shoulder
- pelvic pain
- peripheral neuropathy
- phantom pain
- PMS
- postoperative pain
- post workout aching
- reflex sympathetic dystrophy
- sinus pain
- sprains
- strains
- tendinitis
- tennis elbow
- TMJ
- trauma
- whiplash
- and more [332].

They can also be used for migraines, as discussed earlier.

Nerve signals conducting pain move from the source of the pain upstream to the brain (from a pain in the foot up through the nervous system all the way to the brain, for instance). Treatment can be applied anywhere along this path. Therefore, the foot pain, for example, can become settled in the brain, which then can become the chronic source of the pain (called centralization). In this situation, treating the brain is the most appropriate approach. In fact, many chronic pains can centralize quickly. Therefore, dual approaches, treating the local cause (the foot, in the case of a foot injury) and the brain may produce the best, fastest results. It's for this reason that PEMF systems are recommended that will allow for whole-body and local treatments simultaneously.

Pain may be conducted downstream as well (a hip problem can cause knee pain, for instance.) For this reason, it's ideal to treat the source of the pain, not necessarily where the pain is felt. A consultation with a knowledgeable practitioner may be able to give a more informed understanding of the source of the pain so that more effective treatment can be applied.

Sometimes the most effective pain management is to not only treat the source of the pain, but also apply treatments at the brain or along the spine. This combination allows for management of the cause of the pain and at the same time controls the pain signal traffic to the brain where the pain is ultimately recognized.

Pancreatic Conditions

The pancreas is a glandular organ in the digestive and endocrine systems. As an endocrine gland, it produces several important hormones, including insulin, glucagon, somatostatin, and pancreatic polypeptide, which circulate in the blood. As a digestive organ, it secretes pancreatic juice containing digestive enzymes that assist digestion and absorption of nutrients in the small intestine. These enzymes help the stomach and salivary glands to further break down carbohydrates, proteins, and fats.

As the human body ages, and especially as blood sugars may increase due to insulin resistance, our pancreatic islet cells change in shape and function. Not only does the number of pancreatic β-cells decrease as the balance of new cell growth and natural cell death shifts, but the genetics of the islet changes to contribute to a tissue that is no longer fully able to perform its primary function and contributes to the increased incidence of diabetes seen in elderly populations.

The volume of pancreatic enzyme excretion increases to between the ages of 20-30. After that, it gradually decreases over time. Not only does the pancreas produce enzymes, but it also produces bicarbonate, which neutralizes the acid in the food leaving the stomach. Bicarbonate also decreases gradually after age thirty. Three of the major enzymes produced by the pancreas are lipase, phospholipase, and chymotrypsin. These three enzymes also decrease progressively after age thirty. Although not all people over thirty require enzyme or bicarbonate substitution, individual cases of pancreatic insufficiency might be explained by aging, even without malnutrition [224]. As we age, pancreatic function can begin to fail even without pancreatitis. This is especially evident in diabetics, both types I and II.

To study pancreatic function, rats were placed into two groups and exposed to either a 10 Hz, 1.8 to 3.8 mT (18 to 38 gauss) rectangular waveform for thirty minutes per day, for 1, 3, 6, 9, or 14 days. The second group was exposed to a sinusoidal 40-Hz, 1.3 to 2.7 mT (13 to 27 gauss) magnetic field using the same protocol. A third group was a control. Serum glucose concentrations were decreased by both magnetic field exposures from day three to day fourteen. The glucose concentrations became normal during the recovery period. Insulin concentrations in both magnetic field exposure groups were significantly elevated on day three and nine. For the rectangular field, however, the insulin concentration decreased sharply on day fourteen. By twenty-four days, however, the insulin level in the rectangular field group was significantly greater. In the sinusoidal field, insulin concentrations became normal by day fourteen and remained that way. Neither magnetic field exposure significantly affected the pancreatic enzymes amylase or lipase [221].

This study may have implications for helping insulin production and glucose control in prediabetics and diabetics, particularly type II diabetics. These results seem to indicate that those individuals with inadequate insulin secretion and high blood sugar levels may benefit from PEMFs. It may be worthwhile to monitor normal individuals without high blood sugars for a potential drop in blood sugar levels while doing PEMF therapy, particularly in those who are already prone to hypoglycemia. This is not a contraindication but simply a precaution.

Pancreatitis is a common and often disabling condition for which there is no adequate medical therapy. Inflammation is a hallmark of pancreatitis. Typical therapies are pain management with potent medications and reducing the function of the pancreas by restricting food. In these situations, doctors rely on the natural capacity of the body to heal itself, including the pancreas. Chronic pancreatitis can lead to self-digestion of the pancreas by the enzymes the pancreas produces leading to pancreatic cysts, chronic inflammation, and possibly even to pancreatic cancer.

Russian research in animals discovered that PEMFs work well for pancreatitis. Based on this information, researchers began to help humans with this therapy. Even static magnets placed over the upper abdomen and over the upper part of the lumbar spine improved symptoms of patients with acute pancreatitis within fifteen days in over 70% of the patients, and by twenty days 98% were better. They not only had clinical improvement, but they also had improved laboratory tests. The effectiveness of medications was greater as well. The downside of using static magnetic fields is that they had to be applied twenty-four hours a day, often for upwards of twenty-five days for the benefit to be seen [190].

In chronic pancreatitis, the kind that can lead to pancreatic cysts or significant reduction in pancreatic function, 18 to 24 mT (180 to 240 gauss) PEMFs were applied twenty minutes daily for at least fifteen days. Both clinical symptoms and laboratory tests improved. Trypsin is a protein breakdown enzyme resulting from pancreatic excretion of a precursor. It is elevated in pancreatitis. In the treated patients, trypsin levels decreased, showing objectively improvements in pancreatic function [190].

Paraplegia and spinal cord injury

In paraplegia and spinal cord injury, pulsed electromagnetic fields (PEMFs) will help these patients in a supportive fashion. Obviously, PEMFs will not reverse the spinal cord injury. Spinal cord injury is a complex problem that varies tremendously from person to person. From this perspective, it is hard to generalize the benefits from one person to the next. In general, however, there may be benefits in improving motor function, pain, basic tissue health, spasticity, and bladder function.

In Europe, doctors are using PEMFs in cerebral palsy patients who often share similar features to spinal cord injuries, particularly with spasticity. The tissues in the body below the level of the spinal cord lesion are often unhealthy because of the lack of appropriate spinal cord nerve “trophic” or nutritional support. These tissues are more prone to breakdown and prolonged wound healing due to these trophic changes. PEMFs protect the tissues by maintaining an optimized level of vitality at the cell level in most of the body, including the skin, muscles, and soft tissue. In addition, if there is any risk of tissue breakdown or wounds from pressure issues, these tissues would heal much faster. It is expected that with regular, daily health maintenance use of PEMFs, the tissues would be much less likely to break down in the first place. In several lymphedema patients, where the tissues are similarly poorly nourished because of inadequate drainage, I have seen PEMF therapy to cause a dramatic reduction in instances of infection.

There is animal research that PEMFs may be able to help with sprouting and regeneration of damaged nerve fibers. This has not been clearly proven in humans with spinal cord injuries.

It is known that PEMFs increase brain derived neurotrophic factor (BDNF), so this may be a way that PEMFs may be helpful to restore some amount of spinal cord function.

One of the most important uses of PEMFs in spinal cord injury is the reduction of spasticity and neurogenic or overactive bladder. This is covered in other topics in this section, specifically, multiple sclerosis and urinary incontinence.

Parkinson's disease

Parkinson's disease (PD) is the second most common neurodegenerative disorder in people over the age of sixty. Aging is the major contributing factor for increased risk of developing PD. With the aging of the population worldwide, the frequency of PD is expected to increase dramatically in the coming decades. Nearly one million people in the US are living with Parkinson's disease. It is estimated that 6-10 million people worldwide have PD, affecting all races and ethnicities. The incidence of PD rises rapidly with age, affecting approximately 1% of the population older than sixty years and approximately 4% of those older than eighty years.

Parkinson's disease (PD) is a chronic and progressive movement disorder primarily, meaning that symptoms continue and worsen over time. The cause is unknown, and there is no cure. Conventional treatment options include medication and surgery to manage symptoms. Neither reduces progression.

PD most obviously involves the malfunction and death of vital nerve cells (neurons) in the brain, primarily an area of the brain called the substantia nigra. Some of these dying neurons produce dopamine, a neurochemical that sends messages to the part of the brain that controls movement and coordination. As PD progresses, the amount of dopamine produced in the brain decreases, leaving a person unable to control movement normally. Loss of cells in other areas of the brain and body contribute to Parkinson's. For example, researchers have discovered that the hallmark sign of PD—clumps of a protein alpha-synuclein, which are also called Lewy Bodies—are found not only in the mid-brain but also in the brain stem and in scent cells.

These areas of the brain correlate to non-motor functions such as sense of smell and sleep regulation. The presence of Lewy bodies in these areas could explain the non-motor symptoms experienced by some people with PD before any movement (motor) signs of the disease appear. The intestines also have dopamine cells that degenerate in Parkinson's, and this may be important in the gastrointestinal symptoms that are part of the disease.

Standard medication treatment of PD can be only 50% effective overall. As the dose of taken medication is wearing off there can be a decline in the drug's efficacy. For example, in the morning shortly after taking it, the medication may be 90% effective, in the afternoon only 50% effective and in the evening only 30% effective. Twice-weekly treatments with extremely low intensity PEMFs applied to the head for ten weeks has been shown to eliminate these medication declining efficacy symptoms. At ten weeks after starting the PEMFs, there was 40% improvement in response to medication with minimum change in efficacy during the course of the day or evening. PEMFs appeared to enhance response to medication. Since decline in the response to medication is a phenomenon associated with progression of the disease, these results suggest that intermittent application of PEMFs may reverse the course of progressive PD [393].

Dopamine is considered the most important part of the causes of PD and is the primary target of medical therapies. Yawning and stretching are dopamine behaviors. When they are seen in people with neurodegenerative disorders, it is considered that they indicate release of dopamine in the brain. Extremely low intensity PEMFs have been found to increase yawning and stretching [399].

Dysfunctions in smell are also common in PD. The smell center of the brain also contains large amounts of dopamine neurons. However, anti-Parkinson's drugs do not affect the smell threshold in people with PD. Low intensity PEMFs have improved smell in this situation [400].

Freezing is a symptom characterized by difficulty in the initiation and smooth processing of repetitive movements. It is a unique and well-known clinical feature of PD. It usually occurs in PD of long duration and advanced stage and is a major cause of disability often resulting in falling. Freezing manifests most commonly as a sudden attack of immobility usually experienced during walking, attempts to turn while walking, or while approaching a destination. Less commonly, it is expressed as arrest of speech or handwriting. Generally, freezing is resistant to medication, although sometimes a reduction or increase in dose may improve this symptom. Brief applications of low intensity PEMFs have been shown to improve freezing. The effect of each PEMF treatment lasted several days after which freezing gradually reappeared [387]. In an extension of this work, weekly applications of PEMFs to the head reduced freezing by about 50% and falling by about 80-90%, in a six-month follow-up period.

Freezing (locking up) and falling are also common in other neurodegenerative conditions such as progressive supranuclear palsy (PSP). The effectiveness of medications in PSP is even worse than PD.

Some people with PD have a disorder of body image in which they perceive a part or parts of their bodies as disproportionately large. Low intensity PEMFs have reversed this disorder [396].

Speech impairments occur in more than 50% of PD patients. Speech impairments, including severe stuttering, that responded only marginally to medication, improved dramatically when PEMF treatments were given weekly over four years. The speech impairment reappeared on the several occasions when regular PEMF treatments were not done [394]. This suggests that PEMFs may help to control symptoms but may take years to improve the physical brain.

Cognitive impairment is common in PD. One of the ways this is assessed is by using various drawing tasks, such as drawing a representation of oneself, a bicycle, or a clock face. Drawing impairments are typically indicative of dysfunction of half of the brain. PEMFs of 5 and 7 Hz applied for twenty minutes at a time can dramatically improve drawing performance, even as soon as after two treatments. Drawing performance continues to improve as PEMF treatments continue to be provided [395].

Other groups also looked at the use of low intensity 8 picoTesla PEMFs in the treatment of PD, at 2 Hz or 8 Hz, for thirty minutes every forty-eight hours for sixty days. The treatment effects last beyond the time of stimulation depending on symptoms: Less than twenty-four hours for motor impairment, less than forty-eight hours for activities of daily living, and other symptoms later than forty-eight hours. This shows that chronic stimulation is probably necessary to obtain adequate results with PD [32].

High intensity PEMFs like rTMS improve the movement problems of PD by about 54% overall. Results are better when high frequency (greater than 5 Hz) is applied to the motor cortex, for 23% improvement. Results were better for low frequency (<1 Hz) when applied to the front parts of the brain, with about 50% improvement. A greater number of pulses per session or across sessions are associated with larger benefits. Given the limitations of rTMS treatments, that is, requiring a professional setting with a limited number of treatment options, it appears that treating for more than a week is not much better than treating for less than a week. But, this appears to be driven by the number of pulses delivered [86]. The work by Sandyk indicates that longer-term treatments are necessary to achieve more sustainable results.

One rTMS study looked at the treatment of 49 PD patients. Their symptoms had been well controlled for three months with medications. Patients were divided into four groups to receive various protocols of rTMS: (1) stimulation once a day at 3,450 gauss; (2) stimulation twice a day at 3,450 gauss; (3) stimulation twice a day at 5,750 gauss; and (4) stimulation twice a day at 8,050 gauss. Treatments took place for ten days. The patients were evaluated three times before rTMS to obtain baseline data, then on day three and seven of treatment, and then at one and three months after the end of treatment. They measured range of movement and disability in activities of daily living and short-term memory. In group 1 (who received treatment once per day), there were no significant changes in symptoms at any time. By contrast, all other groups (receiving treatment twice per day) had significant improvement in symptoms at the one-month assessment. But, there were no differences in scores between the treated groups. At the three-month evaluation point, the PD symptom scores were still significantly better than baseline values but there were significant inter-group differences, with group 3 showing the most improvement. The results show that this protocol causes long-lasting dose-related symptom improvements in PD and may even allow dose reduction in medication [262].

In another rTMS study, PD patients were evaluated to see if rTMS could improve muscle function assessed by simple reaction times. It had been previously shown that simple reaction time was significantly improved in normal individuals and in those with PD. Assessments were done at the time of peak medication effect. For comparison, the same tasks were studied in ten normal volunteers. There were significant differences between PD patients and normal volunteers during rTMS with the coil on the head. In PD patients, rTMS significantly shortened reaction time and movement time without affecting errors. The mean performance of PD patients improved during rTMS and patients reported that it was easier to perform the test during rTMS. All patients were significantly slower in the un-medicated state compared with the medicated state. Their performance in the un-medicated state improved significantly with stimulation [327].

One study looked at a 25 Hz PEMF with intensity of 10 mT (100 gauss) applied for twenty minutes with ten to twelve exposures as part of comprehensive rehab therapy in PD patients. Walking improved significantly and so did ability to change position. Muscle tension in the lower extremities was reduced in 85% of the patients, vertebral complaints in 85%, and general improvement was reportedly improved in 96% [190].

So, it appears that PEMFs of various intensities can be helpful in the management of PD. Since the ultimate goal is to help to repair the brain, not just improve function temporarily, long-term treatment frequently appears to be necessary. What is not known is whether the combination of periodic high intensity PEMFs along with a home therapy program with a lower intensity PEMF system may be the most helpful. It also appears that PEMFs may be synergistic with medication, which has a history of losing its effectiveness over time. It is not known how well PEMFs alone, without medication, may be able to help the symptoms and progression of PD.

Premenstrual syndrome (PMS)

One study found significant relief of PMS symptoms in women with severe and long-standing PMS with daily PEMF stimulation for three menstrual cycles. Symptom scores dropped 64% by the second cycle and 76% by completion. Each premenstrual symptom, including premenstrual dysphoric disorder (PMDD) symptoms, such as, depression, anxiety, emotional ups and downs, irritability, difficulty concentrating, fatigue, change in appetite and other physical symptoms, breast tenderness, and bloating all decreased. Only one woman out of fifty did not show improvement.

Some women with multiple sclerosis experience premenstrual worsening of symptoms, which improve dramatically with the onset of menstruation. In two suffering from premenstrual worsening of their symptoms, 2 to 4 Hz low intensity PEMFs cleared the problem. They were forty-one and fifty years old. They both said their symptoms worsened about one week before their menstrual periods.

The forty-one-year-old received three treatment sessions per week over two months, and one or two sessions per week thereafter for the next twelve months. Each session consisted of two forty-five-minute periods of PEMF treatment separated by a fifteen-minute break, for a total of ninety minutes of treatment. In addition to the PMS benefits, she reported improvement in level of energy; mood, short term memory, and concentration span; increased strength in the upper limbs, improved balance, especially trunk control, diminished spasticity in the lower limbs, and reduction of nocturnal urination to an average of once per night. As early as two months after starting treatments, she no longer experienced distinct episodes of premenstrual worsening of her symptoms.

The fifty-year-old woman received three treatment sessions per week, consisting of two successive treatments lasting twenty-five minutes separated by a fifteen-minute minute break, at 4 and 4.5 Hz, for four months. She made a dramatic recovery with improvements in balance, level of energy and mood, resolution of daytime sleepiness, diminished heat and light sensitivity, and decreased frequency of daytime and nocturnal urination. After the first two months, she didn't experience premenstrual worsening of her symptoms and reported that her symptoms remained fairly even throughout her cycle. She also had a burst of energy with the onset of menstruation.

These two examples indicate that brief application of PEMFs to the brain modifies the activity of neurotransmitter systems, which trigger premenstrual exacerbation of multiple sclerosis symptoms [384].

Prostate hyperplasia - benign prostate hyperplasia (BPH)

Prostate hyperplasia, also known as benign prostate hyperplasia (BPH), is a common problem for men. It can lead to urinary obstruction, which can be considered a medical emergency, if severe enough. The presence of biopsy proven BPH increases from 8% in men aged 31-40, to 40-50% in men 51-60, and to over 80% in men over eighty. BPH is a result of urogenital aging. Recent studies suggest that an age-related impairment of the blood supply to the lower urinary tract plays a role in the development of BPH. Upright posture appears to be a contributing factor as well. BPH is not seen in four-legged animals except for dogs and chimpanzees [258]. This appears to be due to a negative gravitational effect on the veins draining testosterone from the testes. As a result, dogs are used as a research model for human BPH.

Recent studies suggest that an age-related impairment of the blood supply to the lower urinary tract plays a role in the development of BPH and thus may be a contributing factor in the development of BPH. Additionally, chronic inflammation has been identified as a significant cause of BPH and lower urinary tract symptoms (LUTS) [132].

Medications may slightly reduce prostate size and improve symptoms but have less benefit as the prostate gets larger. A definitive solution for BPH is surgical, among other invasive interventions, to reduce the size of the prostate and improve the flow of urine. BPH has been treated with various types of destructive high-energy electromagnetic radiation methods such as transurethral needle ablation (TUNA), radiofrequency, interstitial laser therapy (ILC), and holmium laser resection (HoLRP). Prostatectomy is done by transurethral resection of the prostate (TURP) and is one of the most common surgical therapies. Unfortunately, all these therapies often lead to major complications, including lifetime urinary incontinence and impotence. Because of the complications of these invasive procedures, men will often try to live with their obstruction symptoms as long as possible.

In addition to suffering from their BPH symptoms, recent research has found that almost 50% of men with BPH have overactive bladders (OAB). The overactive bladder may be a bigger contributor than the BPH to frequent urination. The common treatments used for BPH, which include medications and prostatectomy, fail in one third of the men who have OAB. See the "Urinary incontinence and overactive bladder" topic in this section [377].

Because inflammation, reduced circulation, and OAB are identified as causes or major parts of BPH symptoms and progression, PEMFs become an ideal therapy for BPH.

There have been two therapeutic studies recently that lend support to the use of PEMFs to noninvasively, and safely, reduce the size of the prostate. One of these studies is in humans, the other in dogs.

In the human study, half of the patients with BPH, age 68-78 years old were treated with medication for at least four weeks, and another group was treated only with high intensity PEMF for two weeks, thirty minutes daily, five consecutive days per week. Patients of both groups were evaluated before and after drug and PEMF treatment by blood PSA and acid phosphatase blood tests and ultrasound (U/S) estimation of prostate volume and residual urine, estimation of urine flow rate, and measurement of an International Prostate Symptom Score (IPSS). There was a significant decrease, before and after treatment, of IPSS, U/S prostate size, residual urine, and urine flow rate in the PEMF-treated patients. In contrast, the medication treatment group had only improved IPSS. Follow-up of the PEMF treated patients for one year revealed that results obtained by PEMF treatment were still maintained [139].

The dog prostate is a model for understanding abnormal growth of the human prostate gland. In a different research study, the effectiveness of PEMFs in dogs was evaluated for modifying prostate blood flow and its effect on BPH. PEMFs were applied for five minutes twice a day for three weeks on twenty dogs with BPH. They assessed prostate size by ultrasound, libido, semen quality, testosterone levels, plasma volume, composition, and pH. The PEMF signal (1,000 gauss) produced a significant reduction in prostatic volume by an average of 57% without any interference with semen quality, testosterone levels, or libido. Doppler prostate ultrasound showed improved circulation. It further supports the theory that impairment of blood supply to the lower urinary tract may be a causative factor in the development of BPH [231]. These results are easily applicable to human males.

Not infrequently, chronic prostate enlargement is caused by history of infection in the prostate. These infections are notoriously challenging to eradicate. One large study evaluated the treatment of chronic prostate inflammation [190]. About 10-15% of men suffer from this, which can cause pain, disturbances in reproduction, and sexual dysfunction. The cause is unclear and current treatments, especially antibiotics, are largely unsatisfactory. While therapy must be comprehensive, PEMF therapy has been found to be of add-on benefit. A medium intensity (up to 10 mT) PEMF was used for thirty minutes, 25 Hz, with exposures to the perineal area. Some were also treated with antibiotics. PEMFs were for nine weeks, daily for the first two weeks, three times per week for the next week, twice per week for two weeks, and then once a week for four weeks, for a total of twenty-five treatments. There were statistically significant improvements in pain scores, scores of sexual complaints and burning on urination. Bladder flow studies improved in 83% with abnormal urine flow curves. Signs of pelvic floor muscle spasm were also reduced. No changes were found in laboratory or other tests. There was no change in the PSA. Of the four men who did not respond, prostatitis was present for more than ten years.

Little benefit was typically seen immediately after the treatment course ended. Even though most benefited from the treatment early, the maximum relief was found three months after therapy ended. Obviously, patience and dedication is necessary in this situation to achieve the best results.

Since prostate enlargement takes place over decades and is, in major part, related to reduced venous drainage, inflammation and circulation problems, any benefit from PEMF therapy in reducing the prostate size would be expected to happen over longer periods of time as well. If there is a significant mechanical obstruction caused by the large prostate, which is not acceptable to live with (and many men do live with this problem), then a surgical or other prostate treatment approach should be attempted.

While PEMF therapy may have little direct short-term value on the actual size of the prostate itself, there can be significant benefit in reducing discomfort and possibly improving bladder and urine flow control. Even if surgery or other procedures have to be used, recovery may be helped with PEMF therapy. PEMFs would also help medications, including antibiotics, do their work.

Safety of stimulation of the prostate. Since cancer of the prostate is common and PEMFs are being suggested as useful for the treatment of BPH, a concern is raised that PEMFs might potentially stimulate prostate cancer growth or development. BPH can be a setting in which prostate cancer may be more likely to grow due to the chronic inflammation present. Research shows the risk may be unlikely. There is evidence to show that PEMFs could possibly reduce the growth of prostate cancer cells even in advanced stage hormone resistant prostate cancer. Taxol is frequently used in this setting. Sixty Hz PEMFs from 1 to 5 G were compared with and without Taxol. After forty-eight hours of treatment with taxol, prostate cancer cells died. PEMF exposure also induced cancer cell death in the prostate cancer cells. The effect is better when the two are combined [311]. More research is needed to verify and expand on this finding.

Scleroderma or progressive systemic sclerosis (PSS)

Scleroderma or progressive systemic sclerosis (PSS) is a complex condition with a major autoimmune component. PEMFs may be effective for controlling certain aspects of scleroderma but would not be expected to cure or turn off the condition. Basically, PEMFs would be helpful to control some of the complications and side effects of the scleroderma and may actually slow down its progression. There is no reason that it could not be used alongside any other therapies, including disease modifying medical regimens.

Raynaud's disease or syndrome is common in scleroderma. Twenty scleroderma patients with Raynaud's syndrome were treated with a PEMF applied over the upper spine from the base of the neck down and the mid back. They found 95% had improvement in excess palm sweating, cold sensitivity, reflexes, and ulnar nerve conduction. Nerve conduction studies improved significantly. That means that nerves trapped in the scarred down scleroderma tissue were able to function better [190].

A similar group of thirty people with Raynaud's syndrome, either primary (fifteen) or secondary to scleroderma (fifteen), were treated with a 50 Hz PEMF for 30-60 minutes daily for twenty-four days. Blood flow and biopsy samples from the fingertip taken before, during, and after treatment confirmed observed clinical improvement [328].

Another group of people with advanced scleroderma was evaluated with a PEMF system in combination with conventional and alternative therapies, which included physical therapy, supplements, and massage. For this study, eighty patients were divided into a treatment group, a comparison group, and a control group of healthy people. The control group only had usual therapies. PEMF treatments were every other day for a course of twelve treatments. Some 40% of the treatment group recovered in full, with significant improvement in another 22%. In addition, 95% showed at least some improvement. The control group had full recovery in only 3% and significant improvement in 67%. Altogether, 73% showed at least some improvement. The active treatment group had much better improvement in immune tests compared to the control group. That means that PEMFs facilitate clinical as well as immunological improvements in scleroderma/PSS [5].

While these studies indicate benefit in scleroderma patients with even a limited course of use, it would be expected that continuing benefit would be seen with continued use over the long-term. It may be necessary to continue traditional disease modifying agents (DMARD treatments) at the beginning, depending on the severity of the scleroderma, and then gradually taper them off with continued PEMF use and monitoring of clinical parameters. Physical therapy and stretching following PEMF therapy would aid in releasing some of the contractures seen with this condition.

Shingles

Shingles has elements of a number of topics in this book, including virus infection, skin lesions, pain, and an assault on nerves. Shingles results from reactivation of dormant herpes zoster virus living in the body following a previous exposure to chickenpox virus. Shingles immunization is not completely protective or preventive for having shingles attacks. The primary benefit of immunization is to reduce the severity of any attacks and to reduce the severity and likelihood of disabling postherpetic neuralgia (PHN). So, PEMFs, given all they do in the body, would be expected to be of benefit in the management of shingles. For those people using PEMFs on a maintenance basis, there is the potential for reducing the possibility of having shingles attacks.

PEMFs are expected to decrease the inflammation and pain, help heal the skin lesions related to shingles attacks, and shorten the overall course of the attack. The potential for benefit will depend on how soon treatment is started after the attack becomes apparent. This is typical for most other health conditions as well—the sooner PEMFs are used, the better.

PEMFs are somewhat antiviral (see the antiviral topic in section 2), but most of their activity is expected to be through the modulation and strengthening of the body's own immune responses to these infections. Shingles attacks typically occur and recur when someone is under major stress. This could be a physical stress like from a personal injury or major illness, or emotional stress, like from the loss of a friend or family member. During these trying circumstances, the immune system dramatically decreases in its natural ability to control the survival of the shingles virus in the body. When the immune system decreases significantly, the virus can get out of control and develop into an attack.

PEMFs should be applied not only to where the pain is being experienced, but also to the spinal column at the level where the virus lives. For example, if the pain is in the mid chest or under the breasts, then the treatment area should be in the upper back just below the level of the shoulder blades. If the problem is in the abdomen, then the treatment area should be in the lower back. So, part of the treatment time should be spent where the pain is or where the lesions appear, and the rest of the treatment time should be spent where the virus actually lives, which is usually along the spinal column.

In the case of acute lesions, patients typically need to be on either an antiviral, steroids or both to reduce the level of inflammation. I would never use PEMFs in this case without using some kind of an antiviral, anti-inflammatory, or immune-modulating treatment protocol. We do need to quiet down the acute and uncomfortable situation using standard medical therapies while at the same time beginning to stimulate the process of natural healing with PEMFs. In this situation, the PEMFs will also be helpful for reducing the level of neuropathic pain (also see the pain section earlier). This will allow better rest, which also gives the body's immune system a better fighting chance.

In the later stages of shingles, we are dealing with nerve pain, called post herpetic neuralgia. In this situation, low intensity, low-frequency PEMFs are likely to reduce the level of pain substantially, even from the earliest days of treatment, primarily by reducing nerve cell and tissue inflammation, as well as the natural pain reducing benefits of PEMFs.

Once you have had shingles, the risk of recurrence is increased, even despite shingles shots. In that instance, it is easy to remember to use PEMF therapies since there is still discomfort. The challenge comes when the pain and rash go away. This does not mean the virus is dead or gone from the body. Typically, it still survives in the area that caused the problem in the first place. It may also survive in other parts of the body, creating the potential of additional shingles outbreaks elsewhere in the body. For this reason, once you have had a shingles attack, regular therapy with PEMFs is recommended to the area of the spine where the shingles is likely living, increasing the natural immune functions of the body in the local tissues to keep the virus quiet.

There is evidence that PEMFs work on the unbearable neuropathic pain of shingles. Postherpetic neuralgia (PHN) is one of the most intractable neuropathic pain disorders, especially in elderly patients. There is evidence that rTMS reduces neuropathic pain. To study this, forty patients were randomly assigned to receive ten sessions of real or sham rTMS over the side of the head above the ears (motor cortex). Each session included a series of 300 five-second pulses at 10 Hz, with three seconds between each series, for a total of 1500 pulses per session. Pain intensity was measured before stimulation from the first intervention (T0) to the final stimulation (T10), and one and three months after final stimulation (T11 and T12). Other measures included scores on the McGill pain questionnaire, self-rating depression scale, quality of life (QOL), sleep quality, global impression of change, medication regulation, and adverse events. The real rTMS group had greater reduction of visual analogue scale (VAS) at each time point except for T0 and T1, indicating benefits take time to be evident. Mean VAS reduction in the real rTMS group was 17% when duration of PHN was longer than six months. These analgesic effects were associated with long-term improvement in QOL. Positive results were seen in 50% who had real stimulation. In the real rTMS group, six reported minor adverse events with four reports of neck pain and headache, and two reports of dizziness and dry mouth. These did not require a change in treatment. Of the twenty patients from the sham rTMS group, four complained of neck pain and headache, and one patient complained of dizziness [254].

While there are few studies of PHN directly, other comparable neuropathic pain studies of PEMFs have been done. rTMS over the side of the head above the ears (motor cortex) has been shown to alleviate neuropathic pain. rTMS at this location activates the endogenous opioid system in a wide brain network associated with processing of pain and may partly explain the clinical analgesic effects of rTMS [222].

The long-term maintenance of analgesia was studied for rTMS of the motor cortex to the side of the head opposite in people with chronic refractory facial pain, a common complication of shingles (post-herpetic neuralgia). Fifty-five individuals had one daily rTMS session for five days per week for two consecutive weeks, followed by a "maintenance phase" of two sessions for one week, then one session in weeks four and six, and a monthly session for the next five months. The analgesic effect of rTMS was assessed by a 0-10 visual scale from fifteen to 180 days after starting treatment. All pain measures significantly decreased from baseline to day fifteen; the intensity of permanent pain decreased by 39%, paroxysmal pain by 49%, and the daily number of painful attacks by 59%. Those whose pain scores decreased by at least 30% was 73% at day fifteen and dropped to 40% at six months. The analgesic effect was significantly lower when session duration was shortened, irrespective of the number of pulses. So, only part of the patients respond to this technique and session duration should be maintained. It is also not known if better results would be achieved by not reducing the number of sessions over time [175].

Some people with neuropathic pain do not have their pain managed sufficiently with PEMFs. In these cases, the neuropathic pain can be controlled by motor cortex stimulation using surgically-implanted electrodes. However, PEMFs, using rTMS of the cortex, has been reported as a pain control bridging therapy for as long as sixteen months in drug-resistant peripheral pain with monthly sessions [228]. Therapeutic use of rTMS in pain syndromes is limited by the short duration of the induced effects, but prolonged pain relief can be obtained by performing rTMS sessions every day for several weeks. The rate of improvement produced by rTMS may be predictive for the outcome of the implanted procedure [229].

People with chronic neuropathic pain often have comorbidities like depression and sleep problems. Through functional connectivity of many brain pathways, rTMS of the motor and sensory cortex may coincidently activate the target area for treating depression with rTMS. Thus, the analgesic effect of rTMS could be mediated indirectly via improvement of psychiatric comorbidities or sleep. Sixteen individuals with chronic drug-resistant neuropathic orofacial pain participated in a randomized controlled crossover rTMS study. They had baseline and two active and one placebo rTMS treatments. The analgesic effect of stimulation of the right sensory cortex alone was not associated with improvement of psychiatric conditions or sleep, whereas combined stimulation of the two brain areas improved sleep without significant analgesic effect. Psychiatric and sleep disorders did not predict the rTMS treatment outcome [241].

Most of the research cited here is from using high intensity PEMFs to the brain and spine, and typically carried out in research or medical settings. However, I have seen medium intensity portable devices work very well, allowing home-based use. This would be most effective for smaller areas of involvement, such as the face or head. Other medium intensity systems that have larger pad applicators can cover larger area shingles lesions, such as the trunk, chest, or back and may shorten the overall course of the shingles attack, in addition to reducing the pain.

Skin Conditions

Eczema and dermatitis

Some examples of how PEMFs can work for skin problems include atopic eczema or dermatitis, psoriasis, and ulcers that won't heal. In eczema, PEMFs were found to improve significantly or completely 90% of individuals, with the remainder also showing improvement. To achieve these results only ten minutes of treatment for up to fifteen sessions was needed with a medium intensity PEMF. In psoriasis, using medium intensity magnetic fields similarly to the eczema patients more than 50% had either marked improvement or complete remission. The rest showed more modest improvement. Physical markers of inflammation also showed improvement [310].

Fungal skin infections

PEMFs have even been shown to inhibit the growth of fungi frequently found on the skin. Fungal conditions of the skin, particularly the toenails are common. Different field strengths and frequencies had similar benefits, with more benefit at higher frequencies and longer treatment times. The degree of benefit depended on frequency, exposure time, and field intensity. Benefit varied from 8 – 20%, with longer treatment times (up to 6-12 hours a day) and higher intensity being more effective. Personal use PEMFs are likely to do better than from a professional, since professional treatment times are typically limited to under half an hour per day [62].

Psoriasis

Psoriasis treatment often involves the use of ultraviolet phototherapy (UVA or UVB). Ultraviolet treatment induces the death of the inflammatory skin lymph cells that cause inflammation and overproduction of skin cells, the hallmark of psoriasis. Unfortunately, ultraviolet can also increase the risk of cancer of the area of treated skin.

Sinusoidal PEMFs of 60- and 100-Hz (1 or 2 G) for twenty minutes can affect DNA synthesis in circulating peripheral blood lymphocytes (PBLs). The PEMFs selectively induce T-cell cell death (apoptosis) in human tissues and enhance healing of psoriasis by limiting the production of molecules that promote inflammation (*Johnson*). The capacity of a PEMF to induce regression of psoriatic manifestations was investigated in 110 patients. The best results were obtained in the scalp form, 100% with good results, the form with localized patches in the classic sites in males (74% good results), and guttate forms in females (75% good results). The most favorable ages were the second, fifth, and sixth decades of life. Longer-established cases of psoriasis responded better than more recent ones. Treatment with PEMF appeared particularly successful if started in March/April with 80% good results, suggesting a seasonal pattern or the synergistic effect of the seasonally increasing sunlight exposure [72].

Five patients with PV and three patients with PA were given daily fifteen-minute treatments for three weeks with PEMF of 50 Hz sinusoidal, 50 G with a coil that circled the pelvis. Eight control patients received a placebo treatment. None received either UV-A or Psoralen therapy prior to the PEMF treatment, although they did receive coal tar along with the PEMFs. Blood evaluations were done before and after three months of therapy, and clinical progress was also observed. Inflammatory cell phagocytosis, which is highly activated in a chronic disease like psoriasis, decreased to normal levels. T-helper and natural killer cells increased following PEMF therapy. IgG significantly increased. PEMFs caused slight paling of psoriatic lesions, but no significant effect on the arthritic process [304].

PEMFs under 50 Hz allow the dose of ultraviolet to be reduced, making ultraviolet treatment safer and allow effectively shorter treatment times. Other types of inflammatory skin disorders should also see similar benefits [310].

Sleep

Sleep disturbances are common but not easily diagnosed as a single condition. Insomnia, for example, is not a disease, as there is no single definition of it that applies to all people reporting the condition. Multiple aspects are at play in any given person's sleep problem, including stress and anxiety levels. Sleeplessness itself varies dramatically from person to person with some people struggling to fall asleep (latency) and others struggling to stay asleep, alongside physiological urges like needing to go to the bathroom in the middle of the night or suffering with pain.

PEMF therapy has positive effects on calming the brain (see "entrainment" in other sections of the book) and on regulating circadian rhythms. Circadian rhythms have an important role in controlling sleep patterns and cycles.

Stresses, whether physiologic or emotional, can affect circadian rhythms (see section 2 for more information on circadian rhythms). Research done in Germany in the 1960s through the 1970s, in a deep bunker, deprived test subjects of external stimuli such as temperature, humidity, light, sound, and even the natural magnetic field of the earth. These individuals ended up having disturbed circadian rhythms. They found that weak square wave 10 Hz electromagnetic fields reversed the effects of these disturbed circadian rhythms [484].

Magnetic fields from a small 0.5 mT (5 gauss) 4 Hz generator were tested in a double-blind study. Effects on sleep were studied prior to treatment and after two and six weeks of treatment. They found that this field and intensity was effective in reducing sleep disturbances in 83% of the exposed group, compared with 57% in the controls. There is a strong impact psychologically of someone being studied, and changes are seen even if a placebo device is being used (called the Hawthorne effect). Nevertheless, the people receiving active treatment consistently had better results for sleep whether it was at two weeks or six weeks. Results were stronger at six weeks [123].

In a four-week double blind, placebo-controlled study, impulse magnetic-field therapy was tested for insomnia. A hundred people with insomnia were randomly assigned to either active treatment or placebo. They fell into one of three groups: (1) trouble falling asleep (sleep latency); (2) interrupted sleep; or (3) nightmares. The researchers looked at sleep latency (how long it takes to fall asleep), frequency of interruptions, sleepiness after rising, daytime sleepiness, difficulty with concentration, and daytime headaches. In those with active treatments, the values of all criteria were significantly improved. As is often seen with this kind of research, the placebo group also had significant symptomatic improvement. However, the differences between the two groups hugely favored the active treatment group. Some 70% of the people given active treatment experienced substantial or even complete relief of their complaints; 24% had clear improvement; and 6% slight improvement. In the placebo group, only one patient had clear relief; 49% had slight or clear improvement; and 49% saw no change. No one had any adverse effects. The PEMF therapy helped about 90%, versus only about 50% in the placebo group. This study was useful in showing that most basic types of sleep problems can be substantially helped with the use of PEMF therapies [334].

Even low intensity PEMFs may enhance the effects of sleep medications and psychotropic drugs. This may result in a hangover-like effect in the morning. If this should happen, then the dosing of the medications may be able to be decreased, under appropriate supervision [418].

One research laboratory has done an extensive amount of research on magnetic field stimulation and sleep [148]. They discovered that using 20-30 μT (0.2-0.3 gauss) magnetic fields at 60 Hz didn't significantly alter sleep patterns. However, with the magnetic stimulation alternated one-hour on/one hour off, over eight hours of sleep, and when on, further switched on and off every fifteen seconds, different effects were found. This intermittent exposure to the magnetic field resulted in significant changes to nighttime sleep. Effects included: (1) poor and broken sleep (decreased sleep efficiency); (2) increased time in Stage 2 sleep; suppression of REM sleep; and (3) self-reports of sleeping less well in the night and feeling less rested on awakening in the morning. These studies were intended to replicate the effects on sleep of the electromagnetic noise from power lines in peoples' homes. That is why 60 Hz was used. However, continuous 60 Hz exposure at these very low intensities does not seem to alter sleep significantly. It's only when they are switched on and off that disruptions in sleep patterns were seen. This may be useful in considering whether to use PEMFs with intermittent pattern signals during the night with brainwave resonant frequencies or to use only devices with continuous PEMF signals through the night. There are more PEMF systems that can be run throughout the night. The only systems I would recommend to run all night should not be at any frequencies higher than 7 Hz and preferably 5 Hz or below. These can be placed near the bed, under the pillow, or between the mattress and the box spring. While they can be effective as a whole-body system, because of the inverse square rule, it is recommended that they be used as near to the head as possible. The exception would be people who are exquisitely sensitive to PEMFs, that is, have electro-sensitivity. In this situation, the PEMF signal should be placed as far away from the head as possible and still retain a benefit.

Most of our emphasis has been on the use of healing ELF PEMFs fields. However, sleep patterns can also be disrupted significantly by background high frequency EMFs coming into the sleep environment [170]. Wi-Fi in the room or building is often broadcast 360° and, as we know, penetrates through walls. The room in a house with a router is broadcasting to other rooms in the house, and even beyond to other surrounding homes and to the street. If this is the common form of router, that is, on all the time, it is broadcasting during the night. Even a router in a neighbor's apartment or home will be broadcast into your sleep area potentially. At the very least, some sensitive people do better with their sleep if their own home router is turned off during the night. The Europeans have available demand routers that only turn on when a signal is coming through. Having a cell phone or other Wi-Fi device on or near your bed is a definite no-no.

Even a clock radio near your head on a bed stand is still emitting a strong enough electromagnetic field to interfere with some people's sleep. Electronic equipment in a bedroom that may be turned off but is still plugged into the adapter or the wall outlet and has a power light is emitting an EMF into the sleep environment. This may still be subtly perceived by the body.

Smart meters on a wall of the house or corner of the building, including that of neighbors, or cell phone towers in the neighborhood may produce a strong enough signal to interfere with sleep.

High frequency EMF signals are not typically healing, but PEMFs may be used to present the body with a more balancing and entraining delta or theta signal of sufficient intensity during sleep to offset disturbing environmental signals, if one is particularly sensitive to them. Home-based systems that can run all night in the bedroom may be helpful for those people who have sleep disruptive EMF sensitivity.

I have found that a medium intensity PEMF device placed either on or under the mattress or under the pillow, is especially helpful when run all night. Delta or low theta frequencies entrain the brain to help people fall asleep better, and when run all night, they keep people asleep better. Higher intensities entrain the brain better and faster than lower intensities.

Smoking cessation

Tobacco smoking is the leading cause of preventable death in developed countries. Brain stimulation methods are gaining increasing interest as possible addiction therapies.

One researcher reviewed fifteen studies that used various brain stimulation techniques on tobacco addiction. rTMS was found to be the most well studied method with respect to tobacco addiction. Results indicate that rTMS to the left side of the upper forehead (dorsolateral prefrontal cortex) were the most efficacious in reducing tobacco cravings, an effect that may be mediated through the brain reward system involved in tobacco addiction. In the reviewed studies, rTMS was shown to reduce the amount of smoking, but no brain stimulation technique at this date has been studied for abstinence rates [486].

Using noninvasive brain stimulation can reduce nicotine craving and smoking. If you stimulate regions in the brain that are associated with craving for drugs, you can change the circuitry in the brain that modifies this dependence and eventually reduce smoking. This was studied in 115 smokers who had thirteen sessions of PEMF treatment over three weeks. The study participants smoked at least twenty cigarettes a day and had failed at least two previous attempts to quit. The researchers divided the participants into three groups: One received up to 10 Hz HI-PEMF brain stimulation, another 1-3 Hz stimulation, and the third received sham treatment. The groups were further divided into those who saw a visual cue—a picture of a lit cigarette—just before stimulation and those who didn't. The idea of the cue is to make sure attention is directed at smoking and not some other craving. After thirteen treatments, those who received the highest PEMF frequency level of stimulation (10 Hz) plus the visual cue had the best results, and 44% quit. After six months, a third were still not smoking compared to 28% of those who weren't shown the visual cue before treatment. This is in contrast to the 15-20% cessation rates at six months using nicotine patches. Adding HI-PEMF brain stimulation to other smoking cessation methods like nicotine substitution might make both treatments even more effective [111].

Stroke

The goal in using PEMFs for the treatment of stroke is to reduce the extent of damage, improve symptoms and function, and to heal as much of the damaged brain as possible. These goals are the same as anyone treating any condition causing damage to the brain, including traumatic brain injury (TBI) or concussion.

There is evidence that PEMF stimulation may accelerate the healing of tissue damage following shutting off blood supply (ischemia). Animals had blockages of their carotid artery created for about two hours, followed by four hours of the carotid being opened up. PEMF exposure (75-Hz) was started ten minutes after onset of ischemia and continued throughout reopening of the blood supply. The PEMF did not reduce the total area of injury seen on MRI. However, PEMF exposure reduced brain edema by 65%. The area of damage was core ischemic brain cell injury. Electrophysiologic testing in the PEMF treated group found about double the recovery, 55% vs. 28%. Preliminary data suggest that exposure to a PEMF of short duration may have implications for the treatment of acute stroke. While it is hard in the conventional medical system to be able to treat people in the acute phase of brain injury whether it is stroke or trauma, at least if somebody owns a PEMF system when they have a stroke, it can be used immediately to reduce the extent of the damage. This is critical to reducing the length of time for recovery [152].

PEMFs have been studied using different nerve tissue cells in the laboratory setting. The primary aim of this particular research was to evaluate the effect of PEMF exposure in inflammation and low oxygen-induced cell injury. PEMF exposure counteracted low oxygen supply (hypoxia) damage significantly, reducing cell death by inhibiting activation of various tissue chemical processes involved in oxygen deprivation. PEMFs significantly decreased low oxygen-induced oxidative stress after twenty-four or forty-eight hours. Moreover, PEMFs were able to reduce some of the most well-known inflammatory chemicals (cytokines), such as tumor necrosis factor-α (TNF-α), interleukin (IL)-1β, IL-6, and IL-8 release. These results show a protective effect of PEMFs on hypoxia damage in neuron-like cells and an anti-inflammatory effect suggesting that PEMFs could represent a potential therapeutic approach in benefiting ischemic brain conditions [474].

In another study, high-intensity, low-frequency TMS were used in patients' stroke rehabilitation. The patients had their strokes within 1-9.5 years before treatment with the PEMFs. During a fifteen-day rehab hospitalization, each person received twenty-two treatment sessions of twenty-minute low-frequency PEMF and 120-minutes intensive occupational therapy (OT) daily. The PEMF of 1 Hz was applied to the side of the head opposite the area of the stroke, i.e. on the same side as the paralysis. Intensive OT was provided after PEMF. Improvements were seen up to four weeks after discharge in 39% of the patients. The fifteen-day inpatient PEMF treatment plus OT protocol is clinically useful neurorehabilitative treatment for post-stroke patients with upper limb paralysis [195].

PEMFs are expected to influence nerve cell firing and function of selected brain areas. It appears that low frequency ≤ 1 Hz suppresses, while high frequency ≥ 5 Hz activates local neural activities. There was the question of which side of the brain to stimulate, the side with the lesion or the opposite side. Several studies have confirmed that low frequency PEMF applied to the brain hemisphere opposite to the side of damage can significantly improve movement of the affected upper limb in post-stroke patients. The side of the brain with the stroke may try to protect the non-stroke side by decreasing its activity. Intensive OT, especially using constraint-induced movement therapy (CIMT) for upper limb paralysis also appears to activate areas around the stroke lesion in chronic stroke patients. In chronic stroke, CIMT is currently considered most useful.

In the Kakuda study, follow-up evaluation after discharge showed persistent improvement of motor function of the affected upper limb up to four weeks after treatment ended. The duration of improvement of motor function of the affected upper limb appears to be relatively short after a single session of low frequency PEMF. A different study reported that the improvement induced by application of low frequency PEMF to the non-lesional hemisphere daily for five consecutive days was maintained for two weeks after intervention. In yet another study, the improvement of motor function of the affected upper limb in patients who received CIMT was also maintained up to several months after the intervention.

Whether there are longer term effects using each of the two interventions remains unknown for now. What is also not known is whether continued use of PEMFs in the home setting long-term may continue to show improvements. This may be expected to be true given that the brain tends to repair very slowly, even given appropriate stimuli. Since PEMFs are known to stimulate neural stem cells [142], and adults don't produce an abundance of brain stem cells, long-term PEMF stimulation may produce gradual long-term benefits in recovering damaged, reduced, or lost function.

Another study [22] of higher intensity, low frequency TMS PEMF for stroke investigated the long-term behavioral and neurophysiologic effects of combined HI-PEMF and physical therapy (PT) in chronic stroke patients with mild motor disabilities more than six months post stroke. In this study, thirty patients were enrolled in a double blind, randomized, single-center clinical trial. They each received ten daily two PEMF sessions per day, twenty-five minutes each, 1 Hz high intensity PEMF over the intact (not affected) motor cortex, with either real or sham approaches, administered either immediately before or after forty-five minutes of standard task oriented upper limb exercise PT. Outcome measures assessed dexterity, force, interhemispheric inhibition, and corticospinal excitability, multiple times up to three months after the end of treatment. In a second aspect of the above study, neural excitability of both hemispheres was assessed at baseline, pretreatment, day six (pre-treatment) and at each of the post treatment follow-ups.

The researchers found that treatment induced progressive rebalancing of excitability in the two brain hemispheres and a reduction of inter-hemispheric inhibition in the real treatment group. PT produced improvements in all groups. The aspects of functions that were trained showed only small and transitory improvements in the sham patients. The real treatment group had greater behavioral and neurophysiologic improvements especially in the group receiving treatment before PT, with robust and stable improvements. The ones receiving treatment after PT showed a slight decline in their improvement over time. They concluded that priming PT with inhibitory HI-PEMF before the PT (in the hemisphere opposite to the stroke lesion) is optimal to boost brain plasticity related to the functions trained with PT and rebalances excessive motor excitability. These results suggest that higher intensity PEMF is a valid and promising approach for chronic stroke patients with mild motor impairment.

An important aspect of this study was that they checked for cortical excitability, that is, brain hyperactivity. Chronic stroke patients typically show less excitability on the damaged side of the brain compared to the normal opposite side of the brain. In a normal non-stroke brain there is a cross communication between the sides of the brain where each side balances the other with inhibition and stimulation. Because of the damage to the side affected by the stroke, the opposite side becomes uninhibited and can irritate the affected side, creating spasticity in the affected extremity. Before the study, the researchers believed that doing higher intensity PEMF before PT could potentially prime functional neural networks for the PT intervention to work better, leading to superior outcomes.

This study provided evidence that higher intensity PEMF stimulation induces reduction of interhemispheric inhibition from the intact side of the brain to the affected side, long-term increased excitability of the lower functioning affected side, leading to improved and obvious functional improvements, in particular when PT is preceded by the higher intensity PEMF. One to three months after treatment, the group receiving PT first started to show a decline in performance and excitability of the affected side. In the group receiving higher intensity PEMF first, the outcomes remained stable over time by boosting brain plasticity (adaptability) caused by use of the damaged side of the brain and the affected extremity. These improvements all happened mainly by stabilizing the physical learning processes of the brain. They found evidence of a daily, cumulative lowering of excitability in the intact hemisphere. This was paralleled by a strong cumulative increase in the excitability of the affected hemisphere.

They also found direct neurophysiologic evidence that ten days of higher intensity PEMF treatment is more effective than five days. The sham PEMF stimulation group showed only a modest improvement lasting only a few weeks with no significant changes in excitability. This is not surprising since the PT was relatively short, patients were all chronic post-stroke, and all had already received cycles of rehabilitation before. Even though it is known that PT this late after stroke is less effective, this study indicates that brain stimulation may overcome this limitation.

The practical importance of this important randomized controlled trial is that the use of higher intensity PEMFs and PT, even up to six months after a stroke, may still produce significant improvements in function, thought to be lost permanently. The questions that ultimately remain are whether similar benefits can be seen more than six months after the stroke and whether various higher intensity PEMF systems may produce similar results. Given the lack of toxicity for PEMF therapies, below the level of inducing seizures or contractions, post stroke patients may find significant benefit from these therapies.

Preliminary results were reported of experiments investigating the effects of lower intensity PEMFs on brain microcirculation, arterial circulation in and around the skull, brain electrical activity, and the flow properties of blood (*Bartko*). The studies included forty-eight healthy people and thirty-six suffering from various neurological disorders, primarily stroke. PEMFs of 5 mT (50 gauss) and 50 Hz were applied to their heads only once for thirty minutes while they lie relaxing. Objective measurements were made of flow and circulation and brain electrical activity was evaluated by EEG. PEMF stimulation appeared to improve cerebral blood flow in stroke patients. PEMFs increased blood flow in arteries outside the skull and decreased flow inside. Even though the stimulation was primarily to the head, thermography showed definite increases in circulation in both the head and upper and lower limbs. Even with 50 Hz stimulation, which is expected to be stimulating, healthy individuals showed decreases in delta and/or theta band activity and increases in alpha band activity. Stimulation in those with stroke resulted in decreased delta band activity. Stroke typically causes increases in delta activity; the more damage, the greater the amount of delta. So, a reduction in delta shows evidence of improvement in brain function. As is commonly seen with PEMFs, stimulation caused significant decreases in platelet adhesion. Similar changes were seen in plasma and whole blood viscosity and the shape of red blood cells. These kinds of changes would reduce the risk of additional stroke, as would be seen with the use of antiplatelet agents such as aspirin.

In another lower intensity PEMF study [424] ninety-five patients were treated with PEMFs, fifty-nine with active treatments, and twenty-five sham controls. Patients had spastic paralysis from two to twenty-four months after stroke. Seventy patients made up a group exposed to the PEMF and the other twenty-five were the control group in which sham-exposure was made. The head was exposed to the PEMF, which was sinusoidal wave shape, 40 Hz, 10 mT, three times a day for twelve minutes over twenty-one days, and repeated every six to eight weeks. PEMF was a component of a complex therapy program that also included medication and physical therapy. In actively treated patients, there was significant decrease of muscle tension (88%), increased muscle contraction force (76%), increased active motion in paralyzed limbs (74%), decreased severity of aphasia (64%) and improved gait (71%). The positive therapeutic effects are due to stimulation of neuron metabolism in the central nervous system, improved nerve conduction, restored spontaneous activity in injured neurons, improved circulation of the brain, and the flow properties of blood. PEMF therapy makes the complex therapy of stroke more efficient.

One group did double blind clinical studies in stroke patients [159] and found improvement in spasticity and pain syndromes (neuralgias, migraine, and muscle contraction). They compared the effects of PEMF with functional electric stimulation and direct stimulation of the spinal cord by implanted electrodes and found them to be somewhat similar. The advantages of PEMF treatment are much easier handling, easy variation of parameters without harmful side effects, convenient application, and that it is not painful to apply.

The above research is promising and provides more therapeutic hope and another option for helping the management of this devastating condition. It's likely the primary value of PEMF therapies for stroke will be that they can be used long term in the home setting with relatively affordable higher intensity PEMFs systems. As with so many of the conditions that PEMFs are helpful for, they need to be considered in the context of a comprehensive care program.

Testosterone

Testosterone is an androgen hormone produced in both men and women, though in much higher amounts in men. It helps maintain a variety of essential functions in the body, including affecting levels of body fat, muscle mass, sexual health, disease prevention (by improving insulin sensitivity, among other things), mental function, depression, cardiovascular and musculoskeletal health, and bone strength.

About 50% of men at age fifty have testosterone deficiency, as a natural part of aging. Most women at age fifty have declining testosterone levels, at least in part related to declining estrogen and progesterone levels. Testosterone deficiency has many causes. The internet is full of solutions for reversing testosterone levels, not the least of which is testosterone replacement using bioidentical hormones.

The question is whether, relative to the subject of this book, these naturally declining testosterone levels can be improved or reversed using PEMFs. Stimulation of the testes with PEMFs increases production of testosterone. The Leydig cells obtained from the testes of mice were exposed to a sinusoidal, 50 Hz, 100 μT (1 gauss) PEMF continuously for forty-eight hours. They found a marked increase of testosterone production [126].

Women in perimenopause and menopause may also have an interest in increasing testosterone to support their bones, muscles, connective tissues, cardiovascular system, and cognitive function. Since the ovaries also produce testosterone, it makes logical sense that PEMF stimulation over that area of the abdomen, would also increase testosterone production for women, and at the same time also increase estrogen production. This possibility has not been formally studied. However, a field strength of at least one gauss (100 μT) at the site of the ovaries may be necessary based on the Leydig cell study cited above. Therefore, based on the inverse square law, a magnetic field intensity of at least 1000 gauss (100 mT) would be necessary to provide adequate stimulation. The 48-hour stimulation used in the mouse study is not practical in humans. It's feasible that daily stimulation would still produce enough testosterone to enter the circulation and become available in the tissues to act throughout the day. The duration of stimulation necessary to provide benefits still needs to be determined.

Tremor

Neurological disorders or conditions that that can produce tremor include multiple sclerosis, stroke, traumatic brain injury, and neurodegenerative diseases that damage or destroy parts of the brainstem or the cerebellum. Other causes include the use of some drugs (such as amphetamines, corticosteroids, and drugs used for certain psychiatric disorders), alcohol abuse or withdrawal, mercury poisoning, overactive thyroid, or liver failure. Some forms of tremor are inherited and run in families, while others have no known cause. There are two types of tremor: resting and action (intentional). In resting tremor, the hands are shaking even without any movement. With intentional tremor, the hands do not shake at rest but only begin shaking when movement or actions are attempted. Essential tremor (sometimes called benign essential tremor) is the most common of the forms of abnormal tremor. The hands are most often affected and tremor is typically present as an action or intention tremor. These often run in families. Parkinsonian tremor is caused by damage to structures within the brain that control movement. This tremor is mostly a resting tremor.

There are fundamentally two medical approaches to the treatment of these tremors. One is medication. The medications most commonly used are for seizure disorders, anxiety medications, or beta blockers. All of these can have significant side effects, particularly in the elderly. Another option is neurosurgery to destroy (ablate) the brain tissue causing the tremor or doing deep brain electrical stimulation (DBS), an electrical procedure with electrodes implanted into the brain.

PD causes the characteristic hand movements known as "pill rolling" tremors. After a PD patient no longer responds to drugs such as levodopa, creating surgical lesions has been shown to improve PD symptoms, although often leaving the person with significant new deficits. An example of this is Michael J Fox, the actor, who has been left with speech changes and awkward involuntary movement patterns. DBS is being increasingly used as an alternative to brain surgery. DBS stimulation at 130 to 180 Hz appears to mimic the effects of surgery, and is generally less destructive. Such stimulation has been shown to improve tremors by around 80%, slow movement, and rigidity by at least 60%, and gait and postural disturbances by 40-50%. However, DBS is an invasive procedure, and doesn't work on everybody [112].

So, in a continuing search for more effective and less invasive and toxic therapies, PEMFs need to be considered (see the Parkinson's disease topic in this section). There is some research to support the use of PEMFs in the treatment of tremor.

A PEMF study was done evaluating low frequency (1 Hz) rTMS of the cerebellum, that is, the lower back part of the brain. They did five days of daily rTMS treatments to both sides of the back of the head in essential tremor (ET) patients. They also did resting-state functional MRI (fMRI) imaging in eleven ET patients and eleven healthy subjects. Resting-state fMRI was done at baseline in patients and control subjects. fMRI was repeated in patients after five days of bilateral 1 Hz rTMS. Tremor was assessed clinically and with electromyography (EMG) and hand movement recordings at baseline (before the cerebellar stimulation) and after the end of the stimulation period at days five, twelve, and twenty-nine. Repeated rTMS over the cerebellum (back of the head) significantly improved total and specific scores for tremor, drawing, and functional disability and reduced the degree of tremor. The fMRIs also improved. The benefits persisted for three weeks after the last treatment session. The conclusion is that cerebellar stimulation could be an effective treatment option for patients with severe essential tremor [344].

Unfortunately, rTMS is not widely available, not typically covered by insurance, and expensive. While the patients in this study were followed and studied for up to a month, it is not clear how long the benefits from this type of therapy will last, beyond the three weeks seen in this study. With treatment resistant depression, typically, patients have to have repeated courses of treatment with rTMS to have sustainable results. Relatively high intensity PEMF devices are available commercially and available for treatment in some doctors' offices and now with slightly lower intensity systems, in the home setting.

However, even very weak PEMFs have significant brain effects and help tremors. One very weak sinusoidal picoTesla PEMF in a patch (3 inches x 3 inches) with sixteen small coils (7.5 pT, 2.5 Hz) was placed on the top of the head. In PD patients, tremor was dramatically reduced, muscular rigidity decreased, visual-spatial orientation, and gait improved [184]. Sandyk has also reported extensively on the use of a very weak PEMF system in PD.

Multiple sclerosis (MS) patients often have intention tremors. Sandyk's patients [383] had two or three sessions of 7.5 pT, 2-5 Hz sinusoidal PEMF therapy delivered to the head, for twenty-, thirty-, or forty-five-minute periods. The PEMF treatments reduced both intention and postural tremors. One patient was able to hold a cup of water steadily in his right hand and drink from it after receiving treatment, something he could not do before.

One group of authors in Russia reported on the use of variable intensity PEMFs for treatment of nervous system diseases. They had more than twenty years of PEMF experience, treating about 5,000 patients with trauma or diseases of the nervous system. They used different kinds of magnetic systems. The PEMF treatments were 1-30 mT, 15-20 minutes 1-2 times a day, for 3-4 weeks. Some magnetically sensitive people only needed 7-10 days of treatment. The majority of patients with neurological disturbances showed positive responses. One hundred fifty patients with circulation problems had psycho-physiologic disturbances. Their examination results for sensorimotor reactions, dynamic tremors, attention, memory, and circulation showed that disturbances became normal simultaneously after PEMF therapy. Positive results were seen also in some of the patients with epilepsy, syringomyelia, PD, MS, and nerve lesions [104].

Another group [421] reported the results for tremor in the treatment of patients with MS. Fifty-eight patients were treated. Thirty-eight had PEMF therapy added to typical PT and kinesio therapy. The control group only had typical PT and kinesio therapy and sham PEMF exposure. PEMF therapy (10 Hz, 7 mT, half-triangular and triangular waveform) was for twelve minutes a day, over twenty-two days. A number of different aspects of MS improved and intention tremor decreased by 53%.

Therefore, the use of PEMFs whether very low intensity, medium intensity or high intensity appear to be helpful for the treatment of tremor, without the need to resort to invasive procedures. Since these usually chronic problems and are not medically dangerous, though functionally disturbing, safe procedures like PEMFs should be attempted first before considering an invasive approach. It may also be possible that medications combined with PEMFs may work better than either one alone and perhaps even at lower doses of medications.

Wounds

Many of the actions of PEMFs responsible for healing have already been discussed throughout this book, including decreased inflammation, improved oxygen levels, reduced sodium levels, increased growth factors, stimulation of regeneration, and stabilized electrochemical gradients across cell membranes. Wound management carries a large burden of disability and cost to society. Conventional treatments currently used are slow to produce results, expensive, and time-consuming. Existing approaches to wound management can be augmented significantly by the concurrent use of PEMFs. In many cases, PEMFs may be able to be used alone with great success.

There is plentiful research evidence showing benefits of PEMFs on wound healing. Skin wounds respond better with a medium intensity PEMF applied forty minutes a day. Skin wounds treated with a homeopathic salve and magnetic fields do the best and heal fastest, so that significant healing is evident already on the third day after treatment begins. By the tenth day, this combination treatment produced healing results in 89% of study participants [308].

The healing of open surgical wounds with PEMF stimulation was significantly enhanced ten and fifteen days after surgery. The mean decrease in wound size area was 28% for PEMF compared to 23% for controls on day ten, and 68% for PEMF compared to 47% for controls on day fifteen [403].

In order to compare the effectiveness of different therapies on wounds, often you have to have a comparable wound. This is generally only possible experimentally by doing the research on animals. The process often used is that a uniform surgical wound is created in rats and they are exposed to PEMFs for twenty minutes daily and compared to rats that have the same wounds but don't have PEMF treatment. The results are strikingly in favor of PEMFs. Further differences are seen when some of the stimulation aspects are compared. When more treatment time is provided, healing happens better and faster. Most of the healing is better in the early stages of the wound, when it is the most vulnerable. In addition to stimulating regeneration of the tissue by stimulating tissue growth factors, PEMFs also decrease the likelihood of bacterial contamination and inflammation, not allowing the wound healing to stall or degrade [19].

When wounds are large enough, grafting often has to be done to make sure that appropriate closure and healing occur. This means that tissue is moved from a healthy part of the body to the wounded part. This is called a tissue graft or skin flap. It is a complicated process and there is great risk in it failing. One of the key aspects of this process is being able to transfer the blood vessels attached to a piece of skin to the location of the graft. The transplanted skin graft is deprived of blood and oxygen temporarily. In animals exposed to PEMFs the percent of skin surviving a sudden blood loss increased by 30%. The same thing has been seen when the blood is deprived to the heart muscle experimentally. Even here, there appears to be a 30% reduction in the area of damaged tissue with upwards of a twenty-four-hour exposure of PEMFs. Furthermore, the PEMFs increased the amount of new blood vessel growth (angiogenesis) in the area of damaged tissue over 200% more than would normally be seen. The best effects appear to happen within the first hours of the loss of blood flow [68].

Even if already infected, these wounds may especially be helped by PEMF therapies. Benefits have been found in both animals and humans with infected wounds. In one review, researchers found pronounced pain relief and anti-inflammatory effects of the PEMFs. Treatment was applied only during the time of dressing changes. The first PEMF procedure eliminated pain in 25% of the patients while the others needed 2-3 procedures to achieve pain relief. The average hospital stay was 3.3 days shorter in those who received PEMF treatment. In those with open wounds, PEMFs showed evidence of wound healing 3.5 days earlier. PEMFs also reduced bacterial contamination of the wound, swelling, and pain even in sutured wounds. Sutured wounds with underlying infections are especially challenging to deal with [78].

Other slow healing skin wounds include ulcers from poor blood flow seen in venous insufficiency and venous stasis. They are slow healing often because the underlying condition, that is, the venous insufficiency is hard to control. In a human study, patients were treated four hours a day with a medium intensity PEMF system for a maximum of three months. At three months, 67% of the actively treated patients had healed ulcers versus 37% in the control group. No ulcers greater than 15 cm^2 healed within ninety days. If only patients with ulcers less than 15 cm^2 were considered, then the healing rates were 85% in the active group and 58% of the control group. When followed beyond ninety days, for the overall group, the healing rate rose to 88% in the active group and 42% in the control group. In 50% of the controls the ulcer recurred compared to 25% for the group with active PEMF treatment [294].

The value of the use of PEMFs in wound healing appears to be compelling. I know of patients who have been in wound centers or nursing rehab facilities for months trying to heal wounds using conventional approaches. One of the strategies they have not used is PEMFs. There are FDA approved PEMF devices that have been used in nursing facilities for years with significant success. However, PEMFs for home-based wound care can be helpful and can be combined with other standard wound care approaches. In addition, PEMFs can be applied over bandages and dressings without any problems. Given the above evidence, these PEMF-treated wounds should be healing much faster, with less risk of further breakdown and infection.

Abdominal surgery recovery

I recently had to have an elective laparoscopic appendectomy for a cyst blocking the opening of my appendix, discovered on a routine colonoscopy.

The procedure resulted in three "stab" abdominal wounds. I was discharged in the morning after the procedure with the usual recommendations for post-op care, including pain medications. On arriving home, I immediately began using my portable battery-operated PEMF device, which produces about 300 gauss and 10 Hz. I ran it continuously over the two larger stab wounds for about six hours before going to bed. The only pain medications I took were a couple of acetaminophen tablets at bedtime. I slept fairly well that night, with minimal discomfort – less than most patients experience that soon after surgery without heavier duty medications. The next day I ran the PEMF device most of the day and didn't need any pain medications. My abdomen was feeling good enough to be able to ride in a car. When I looked at the surgical wounds, the swelling, redness and bruising had all dramatically decreased. At the end of the day I took only two acetaminophen tablets at bedtime. I continued the same routine on the third day experiencing much less discomfort with movement, coughing, getting out of a chair, and walking upstairs. Even sleep that night was not too uncomfortable.

The following morning, I went to work. Most people are told by their surgeons to wait one to two weeks before they can return to work. It would be hard to dispute the value of the PEMF treatment in this rapid recovery following laparoscopy.

This anecdotal single case experience is well supported by the research evidence on accelerated wound healing potential of PEMFs given above. I am hopeful that wound management after surgery can be improved by more routine use of PEMFs, especially in the post-operative period in the home setting. PEMFs may offer the opportunity to have enhanced and faster recovery with more post-operative comfort, less pain, and less risk of wound infection or poor healing, whether after abdominal surgery or other surgeries.

Thumb re-attachment

An extreme example of wound repair is the healing of a severed thumb tip. This is from my case files.

A three-year-old had a complete avulsion of the right thumb from just behind the nail. The detached terminal piece of the thumb was surgically sewn back on. Other than that, the only other interventions were keeping the thumb clean and the initiation of PEMF therapy.

Figure 3.0 July 12, 2012.

In Figure 3.0, note the appearance of an avascular tip of the thumb. On this day, she started 1.5-3 hours per day using a battery-operated 10/100 Hz continuous signal with a maximum intensity of approximately 200 gauss (20 mT). More treatment time with the PEMF was recommended, but this was the only level of cooperation that was possible by this young child. Normal treatment, which was recommended by the surgeon, would have been to debride the stump and place a graft, leaving her finger deformed for life.

Figure 3.1 August 27, 2012

About six weeks later (Figure 3.1), the tissue has almost completely regrown. Redness of this finger (not visible in this black-and-white figure), has now replaced the previously purple color indicating lack of blood supply. The redness is normally seen at this stage of healing and is the sign of the natural acute inflammation needed for healing the injury. Note that most of the swelling is gone, the sutures have been removed, and the nail has fallen off as expected. There is a good nail bed and the expectation that the nail should be able to re-grow. All that remains of the injury is a piece of scab at the fingertip. This is expected to fall off shortly, leaving the remaining skin to heal completely.

Figure 3.2 October 2, 2012

Another five weeks later (Figure 3.2) and twelve weeks from the original injury, the thumb is almost completely healed. There is some swelling and inflammation left, indicative of a continuing healing response. The fingernail is growing in. The lateral corner of the fingertip is still slightly deformed but should continue to improve over the next few months, given the age of the child. The family is pleased with the result. What would have been a thumb deformed for life will be a normal digit.

Given the initial presentation of an avascular fingertip in a completely severed terminal finger, it would be reasonable to expect the loss of the end of that finger. It is not clear how exactly this healing process happened, but it can be assumed that many of the elements of wound healing were improved or stimulated by PEMFs, especially revascularization. Fortunately, the age and cooperation of the child helped. Also, fortunately, the treatment had been begun rapidly enough after the injury that there was little opportunity for significant permanent tissue loss.

SECTION FOUR
Selecting a PEMF System

Most of this book is intended to provide you with education about how PEMFs affect the body and explain research done on the different health conditions for which they are useful. Perhaps the most important aspect of the book goes beyond being informational. If you have a health condition, it is not enough just to learn about it; you should also know how to assess the resources available to treat it.

Eventually, the only way to get the benefits of a PEMF system is to actually own one and use it. Determining which system may be the best for your individual needs can seem overwhelming.

My goal as a physician has been to provide the right system for the person based on the health condition(s) present, their ability to use a particular system, and their budgetary constraints. I am also continuously gathering information from scientific studies so that I can be as informed as possible. I would never recommend a PEMF system that I have not used myself. Every system I work with has advantages and disadvantages, with each system treating some problems better than others.

Once you have consulted your physician, this section will help you determine which of the many parameters you should focus on while you're doing your research on which unit to choose.

SYSTEM PARAMETERS

The first and perhaps most important thing to know when sorting through the huge amount of PEMF information available online and elsewhere is that there is not one best system. There are dozens of PEMF systems on the market and each is unique. Some are intended for daily use, some for use in a clinician's office; some treat the entire body at once; and some treat only a small portion of the body. Of course, each manufacturer believes they have created the optimum system, and each will have a slightly different philosophy about what PEMF parameters drive the most change in the body.

All the patients I've met along the way taught me something else about how PEMFs worked and what PEMFs would work the best for a given set of circumstances. If nothing else, I've concluded as a physician that there is no such thing as one-size-fits-all or even one-size-fits-most.

In many ways, the more we learn, the more we know we have yet to learn. As I discussed in the first two sections of this book, PEMF therapies have a multitude of simultaneous effects on the body through a combination of mechanical, chemical, electrical, magnetic, and tissue effects. There are many problems, conditions, and health needs that will be positively affected by almost any type of magnetic field regardless of frequency, waveform, intensity, or coil configuration.

While there are many brands and options with a variety of parameters from which to choose, the most important considerations you can make before deciding on a system are personal ones: Your health history, lifestyle, budget, and current health concern(s) or objectives must all be examined before making a purchase decision. Clinical judgment should drive the recommendation of a given device for a given condition.

When we work with someone to make a system recommendation, the discussion always begins with a lot of questions. Are you always on the go, or is your lifestyle more stationary? Are you an athlete? Is your health condition chronic, or do you have a new, localized injury? Is this purchase for yourself, or do you want to treat friends, neighbors, or the family with the same system? Are you going to be using the system in your home, or are you a practitioner? What kind of budget are you working with?

Probably the most important piece of information used to guide your purchase decision is about what you hope to treat. The ideal system will be wildly different depending on that answer; chronic health conditions need different stimulation than healthy bodies looking for health maintenance. If you have a lot of health concerns, or if you're hoping to treat multiple people with one system, the recommendations change again.

- If your goal is overall health maintenance, then a full-body system with a reasonable range of frequencies, a medium intensity, and a comparatively lower price point is more likely to be recommended.
- If you are struggling with severe or chronic pain, a higher intensity system (whether it's a full-body or local system) is likely to be recommended.
- If you are trying to treat a lot of different conditions with the same system, a system with a wider range of frequencies and somewhat higher, adjustable range of intensities would probably be best.
- If you are an athlete needing to use the unit on the go or someone who travels frequently, a battery-powered device may be best.
- If you have extreme sensitivities to medications, foods, smells, electrical equipment, or supplements, then a low-intensity system should be considered.
- If you are looking for something simple, we may suggest a unit with as few buttons or programs as possible, or a full-body unit with few options.

There are a variety of elements that make up the technical specs of each PEMF system. The most widely discussed and studied are frequency and intensity, but waveform, coil configuration, and application area are also looked at with some regularity. Knowing which parameters are most likely to affect your health concerns or objectives is important in helping you compare similar systems to one another.

Frequency Range

A frequency range is always an important aspect of a PEMF system. Some systems produce a single frequency, some produce frequencies within a small range, some have a huge range of optional frequencies.

Most full-body PEMF systems have at least one frequency that mimics that of the brain—roughly between 1 and 30 Hz. These frequencies are sometimes referred to as "earth-based" frequencies, which is somewhat of a misnomer since there is a vast array of frequencies present on our planet and in our atmosphere (see the appendix for more information).

For every system that produces only brainwave frequencies, there is a system that produces much higher frequencies—some into the kHz range. Both high and low frequencies have been studied extensively, and each range has its place therapeutically. The body itself produces a vast array of frequencies, and different cell types, organ systems, and pathologies all communicate in different ways, creating their own biological windows that create or respond optimally to unique frequencies.

While a wide variety of frequencies have been studied individually, little comparative work has been done. One study may find that a specific frequency is great for arthritis pain relief, but it is not to say that other frequencies would not work just as well or even better. Having access to a wide variety of frequencies lets you cover more ground in the body, since the body will tend to choose what frequencies it needs at a given time (and then ignore the rest). Additionally, what frequencies your body wants today could be different tomorrow or next week.

Selecting a PEMF system based on its available frequency range is something we do in a few cases. A good example is if a person has a problem with sleep. In that case, they will absolutely need access to lower frequencies. Another time we heavily consider frequency ranges is when people are dealing with a disease that presents itself in multiple ways, such as post-treatment Lyme disease syndrome. A broader range of frequency choices would be more helpful in this situation. When more alertness is desired, higher brainwave frequencies would be more useful. If there is a lot of anxiety, EEG research shows that lower frequencies, especially in the alpha range (9-13 Hz) are best. When we're trying to regenerate tissues, 10 Hz can be important. Musculoskeletal problems often require multiple frequencies, and 50 Hz or 100 Hz can be the most useful. Sometimes the frequency options mentioned above are available individually or as packages within built-in protocols.

Intensity Options

Intensity levels vary dramatically between PEMF systems. It's important to note that intensities are all relative, and consumer PEMF systems don't produce intensities as high as MRI machines. So, in the world of PEMFs, "high intensity" and "low intensity" are relative. Just as a wide variety of frequencies have been studied tremendously, so have a wide variety of intensities, as is evident from the research sections of this book.

When extrapolating information from research to help guide your decision, it's also important to consider how the research was done. There is an often-cited NASA study, for example, that used very low intensities. Many manufacturers of low-intensity systems tout that research as proof that their system is going to be effective on stem cells. But what is left out of the conversation is that the research in that particular study was done in vitro, meaning it was done on a cell sample in a culture dish, outside a living organism. Translating that into human use will require that intensities be made much, much higher (see the dosimetry discussion in section 1). Very low intensity PEMF systems are only likely to affect stem cells within about a quarter of an inch into the body at the most, depending on multiple other factors.

Not many PEMF systems are available within what can be considered a "medium" range; it's mostly either extremely low intensity or relatively high intensity. Manufacturers and distributors of low intensity systems may claim that higher intensities are unnecessary or even harmful (not true), and manufacturers and distributors of high intensity systems may claim that lower intensities are ineffective (also not true). Research supports a variety of options.

The truth is in the theme of this book—it all depends on what you need. Are you a practitioner who needs to provide rapid relief from musculoskeletal pain? Low intensities aren't going to be your best option. Are you an electro-sensitive person who wants to bring about gradual subtle changes to an already over-stimulated body? Medium or high intensities may aggravate you. Very low intensities will be better, at least at the beginning. The choice of intensity of a PEMF system is often tied to how quickly you can expect to see results with that system, with higher intensities generally producing faster results (especially in terms of pain relief), musculoskeletal healing, injury recovery, and tissue regeneration.

Some PEMF systems use a philosophy called "graduated intensity" where the magnetic field intensity varies at different points on the applicator. For example, you may see a PEMF system with a higher intensity at the feet than at the head (I often recommend customers flip the mat around in this scenario so that the head gets a stronger treatment, depending on the condition(s) being treated), or a system that has higher intensity along the center of the mat (where the spine would be) than on the sides. This isn't really a pro or a con, just a different philosophy from a given manufacturer.

Long-term use of both low, medium, and high intensity PEMF systems are considered safe (see the safety discussion in section 5).

Waveforms

Waveforms can be downright confusing for consumers, but they are an often-cited parameter when comparing one PEMF system to another. A huge variety of waveforms exist in nature, in the body, and in PEMF devices. The most common are sinus, saw tooth, and square, though there are trapezoidal, rectangular, impulse, triangular, and many other different options in engineering.

It's important to note that within each loosely defined waveform exists a huge range of variation. There is no cut-and-dry sine wave, for example. Some manufacturers say they use a NASA square wave. There is such a thing, but it's different from all other square waves and only existed in the original NASA research done more than a decade ago. While many PEMF systems produce a square wave signal, none produce the exact same NASA square wave (which, even in research subsequent to NASA by one of the original scientists, was tweaked further).

The main reason waveforms are important is because they either mimic (enhance) or counteract (diminish) processes in the body. Waveforms also tend to be tied to intensity; square waves may be able to produce higher intensities than sinus waves, for instance. The key, as mentioned in section 1, is the intensity generated by the upslope of the waveform in the time that it takes to reach a peak (dB/dT). This is the only truly effective value to be able to compare PEMF systems properly.

Most PEMF systems produce a single waveform. Some produce one waveform on a full-body mat and another waveform on the pillow or probe applicator. Some have the option to change which waveform you're using for a given program. While this variety is an attractive feature, waveform should probably not be the deciding factor in terms of which PEMF system will be best for your needs, not even if it's square wave or saw tooth systems. Just as little comparative research has been done on frequency selection, we are not aware of research directly comparing waveforms for given conditions. This is one area where we would like to see new research done.

Other Aspects

The two other most frequently cited aspects of PEMF systems are the coil configuration and the application area.

All PEMF systems use copper coils to produce the desired magnetic field, but the configuration of those coils can vary system to system. Some have tightly wound coils that are all the same size, some have coils wound concentrically, and some have varying sizes of coils spread out in varying patterns within a mat. All of these configurations will produce a magnetic field as designed by the manufacturer. Some configurations lend themselves to a higher intensity magnetic field, some produce a more uniform field across the surface of an applicator, and some intentionally focus the magnetic field on one part of the mat or applicator. There is no right or wrong, just differing objectives.

Application area refers to how much of the body is being treated with the magnetic field—is it a full-body system or a local system? Full-body systems usually come standard with a smaller applicator as well. Within a given brand, the full-body mat usually produces lower intensity than the smaller pad. The reason for this is that the PEMF machine has a maximum energy output regardless of the numbers of applicators attached. The more applicators or the more widely spread out the coils are, the more dispersed the energy. Densely packed coils will produce much more energy than loosely packed, wider area coils. That's why many local PEMF systems produce higher intensity in their applicators than full-body systems. This is practically important, because you can stimulate a small group of tissues locally with more intensity than you can when you're stimulating the entire person. This relates to the Clinical Dosimetry Model discussed in section 1. Every time tissues are stimulated, there is some degree of amplification. The more cells that are stimulated, the more amplification. That is why lower intensities tend to be better tolerated with whole-body stimulation.

Other aspects in considering which PEMF system to get include your ability to get good customer service and support, the reliability of the manufacturer, and the experience and knowledge of PEMFs of the salesperson, distributor, or other person recommending a particular PEMF system to you. Most of the time, PEMF systems are not covered by insurance, even if they are FDA approved. Most home-use PEMF systems are not FDA approved for specific health indications; they are considered wellness devices. Use of the term "wellness" in this scenario describes complementary modalities that are not condition-specific.

HOW TO CHOOSE A PEMF SYSTEM

The primary criteria to consider are intensity, possible treatment area sizes, frequencies or programs, ability to self-design programs, program times, portability, and ease-of-use. All systems have limitations.

Intensity and Treatment Area

These are the parameters I tend to narrow down first.

Intensities can be classified easily into:
-extremely low: less than 50 µT (0.5 gauss)
-low: 0.5 gauss – 10 gauss
-medium: 10 gauss - 100 gauss
-high: 100 – 1000 gauss
-very high - greater than 1000 gauss

Most commercial PEMF systems rarely get above 100 gauss. Most whole-body PEMF systems fall in this category, although a large number, including some of the most expensive systems, are less than 1 gauss (100 µT). To put things in perspective, recall that the Earth's magnetic field averages about 50 µT (0.5 gauss). Most clinical research has been done on medium to high intensity systems. Some people do see significant benefits from low and very low intensity systems although my experience echoes the evidence from a review of the available research that shows that benefits tend to happen faster and better with medium to high intensity PEMF systems for individual health conditions.

The size of the applicator or applicators will determine the surface area of treatment. A long and wide pad applicator will typically treat the entire body. A regional applicator is one that treats an area of the body, for example, the abdomen, the chest, the pelvis, hips, shoulders, or upper or lower back. These are often called pillow applicators and come in various sizes depending on the system. Local applicators treat a small area, for example, a hand, a knee, elbow, foot, or part of the shoulder. There are many different configurations for these including small flat pads, circular open coils, and paddles. While not always true, generally, the smaller the applicator the higher the field intensity, even with the same PEMF system. This happens because the control units will put out the same amount of energy whether a large area of coil is used or a smaller area. With smaller area coils, more energy is delivered to the coil resulting in a higher field intensity. To be certain, one needs to obtain the manufacturer's intensity measurements, usually stated as maximum field intensity.

Whole-body PEMF systems are typically used for health maintenance and if a number of local areas of the body need to be treated. This can be accomplished more easily, saving time by using a whole-body system. Systemic health conditions such as osteoporosis, autoimmune diseases, vascular diseases, or multi-area skin disorders may normally also require a whole-body PEMF system.

Frequencies

Then there is the important question about frequencies, waveforms, and built-in programs.

Some PEMF systems:

- do not use frequencies, they only have single EMF pulses that are repeated based on intensity. This repetition or pulsation rate is erroneously interpreted as a frequency.
- only have one frequency, which does not necessarily mean the system is not useful, but it does limit flexibility in the actions and benefits that specific frequencies have, based on research or treatment goals.
- have a broad capacity for selecting individual frequencies.
- only have a built-in, limited set of frequencies or frequency sets.
- have the ability to select individual waveforms, but this is rare, and not necessarily that useful.
- allow for tuning or frequency selection for brainwave entrainment.
- have recommended frequency sets for specific conditions.
- have non-selectable background frequencies which can then be modulated with user selectable, specific frequency sets.

I'm not a fan of systems that recommend specific frequencies for specific health conditions. These programs may be for arthritis, depression, anxiety, inflammatory bowel, back pain, etc. I've found that these manufacturers have not done an adequate amount of research to show that those selected frequencies are either the best or exclusive for a specific condition. In addition, many of these manufacturers do not provide the data on the actual frequency packets used for the treatment of specific conditions. It's been my experience that, except for brainwave entrainment considerations, most frequencies will have benefits for most conditions, although results will be variable if the optimal frequencies are not used. The science on this is still far from satisfactory to have rigid rules about which frequencies are best for which conditions.

In fact, often the frequency packets used in the preset programs are counter to brainwave entrainment considerations. For example, if a condition specific packet has 30 Hz as one of its frequencies and a person is at the same time anxious, this treatment could potentially make a person more anxious, or may create more of a challenge for someone to fall asleep if used near bedtime. Also, if a condition-specific packet has a low-frequency, such as 5 Hz, this may not be desirable if one is about to drive, operate machinery, or function in a work setting, since it tends to slow down the brain waves and make a person more tired or less alert. Even with that said, it is often unpredictable how people will respond, with some paradoxically reacting the opposite of what would be expected.

As you can see from the large number of research studies summarized in the section 3, many frequencies have been studied and proven effective in a variety of conditions. It can't be said that a specific frequency will only do certain things or that specific conditions can only be treated with specific frequencies. Rarely is a selection of frequencies an all or none process. Any individual frequency will cause its own biologic effects and have additional effects on brainwave entrainment. Biologic effects do not specifically equate to the management of any particular condition, but to the biological state of the tissues as part of the health condition, whether local, regional, or systemic. Clearly, local treatment has systemic effects and systemic treatment has local effects.

Program times

Most, but not all, PEMF systems have time limitations for their programs. Some only run for fifteen minutes, some for an hour, and some can be run continuously. Often these PEMF systems require the user to re-run the program, possibly multiple times. PEMF system representatives that say only eight minutes a day is necessary are ignoring the available research. There are PEMF systems that can run for hours at a time. The amount of time needed for treatment will vary based on the individual or condition being treated.

Portability

Except for battery-operated PEMF systems, access to an electrical outlet is necessary to operate most PEMF systems. That can be a major constraint for people, depending on the amount of time necessary for treatment. This may be particularly true for people who need to treat multiple areas of the body in a given treatment session or in a given day. A battery-operated system will allow an individual to carry on daily activities, including driving, thus allowing for extended treatment times. Even medium intensity PEMF systems may need to be used for hours at a time for best results. In this situation, battery operation is essential. It's important to choose a PEMF system that will fit your lifestyle or work habits.

Ease-of-use

Certain applicators for PEMF systems are challenging to use, because of bulk, size, awkward configuration, or complex set up. It is necessary to understand how one is going to use a system to be sure that the right system be chosen for one's needs and ease-of-use.

Return periods

All reputable PEMF manufacturers should allow you to return the system within a window of time after the purchase, usually between thirty and ninety days depending on the device and the manufacturer. There are some exceptions to this rule. Hygiene, for instance, can be a concern with some PEMF devices, like those intended for prostate issues. Return periods nearly always have a restocking fee associated, so it's important to understand the cost of a return before you make a purchase decision.

EXAMPLES OF PEMF SYSTEMS

Next is a table summarizing the PEMF systems I have tested and used, with information on their maximum intensity, area of treatment, applicators, frequency, treatment time available, availability of programs, waveforms used, relative cost, and other features.

PEMF system comparisons

PEMF System	Max Intensity (Gauss) A=adjustable	Treatment Area*	Applicators	Frequency range (Hz)	Treatment time (mins)	Program or memory storage	Programs	Waveform**	Cost	Other
Almag	200	L	1	7.8	15-20	no	0	SI	$	
BioBalance	5/10 A	WB/R	2	0.5-1,000	10 min - 12 hrs.	no	6	SI	$$	
Biotorus	35 A	R	1	1-72.7	5-60	no	3	SA	$$	
Centurion EZY	50 A	R	1	2-30	20-60	no	4	SQ	$$$	
EarthPulse v5	1100 A	L	1-2	1-14.1	15 min to 12 hrs.	no	10	SQ	$	
ePad relax	0.4	WB	1	3/5/8	25	no	3	RE	$	1
ePad Friends	0.4	WB	1	3/8/25	25	no	3	RE	$	
FlexPulse	200 A	L	2	3-1000	10 - continuous	no	6	SQ	$$	1
iMRS Professional	0.64/3 A	WB/R/L	3	0.1-32	2-60	no	4	SA/SQ	$$$$	
Lenyo Fractal/Meridian	0.1	WB/R	2	1-200,000	10-20	no	32	SQ	$$$	
MAS Special Multi +	100 A	WB/R	2	0.2-9999	1 min - 12 hrs.	yes	90+	SE	$$$$	
Medithera	0.75 A	WB/R/L	3	0.3-250	1-59	yes	3	SA	$$	
Micropulse	200 A	L	2	10/100	continuous	no	1	SQ	$	2
Parmeds Home (Curatron HT)	70/200 A	WB/R/L	3	1-50	15-30	no	10	SQ	$$$$	
Parmeds Pro Special (Curatron XPSE)	150/1000	WB/R/L	3	1-50	20-40	no	10	SQ	$$$$	
Parmeds Super (Curatron PC)	100/150/1000	WB/R/L	3	1-50	20-99	yes	expanded	SQ	$$$$	3
PEMF-120	20,000 A	HB/R/L	4	NA	1-10	no	NA	NA	$$$$$	4
Pulsed Harmonic A2000	1500 A	HB/R/L	3	NA	15-225	no	NA	NA	$$$	
SOTA Pulser	2500-5000 A	L	1	NA	0.5-1	no	NA	NA	$	
TeslaFit Pro	12,000 A	HB/R/L	4	NA	5	no	NA	NA	$$$$$$	5
TeslaFit Plus	5400 A	HB/R/L	4	10	5,15,30	no	NA	NA	$$$$	5
Pulsed Harmonic A2000	1500 A	HB/R/L	3	NA	15-225	no	NA	NA	$$$	

*L=local R=regional HB= Half body WB= whole-body ** RE= rectangle SI=sinusoidal SA=saw tooth SQ=square SE=selectable NA=not applicable
Other 1. Rechargeable battery 2. 9 V Battery 3. PC expands programmability 4. Spark chamber 5. Pulses

Here are pictures and brief descriptions of the systems, allowing you to see what their configurations look like.

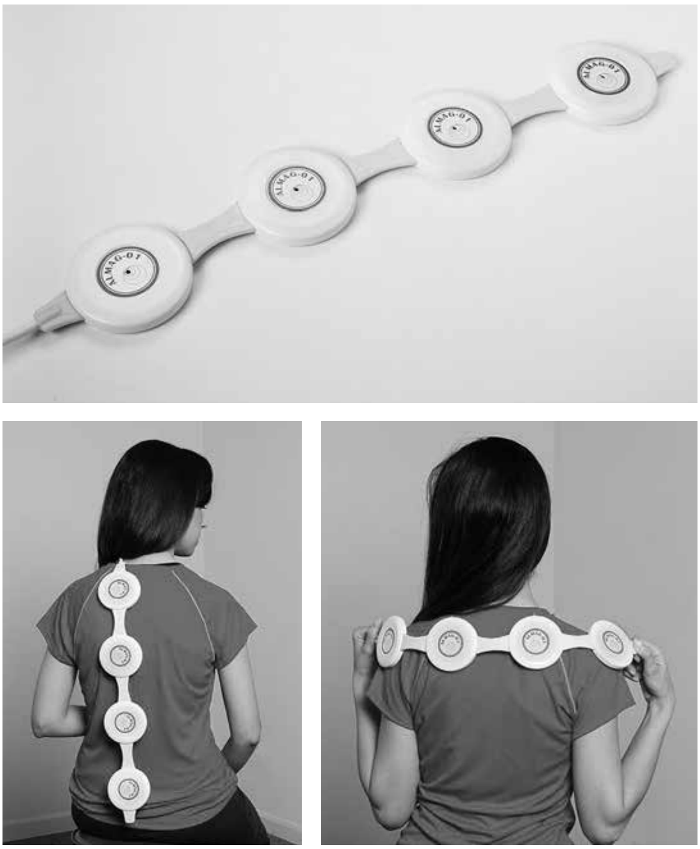

Figure 4.0 Almag

ALMAG

- Waveform: sinusoidal
- Maximum Intensity: 200 gauss (20,000 μT)
- Frequency: 7.8 Hz
- Number of Programs: N/A
- Program Duration: about 20 minutes

Figure 4.1 BioBalance

BIOBALANCE

- Waveform: sinusoidal
- Maximum Intensity: 10 gauss (100 µT)
- Frequency Range: 0.5 Hz to 1,000 Hz
- Number of Programs: 6
- Program Duration: 10 minutes to 12 hours
- *optional battery operation

Figure 4.2 Biotorus

BIOTORUS

- Waveform: saw tooth
- Maximum Intensity: 35 gauss (3500 μT)
- Frequency Range: 1.3 Hz to 72.7 Hz
- Number of Programs: 3
- Program Duration: 5 to 60 minutes

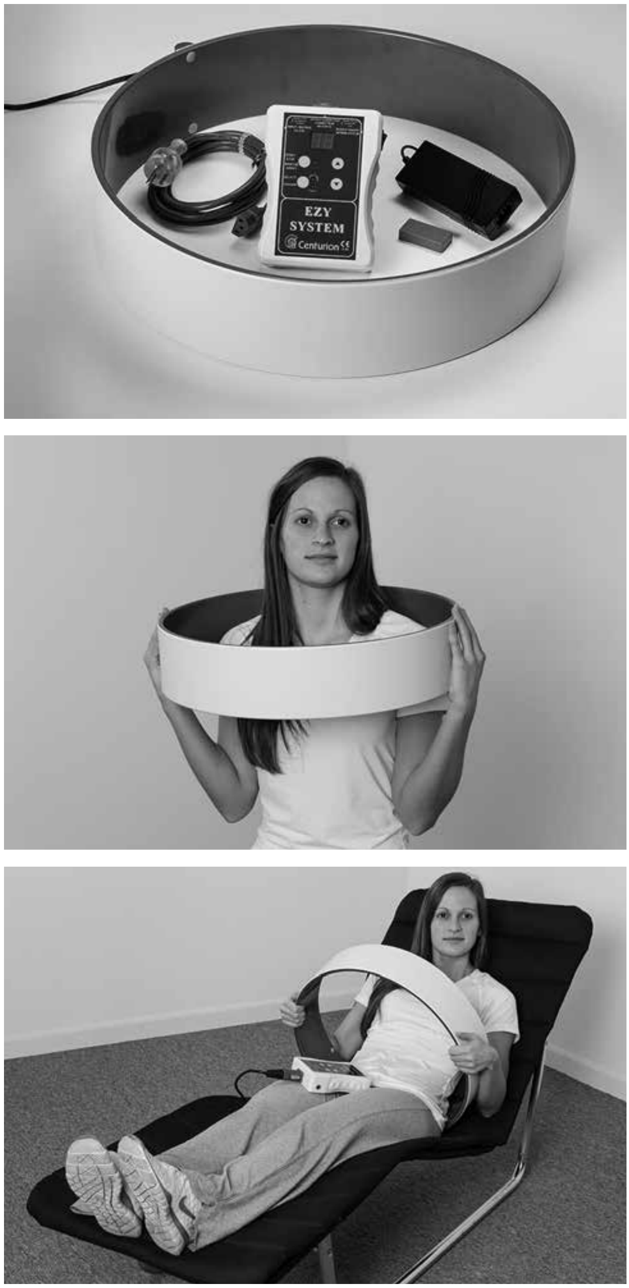

Figure 4.3 Centurion

CENTURION EZY

- Waveform: square
- Maximum Intensity: 50 gauss (5,000 µT)
- Frequency Range: 2 Hz, 8 Hz, 15 Hz, and 30 Hz
- Number of Programs: 4
- Program Duration: 20 to 60 minutes

Figure 4.4 EarthPulse v5

EARTHPULSE v5

- Waveform: square
- Maximum Intensity: 1,100 gauss (110,000 μT)
- Frequency Range: 1 Hz to 14.1 Hz
- Number of Programs: 10
- Program Duration: up to 12 hours

Figure 4.5 ePad Relax and ePad Friends

ePAD RELAX and ePad FRIENDS

- Waveform: rectangle
- Maximum Intensity: 0.4 gauss (40 µT)
- Frequency Range (Relax): 3 Hz, 5 Hz, and 8 Hz
- Frequency Range (Friends): 3 Hz, 8 Hz, and 25 Hz
- Program Duration: 25 minutes

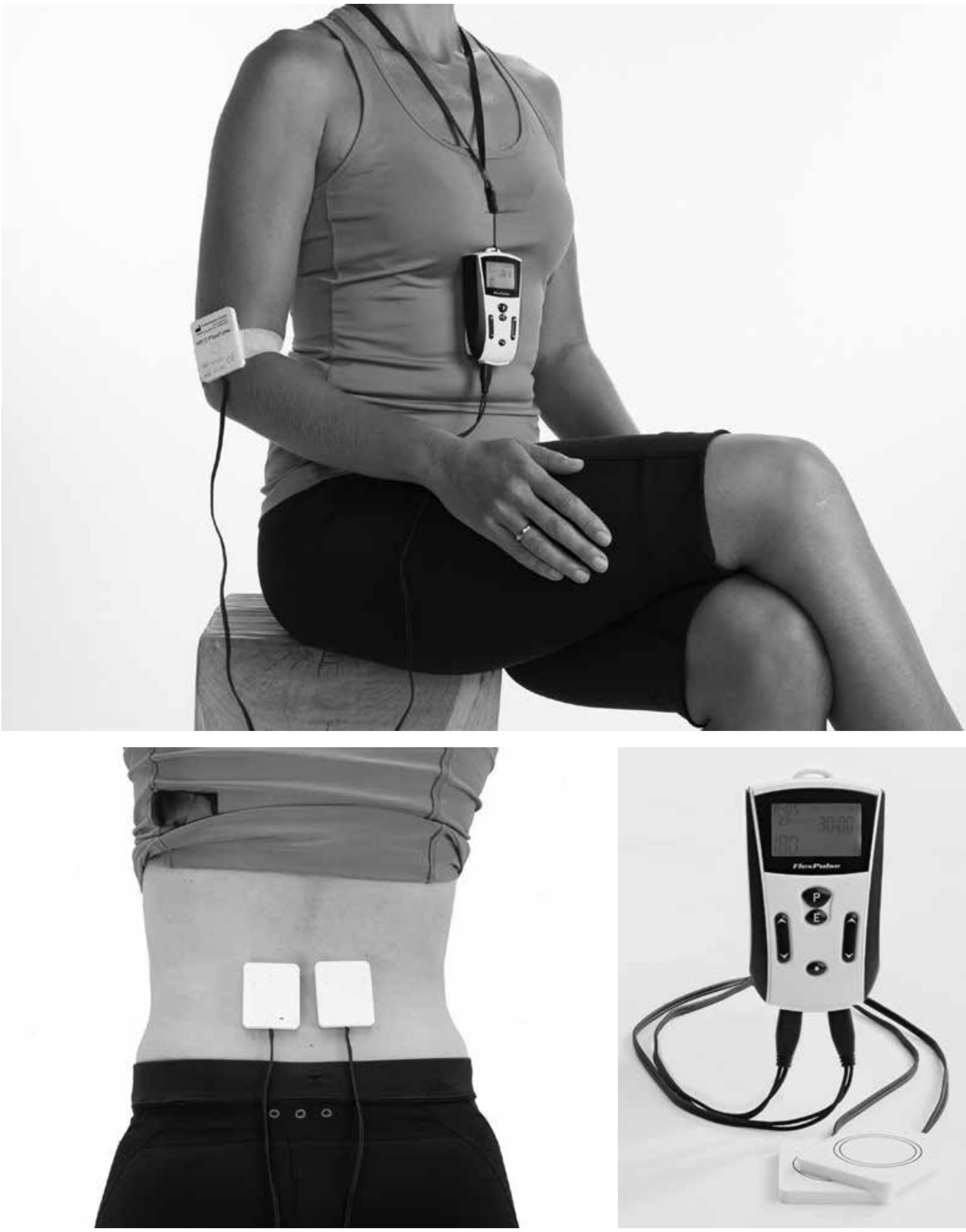

Figure 4.6 FlexPulse

FLEXPULSE

- Waveform: trapezoidal
- Maximum Intensity: 200 gauss (20,000 μT)
- Frequency Range: 3 Hz, 7.8 Hz, 10 Hz, 23 Hz, 100 Hz, 1,000 Hz
- Program Duration: 1, 2, 4, or 6 hours, or continuous mode
- *battery-operated

Figure 4.7 iMRS Professional

iMRS PROFESSIONAL

- Waveform: saw tooth (mat) and square (pad)
- Maximum Intensity (Professional): 0.64 gauss (64 μT)
- Frequency Range: 0.1 Hz to 32 Hz
- Number of Programs: 4
- Program Duration (Professional): 2 to 60 minutes

Figure 4.8 Lenyo Fractal and Meridian

LENYO FRACTAL and MERIDIAN

- Waveform: square
- Maximum Intensity: 0.1 gauss (10 μT)
- Frequency Range: 1 Hz to 200 kHz
- Number of Programs: 32
- Program Duration: up to 19 minutes (preset)

Figure 4.9 MAS Special Multi+

MAS SPECIAL MULTI +

- Waveform: selectable
- Maximum Intensity: 100 gauss (10,000 μT)
- Frequency Range: 0.2 Hz to 9,999 Hz
- Number of Programs: 90+
- Program Duration: 1 minute to 12 hours

Figure 4.10 Medithera

MEDITHERA

- Waveform: saw tooth
- Maximum Intensity: 0.75 gauss (75 μT)
- Frequency Range: 0.3 Hz to 250 Hz
- Number of Programs: 3
- Program Duration: 1 to 59 minutes

Figure 4.11 MicroPulse

MICROPULSE

- Waveform: trapezoidal
- Maximum Intensity: 200 gauss (20,000 μT)
- Frequency Range: 10 Hz and 100 Hz
- Number of Programs: 1
- Program Duration: continuous
- *battery-operated

Figure 4.12 Parmeds/Curatron Home, Pro Special, Super

PARMEDS/CURATRON HOME, PRO SPECIAL, SUPER

- Waveform: square-gated sinus
- Maximum Intensity (Home): 200 gauss (20,000 μT)
- Maximum Intensity (Pro Special and Super): 1,000 gauss (100,000 μT)
- Frequency Range: 1 Hz to 50 Hz
- Number of Programs (Home and Pro Special): 10
- Number of Programs (Super): 10 + 68 (with software)
- Program Duration (Home and Pro Special): up to 30 minutes (preset)
- Program Duration (Super): up to 40 minutes (preset) or up to 99 minutes (with software)

Figure 4.13 PEMF-120

PEMF-120

- Waveform: impulse
- Maximum Intensity: 20,000 gauss (2 T or 2,000,000 μT)
- Pulse Rate: 1 to 50 pulses per second (depending on intensity)
- Number of Programs: N/A
- Program Duration: 1 to 10 minutes

Figure 4.14 Pulsed Harmonix A2000

PULSED HARMONIX A2000

- Waveform: impulse
- Maximum Intensity: 1,500 gauss (150,000 μT)
- Pulse Rate: 0.54 to 27.3 pulses per second (depending on chosen intensity)
- Intensity settings: 69 to 1,500 in 15 steps
- Duration: 15-minute steps from 15 minutes to 3 hrs 45 mins

Figure 4.15 Sota Magnetic Pulser MP6

SOTA MAGNETIC PULSER MP6

- Waveform: impulse
- Maximum Intensity (slow mode): 6,000 gauss (600,000 μT)
- Maximum Intensity (fast mode): 2,500 gauss (250,000 μT)
- Pulse Rate (slow mode): 1 pulse per 5 seconds
- Pulse Rate (fast mode): 1 pulse per second
- Number of Programs: 2
- Program Duration: 20 minutes

Figure 4.16 TeslaFit Pro and Plus

TESLAFIT PRO AND PLUS

- Waveform (Pro): impulse
- Waveform (Plus): impulse/square
- Maximum Intensity (Pro): 7,000 gauss (700,000 µT)
- Maximum Intensity (Plus): 3,500 gauss (350,000 µT)
- Pulse Rate (Pro): 1 to 50 pulses per second (depending on chosen intensity)
- Frequency Range (Plus): same pulse rates as Pro, plus 10 Hz
- Number of Programs (Pro): N/A
- Number of Programs (Plus): 3
- Program Duration (Pro): 5 minutes
- Program Duration (Plus): 5 or 15 minutes (high power), or 30 minutes (low power)

Many more choices for PEMF systems

The PEMF systems I reviewed above are by no means the only systems available for people, but they are the only ones I currently recommend. There are many PEMF systems available in Europe and Asia that are not available in the US and Canada.

I have used many others and didn't include them for a number of reasons:

- they could have had similar attributes to systems I was already using,
- the construction was faulty or shoddy,
- access to service and parts was not reliable,
- the companies had not been in operation long enough to establish a strong track record,
- they were too complicated,
- they were intended more for professional use only,
- the cost was too high for the probable value,
- marketing was too aggressive,
- the warranty periods were too short,
- they didn't have the right applicators,
- they were too difficult to use or,
- they were part of multilevel marketing companies with prohibitive participation contracts.

I have also not listed PEMF systems that are FDA-approved, therefore requiring prescriptions and the need to be ordered by doctors. The typical medical indications for these systems include healing nonunion fractures, bone fusions, treatment-resistant depression, wound healing, and edema. Because of FDA restrictions, these systems are not typically available for use for reasons other than their FDA approved indications.

SUMMARY

There are many potentially confusing choices for selecting an appropriate PEMF system for yourself, family, friends, or pets, but we hope to give you some guidelines on how to think about making a purchase of a magnetic system. There is a limited but increasing number of clinicians who are treating people in their offices with PEMF systems, but you should not be misled into thinking that this is a long-term solution. Most of the time this would only be considered a trial run. Likewise, healing does not happen because of one or two treatments. We need to understand and respect the nature of the body and how it heals. The pharmaceutical and supplement industries understand this. You will usually need to be taking these for the long-term, if not the rest of your life.

We understand that PEMFs may feel like an expensive investment in the short-term, but in the long term, you will have the convenience and ability to be treating yourself independently at your own pace and with almost no risk of toxicity. Ultimately, the cost may end up being only pennies per day, especially when multiple family members may be using the system for years.

The example systems I presented above will give you some sense of how to evaluate any given PEMF system you may be considering for your own health care and healing. These are typical samples of what you may be likely to encounter or be recommended by others. As I've said many times before, do not be led into believing that any one system is a cure-all. There is no such thing as "one-size-fits-all." However, there is likely to be an ideal system for you or an alternative one that you will be able to find benefit from and afford.

SECTION FIVE
Using a PEMF System

Now that you have an understanding of how PEMFs affect the body, what conditions magnetic fields can treat successfully, and a basic guide on how to approach selecting the right unit for your needs, we will conclude with an overview of how to use a PEMF system. Generally, recommendations are made based on the specific characteristics of a particular. As we've said before, no one size fits all. Once the features of a system are understood, it's easier to see how it should be used to achieve the best results.

This section will discuss the actual application of a PEMF system, including how to select a protocol and what to expect from treatment. We will give a few examples of actual people we have made system and protocol recommendations to, so you can see the complexity that goes into making these decisions. These system and protocol recommendations are starting points. Adjustments in systems and protocols may need to be made over time as people heal. We will conclude by talking about basic "rules of the road" along with cautions, contraindications, and potential adverse reactions.

APPLYING PEMF THERAPY

Once you have chosen a PEMF system, you need to use it correctly to get the most benefit. Treatment outcomes will be largely dependent upon directing the magnetic field therapy to the correct body area or areas. The body is a complex organism, and while it is made up of many moving parts, it is still one interconnected whole. It is the philosophy of integrative medical practitioners to treat the whole person, and on the most basic level, this means the entire physical body.

To that end, it is often preferable to treat the entire body when using therapeutic magnetic fields, even if what you identify as needing treatment is only a small area. It is with whole-body stimulation that people tend to get the most benefit in terms of preventative care as well.

Even in my early days of working with magnetic fields, I knew that the therapy stimulates acupuncture points and meridians. Traditional Chinese medicine holds that there are as many as two thousand acupuncture points on the body. These are connected by twenty meridians, which are highways of communication and energy exchange. These meridians are connected to one another, but also to the internal organs, the senses, and the supporting tissues. Treating the entire body at once stimulates all of these acupuncture points and meridians, resulting in a more complete therapy. This is another reason why I strongly emphasize whole-body PEMF stimulation.

When you expose any portion of the body to a therapeutic magnetic field, you affect a myriad of chemical, mechanical, electric, and magnetic processes. Exposing the entire body to a therapeutic magnetic field at once only serves to amplify these effects.

It is also sometimes the case that where we identify the problem (usually an ache or pain) is not necessarily where the problem itself originates within the body. This is called referred or trigger point pain. Take sciatic pain for example—you may experience the greatest discomfort in the leg, but the issue originates at the base of the spine. Were you to treat only the leg, you may not achieve the best results from your PEMF device. It is recommended to get clinical advice on the source of pain so that treatment can be appropriately targeted. Armed with that information, if you treated the entire body, you'd be covering all your bases. Full-body PEMF therapy lets us take the guesswork out of knowing where on the body to direct treatment.

Full-body PEMF systems always include a mattress applicator, and usually also include a smaller pillow pad applicator as part of a standard package. The mattress applicators vary dramatically in weight, size, appearance, and portability, but all contain some configuration of copper coils embedded within.

If you have time, it's a good idea to first use the whole-body pad for a session, and then follow that up with a treatment using the smaller pillow pad if you have a local area that needs more attention.

When using a localized PEMF device, often the biggest challenge is knowing where to direct the magnetic field. This is easy in the case of an obvious injury like a broken bone, but more difficult when dealing with a systemic or complex health concern.

Localized PEMF devices have all the same components of many of the full-body systems on the market, they just tend to come in a smaller package with a smaller applicator. In some circumstances, a localized PEMF device is battery-powered, making it convenient to use while on the go. There are large PEMF devices that are still intended for local use, they tend to be installed in doctor's offices or hospitals and are used for intensive treatments.

Whether working with a whole-body system or a localized unit, the treatment process is virtually the same—you power your unit on and apply the magnetic field to the body. This means you will either lie or sit down on a mat (in the case of a full-body unit) or strap or wrap the applicator to a chosen body part (as is often the case with portable devices). The average treatment time is about thirty minutes, twice per day, but individual health circumstances and the intensity of the PEMF system will determine your actual needed treatment time.

You need to have a good understanding of the intensities of the system you are using. Most of the time smaller applicators are significantly stronger than the whole-body pads. While whole-body pads may be effective for local problems, extra attention with a higher intensity local applicator may be better.

General rules for application of magnetic fields

We recommend certain approaches for users to achieve better results with MF therapies and avoid any significant adverse effects. Some of these are:

- Applicators should be located as close as possible to the body. Using a system over a shirt or jacket vs directly on the skin makes no difference.
- Other modalities may still be used and considered in a complementary approach.
- Magnetic therapy should be applied as soon as possible after a problem begins. PEMFs can influence acute issues more rapidly than chronic or pathological problems.
- Exposures must be long enough and repeated regularly. Consistent use provides the best results.
- If possible, do not stop magnetic therapy suddenly until a sufficient number of treatments have been performed.
- Individualization of the approach is necessary, especially in painful conditions.
- Consult your doctor before beginning any new treatment.

Managing treatment expectations

One of the most common questions people have before starting PEMF therapy is about how quickly they will see results. The answer, of course, is dependent on a variety of factors. Once the nature and severity of the problem is understood, expectations can be reasonably set and an estimate can be made as to when and what improvement may be anticipated.

Having proper expectations is important in the use of PEMF therapies. If you are depressed or anxious, for example, small health improvements may seem inadequate. To set realistic expectations, we must first understand the nature of the problem, the depth of the damage or dysfunction, the types of tissues involved and their respective regeneration potential, and the age of the person.

Every body is different. Many people experience tremendous results within the first week or two of using their system. For some people, results come more slowly, and we can react to that by fine-tuning the treatment protocol. The body takes time to heal once it is given the appropriate signal or stimulus. A fracture, for example, will take eight to twelve weeks to heal to a point where the bone can be used. This does not mean the healing process is complete, just that the body part is usable once again. Magnetic therapies can speed the healing rate, but they do not typically cause instantaneous and complete miraculous healing. Illness is rarely, if ever, an instantaneous happening—the same is true of healing. We did not get to our current health state overnight, and we are unlikely to heal overnight. You should be suspicious of anybody who tells you that you should expect miraculous results from your PEMF system.

Truly acknowledging the damage present in your body is a critical piece to solving the healing timeline puzzle. Gauging a specific tissue's degree of involvement in the given health concern is important in understanding the amount of time it will take that tissue to heal. Problems in the body have degrees of involvement and different tissues are involved in any given condition. Understanding the levels of healing (see the clinical rationale and levels of disease in section 3) and at what level or levels the problem or problems being treated are at will help to determine how quickly responses will be likely.

Most people starting PEMF therapy feel more relaxed and sleep better relatively quickly. Pain reduction often happens to a significant degree early in the process, gradually improving with continued use over time as tissue healing progresses. For tissues that do not have the capacity for regeneration, PEMFs are valuable in reducing pain, reducing swelling, improving circulation, and stimulating whatever regeneration may be possible.

It is also worth noting that PEMF therapy will not work for everyone. As reported in sections 2 and 3, there is always a percentage of study participants that receive little to no benefit from the therapy. Though it is often possible that these participants would have found improvements with different parameters (more time, higher intensity, or different frequencies), PEMF therapy is not a panacea, and there are circumstances where no benefit will be found.

Selecting treatment parameters

Mild problems that don't have deep levels of pathology, such as a mild muscle or ligament strain, a superficial burn, cut, insect bite, bruise or puncture, will heal rapidly. In this situation, a minimum amount of stimulation may be necessary. Every treatment is a trial and error process. If you use your system for just five or ten minutes, or use it at a low intensity setting and do not get the results you want, you may need to increase your treatment time or intensity level. The body will tell you what it needs.

In some cases, the best results will be achieved with twenty-four hours a day of use for a few days. After that, less time may be necessary. Of course, this isn't feasible unless your PEMF system runs off batteries. Most whole-body systems limit the treatment to 30-60 minutes at a time. Several back-to-back treatments can be applied to extend the total amount of treatment time. If you happen to have a PEMF system that runs continuously, then you can use that for as long as you wish without having to reset it after each treatment run.

There is no hard and fast rule as to the maximum treatment time that can be used. PEMF manuals may indicate what they recommend, but recall that it is almost impossible to do harm. You cannot overdose on the PEMFs I recommend. If you listen to your body, it will tell you when it has had enough for that treatment session or that day, usually in the form of jitteriness or a feeling of excessive energy.

Selecting treatment locations

The best place to do a PEMF treatment is wherever you are most likely to use it. Some people relax, nap, read, listen to music, or watch TV or movies while they do their treatments. Most PEMF treatments tend to make you relaxed and many people report that even reading can be challenging while a treatment is happening.

Most PEMF systems—except for the high intensity ones—will not interfere with electronic devices, meaning you can usually do work on a computer, laptop, or mobile device without problem. However, with high intensity PEMF systems, I have personally blown two remote control units and had my laptop freeze, fortunately without any damage. The rule of thumb is that with high intensity PEMF systems, electronic devices should be kept about two to three feet away. Always follow manufacturer instructions.

Using low vs. medium vs. high intensity systems

Every PEMF system has limitations or characteristics for treatments, and these will determine how you use your device and how you will see benefits happen. As stated above, the time that a person has available for treatment will also be another major limiting factor. Deeper, more involved, complicated, and more severe problems will take longer to heal and require more treatment time. Low intensity systems will take the longest, typically. There are always exceptions to this rule.

Even if one wants a high intensity system for healing, there will still be the limiting factor of how the tissue can possibly respond. PEMFs cannot make tissues do anything they aren't naturally capable of doing anyway. Higher intensity and more time do not always get the job done faster or better. While little harm can be done from extended exposure, results may not happen any faster, nor as fast as one expects or hopes. Finding the right balance then of time and intensity becomes the determining factor in the success and timing of healing.

Treatment consistency

It's preferable to do daily treatments with your chosen PEMF system as opposed to infrequent high intensity treatments or an increased intensive number of treatments back to back to speed things up. The dynamics or momentum of the underlying problem often determines the level of intensity or density of number of treatments.

Understanding the "momentum" or aggressiveness of the particular negative process of the tissue will tell you how often you have to treat. For example, if we are treating pain and the PEMF reduces the pain significantly but it returns in four hours in the first few days of initiating treatment, then it may be best to repeat the treatment every four hours. Over the ensuing few days, it may take six to eight hours for the pain to come back. With continuing treatment, the time that pain may return usually gets longer. In these cases, the interval between treatments would then increase gradually as the healing process of the body progresses and takes more permanent hold.

I see people who have pain relief for weeks after a single treatment and then, as the problem seems to be returning, they do another treatment, which then may also last for a few weeks. Other people do not achieve pain relief until two or three weeks after they've begun the treatments. Consistent daily home treatment then becomes much more important to be able to keep up with the frequency of treatments the body needs to continue to maintain relief and effect more permanent healing.

In time, the hope is that the pain-relieving treatments are not needed at all and then the PEMF system can simply be used for health maintenance or until a new problem arises (which one inevitably will). Thankfully, your PEMF system will have you ready to deal with it.

Special considerations: referred pain and trigger points

Referred pain presents in an area different from its source and it must be treated differently than traditionally presenting acute or chronic pain. There are numerous areas in the body where pain is felt remote from the actual area causing the pain. Knowing whether you have referred pain or not is important, since it will change the approach you take for the treatment. A problem in the back may lead to pain being felt in a hip, groin, or in the lower extremity. Treating the back would provide a better pain solution than treating the area where you feel the pain. Neck problems can be referred into the shoulders, upper chest, upper back, or down into the arms and hands.

In addition to typical neurological referred pain, you can have different referred pain patterns associated with trigger points. These are also managed similar to referred pain approaches.

Other information resources or clinicians can guide you on referred pain or trigger point patterns.

Using magnetically treated water

Science shows that magnetically treated water is more usable by the body and the cells. You can use expensive specialty waters, which may have unique properties, but once you own a PEMF system, you can create your own "activated" water.

There are no hard and fast rules with this process. Some Russian literature states that twenty-five minutes on a medium intensity PEMF device structures a two-liter bottle. Low intensity PEMF systems may have less of an effect or may take longer to create an effect on restructuring water.

I would not recommend using plastic or metal containers. Glass containers with plastic caps are preferred. PEMFs may be able to dislodge plastic molecules into the water, particularly for the lower density plastic containers.

If you are using your whole-body system and are lying on your back, simply place the container between your legs and expose the water to the magnetic fields for about twenty-five minutes. Minerals in the water would magnetically structure the water faster because of resonance and ion charge production effects. It's better not to use distilled water without adding trace minerals.

Water activated by externally applied magnetic fields may not hold the restructuring for a long time and therefore it needs to be consumed the same day it was produced. A fresh batch would need to be produced every day. There is no rule regarding how much water should be consumed for optimal benefits. I normally recommend the usual amount you need to stay hydrated.

This magnetically treated water can be consumed normally, and it may also be added to smoothies, to brew teas and make coffee, and for soups. It has been reputed to soften and make these other foods more savory. It may also be used as the water you give your pets and to water plants.

Scenarios of a few actual people I have consulted - with system recommendations

So far, I have presented basic information about how people can consider using PEMFs for specific health conditions. I thought it would be helpful to see how we work to recommend PEMF systems using actual individual situations. First, I determine the circumstances of the individual and then consider which PEMF system attributes would work best for them to produce the best results. Part of the consideration is to at least some extent set expectations for improvement or benefit. Every recommendation I make is individualized, but hopefully you will get some sense of the process. The recommendations below do not actually give the name of the specific system recommended. Many systems may be similar but not exactly the same and therefore results may vary.

1) A woman with multiple sclerosis. This fifty-nine-year-old woman had a low intensity whole-body system and a battery-operated medium-high intensity system. MS was causing minimal physical problems. She had some optic neuritis episodes, and a pen applicator helped. She had been using the portable system coils on either side of her head for less than a half an hour at a time. I recommended that she use the portable system for longer times, and recommended that she treat both the neck and head since many of the neurological issues caused by MS start in the brain and affect the spinal cord. The whole-body treatments should be continued daily to keep the tissues as healthy as possible.

2) A woman with electro-sensitivity. She was recommended a very low intensity whole-body system. Treatments should be limited at first in time and intensity, following the mantra of going "low and slow" because of her sensitivity. This system will allow her to increase the intensities and the amount of time of exposure gradually. The first several treatments should probably be no more than five minutes at the lowest intensity with the whole-body system. Depending on tolerance, these could be increased by five-minute increments and one intensity level every two to three days. The goal would be to reach the maximum time and the maximum intensity, however long that might take. Local application with a pillow applicator could be done to the lower extremities if sensitivity was too much.

3) A male psychologist. He wanted a PEMF system for himself and his work in psychology. Other psychologists have found that treatment of patients before counseling sessions produced much better results. I recommended a medium intensity whole-body system with a variety of frequencies and intensities. He needs to have the flexibility of selecting brain-tuning frequencies. He would also benefit from having a 1,000 Hz signal for depression in some of his clients.

4) A man with prostate cancer. This seventy-three-year-old has prostate cancer that has spread to a large area in the bones, the lymph glands, and to other bones. He has pain in the rib cage and in the shoulders. He also has post-herpetic neuralgia as a complication of shingles near the waist. He is doing chemotherapy. He was looking for a PEMF system to help with his pain and improve the results of the chemotherapy. I recommended a high intensity system to help to manage the pain and stimulate stronger bones. Ideally, treatments would need to be done twice a day for an hour each time.

5) A couple with multiple issues including osteoporosis and lung cancer. This seventy-two-year-old woman has degenerating discs and osteoporosis with a

history of several fractures. Her husband has lung cancer. She failed medical therapy for her osteoporosis. Help for osteoporosis will require a high intensity whole-body system combined with hormones, diet, exercise, and appropriate supplements. For the best results, PEMF therapy would need to be done twice a day for at least an hour each time given her significant osteoporosis and history of fractures. Setting expectations was important, since she wanted results quickly. I told her the bones don't heal that quickly, and that it would take at least a couple of years with repeat bone density testing to determine the results. Her husband should use the same system similarly to keep his body healthy and help the body deal with the cancer process, as well as to augment the results of any additional cancer therapies.

6) A man with sleep, digestive, and depression issues. This middle-aged male has sleep and digestive issues, along with high stress levels and some depression. He has a problem with waking up early, then working on his computer, and finally falling back to sleep. He had a low intensity whole-body system and a higher intensity localized sleep system. He was using the pillow applicator from the whole-body system for his sleep issues. I suggested a whole-body pad throughout the night to help with basic sleep. Alternatively, he could use the smaller sleep system at the headboard or under his pillow to help him to stay asleep. Since the smaller unit is higher intensity, it would likely do a better job of keeping him asleep. He was considering another PEMF system that did not have the specific sleep brainwave frequencies, so I informed him that this could be useful for other purposes, but would not likely help sleep. If he had problems finding time to use the whole-body system during the day for health maintenance, he could sleep on it all night running the brainwave pattern frequencies, which would still help with other non-sleep issues.

7) A man with multiple issues, including old injuries and heart problems. This fifty-four-year-old male has heart blood vessel calcifications and metabolic syndrome. He also wanted to heal old sports injuries in his knees and shoulders. He has a dog with hip and foreleg/elbow problems. He had looked at various machines and we discussed several systems. He didn't want to use a system that was operated from a PC, even though it would allow better frequency selection, and he wanted something with a comfortable pillow applicator. He liked the idea of being able to have some selection of frequencies but wanted a relatively simple system to operate. I recommended a medium intensity whole-body PEMF system with built-in programs.

8) The wife of a man with multiple issues. This retirement-age female's husband had Parkinson's, diabetes, chronic cough, and a heart condition. He

was bedridden. She already had a low intensity PEMF system and was only using the whole-body pad for eight minutes at a time, based on the recommendations of a previous salesperson. The applicator was placed primarily over the upper half of his body because she had difficulty rolling him over to put the PEMF body pad under him. I recommended that she begin increasing the amount of treatment time and intensity gradually every several days until she reached the maximum time and intensity. Because of his Parkinson's disease, she should use the pillow applicator to the back of the head and to the upper back for his lung issues, separately at other times of the day. This would actually make it easier for her, because then she wouldn't have to roll his whole body over. Had she come to us before making this purchase, we would have likely suggested a higher intensity whole-body system.

9) A man with adverse reactions. This middle-aged male was treated in a practitioner's office with a very high intensity PEMF system for back and hip pain. He experienced a dramatic increase in his pain. It was clear that he had an uncommon major reaction to what appeared to be inappropriately high intensity treatment. This was almost certainly due to the fact that he had artificial metallic discs and metal in his right hip. PEMF systems do not normally cause a problem with metal implants unless they are powerful and used too strongly. I recommended a medium intensity battery-operated system that would provide more gentle treatment throughout the day to create better healing and the more comfort, while allowing him to maintain his usual activities.

COMBINING PEMFS WITH OTHER THERAPIES

Magnetic therapies can and should be combined with other types of therapeutic approaches. Rarely will they interfere with each other. I usually recommend basic nutritional support and supplements. The goals for treatment need to be identified and the physical abnormalities understood. This will guide how to combine treatments, if at all. Some issues can be managed without the need for other types of treatments. Always consult your physician before beginning a new therapy.

Acupuncture

PEMF therapy may be used at the same time acupuncture is being used.

Acupuncture needles are stronger in action locally than most PEMFs, except for higher intensity systems. Needles with electrical current applied are even stronger. Moxa, acupressure, and cupping are not typically as strong as PEMFs. When I think that acupuncture is the desired therapeutic approach to help with a given problem, I usually recommend a PEMF system first. Acupuncture may be most cost effective for acute problems, but PEMFs are usually a better longer-term solution for chronic problems since they can be used at home.

Since PEMFs act directly on cells and tissues in the area of the magnetic field, an area larger than the area of an acupuncture needle, I recommend using them together to gain the benefits of both. For example, for spinal arthritis, a deep joint problem with significant pain, multiple tissues are often involved. The PEMF will address any edema in muscles, ligaments, or nerves, relax muscles, and start cellular repair of both joints and other soft tissues. Acupuncture helps pain almost immediately but is less likely to have a longer-term benefit. The secondary actions of acupuncture on the immune system, other hormones, and repair mechanisms take more time to play out. This means that with both therapeutic systems, the primary actions of both are more active than waiting for secondary actions of either one to kick in.

If someone were using both types of therapies on the same day but not simultaneously, I would suggest doing the PEMF treatment first and then follow later in the day with the acupuncture.

Massage

Massage works well directly on the muscles, superficial soft tissues, and ligaments. It helps to stimulate acupuncture points and meridians, improve circulation to tissues, relax muscles, and secondarily to flood the body with endorphins. Since many toxins and wastes are stored in muscles because of a great amount of tension and related blockages of circulation, regular massage would help provide rapid structural relief.

Massage and PEMF therapy significantly improve the benefits of each other. PEMFs used prior to massage would help the client in general and specifically help muscles to relax prior to the massage. That would allow the massage therapist to get deeper into the tissues more easily.

Regular daily use of whole-body PEMFs at home will decrease the need for massage by keeping tissues detoxed and relaxed more consistently, and by keeping the cumulative physical effects of stress to a minimum. The combination of regular local or whole-body PEMFs and massage would keep the body from aging as fast and prevent problems from developing or worsening.

I would place osteopathic, chiropractic, or physical therapy manipulation alongside massage in terms of potential magnetic field use and how to think about it as discussed above.

Infrared

The two types of infrared therapy are far infrared (FIR) and near infrared (IR). Infrared is primarily used to generate heat in tissues. In addition to generating heat, FIR/IR also introduces high frequency EMFs into the body. Infrared does not typically penetrate the body deeply, with a FIR/IR signal usually dissipated within one to two inches into the body because of interaction with the tissues. This is one of the reasons why FIR/IR is used in saunas to detox the body, primarily through the skin.

There are both passive and active FIR devices. The active infrared systems are driven by using electrical line current and tend to create more dynamic action in the body than the passive systems. Active systems tend to be used in practitioners' offices. The passive systems are usually designed for personal or home use, and radiate FIR signals using either ceramic or fiber materials. FIR systems have been designed for whole-body applications, including in saunas, blankets, covers, clothing, and others. Active FIR, especially applied to the whole body, tends to generate more heat in the tissues than passive FIR. ELF PEMFs more usually penetrate the body completely without loss of signal, as opposed to higher frequency FIR/IR, which get absorbed by tissue fluids.

FIR/IR, whatever the format, can be used alongside PEMFs to obtain additive benefit. FIR/IR will tend to help local, superficial musculoskeletal problems more dynamically and quickly than many PEMFs, especially low intensity systems. This means that if someone owns a whole-body PEMF system, they can still use an FIR sauna or a local FIR/IR treatment device. For the circumstance of an acute arthritic or musculoskeletal problem I am more inclined to use FIR/

IR to start with for several treatment sessions followed by longer-term PEMF management, especially if I think the underlying problem is or is likely to become more chronic.

Some FIR/IR systems actually use red colored diodes for their IR signals. In order to generate current to the diode, AC current may be modulated in such a way as to introduce ELFs as well as the diode frequencies into the body. This would then make such a device a dual treatment system—using IR and ELF simultaneously. This type of system would be expected to be even more dynamically acting than simple FIR/IR by itself.

As with many other therapeutic approaches, I would suggest using PEMFs before using FIR/IR if they are going to be used on the same day. However, if the FIR/IR creates a significant amount of tissue reactions, then PEMFs can follow the treatment.

Laser

There are essentially two types of laser therapy systems. One is tissue destructive and the other is tissue-healing enhancing. The latter is usually called low-level or cold laser. Low-level lasers are often used in a similar way to FIR/IR. Their beam is very narrow and focused. Because of this level of intensity, they are able to penetrate the body more deeply and can often even pass through less dense areas of the body, such as the hands. More expensive professional models with much higher laser intensities are more likely to penetrate deeper, even thicker body parts, such as the abdomen or lung. Lasers can be used with different colors and therefore have not only the laser light benefits but also may add a benefit or value related to the color being generated. Most, however, are red.

Unlike FIR/IR, laser is used primarily for local area applications. PEMFs can be used alongside laser. Because of the intensity, very high frequency, and focus of the laser beam, PEMFs will have use in a wider area of treatment and will interact with tissues at lower frequencies. Lasers cannot be used safely around certain body structures, such as the eyes and brain. PEMFs do not have these limitations.

Chelation

Chelation therapy, whether IV or oral, creates significant movement of electrolytes, minerals, and metals in and out of cells. This movement, especially of calcium, sodium, and potassium, may create significant interaction with PEMFs. We don't have extensive experience with chelation and PEMF used concurrently. Based on two cases that came to my attention, because of significant temporary side effects, I have begun to recommend that chelation and PEMF not be used on the same day. The primary side effects were significant fatigue and weakness. Both of these passed within twenty-four hours without harm. There is more chance of a temporary negative interaction with whole-body exposure. At this point, because of our minimal experience, we do not advocate whole-body exposure around the time of chelation until practitioners who use both therapies have gained more experience and can give us better guidance.

Light therapy

Active light therapy can include lamps or lights that radiate specific colors, having colored crystals applied, natural spectrum lighting and so on.

Light therapy is most typically a whole-body treatment approach. Specific colors are used for specifically intended actions. Most light therapy, except for that used for seasonal affective disorder (SAD), is often intended for specific actions. Lighting systems are limited by the thickness of the tissues exposed and often blocked by clothing. There is a significant amount of attenuation, absorption, and diffraction of light as it moves into the body. Many of their resonant effects are due to the stimulation of the optical nervous system and not the tissue directly.

For these reasons, PEMFs would not be expected to interfere and may be used concurrently with light therapies. As with most other therapeutic modalities, light therapy practitioners may not understand PEMFs and recommend against them, if asked, since they would also like to see what the effects of their own specific therapeutic systems are without interaction or interference. Some research also indicates that PEMFs may act like light therapy, even though their frequencies are considerably lower.

As before, if somebody is doing light therapy, then PEMF therapy should be done first to avoid frequency interference.

Ozone therapy

Many of the effects of ozone therapy are comparable to PEMFs. Ozone therapy tends to work internally to create the production of oxygen in the tissues. PEMFs improve circulation and oxygenation as well, separate from an ozone action. Research in Cuba has found that combining PEMF therapy with ozone increases the benefits of ozone over standard therapy for arthritis of the knee. As with many other therapies, ozone usually requires application by a practitioner. To be effective, ozone has to be absorbed by the tissues, enter into the circulation system, and then be distributed into the tissues needing therapy. By the time the ozone gets into the tissues needing treatment particularly, it may be dramatically diluted. This is why ozone therapy would be more successful if combined with PEMFs.

Other resonance systems

There are many other therapeutic, energetic, and resonance systems that may be used that were not discussed above. If you understand the principles of resonance, have a basic understanding of the nature of PEMF actions on the body, and understand the conditions for which treatment is being sought, the interaction of PEMFs may be considered. Generally speaking, PEMF therapy is safe for use with most other modalities and would usually be best applied before any other resonance therapies are used on the same day.

LIFESTYLE AND NUTRITION

Magnetic therapies have a large array of actions that support health and reduce the problems associated with many health conditions. These actions work to produce even better results when they are part of a more comprehensive approach, including a supportive lifestyle, good nutrition, and quality supplements. A depleted body does not have the capacity to heal itself as well, even with great stimulation.

In general, since inflammation is a component of most health conditions, an anti-inflammatory diet is usually helpful. A diet consisting heavily of raw vegetables and fruits would be the most anti-inflammatory. It's a good rule to eat foods in the original package nature provides, so the raw components and materials are important here.

When you drink a glass of orange juice, for example, you are getting the sugar equivalent of up to six oranges. When the sugar is liberated from the fiber of the pulp, it becomes much more readily absorbed into the blood, and that rush of sugar is never good. Were you to eat the whole orange instead, you would not only avoid this sugar rush, but also get the health benefits of the fiber and bioflavonoids.

Another important aspect of healthy eating is nutrient density, which has to do with how much nutrition there is in a food in comparison to how many calories are present. Colorful foods tend to have the most healthful qualities, if not in vitamins and minerals, then in phytochemicals like carotenoids.

The debate surrounding vegetarian versus omnivore living is not one to put much stock in, since it is possible to be very healthy or very unhealthy eating either way. If you choose to be vegetarian, be sure to supplement nutrients where needed, and consume plenty of sources of vegetarian protein. If you choose to eat meat, make it lean. It is generally accepted that fried or cooked fats derived from animals (meat, dairy, seafood) are strongly inflammatory in the body. To offset the free radical or oxidative stress caused by these foods, once again, raw fruits and vegetables are the answer.

Finally, it is incredibly important to drink plenty of water, especially when using magnetic therapies, because energy transfers more easily in a body that is well hydrated. The magnetic signal actions will be the most robust in a body with adequate hydration levels.

Because today's foods (including non-organic fruits and vegetables) are often quite depleted and do not contain sufficient amounts of needed nutrients to allow our bodies to function at optimal levels, a good absorbable, broad-spectrum multi-vitamin is important. It will act as a security blanket, covering common diet deficiencies. In addition to a good multivitamin, we recommend that most people take a basic foundation of supplements. These will support the body's general health regardless of underlying health conditions.

Since PEMFs depend on and affect electrolytes, minerals, proteins, fats, and carbohydrates, the lack of or imbalance of these substances is likely to affect the value of PEMFs or any natural healing capability, even processes that are totally normal in the body. A good example is bone healing, a common use of PEMFs. Numerous basic substances are necessary to maximize the growth of new bone. Calcium may be the least of these. Others include manganese, magnesium, Vitamin K, strontium, boron, and silica. If these are not present in the right amounts, bones will not repair properly. That means these factors need to be present as well for EMFs to generate the best results.

In addition to a good quality multivitamin, I recommend these basic supplements:

- vitamin D3 (for most adults 5,000 IU daily)
- omega-3 fatty acids (3,000 mg a day)
- vitamin C (either a sustained-release formula of 1,000 mg twice per day, or general vitamin C 1,000 -2000 mg three times per day)
- curcumin 500 mg twice a day – to reduce inflammation
- magnesium (any form) 350-500 mg/day

When using PEMF therapy, it is important to maintain the proper levels of magnesium in the body. Magnetic fields cause a great deal of ion motion in the body, especially calcium ions. Magnesium is what calcium latches on to as it moves in and out of the cell, so a magnesium deficiency may undermine the value of the magnetic field treatment.

In addition to the foundation supplements, I recommend various supplements based on what a person hopes to treat. Supplement suggestions beyond these basic recommendations would be best guided by personalized professional advice from your holistic or natural practitioner or nutritionist.

CAUTIONS

General

Adverse reactions can happen with PEMF therapies, but they are usually mild. In fact, PEMFs have been proven many times over to be safe even with very high intensity treatments to the brain. Because magnetic therapies have a wide array of actions within the body, it is common to experience some discomfort, especially when treatment has just begun. Illness or disease can become entrenched in the body. The body does what it can to isolate the problems to allow us to continue to function. If we are to repair these deep-seated imbalances, we will inevitably cause reactions. You are not going to remodel a house without creating disruption and removing or repairing the old to allow it to be replaced and made new.

It is our experience that symptomatic reactions happen about 1–5% of the time and tend to be more common when the entirety of the body is treated as opposed to local treatments. Such reactions are commonly seen in other therapies, including the Jarisch-Herxheimer (Herxheimer) reaction seen with antibiotics and aggravations in acupuncture, deep tissue massage, and so on.

Most of these reactions are mild and temporary. Unlike medications (which have to be processed until fully removed by the body) or surgery (which causes its own wounds that must heal), PEMFs do not leave anything behind. Reactions are simply a re-setting of imbalanced processes. It usually hurts to remove a Band-Aid or to set a broken bone. Similarly, PEMFs may cause discomfort during the initial restorative process.

Magnetic therapies alter circulation, stimulate cell and tissue repair, stimulate nerve cells, cause mental and muscular tissue relaxation, affect blood pressure and heart rate, alter the absorption of medications and nutrients, affect acupuncture energy movement, stimulate vision changes, and a myriad of other actions. So, overreactions by the body, perceived or measurable, do happen.

Sudden increases in circulation, especially in areas with restricted or reduced blood flow, may lead to uncomfortable increases in blood flow for a short time after the magnetic field has been applied. While increased circulation is usually positive, it can lead to a surge in oxidative stress. The body will have to respond to this, as it will to any other oxidative stress, including breathing in. It is helpful to have adequate antioxidant support in the body before beginning treatment. Sudden improvements in circulation may also lead to aggravations of existing extensive or severe inflammatory processes, typically in internal organs, the skin, muscles, or joints. Aggravation of existing hives is likewise possible and should be considered before starting treatment.

When nerve cells are suddenly stimulated, pain may be temporarily aggravated due to the increased signal traffic in theme or improved circulation. We see this in individuals who have had prior fractures or scars where nerves have been torn or damaged. Magnetic fields applied distal to the fracture site or scar may temporarily cause pain at the fracture or scar site, even if the injury is old. A sudden burst of sensation passing through the fracture or scar site tissues back to the central nervous system may be unexpectedly, unusually irritating.

One of the most important things to know about a new onset of pain is that it's best to understand what its source is so that a major developing problem in the body is not masked by the successful management of the pain itself. For example, the pain of appendicitis may not seem like it may be related to an inflamed appendix. If the pain area is treated with PEMFs, it will be reduced, but the inflamed appendix may continue to develop if not adequately treated. Appropriate medical attention is necessary to prevent a major problem. So, for new pains that you've never had before, especially from internal organs, it's better to get a professional opinion to determine the probable cause before doing aggressive PEMF treatments.

If there are multiple blockages along the body, magnetic treatment may cause the phenomenon of "chasing the pain." In this situation, when one area is treated and improved, another area that may have been previously quiet now begins to show pain or discomfort. Normally these problems are not a concern, but should be recognized as a normal consequence of magnetic therapy. In some situations, where the magnetic therapy causes pain in a body part that does not normally have pain, this may be an indication of a significant unidentified underlying problem in that body part, and medical evaluation should be considered. In this case, the magnetic therapy serves as an early warning process. I have seen this several times; the individuals were warned and received appropriate intervention earlier than would have been likely otherwise. This kind of early warning alarm prevented much worse future damage.

Magnetic therapies commonly lower blood pressure and decrease heart rate—actions that are usually positive. However, these actions can pose a concern for individuals who are elderly, on medication with blood-pressure-lowering actions, are frail, have easily altered blood pressures, have been on extensive bed rest, are in shock, have overwhelming systemic infection, or who have non-brisk compensatory vascular reflexes. Because people in these situations can feel faint when rising from a seated or lying position, they should be warned about this possibility and the need to allow the blood pressure and heart rate to stabilize when changing positions. Usually these reactions settle down as magnetic therapy continues and stabilizes body functions and other appropriate interventions are taken that support the body, such as increasing hydration or improving nutrition. Similar situations happen throughout healthcare constantly. As a result, adjustments in therapy are made to achieve positive outcomes.

General reactions occasionally happen as well, particularly in those who have or are suspected of having magnetic field sensitivity. In individuals with electrical hypersensitivity and electromagnetic hypersensitivity, these reactions are more common, more uncomfortable, and possibly longer lasting. Rarely does magnetic therapy have to be discontinued as a result. Most of the time, small adjustments in the treatment protocol (such as lowering intensity, lessening treatment times, and limiting the amount of the body exposed to the PEMF) will resolve the issues.

Possible electromagnetic hypersensitivity reactions include increased fatigue, aggravations of sleep, increased pain, vague weakness or loss of energy, metallic tastes, dizziness, brain fog, thirst, increased urination, warmth or cold sensations, prickly sensations in the skin, colors in the visual fields, heaviness of the extremities, and palpitations. Mostly, people who experience these reactions are thought to have systemic blood pressure control problems or autonomic instability or neurotoxicity due to chronic infections, chemical sensitivity, or environmental toxicities. Many have chronic regional pain syndromes (RLS), fibromyalgia, or chronic fatigue syndrome. The degree of the sensitivity reactions will determine the approach to take with adjusting the magnetic therapy.

In these hypersensitivity situations, PEMF therapy must be used low and slow, meaning with a low intensity and short treatment times. Even with the best attention, benefits may be more difficult to achieve because the appropriate and necessary intensities are not possible. Still, results can be dramatic. Most of these individuals need to be on a significant supplement and nutrition program to achieve the best results.

PEMFs can open cells and cell membranes to the point of unloading toxins stored in the tissues of the body. This type of response is, in the long run, a desirable action. However, it may be unpleasant while it is going on. The length of the detoxification will vary from patient to patient. Rarely will PEMF therapy have to be stopped. Those individuals with multiple chemical sensitivities may find magnetic field therapy intolerable until the major detoxification can be achieved.

Research in the pain management program at Hopkins found that some individuals with chronic pain have personality traits that result in poor treatment outcomes. These individuals often experience negative reactions even to placebo magnetic fields. When they are followed over time, some complained that their problems had been made worse by the (placebo) treatments. In these situations, it is not possible to help individuals with these personality traits adequately, and therefore PEMF therapy is not an appropriate treatment modality for them.

Since many health problems for which PEMFs are being used are stubborn and chronic, it may take up to six months to achieve desirable results. If the treatment program is too gentle, the intensity insufficient, or there is an inadequate amount of time spent on the system being used, results may not be seen in the first few months and therapy has a higher risk of being abandoned prematurely.

Interaction with medications

By strongly affecting various physiologic processes and enzyme and chemical actions in the body, PEMFs may interact with medications. Since magnetic fields open cell membrane channels, medications, supplements, and nutrients may more easily gain access to cells. Some medications have narrow toxicity profiles and require close monitoring, including regular or frequent testing. These may include monitoring blood sugar levels in those on insulin, where blood sugars tend to run in a low range of normal. Seizure medications, some medications for serious neurological conditions, or medications for major heart rhythm disturbances may require closer monitoring with the initiation of PEMF therapy, especially when whole-body or more intense magnetic field strengths are being used. If there is a concern about the use of PEMFs end interactions with medications, consultation with your doctor is recommended. In most cases, this type of interaction is desirable, since medications, nutrients, or supplements may be more effective because they access the cells better. This has been shown to be true for chemotherapy for cancer, which appears to be more effective when combined with magnetic therapies. It is presumed that this is because the chemotherapy is able to penetrate the cancer cell membranes better.

Some people confuse this action with electroporation. In electroporation, electrical fields are used to punch through cell membranes to deliver medication or genetic material. Electroporation unfortunately leaves the membrane damaged. Nothing anywhere near close to this happens with PEMFs. There is simply an improvement of the natural movement of molecules across cell membranes. PEMFs do not create unnatural cell membrane motion.

Dealing with adverse reactions

The best way to deal with potential adverse reactions is to anticipate them. Once the potential circumstances for these are identified with careful history taking or understanding of the individual, explanations may be given for the possibility of these reactions. Most commonly, they can be managed by simply continuing the therapy, since they are usually temporary. Once the body adapts to the stimulation from the magnetic fields, the reactions will decrease and stop. The more deep-seated the physiologic disturbance, the more care needs to be taken with how the magnetic fields are applied initially in intensity, frequencies, and duration of treatment, and then adjusted for optimal use. For more physiologically and psychologically robust individuals, the magnetic fields can continue to be used along with appropriate symptomatic support until the body adjusts to the treatment.

For individuals who have experienced more severe chronic pain or physiologic disruptions, small changes in physiologic reactions can be intolerable. In these individuals, magnetic therapies should be initiated at the lowest level of strength possible for the shortest periods. Some practitioners have suggested initially using magnetically treated water, and in some cases, this is necessary before magnetic therapy is even started. With some individuals, appropriate nutritional and supplement support is necessary for several weeks prior to initiating magnetic therapies. Once the physiology is better stabilized, magnetic therapy reactions are less likely. Appropriate mineral, vitamin, amino acid, and antioxidant supplementation may be required. Since magnetic fields have been found to decrease melatonin levels in some individuals (more commonly females), melatonin supplementation may be helpful.

Rarely, adverse reactions appear after magnetic therapy has been in place for some time. In this circumstance, it's likely that a new level of underlying imbalance is being uncovered or a new problem has arisen. If it is the former, the settings used prior to the beginning of side effects should be reapplied for one to several weeks to allow for further accommodation of the body. My usual approach is to decrease the field intensity first and if that does not improve the reactions, then I would adjust the amount of time of exposure. If it is the latter, an evaluation by a clinician may be necessary to determine if there is a new issue developing.

Adherence with supplementation support should also be confirmed. When people start feeling better, often, their usual care routines are dropped and previous problems reemerge. This is a good sign that healing is not yet complete. Also, when people start feeling better, they will often pick up their activities, which can then aggravate the underlying problem or cause a new problem to develop. Remember, the body takes time to heal, and while improvements with PEMFs can be dramatic, the body will tell us when it's ready for the next steps.

CONTRAINDICATIONS

The only absolute contraindication for use of a PEMF device is placing an active applicator over implanted electrical devices like pacemakers, defibrillators, cochlear implants, intrathecal pumps, and many others, because the magnetic field can shut the device off or otherwise interfere with its function.

Safety of PEMFs has not been established in pregnancy, although there is no evidence of harm. Therefore, because of the lack of evidence of safety, most manufacturers warn against using PEMFs therapeutically during pregnancy.

PEMFs are contraindicated in organ transplant patients. This is because these people are on immune suppression to prevent organ rejection. We do not want to risk adversely affecting the immune suppression/rejection process. There is a chance that PEMFs may actually stimulate or activate a more aggressive rejection process by stimulating the immune system.

PEMFs should be used with caution in active Grave's disease or in the case of active bleeding. In Grave's disease, PEMFs may stimulate the thyroid gland to produce more thyroid hormone. This is not desirable because the thyroid gland is already producing too much thyroid hormone. In the case of active bleeding, PEMFs decrease the stickiness of platelets, normally a desirable aspect of PEMF therapy, and do not allow the body to create a proper clot to stop the bleeding.

Very high intensity PEMFs should be used with caution or only with professional guidance in people with implanted metals such as joint replacements, dental implants, mechanical heart valves, metal stents, or metal staples in blood vessels. With implanted metals, very high intensity PEMFs may stimulate the nerves in the area of the metal, creating significant pain. It's unlikely that permanent problems will develop, but the increased pain will not be well tolerated. Metal clips placed in or near blood vessels are already under shear stress. High intensity PEMFs may add to this shear stress and should be avoided.

Do not use high intensity PEMFs over breast implants. Use caution with high frequency PEMFs (beyond 100 Hz) because of the risk of agitating the plastic or silicone in breast implants, which could possibly cause thinning and risk of leakage.

PRECAUTIONS

Despite PEMF's generally recognized safety, account must be taken of some possible actions that should be considered in using this therapy. While few of these are serious, they must be anticipated and people should be alert to their potential.

Precautions should be taken in introducing PEMFs with people with autoimmune disorders, particularly those with severe conditions. In those situations, our motto is to go low and slow. Use a low intensity to begin with, gradually progressing the time and intensity to tolerance.

Adrenal gland, hypothalamic, and pituitary dysfunctions that are clinically significant enough to be endocrinologically or physiologically symptomatic may be over-stimulated by PEMFs before the body is ready to deal with that level of stimulation. Again, the rule is to go low and slow.

Active infections, whether bacterial or viral, should be managed appropriately medically because PEMFs may not have a predictable or fully reliable benefit. However, once medical therapies are initiated, PEMFs may be used to help with the management of the infection.

Cancer is not a contraindication to the use of PEMFs. However, the sickest individuals who are the most depleted by their cancer therapies are going to be the most vulnerable to excessive PEMF stimulation. Go low and slow here as well. Current evidence appears to suggest that PEMFs can be an appropriate complementary and integrative approach to use in the management of cancer, along with behavioral management, nutrition, and lifestyle.

Individuals with psychoses should only be managed by experienced professionals in attempting the use of PEMFs. There is new and ongoing research exploring the use of high intensity PEMFs to the head in these conditions, but there may be unpredictable results, unexplained relapses and, in combination with powerful psychotropic medications, PEMFs may cause significant reductions in blood pressure and destabilize patients under control. Appropriate use and understanding are required to prevent problems.

Based on available research, PEMF therapy appears to be useful in the management of neurological diseases with seizure disorders, but any expectation of stopping medication needs to be mindful of clinical and legal implications. PEMFs need to be applied in these situations with caution and careful consideration.

Excessive menstruation is similar to active bleeding and PEMFs need to be used with caution so that blood loss is not increased.

Caution should be exercised in people with known low blood pressure, or predisposition to it, as well as people with severe or accelerated hypertension since sudden, significant blood pressure decreases may occur, causing vertigo or fainting. This reaction usually disappears within thirty minutes after the exposure and adaptation usually begins after five exposures.

SAFETY

The safety of PEMF treatments has been thoroughly studied. The two primary concerns are exposure time and intensity level. Each of the hundreds of research studies cited in this book was, in a way, also a test of the safety of the stimulation itself. Even those studies that did not conclusively show a benefit at least showed few if any adverse effects.

There are no long-term PEMF therapy studies in humans. Long-term occupational exposures provide some information regarding PEMF risk. For example, assessments were done of utility workers occupationally exposed to strong electromagnetic fields (EMFs), either doing live-line maintenance tasks or in substations, for at least one year. The live-line workers were exposed to magnetic fields as strong as 7 mT (70 gauss) peak. Substation live-line maintenance workers were exposed at lower peak magnetic field levels of up to 700 µT (7 gauss). Substation workers suffered from long-term illnesses at an annual incidence of 95 per 100,000 while it was 200 per 100,000 for control employees. The workers exposed to strong EMFs do not seem to be at increased risk for any specific health problems [82].

The highest intensity PEMFs most humans will ever be exposed to are those produced by an MRI machine. Most MRI machines produce intensities between 15,000 and 30,000 gauss (1.5 – 3 T). Like the therapeutic PEMFs discussed in this book, the diagnostic magnetic fields produced by an MRI are non-ionizing. Though guidelines suggest pregnant women only undergo MRI when essential, there have been no demonstrable effects of these high intensities on a fetus, suggesting their safety even on tissues as sensitive as those in a developing baby.

There are only a few FDA-approved PEMF systems on the market. The primary mandate of the FDA is to ensure safety, even before proving efficacy of treatment. Keeping that in mind, we can examine the treatment parameters for one such FDA-approved PEMF system, the NeuroStar. This system (which uses the acronym TMS—transcranial magnetic stimulation—instead of PEMF) is indicated for major depressive disorder and is an extremely high intensity system with stimulation aimed directly at the brain. NeuroStar type systems produce intensities comparable to those of an MRI machine. Stimulation intensity in these types of systems is usually measured based on the Motor Threshold, which refers to the intensity required to cause muscle contractions when the coil is placed over the primary motor cortex of the brain. This intensity will vary from patient to patient, so protocols are usually measured as a percentage of the Motor Threshold, where the person administering the treatment will turn the intensity up until the patient experiences muscle contractions, and then either leave the intensity there, or turn it up or down somewhat. The most common Motor Threshold parameters are between 90% and 120%. Average treatment sessions last for forty-five minutes. In

NeuroStar clinical trials, more than 10,000 treatments were administered with no occurrence of adverse side effects.

Below, we have selected a variety of studies done on the safety of PEMF therapy, covering a wide range of treatment parameters including both high intensity treatments and long-term exposures.

Safety of stimulation of the brain

When PEMFs are aimed at the brain for any reason, concern about safety and risk of brain harm is automatically raised. There is much evidence to suggest that there is minimal risk, with a significant potential for benefit. The safety and risk of PEMFs have been assessed in a number of studies.

In one such study, no significant side effects were seen after intense TMS or rTMS treatment programs. One patient received seventy treatment sessions over twelve months, or 420,000 pulses, with no side effects. One seventy-five-year old patient received 130 sessions over twenty-six months with a total number of 156,000 stimuli, while seven patients received sixty sessions over twelve months with a total number of 72,000 stimuli [371]. In another study, healthy men were given 12,960 high intensity rTMS magnetic pulses a day for up to three days in one week. This equals 38,880 magnetic pulses over one week, one of the largest exposures of rTMS reported to date. Despite this intense treatment regimen, no significant side effects were seen [10].

Even in the setting of relapsing remitting multiple sclerosis combined with TBI, no patient showed problems [180]. PEMFs even appear to reduce the risk of seizures [319] and do not promote brain glioma tumor growth [378]. Newborn brains are considered especially vulnerable. The brains of newborn rats exposed to high intensity magnetic fields did not show any evidence of harm [110].

Regarding seizures and epilepsy

As long as I've been working with PEMFs, people have always expressed concern that having them around the head may cause seizures. There is now a large body of research regarding the use of PEMFs of different intensities and their association with seizures. Most of the evidence indicates that PEMFs are unlikely to cause seizures, even with high-intensity PEMF systems. Research at the University of Louisville School of Medicine done on a patient with partial seizures un-responsive to medications found that the number of seizures during the month of stimulation as compared to the month before stimulation, was reduced by 70% and there was a 77% reduction in the risk of seizures between episodes of seizures. No seizures occurred during slow frequency (about 1 Hz) TMS. If anything, the TMS inhibited the cortical brain hyperactivity normally seen in these brains [278]. Another review of localized epilepsies of the limbic area of the brain showed no significant EEG spike activation, indicative of seizures, with rTMS. Instead, they saw reduction of epileptic activity in some patients [435].

People with intractable epilepsy often have invasive destructive brain lesions and are monitored preoperatively. Brain electrodes are implanted close to the suspected epileptic focus to monitor the brain while anticonvulsant medication is being reduced. rTMS stimulation did not induce any seizures. Not even brain electrical discharges were influenced by the magnetic stimuli. There is no evidence that magnetic stimuli activate known pre-existing epileptic areas, even in patients with low seizure threshold [407]. Similarly, TMS stimulation with a round coil held flat on the scalp over different positions did not trigger seizures or induce epileptiform discharges from the epileptic focus with any of the stimulation protocols in another group of individuals [106].

TMS in patients with loss of consciousness, some thought to be from a seizure focus, did not cause any seizures, even in situations with a history of epileptic seizures [240].

In partial or generalized epilepsy, TMS did not provoke seizures or EEG changes, especially in drug-treated epileptic patients. Long-term follow-up found that the epileptic condition was not made worse by TMS [450].

Based on this plethora of clinical research, both with the express intention of determining safety, and the thousands of studies done otherwise, magnetic field exposure has shown no important adverse side effects. PEMFs of wide ranges of intensity and treatment times are safe, regardless of the area of the body being treated, or the gender or age of the patient. Even pets and other animals do not appear to have issues.

Of course, there are contraindications and a small fraction of people may experience unpleasant reactions. Unless expressly stated as a caution or contraindication, such reactions are little more than disagreeable and can be reversed with a protocol adjustment.

CONCLUSION

Good health is not an accident; achieving it takes diligence, effort, and persistence. It is also not a destination to be reached, but an ongoing, lifelong journey. Good health also includes timely repair, recovery, and regeneration when the body is suffering, whether it's from a minor cold or severe trauma.

In scientific terms, we talk about primary prevention, secondary prevention, and tertiary prevention. Primary prevention is not allowing a problem to develop in the first place. Secondary prevention is to catch problems early in their course and intervene aggressively at that point to reverse the problem or condition. Tertiary prevention is to intervene aggressively with known existing health conditions so that they do not develop complications or progress.

All of these types of interventions not only require physical approaches, but also nutritional, mental, and emotional approaches. After nearly fifty years of medical experience, I've learned that all these approaches are needed to accomplish good health and recovery from disease and dysfunction. When any one of them is missing, healing is not optimal.

What we know from a large body of quality science is that the body is an electromagnetic apparatus. What is typically missing in the arsenal of tools used to achieve good health at all stages of prevention and treatment in modern culture is the addition of tissue energy enhancement using electromagnetic therapy. PEMF awareness has been growing gradually over the twenty-five years that I've been using them to help people improve their health and treat various health conditions. There are more and more companies introducing PEMF devices into the United States and Canada. Other parts of the world, especially Europe and Eastern Europe, are much more aware of magnetic fields for therapy.

I am often asked why PEMFs are not better known by not only the healthcare community, but also by the public. The answer is relatively simple: money. There are three aspects to this. One is the availability of funds to do research. The second is the cost of promotion and education to the public and healthcare communities as a whole. The third is the cost of the technology itself. Efficient and effective PEMF systems are complex and are often relatively expensive. They are not your typical off-the-shelf products.

One of the major purposes of this book is to inform the public that PEMFs have a wide range of uses and value across a variety of conditions for all levels of prevention. As a practicing physician with an academic health background, I want to be sure that you are aware that there is a large body of scientific evidence to support the use of PEMFs. This evidence shows the effectiveness of PEMFs, almost regardless of the type of system used. Each one has value. All health conditions can be helped to varying degrees, depending on the severity of the condition, the general health of the individual, the likelihood of the body to be able to heal itself and with appropriate application. All conventional therapeutic systems have significant limitations when it comes to doing tertiary prevention. But, because PEMFs can be applied to virtually every tissue in the body and help virtually every condition a body can get, they can be used across the full range of levels of prevention.

I tell my patients that I am not their doctor—they are their own doctors, and I'm only their consultant or educator. So too with PEMFs. I'm trying to teach you how to be your own doctor, in general, but more specifically with knowing what PEMFs are, how they work, what they do, how to select a system for your own use, how to use one, and how they are likely to help you and perhaps other family members or colleagues.

I thank you for letting me be a part of your healing village. I hope that as we continue to increase our knowledge of PEMF therapy, it becomes more readily available to the public, the public becomes more aware of it, and together we can help bring this power tool technology to those who need it most.

APPENDIX

The fundamental purpose of this book was to show the huge body of valuable scientific research that has been done on PEMF therapy. The body of work done on magnetism in general, however, is so far-reaching it could never be compiled into a single resource. To fully understand PEMF therapy as intimately as I do, these other aspects of magnetism are of significant value. We have elected to include this appendix to offer a more general education on peripherally related themes for those readers who want a broader understanding of the topic.

GEOMAGNETIC AND BIOMAGNETIC FIELDS

Earth's Static (DC) Magnetic Field

It is still not completely understood how the Earth generates its magnetic field, but it is theorized that it is due to the difference in the speed of the motion of the molten core relative to the motion of the planet's crust. Because of the variation of the depths of the crust, the surface magnetic field intensities vary around the planet, typically within the range of about 0.3 to 0.7 gauss, with the highest intensity at the poles and the lowest at the equator. Even away from these areas, there is significant variation in intensity around the surface of the planet. Earth's magnetic field lines are oriented north and south, and they are tight and close together at the magnetic poles, with the widest separation at the equator.

When people read about magnetic fields, they normally think about the north and south pole of the magnetic field. This is a source of significant confusion for people. The magnetic poles of the Earth are not the same as the geographic poles. The geographic North Pole of the planet is the south magnetic pole. When a compass needle points north, it is actually pointing toward the south magnetic pole. The compass needle is a magnetized piece of metal, with a typical north and south end. As with any magnet, likes repel and opposites attract. That means that the north end of the compass is attracted to its opposite, the south magnetic pole. While this discussion about the Earth's polarity is important for understanding its magnetic field, it is commonly also used when discussing static magnets. It is largely irrelevant to the discussion of PEMFs.

Human life is completely dependent on the Earth's magnetic field. This has been demonstrated in research by depriving the body of it. Since PEMF research and treatment done on humans always has the background field of the Earth present, this interesting fact is of little consequence. Other than humans landing on the moon, astronauts do not venture beyond the reaches of Earth's magnetic field, the magnetosphere. The moon is within the magnetosphere only six days of its orbital cycle. The International Space Station remains within Earth's magnetic field since it is in low orbit. The study of what would happen to the body outside of the field is of great interest and importance as humans consider venturing further out into space, beyond the moon and the magnetosphere.

Magnetic Rock Formations

The rocks on the surface of the planet are mineral structures. They are bathed in ions in the air and atmosphere around them. These ionic atmospheric currents can interact with the mineral content of rocks to induce small amounts of charge. Rocks can also have been hit by lightning, essentially making them into large static magnets. Plus, there are differences in local magnetic fields of the planet given the variation in the thickness of the Earth's crust, interacting with mineral rocks to different degrees. As a result, humans and animals moving on the surface of the planet, whether by walking, running, or riding can generate fluctuating charges (EMFs) in the body. These generated charges are what keep us alive and vital.

Geomagnetic Storms

Sunspot activity, aurora borealis, and solar magnetic storms coming through the polar regions of the planet also affect us. When these are of especially high intensities, they affect our communication systems, including radio, TV, cell phones, computers, and satellites. As these electronics are affected, so are our brains and bodily functions. Russian research has found that with increased solar activity some individuals who are particularly sensitive can have increased levels of seizures or even heart rhythm disturbances.

It's worth noting here that PEMF stimulation would not have such an effect on seizures or arrhythmias, however. (See section 3 for specific discussions on the benefits of PEMFs for these conditions.) In fact, regular use of PEMF therapy would be expected to decrease the likelihood of these types of overreactions from increased geomagnetic activity by helping the body to be better balanced and healthier overall.

Telluric Currents

Telluric currents, also called Earth Currents, are natural electrical currents flowing on and beneath the surface of the Earth (both land and sea) and generally following a direction parallel to the Earth's surface. Telluric currents arise from charges moving in or on the Earth's surface to attain equilibrium between regions of differing electric charge potentials; these differences in potential are set up by several conditions, including very low-frequency electromagnetic waves from space (particularly from the magnetosphere interacting with the Earth's surface), moving masses of charge in the ionosphere and the atmosphere and human activity.

Telluric currents interact in a complex pattern. They are extremely low frequency and travel over large areas at or near the surface of the Earth. They are known to have daily variations where the general direction of flow is toward the sun. Telluric currents continuously move between the sunlit and shadowed sides of the earth, toward the equator on the side of the earth facing the sun and toward the poles on the dark side of the planet. They are often used by geophysicists to map subsurface structures such as sedimentary basins, layered rocks, and faults.

Figure A.1 shows a map of telluric currents around the planet. These are natural and interact with geomagnetic activity, lightning storms, and magnetically charged minerals in the soil. The concept and potential benefits of "Earthing" relates at least to some extent to these Earth currents (*Ober*).

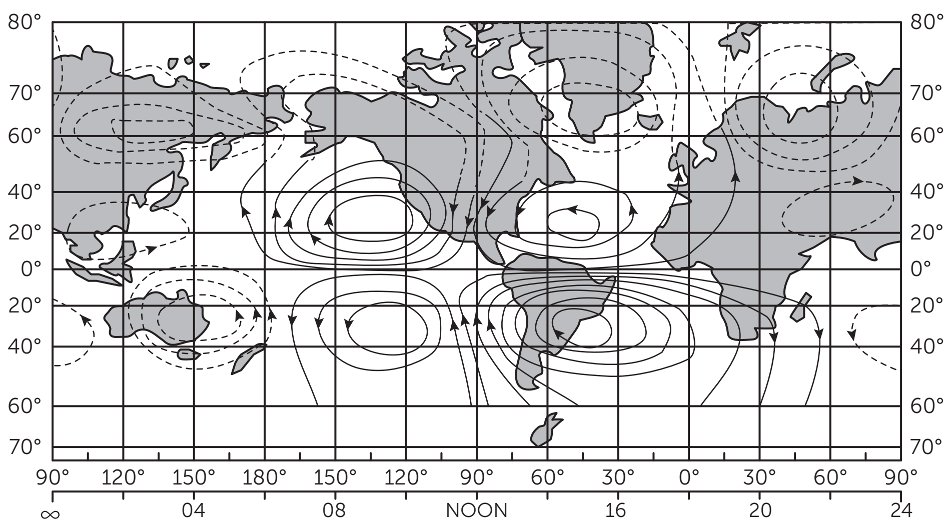

Figure A.1. Telluric Currents

With permission from: Lanzerotti, L.J., Gregori, G.P. (1986) Telluric Currents: The Natural Environment and Interactions with Man-Made Systems. pp.232-257 in Earth's Electrical Environment. NRC Geophys. Study Comm. Washington, DC, National Academy of Sciences.

Telluric currents should not be confused with man-made ground currents. Ground currents or stray currents can be caused by electrical wiring that is not properly grounded. Remember that all currents produce surrounding magnetic fields.

Magnetite

Human and animal bodies contain trace amounts of the crystal magnetite, one of the most magnetically sensitive minerals on Earth. Magnetite crystals have been found throughout the body, but with particularly high concentrations in the brain. These crystals react to very weak external EMF signals. In turn, external magnetic fields directly influence the brain and affect bodily functions. The brain is both a receiver and a transmitter of energy and signals—this is one of the foundations for the biological effects magnetic fields have on the human body. The interaction between magnetite in the body and the Earth's magnetic fields is what allows birds and other animals to navigate or orient themselves along the magnetic field lines of the planet. Humans have been found to have the same ability [27]. Magnetite is one of the aspects of how the body uses PEMFs for healing by their actions at the cellular level [63]. The magnetite acts in the tissues as an oscillator, reacting to PEMFs locally and amplifying the PEMF signals in the tissues.

ELECTROMAGNETIC SCIENCE

How Wires Become Magnets

A PEMF system, speaking simplistically, consists of voltage coming from an electrical outlet, a power generator or control unit, and coils. Power from an electrical outlet is passed into a control unit that then filters out the frequencies from the AC signal and converts them into the specific frequencies that are therapeutically desired. It may also increase the amount of voltage produced to be driven into the applicator coil/s. This transformed AC power is then transmitted through the wiring leading into the applicator(s).

A therapeutic, non-electrostatic magnetic therapy Tesla loop coil consists of an outbound wire, a coil or coils with current running in the same direction, and then a return wire. When an outbound wire and return wire are next to each other, the electric and magnetic fields cancel each other out. It is only when these inbound and outbound wires are separated that an effective magnetic field is produced. See Figure A.2.

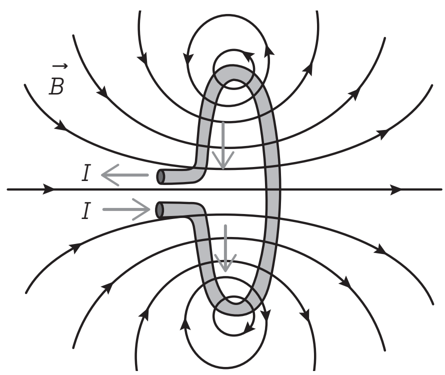

Figure A.2. Current flowing in an electric wire creates a magnetic field.

From: https://physics.ucf.edu/~roldan/classes/Chap27_PHY2049.pdf

In this diagram, "I" represents the current flowing in an electric wire. This flow of current, as is well known in physics, produces a magnetic field "B" around it. You will see in this diagram that when the coil wires separate the magnetic field is activated.

The directionality of the magnetic field can be visualized using what is called the right hand rule. Here again you see the symbols "I" and "B". If you hold a wire in your right hand with your thumb straightened and your other fingers wrapped around the wire, the current is flowing in the direction of the thumb, and the magnetic field extends circularly in the direction of the fingers. See Figure A.3.

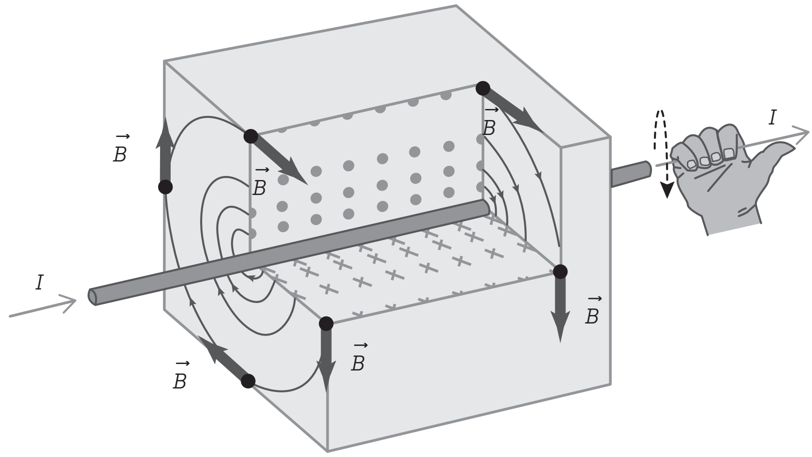

Figure A.3. Right hand rule of the production of a magnetic field by a current flowing through an electric wire.

From: https://physics.ucf.edu/~roldan/classes/Chap28_PHY2049.pdf

The magnetic fields form an infinite closed-loop, as long as current is flowing through the wire. This closed loop has no beginning or end. It has no north pole or south pole. These magnetic fields will penetrate anything that does not block them. Muscle, bone, wood, leather, foam, and other natural materials do not block these magnetic fields.

Static Magnetic Fields

The focus of this book is on time-varying (pulsed) electromagnetic fields (PEMFs), but it is worth having a brief discussion about static magnetic fields, since the two are often confused. A static magnetic field is one in which no change in the flux density or intensity can be found over the time interval of use or measurement. In time-varying magnetic fields, flux density, or intensity changes at one or more frequencies above zero in cycles per second (Hertz).

If you have ever held two magnets in your hands, tried to force them together, and felt a resistance between them, then you have experienced a magnetic field. That type of magnetic field is "static" and comes from a permanent magnet. The magnet itself pulls on other magnetic materials, such as iron or nickel, and attracts or repels other magnets. Static magnetic fields also exist around metals fed by direct current. These are called electromagnets. You see them in junkyards to lift up junked metal. Then when the power is cut off, the metal will fall.

In a therapeutic setting, static magnets are often used in items like bracelets, shoe inserts, necklaces, and so on, to subtly influence the tissues that come in direct contact with the magnet and its static magnetic field.

The Earth's magnetic field is important in considering magnetic therapy with static magnets. Since the overall background magnetic field of the planet completely penetrates our body and atmosphere, any static magnet with field strength below the Earth's magnetic field will not be expected to be active. The magnetic field strength of a static magnet decreases with distance from its surface. Once the field of the static magnet drops to or below the ambient background field strength of Earth, it will be no more effective in the tissues than the background field from that point and farther out.

Small static magnets are commonly used to stimulate the acupuncture meridian system and for local superficial tissue actions. Acupuncture point magnets can vary in intensity from 500 gauss to more than 3,000 gauss. Regardless of intensity, it would not make sense to use static magnets over deep acupuncture points. They should only be used over acupuncture points that are within 10 mm of the skin surface.

With static magnets, a lot of information in books and online focuses on the differential effects of north or south polarity. There is virtually no good published scientific evidence supporting these claims, and even less that has been peer-reviewed. North vs. south polarity is of minimal importance in guiding clinical practice, and is based on limited science. In any case, commercially available multipolar magnets make this argument irrelevant.

Time varying or pulsed magnetic fields are not produced by a stationary permanent magnet, but by moving electric current.

Polarity

I briefly touched on polarity in the static magnets section above. It feels strange to give any print space to a topic that actually has no scientific basis or proof in relation to PEMFs. But, polarity is occasionally mentioned in the PEMF industry, so we chose to mention it briefly here.

Measurement instrumentation, scientists, and engineers tend to use the terms "positive" and "negative" instead of "north" and "south" to avoid confusion about how the north and south pole are geographically and magnetically opposites—the geographic North Pole is a magnetic south pole. The north pole (or the north-seeking pole, to be more accurate) is considered the "positive" pole.

Unlike electricity, magnetic fields do not have a charge. Therefore, the terms "positive" and "negative" or north and south, and even cationic or anionic, do not carry the same meaning for magnetic fields as they do for electrical fields or charge. Gauss's law for magnetism states that there are no "magnetic charges" comparable to electric charges. The sum total magnetic field through any surface is zero. Because PEMFs are always in motion, expanding and collapsing through tissues, they are essentially bi-directional, or "bipolar." A PEMF system can be designed to theoretically produce only a "positive" or "negative" field. In this case polarity means above the 0 electrical line or below it on an oscilloscope. Even so, no systematic scientifically validated differences have been discovered in the effects of one "polarity" versus another.

In fact, often when discussing PEMFs, "polarity" may actually refer to polarization. This simply means the orientation of the magnetic field, typically and simply, whether it's horizontal or vertical in its orientation. Polarization does appear to have little applicability for use in human health.

Bioregulation, Pacers, and Adey Windows

The concept of bioregulation describes the electromagnetic cellular communication process. This process is self-regulating. Cells communicate with each other through various electromagnetic frequencies. When the body's internal environment changes, cells respond and adapt appropriately (if they have enough energy).

Adaptive mechanisms and metabolic processes are regulated by internal (endogenous) and external (exogenous) pacers. Pacers are clock-based control processes that keep everything moving with precision. Most biochemical reactions happen within specific, internally defined periods, commonly within microseconds. This is not unlike the merging of automobile traffic onto highways. Internal pacers are found within the body and promote biochemical reactions that are in tune with one another, while external pacers (including geomagnetic fields) have a direct effect on the internal pacers. The body works to modify external pacers so they do not disrupt the internal pacers, which tend to be much lower intensity. Internal pacers are synchronized so that individual cells can work together to execute complex functions and successfully make up tissues, organs, and organ systems.

Adaptation requires cells to be able to select which signals they will respond to at a given time. In biological communication, this signal selection is done through biological portals called "Adey Windows," named after Dr. W. Ross Adey. Biological windows are the short periods where cell membranes recognize signals (which can be frequency-specific, intensity-specific, or both) from other cell membranes and react by activating intracellular processes.

Selecting the tones for the cells and their various functions is still a matter of significant research. The right frequency is one that speaks to a particular window or function in the body. This is made more complicated by the fact that an individual frequency provided to the body may not be the right one, but harmonics of the applied frequency may end up being so.

As a therapy, bioregulation seeks to present the body with a huge range of frequencies, allowing cells to respond to the frequencies they need at a given time. By providing such a wide range of frequencies, we make sure that all the cells and functions in the body are addressed to the maximum extent possible.

We cannot know at a given time what frequencies the cells need. In one moment, they need one frequency, and as time progresses and the cells adapt, they will need a different frequency or set of frequencies to be able to function optimally. The time intervals between these shifts in frequency requirements can be extremely short (microseconds) to extremely long (days to months). Therefore, bioregulation therapy provides a range of different frequencies, allowing the body to select what it needs in order to penetrate the appropriate window at the appropriate time.

THERAPEUTIC PEMFS VS. HARMFUL EMFS

One of the most common concerns for people considering the value of PEMF therapy is its association with the negative effects of other man-made EMFs in the environment and the so-called "electro-smog" they create. Before we discuss all the beneficial effects of therapeutic PEMF devices, I first want to address this common reservation.

There are many differences between harmful EMFs and the therapeutic EMFs generated by PEMF devices. Magnetic frequencies and waveforms will either amplify or diminish the body's own signals. Harmful EMFs negatively affect the body's natural functions while therapeutic EMFs act in supportive ways, enhancing cellular communication and overall health. The balance of the human organism can easily be negatively affected by electromagnetic changes in the environment, and an unbalanced body is more susceptible to disease. EMFs interact with living systems, affecting enzymes related to cell division and multiplication, growth regulation, and regulation of the sleep hormone melatonin (controlled by the pineal gland metabolism), among many other effects.

The primary differences between harmful and therapeutic EMFs are exposure time, wavelength, and frequency.

Confusion often stems from our electric power grids using 50-60 Hz frequencies, which fall within the same frequency range as many therapeutic PEMFs. There are a few important differences to keep in mind when comparing these EMF sources. By far, the strongest man-made magnetic fields are emitted from high voltage transmission lines (which are the big metal towers, not the single wires that tend to run through neighborhoods on wooden poles). It is generally accepted that a "safe distance" from large power lines is about 700 feet (or 0.1 mile), and a "safe distance" from the neighborhood lines is as little as ten feet.

The intended 50-60 Hz frequency of power lines is becoming increasingly contaminated with surges of radio frequency radiation, often referred to as "dirty electricity." Modern electrical devices tend to induce high levels of these surges or spikes back into the electrical system. Therefore, our power grids are contaminated with frequencies much higher than the intended 50-60 Hz and it is likely that these high-frequency, short-wavelength surges are the cause for some concern.

Cumulative exposure—hour after hour, day after day—to EMFs is of the greatest concern. Ordinary household appliances tend to generate larger cumulative EMF exposures than power lines, as most people do not live close enough to power lines to be dramatically affected by them. The same cannot be said of kitchen appliances, computers, televisions, cell phones, and even electric outlets (especially if it's directly behind the headboard of a bed). Though EMFs from appliances drop off to negligible levels at a distance of about sixteen feet, people are generally much nearer than that to the source of the electromagnetic field—typically eighteen inches from computers, a few feet from televisions, and practically no distance from cell phones.

The question of EMFs, whether from power lines or microwaves, causing cancer was reviewed by the US federal government via the National Institute of Health's National Cancer Institute. There appears to be an increased risk of childhood leukemia but only for those children exposed to at least 0.3 μT on a daily basis. This amount of exposure only happens in about 0.5% of children studied. Studies of childhood exposure to electrical appliances, Wi-Fi, and cell phone base stations show no significant risk. Studies examining preconception or pregnancy exposure risk for cancer in future children have been inconsistent and need further evaluation. In children with leukemia EMF exposure was not associated with poor survival or risk of relapse. For adults, workplace exposure does not increase the risk of leukemia, brain tumors, or female breast cancer. This also applies to work place exposures to radiofrequency/microwave radiation. Whether residential exposure increases the risk of breast cancer is still an open question, requiring additional research.

The types of EMFs of possible concern present in these findings have significantly shorter wavelengths and higher frequencies than therapeutic PEMFs. The electromagnetic spectrum is huge, encompassing all possible wavelengths and frequencies, including X-ray, microwaves, radio waves, visible light, and infrared.

Practically speaking, for therapeutic magnetic field applications, the spectrum is very narrow. The goal of a PEMF system is to produce a magnetic field that will not only be supportive to the body's natural functions, but also to use wavelengths that will go all the way through the body. This requires long wavelengths and low frequencies.

A PEMF frequency of 1 Hz has a wavelength of 100 million meters (more than 62,000 miles). At the upper range of what would be produced by an ELF PEMF treatment system, the frequency can be about 10,000 Hz or so. The wavelength there would be 10,000 meters (about 6.2 miles). For comparison, a low-end microwave-range frequency would be about 100,000,000 Hz. This would correspond to a wavelength of about 1 meter (0.00062 miles). So, ELF PEMF systems have long electromagnetic wavelengths that go completely through the body, including all the PEMF systems I've tested and recommend.

Electromagnetic radiation is classified into two types (ionizing and non-ionizing) based on the radiation's capability of ionizing atoms and disrupting chemical bonds. Ultraviolet and high frequencies, like x-rays or gamma rays, are ionizing. They pose their own health hazards, the most common of which is sunburn, but may also include the induction of cell transformation, producing cancers. Non-ionizing radiation doesn't carry enough energy to disrupt chemical bonds. It only has enough energy to excite electrons into a higher energy state, increasing charge in the tissues, through the process of inductively coupled electrical stimulation (ICES). Almost all therapeutic ELF PEMF systems are non-ionizing and use the principle of ICES.

Most therapeutic PEMF systems produce frequencies in the Extremely Low Frequency (ELF) to Very Low Frequency (VLF) range on the electromagnetic spectrum. These frequencies (below 10,000 Hz or 10 kHz) do not induce damaging heating actions in cells or tissues. PEMF devices also contain various levels of filtering inside the control unit or frequency generator portion of the system, which clean up the surges/spikes, mentioned above, that often come out of the household outlets we use to power the device itself.

Environmental EMFs can make anxiety worse

One important aspect in managing anxiety successfully (see section three) is the need to consider outside influences that may contribute to the anxiety. Some individuals, regardless of how much they try to reduce their anxiety with any particular therapeutic approach, just do not respond. Many times this can actually be due to the background EMFs in their environment. EMFs that would enter the bedroom in particular can be incredibly potent irritants to the nervous system. Unless these EMFs are dealt with and reduced or eliminated, it becomes challenging for any treatment to work.

If PEMFs are being used for anxiety and they don't appear to be working, a key element of to consider is the possibility of extraneous high frequency EMFs contributing to the situation. These EMFs include living near power lines, routers and cellphones near the bed, and contaminated home wiring as potential contributing factors for their anxiety.

External EMFs above the range of 50-Hz and EMF intensities encountered in homes of >1-100 mG, with daily magnetic-field exposure, may be associated with poorer health and more "chronic anxiety" symptoms. This is consistent with a direct effect of continuous long-term 50-Hz magnetic field exposure on the nervous system [39]. Strategies to reduce this environmental exposure need to be considered to be able to achieve the best clinical results. These mitigation strategies are beyond the subject of this book. Information on electromagnetic field mitigation strategies is available at www.magdahavas.com and many other sources.

PEMF'S EFFECTS ON WATER

Water does not exist as a single molecule, but resembles a cluster of grapes with about 30-40 molecules in each cluster. In magnetically activated water, clusters separate into smaller clusters of five or six molecules per cluster. This water is also more organized in structure and motion.

The size and clustering of water molecules is extraordinarily important in the ability of water to move in an out of cells. Water flux between cells is facilitated by proteins embedded in the membrane called aquaporins. These are water channel proteins. In the membrane channel, they prevent bursting of the cells due to changes of the exterior salt concentration (osmotic regulation). In humans, aquaporins regulate the flow of water in the kidney, red blood cells, the eye lens, and the brain, to name just a few. Defects in these proteins are known to be involved in a number of diseases including diabetes insipidus, congenital cataract, and impaired hearing.

Aquaporins have a remarkable efficiency of moving up to three billion water molecules per second. A membrane patch of 10x10 cm^2 with embedded aquaporins can filter one liter of water in about seven seconds. Water molecules move in and out of these membrane channels through a fascinating, delicately choreographed dance. This precise control of the movement of water molecules was found in research done by the Max Planck Society in Germany to have a twofold function. The water molecules are passed on in an ordered way through the channel, which drastically increases the rate at which water passes through.

Dr. Yoshitaki Ohno, a researcher specializing in the study of water, has found that water that is naturally magnetized holds its magnetization pattern permanently. He discovered water in Japan that flowed through lava formations, becoming naturally magnetized because of the mineral content and the way the water flowed through the naturally magnetized rock. Otherwise, water treated by the application of external magnetic fields typically only holds its restructuring for about eight hours, that is, for about a day. Freshly treated batches are therefore needed each day.

When cells are studied under an MRI (which replicates a powerful PEMF treatment), water is observed to act differently from when it is not exposed to a magnetic field. Molecules are re-formed in smaller clusters in a linear arrangement. The molecules are lined up and move in and out of the cells easily. In contrast, when water is photographed after being removed from MRI exposure, molecules are randomly ordered and cluster with neighboring water molecules to form large, molecular clusters. Interestingly, when cancer cells are studied under MRI influence, its water molecules are also organized and calm, in contrast to their aggressive, violent movement without MRI exposure.

There is evidence that MF-treated pharmaceutical solutions are affected by the MF treatment. Their actions are altered, positively or negatively, by these fields—that is, enhanced or reduced effects on the solutions [190].

Eastern Europeans and Chinese researchers have found that magnetically treated water may help to dissolve stones in the urinary and biliary tracts including kidney stones and gallstones. Since calcific stones in the body are often associated with nano-bacteria, MF-treated water may help to work gradually at degrading the stones through a process of erosion, akin to the wearing action of water on rocks in nature.

Magnetic fields can change various physical, chemical, and obvious properties of solutions including surface tension, electrical properties, and the ability of substances to dissolve in magnetic field exposed solutions. Calcium compounds demonstrate long-lasting changes in conductivity on exposure to magnetic fields. Subsequently, when these magnetically exposed solutions were applied to nerve cells, they caused both physiological and biochemical changes. Even outside the body, a brief magnetic field exposure can create changes in fluid conductivity for at least two and half hours after the exposure. Water-salt interactions may well underlie biological magnetic field sensitivity. The solutions altered by PEMFs can produce changes in cell membranes and metabolism [26].

Magnetically restructured water produces a synergistic effect on the insecticidal activity of endosulfan in solution. The results imply that magnetically restructured water could play a significant role in managing different crop pests and human and animal diseases, allowing less than the recommended concentrations of insecticides, antibiotics, fungicides, and other pesticides to be used [426].

Growth of algae, a form of bacteria, in solution exposed directly or indirectly to a magnetic field was significantly affected by magnetic field exposure. Indirect exposure was done by exposing the solution the algae were to be grown in first and then the algae introduced into the treated solution. The results showed that the magnetic field influenced "structural chemistry" of the water to produce "live water" structures; that is different water structures can influence bacterial nutrient uptake, enzyme activities, and the orientation of precursor biomolecules in the liquid crystalline phase during growth. This means that biochemical processes in organisms are affected both directly and indirectly. The degree of these effects increased with increasing duration of exposure [426].

Water treated with magnetic fields first will affect whatever grows or lives in that water subsequently, including cellular molecules, making the water "live." Even growth of fungal spores is decreased by up to 83% if the water is pretreated with magnetic fields [351, 352].

Water exposed to 0.1 T and 0.25 T magnetic fields appears to increase activation of chick pancreas digestive and salivary enzymes, enhancing the breakdown of the substances these enzymes work on, and it makes this happen faster. Pretreatment of water before eating would have the effect of improving digestion [133].

Proliferation rate of some fungi, especially of human digestion-supportive Saccharomyces cerevisiae, appear to decrease when grown on culture media prepared with MTW. The rate of growth on bread did not change when the bread was made with MTW and flour. However, treatment of water and flour by a magnetic field prior to mixing them greatly stimulated proliferation of Saccharomyces in the dough; the content of the yeast cells increased up to five times compared to untreated samples. It's unknown what creates these differences in response [462].

Heart muscle contractility is also apparently affected by PEMFs and acts similarly to hydrogen peroxide. This may be one of the ways that PEMFs also cause muscles to relax, because contractility is decreased. In addition, the ability of oxygen to dissolve in water has been demonstrated by magnetic fields [24].

Cell hydration regulates metabolic activity of cells via changes (1) to the shape of large intracellular molecules, (2) to the number of functionally active protein molecules with enzymes at the cell surface, receptors, and ion channel-forming properties, and (3) to water-flow-induced membrane permeability for ions. Therefore, metabolically controlled cell hydration is of vital importance for living cells.

The sodium-potassium pump, which has the highest metabolic energy (ATP) use in the cell, stimulates the intracellular oxidative phosphorylation process that causes the release of water molecules in cytoplasm (releasing forty-two water molecules for every molecule of glucose oxidized).

Water flow-induced activation and inactivation of membrane permeability for ions can be considered a marker for estimating the impact of EMFs. Water molecules, which are extra sensitive to weak environmental factors, serve as a messenger for the metabolic mechanism controlling water balance on membranes.

The permeability of cell membrane for water molecules is much higher than the permeability of cell membrane for ions. Water flows through membranes have a crucial role in regulation of cell membrane permeability for sodium calcium and potassium ions. Water flows in and out through cell membranes have activation and inactivation effects on inbound ionic currents (particularly, sodium and calcium currents) and the opposite effect on outward potassium ion currents.

The above considerations have led to the water hypothesis, and actions on water are an important explanation for the biological effect of EMFs. The bond angle of water molecules between oxygen and hydrogen (O–H) bonds, which determines water's physicochemical properties, is highly sensitive to EMFs therapeutically and in the environment. EMFs appear to modulate cell metabolism by changing the physical and chemical properties of water. Water in tissues and cells is a common medium for metabolic reactions in cells and organisms [23].

The effect of EMF on physical and chemical properties of water solutions and formation of reactive oxygen species (ROS) in these solutions depend on calcium ion concentration in the water solution. EMFs increase the formation of hydrogen peroxide (H_2O_2) in these physiological solutions (PS). H_2O_2 is one of the main chemical messengers modulating cell metabolism.

EMF-treated water solutions have modulation effects on different types of organisms (including plants, microbes, and human beings).

The sensitivity of cells to EMF-treated water depends on the initial metabolic state of the cells. For example, water uptake by seeds in dormant state is not affected by EMF-treated water solutions. During germination, EMF-treated water solutions strongly elevate water uptake by seeds compared with untreated water solution. Water activity in the cell is dependent on cell metabolism and is more sensitive to EMFs than simple processes such as water absorption by seeds in dormant state.

There appears to be an age effect between metabolic activity of cells and EMF sensitivity of cell hydration of brain and heart muscle tissue hydration of rats. SMF exposure of young animals (with high metabolic activity) leads to relative dehydration in both brain cortex and heart muscle tissues, while in old animals (with lower metabolic activity) it leads to relative over hydration of brain cortex tissue and no effect on hydration of heart muscle tissues.

PEMF treated physiologic water provided to the body appears to act differently than treating the body with its natural water content. Injection of a PEMF-treated PS into the body has a different effect on brain tissue hydration than direct EMF stimulation of the brain, since water molecules are not the only target for EMF effects.

Research has shown that the intracellular signaling system is a primary target for the biologic effects of EMF. Signaling molecules include calcium calmodulin, cGMP, ATP-ases, and cAMP among others. All of these have roles in moving ions and affecting cell hydration/dehydration.

NON-CLASSICAL MECHANISMS OF PEMF THERAPY BENEFITS

Most of the effects PEMFs have on biology have been looked at primarily from the perspective of induced charge or electric fields in the tissues. However, other effects of PEMFs have been described as well [81]. These include quantum effects, magnetic spin effects, genetic magnetoreception, macromolecular effects, and the electromagnetic theory of consciousness. It is beyond the scope of this book to delve into these to any significant extent until the knowledge base is better developed, but all are worth mentioning.

PEMFs in biologic systems act on charged and magnetic particles that are often microscopic in size. It is natural to expect that the actions of magnetic fields on the brain and other biologic structures, are governed by quantum laws at the most basic levels. Quantum effects are typically thought to occur below the level of the atom, or the subatomic level. Every molecule has both a classical physics aspect and a quantum aspect. Quantum actions may be happening and be different from actions expected from classical physics. Research into the actions of quantum effects in biologic systems has become an individual discipline known as quantum biology.

The spin of electrons in tissues is another target of magnetic fields. PEMF stimulation can change the state of electrons spin systems (radicals, ions, or triplet molecules), which in turn can influence the chemical activity of corresponding compounds. In addition to weight and charge, basic particles like electrons and protons have an "angular momentum" called spin and therefore have an associated spin magnetic momentum. The magnetic properties of atoms are determined primarily by the spin of electrons. Chemical reactions in the body are spin-selective, which means that they only allow those reactions where the spin states of the reacting molecules coincide, and are forbidden if the spin is changed. These types of spin issues acting on free radicals (particularly oxygen) result in the production of ATP.

Genetic magnetoreception is related to the actions of PEMFs on the genome or genes of the body. There is a significant amount of research demonstrating the effects of PEMFs on genes in almost all parts of the body. Even weak magnetic fields can induce certain genetic effects due to the actions of specific proteins, which are magnetosensitive. Some of these very ancient regulatory proteins are present in virtually all living organisms, including the cells of bacteria, plants, insects, and animals. They are predominantly localized in the cell nucleus. Some are unique parts of living systems that combine sensory and regulatory functions and act as intermediaries between living nature and the physical environment, and provide living organisms with the abilities to respond to magnetic and electromagnetic fields and adjust their biological clocks to day/night changes and other physical variations in the environment.

"Macromolecular" mechanisms of PEMF stimulation involve large molecules or parts of cells, called organelles. These large molecules can be oriented or deformed under the influence of a magnetic field. This type of change alters their properties and reactivity, including the production of electrical charges, called the piezoelectric effect. The charged particles in living matter, such as ions and molecules that are involved in physical and chemical processes, appear to act as messengers or activators to the next biological level when the effects of magnetic signals are changed in the body, called transduction. Fine adjustments in protein activity, performed by the interaction of biology and physics, involve ions and messenger molecules that shift metabolic processes. These are particularly seen by the effects of PEMFs on ion channels in cell membranes that rely on changes in voltage. These ion channel changes produced by PEMFs result in changes in large molecules, and therefore the end results of PEMF stimulation in affecting circulation, inflammation, swelling, tissue regeneration, and ATP energy production.

There is an electromagnetic theory of consciousness that suggests that an electromagnetic field induced by the brain (by thought, emotion, or PEMF stimulation) is the carrier of consciousness and conscious experience. The concept is that every time brain neurons generate action potentials they also generate a disturbance in the surrounding electromagnetic fields around them that is then experienced by surrounding cells. Therefore, the "information" carried by patterns of frequencies or oscillations produced by "excited" neurons affects the electromagnetic fields of the brain that affect consciousness.

Physicist Dr. Claude Swanson states that at least one of the mechanisms of action of PEMFs is through torsion fields [447]. Right-handed torsion fields are created by processes that increase entropy at the source. Left-handed torsion fields are created by processes that decrease entropy at the source. In torsion fields, energy of the same polarity is attracted to itself and opposite polarities are repelled. Torsion fields travel through most physical media without any lessening. The spin patterns of physical particles can be altered by a torsion field. Therefore, torsion fields can affect matter in unpredictable and paradoxical ways.

The conclusion we can draw about what these non-classic effects of therapeutic magnetic fields might have on biology is that they are vast. In most of our experience, PEMF effects are positive and useful. We may not always be able to explain how the benefits happen, but that's true for most of what we do in healing work and in medicine. Nevertheless, the longer we work with magnetic fields to help people, the more in awe we are of how they help us achieve better health. PEMFs are truly the power tools we need to be healthier physically, spiritually, and emotionally.

REFERENCES

1. Aaron RK, Ciombor DM. Therapeutic effects of electromagnetic fields in the stimulation of connective tissue repair. J Cell Biochem 1993 May;52(1):42-6.
2. Abramovich SG, Fedotchenko AA, Koriakina AV, et al. The characteristics of the geroprotective action of magnetotherapy in elderly patients with combined cardiovascular pathology. Vopr Kurortol Fizioter Lech Fiz Kult. Sep-Oct;(5):7-9, 1999.
3. Adey WR. Electromagnetic fields, the modulation of brain tissue functions - a possible paradigm shift in biology. In International Encyclopedia of Neuroscience, (2004) Third Edition; Smith B and Adelman G, editors. Elsevier, New York.
4. Akan Z, Aksu B, Tulunay A. Extremely low-frequency electromagnetic fields affect the immune response of monocyte-derived macrophages to pathogens. Bioelectromagnetics 31:603–612, 2010.
5. Aleksaniants GD. Use of an electromagnetic field and iodine-bromine baths in the complex treatment of patients with circumscribed scleroderma. Vestn Dermatol Venerol (3):56-58, 1987.
6. Alfano AP, Taylor AG, Foresman PA, et al. Static magnetic fields for treatment of fibromyalgia: a randomized controlled trial. J Altern Complement Med. 2001;7(1):53–64.
7. Altpeter ES, Krebs T, Pfluger DH, et al. Study on health effects of the shortwave transmitter station of Schwarzenburg, Berne, Switzerland (Major report); 1995; BEW (Bundesamt für Energiewirtschaft) Publication Series, Study No. 55, EDMZ 805.755.
8. Amirifalah Z, Firoozabadi SM, Shafiei SA. Local exposure of brain central areas to a pulsed ELF magnetic field for a purposeful change in EEG. Clin EEG Neurosci. 2013 Jan;44(1):44-52.
9. Ammi M, Chautard D, Brassart E, et al. Transcutaneous posterior tibial nerve stimulation: evaluation of a therapeutic option in the management of anticholinergic refractory overactive bladder. Int Urogynecol J. 2014 Aug;25(8):1065-9.
10. Anderson B, Mishory A, Nahas Z, et al. Tolerability and safety of high daily doses of repetitive transcranial magnetic stimulation in healthy young men. J ECT. 2006 Mar;22(1):49-53.
11. Anderson JM. Inflammatory response to implants. ASAIO J 34: 101–107, 1988.
12. Andino RV and Feldman DS. The use of a pulsating electromagnetic field to treat full thickness skin defects in the rabbit model. Bioelectrical Repair and Growth Society (BRAGS), Vol. XIII, 13th Annual Meeting, 10-13 October, Dana Point, CA, p. 49, 1993.
13. Anninos P, Kotini A, Adamopoulos A, et al. Magnelic stimulation can modulate seizures in epileptic patients. Brain Topogr. 2003 Fall;16(1):57-64.
14. Anninos PA, Tsagas N, Jacobson JI, et al. The biological effects of magnetic stimulation in epileptic patients. Panminerva Med 1999 Sep;41(3):207-15.

15. Antimonii GD and Salamov RA. Action of a modulated electromagnetic field on experimentally induced epileptiform brain activity in rats. Biull Eksp Biol Med 1980 Feb;89(2):145-8.

16. Apostolidis A, Jacques TS, Freeman A, et al. Histological changes in the urothelium and suburothelium of human overactive bladder following intradetrusor injections of botulinum neurotoxin type A for the treatment of neurogenic or idiopathic detrusor overactivity. Eur Urol. 2008 Jun;53(6):1245-53.

17. Arrieta O, Blake M, de la Mata-Moya MD, et al. Phase II study. Concurrent chemotherapy and radiotherapy with nitroglycerin in locally advanced non-small cell lung cancer. Radiother Oncol. 2014 May;111(2):311-5.

18. Ascherl R, Blumel G, Lechner F, et al. On the treatment of loosening of endoprostheses by means of pulsing electromagnetic fields. Bioelectricity Bioenerg 14:161–167, 1985.

19. Athanasiou A, Karkambounas S, Batistatou A, et al. The effect of pulsed electromagnetic fields on secondary skin wound healing: an experimental study. Bioelectromagnetics. 2007 Jul;28(5):362-8.

20. Aurora SK, Cao Y, Bowyer, SM, et al. The occipital cortex is hyperexcitable in migraine: experimental evidence. Headache 39(7):469-476, 1999.

21. aus der Beek T, Weber FA, Bergmann A, et al. Pharmaceuticals in the environment--Global occurrences and perspectives. Environ Toxicol Chem. 2016 Apr;35(4):823-35.

22. Avenanti A, Coccia M, Ladavas E, et al. Low-frequency rTMS promotes use-dependent motor plasticity in chronic stroke: A randomized trial. Neurology. 2012 Jan 24;78(4):256-64.

23. Ayrapetyan S. Ch. 16. The Intracellular Signaling System Controlling Cell Hydration as a Biomarker for EMF Dosimetry. In Dosimetry in Bioelectromagnetics, CRC Press 2017, Ed. Marko Markov.

24. Ayrapetyan G, Dadasyan E, Hayrapetyan H, et al. Exogenous hydrogen peroxide as a possible messenger for the stimulation effect of magnetized physiological solution on heart contractility. Bioelectromagnetics. 2008 Oct;29(7):549-58.

25. Ayrapetyan SN, Hunanyan ASh, Hakobyan SN. 4 Hz EMF treated physiological solution depresses Ach-induced neuromembrane current. Bioelectromagnetics. 2004 Jul;25(5):397-9.

26. Ayrapetyan SN, Grigorian KV, Avanesian AS, et al. Magnetic fields alter electrical properties of solutions and their physiological effects. Bioelectromagnetics. 1994;15(2):133-42.

27. Baker RR. Goal orientation by blindfolded humans after long-distance displacement: possible involvement of a magnetic sense. (1980). Science, 210, 555-557.

28. Baker-Price LA, Persinger MA. Weak, but complex pulsed magnetic fields may reduce depression following traumatic brain injury. Percept Mot Skills. 1996 Oct;83(2):491-8.

29. Bakhmutskii NG, Golubtsov VI, Pyleva TA, et al. A case of successful treatment of a patient with breast cancer using a rotating electromagnetic field. Sov Med (8):86-87, 1991.

30. Baldwin D, Woods R, Lawson R, et al.. Efficacy of drug treatments for generalised anxiety disorder: systematic review and meta-analysis. BMJ. 2011 Mar 11;342:d1199.

31. Bandari DS, Sternaman D, Chan T, et al. Evaluating risks, costs, and benefits of new and emerging therapies to optimize outcomes in multiple sclerosis. J Manag Care Pharm. 2012 Nov-Dec;18(9):1-17.

32. Bardasano JL, Ramirez E, Maestu C. Effects of transcranial magnetic stimulation: preliminary results in Parkinson's Disease (meeting abstract). European Bioelectromagnetics Assoc. (EBEA), 5th International Congress, 6-8 September, Helsinki, Finland, P-52, p. 287-288, 2001.

33. Barengo NC, Meneses-Echávez JF, Ramírez-Vélez R, et al. The impact of the FIFA 11+ training program on injury prevention in football players: a systematic review. Int J Environ Res Public Health. 2014 Nov 19;11(11):11986-2000.

34. Bartko D, Turcáni P, Danisová J, et al. The effects of the pulsing magnetic field on the cerebral circulation, eeg power spectra and some properties of the blood. A preliminary data. J Bioelectr 7(1):131-132, 1988.

35. Bartley J, Gilleran J, Peters K. Neuromodulation for overactive bladder. Nat Rev Urol. 2013 Sep;10(9):513-21.

36. Başar E, Schürmann M, Başar-Eroglu C, et al. Alpha oscillations in brain functioning: an integrative theory. Int J Psychophysiol. 1997 Jun;26(1-3):5-29.

37. Bassett CA. Fundamental and practical aspects of therapeutic uses of pulsed electromagnetic fields (PEMFs). Crit Rev Biomed Eng 1989; 17: 451-529.

38. Bayir E, Bilgi E, Şendemir-Ürkmez A, et al. The effects of different intensities, frequencies and exposure times of extremely low-frequency electromagneticfields on the growth of Staphylococcus aureus and Escherichia coli O157:H7. Electromagn Biol Med. 2015 Mar;34(1):14-8.

39. Beale IL and Pearce NE. Psychological and physical health correlates of 50 hz magnetic field exposure in humans living near extra-high-voltage transmission lines. Bioelectromagnetics Society, 17th Annual Meeting, 18-22 June, Boston, MA, Abstract No. 20-1, p. 87, 1995.

40. Bech P, Lindberg L, Straaso B, et al. 2-year follow-up study of patients participating in our transcranial pulsating electromagnetic fields (T-PEMF) augmentation in treatment-resistant depression. Acta Neuropsychiatrica 2015.

41. Becker R and Selden G. *Body Electric: Electromagnetism and the Foundation of Life*, Quill Press, William and Morrow, 1985.

42. Beilin G, Benech P, Courie R, et al. F. 2012. Electromagnetic fields applied to the reduction of abdominal obesity. J Cosmet Laser Ther 14:24–42.

43. Bell G, Marino A, Chesson A, et al. (1991) Human sensitivity to weak magnetic fields. Lancet, 338: 1521—1522.

44. Bellossi A, de Certaines J, Bernard AM. Is there an association between myocardial infarction and geomagnetic activity ? Int J Biometeorol 29(1):1-6, 1985.

45. Berry AK. Helping children with nocturnal enuresis: the wait-and-see approach may not be in anyone's best interest. Am J Nurs. 2006 Aug;106(8):56-63.

46. Bettucci D, Cantello R, Gianelli M, et al. Menstrual migraine without aura: cortical excitability to magnetic stimulation. Headache 32(7):345-347, 1992.

47. Bier RR and Estersohn HS. A new treatment for charcot joint in the diabetic foot. J Am Podiatr Med Assoc 77(2):63-69, 1987.

48. Binhi VN, Fillion-Robin M, Picard G. Physical constraints specifying possible primary mechanisms whereby Tecno AO and superweak EMFs affect biological systems. Bioelectromagnetics Society, 20th Annual Meeting, 7-11 June, St. Pete Beach, FL, Abstract No. A-5-5, p. 30-31, 1998.

49. Bisvas SK and Listopadova NA. Possibilities of magnetotherapy in stabilization of visual function in patients with glaucoma. Vestn Oftalmol. 1996 Jan-Mar;112(1):6-8.

50. Blackman CF. Stimulation of brain tissue in vitro by extremely low frequency, low intensity, sinusoidal electromagnetic fields. Prog Clin Biol Res 257:107-117. Electromagnetic Fields and Neurobehavioral Function, M. E. O'Connor and R. H. Lovely, eds., New York: Alan R. Liss, Inc. 1988.

51. Blank M and Soo L. Threshold for inhibition of Na, K-ATPase by ELF alternating currents. Bioelectromagnetics 13(4): 329–333 (1992).

52. Boggio PS, Rocha M, Oliveira MO, et al. Noninvasive brain stimulation with high-frequency and low-intensity repetitive transcranial magnetic stimulation treatment for posttraumatic stress disorder. J Clin Psychiatry. 2010 Aug;71(8):992-9.

53. Boisnic S, Divaris M, Nelson AA, et al. A clinical and biological evaluation of a novel, noninvasive radiofrequency device for the long-term reduction of adipose tissue. Lasers Surg Med. 2014 Feb;46(2):94-103.

54. Bolotova NV, Aver'ianov AP, Dronova EG, et al. Transcranial physical methods for correction of neuroendocrine and cerebral disorders in adolescent girls with obesity. Ter Arkh. 2012;84(10):33-6.

55. Bolotova NV, Lazebnikova SV, Chicheva GV, et al. The effectiveness of transcranial treatment using the AMO-ATOS-E apparatus for the correction of the reproductive system disorders in adolescent girls. Vopr Kurortol Fizioter Lech Fiz Kult. 2010 Nov-Dec;(6):30-3.

56. Bonavida B and Garban H. Nitric oxide-mediated sensitization of resistant tumor cells to apoptosis by chemo-immunotherapeutics. Redox Biol. 2015 Dec;6:486-94.

57. Bower WF and Diao M. Acupuncture as a treatment for nocturnal enuresis. Auton Neurosci. 2010 Oct 28;157(1-2):63-7.

58. Bowers RR, Lane MD. A role for bone morphogenetic protein-4 in adipocyte development. Cell Cycle 6:385–389, 2007.

59. Brola W, Wegrzyn W, Czernicki J. Effect of variable magnetic field on motor impairment and quality of life in patients with multiple sclerosis. Wiad Lek. 2002;55(3-4):136-43.

60. Brugemann H. Editor. Bioresonance and Multiresonance Therapy (BRT): New, forward-looking forms of therapy with ultrafine body energies and environmental signals. Documentation on theory and practice. 1993. Haug International, Brussels.

61. Buchachenko A. Why magnetic and electromagnetic effects in biology are irreproducible and contradictory. Bioelectromagnetics. 2016 Jan;37(1):1-13.

62. Budak A, Zyss T, Bogusz B, et al Effect of low frequency alternating magnetic field on the growth in vitro of some pathogenic skin dermatophytes. Alpe Adria Microbiol J 7(3):191-196, 1998.

63. Burda H, Begall S, Cervený J, et al. Extremely low-frequency electromagnetic fields disrupt magnetic alignment of ruminants. Proc Natl Acad Sci U S A. 2009 Apr 7;106(14):5708-13.

64. But I and Varda NM. Functional magnetic stimulation: a new method for the treatment of girls with primary nocturnal enuresis? J Pediatr Urol. 2006 Oct;2(5):415-8.

65. But I, Faganelj M, Sostaric A. Functional magnetic stimulation for mixed urinary incontinence. J Urol. 2005 May;173(5):1644-6.

66. But I. Conservative treatment of female urinary incontinence with functional magnetic stimulation. Urology. 2003 Mar;61(3):558-61.

67. But I. Functional magnetic stimulation for treatment of urinary incontinence – presentation of Pulsegen device. #433. ICS 2002 Annual Conference, Heidelberg, 28th - 30th August 2002. Meeting abstract.

68. Cadossi R. Protective effect of electromagnetic field exposure on acute soft tissue ischaemic injury. Second World Congress for Electricity and Magnetism in Biology and Medicine, 8-13 June, Bologna, Italy, Minisymposium MS-15-5, p. 47-48, 1997.

69. Capanna R, Donati D, Masetti C, et al. Effect of electromagnetic fields on patients undergoing massive bone graft following bone tumor resection. A double blind study. Clin Orthop Relat Res. 1994 Sep;(306):213-21.

70. Capone F, Dileone M, Profice P, et al. Does exposure to extremely low frequency magnetic fields produce functional changes in human brain? J Neural Transm. 2009 Mar;116(3):257-65.

71. Carmody S, Wu XL, Lin H, et al. Cytoprotection by electromagnetic field-induced hsp70: a model for clinical application. J Cell Biochem 79(3):453-459, 2000.

72. Castelpietra R, Dal Conte G. Initial experiences in the treatment of psoriasis with pulsating magnetic fields. Minerva Med. 1984 Oct 20;75(40):2381-7.

73. Castro-Diaz D, Cardozo L, Chapple CR, et al. Urgency and pain in patients with overactive bladder and bladder pain syndrome. What are the differences? Int J Clin Pract. 2014 Mar;68(3):356-62.

74. CDC link - https://www.cdc.gov/hai/outbreaks/meningitis.html

75. Cellini L, Grande R, Di Campli E, et al. Bacterial response to the exposure of 50 Hz electromagnetic fields. Bioelectromagnetics 29:302-311 (2008).

76. Centonze D, Koch G, Versace V, et al. Repetitive transcranial magnetic stimulation of the motor cortex ameliorates spasticity in multiple sclerosis. Neurology. 2007 Mar 27;68(13):1045-50.

77. Centonze D, Petta F, Versace V, et al. Effects of motor cortex rTMS on lower urinary tract dysfunction in multiple sclerosis. Mult Scler. 2007 Mar;13(2):269-71.

78. Chadaev AP, Alekseenko ME, Klimiashvili AD. Low-frequency magnetic pulse therapy in the complex treatment of purulent surgical infection of soft tissues. Ross Med Zh (6):35-37, 1996.

79. Chen C, Cui Y, Yue J, et al. Enhancement of the Hydrolysis Activity ofF0F1-ATPases Using 60 Hz Magnetic Fields. Bioelectromagnetics 30:663-668 (2009).

80. Chen Y, Hong L, Zeng Y, et al. Power frequency magnetic fields induced reactive oxygen species-related autophagy in mouse embryonic fibroblasts. Int J Biochem Cell Biol. 2014 Dec;57:108-14.

81. Chervyakov AV, Chernyavsky AY, Sinitsyn DO, et al. Possible Mechanisms Underlying the Therapeutic Effects of Transcranial Magnetic Stimulation. Front Hum Neurosci. 2015 Jun 16;9:303.

82. Chevalier A, Souques M, Coing F, et al. Absenteeism and mortality of workers exposed to electromagnetic fields in the french electricity company. Occup Med (Lond) 49(8):517-524, 1999.

83. Cho H, Seo YK, Yoon HH, et al. Neural stimulation on human bone marrow-derived mesenchymal stem cells by extremely low frequency electromagnetic fields. Biotechnol Prog. 2012 Sep-Oct;28(5):1329-35.

84. Choleris E, Thomas AW, Ossenkopp K-P, et al. Sex differences in conditioned taste aversion and in the effects of exposure to a specific pulsed magnetic field in deer mice Peromyscus Maniculatus. Physiol Behav 71(3-4):237-249, 2000.

85. Choleris E, Thomas AW, Prato FS. A comparison of the effects of a 100 ut specific pulsed magnetic field and diazepam on anxiety-related behaviors in male CF1 mice. Bioelectromagnetics Society, 21st Annual Meeting, 20-24 June, Long Beach, CA, Abstract No. P-91, p. 129-130, 1999.

86. Chou YH, Hickey PT, Sundman M, et al. Effects of repetitive transcranial magnetic stimulation on motor symptoms in Parkinson disease: a systematic review and meta-analysis. JAMA Neurol. 2015 Apr;72(4):432-40.

87. Cieslar G, Sieron A, Radelli J. (1995) The estimation of therapeutic effect of variable magnetic fields in patients with diabetic neuropathy including vibratory sensibility. Balneol Pol 37(1): 23-27.

88. Cohen H, Kaplan Z, Kotler M, et al. Repetitive transcranial magnetic stimulation of the right dorsolateral prefrontal cortex in posttraumatic stress disorder: a double-blind, placebo-controlled study. Am J Psychiatry. 2004 Mar;161(3):515-24.

89. Cohrs S, Tergau F, Riech S, et al. High-frequency repetitive transcranial magnetic stimulation delays rapid eye movement sleep. Neuroreport. 1998 Oct 26;9(15):3439-43.

90. Colbert A, Markov M, Banerji M, et al. Magnetic mattress pad use in patients with fibromyalgia: a randomized double-blind pilot study. J Back Musculoskeletal Rehabil. 1999;13(1):19–31.

91. Collacott EA, Zimmerman JT, White DW, et al. Bipolar permanent magnets for the treatment of chronic low back pain: a pilot study. JAMA. 2000 Mar 8;283(10):1322-5.

92. Conca A, Konig P, Hausmann A. Transcranial magnetic stimulation induces "pseudoabsence seizure." Acta Psychiatr Scand 2000 Mar;101(3):246-8.

93. Cook LL and Persinger MA. Long-term consequences of subtle stimuli during the first twenty-four hours of seizure-induced brain injury. Percept Mot Skills 1996 Oct;83(2):523-9.

94. Costa FP, de Oliveira AC, Meirelles R, et al.Treatment of advanced hepatocellular carcinoma with very low levels of amplitude-modulated electromagnetic fields. Br J Cancer. 2011 Aug 23;105(5):640-8.

95. Crocetti S, Beyer C, Schade G, et al. Low intensity and frequency pulsed electromagnetic fields selectively impair breast cancer cell viability. PLoS One. 2013 Sep 11;8(9).

96. Dallari D, Fini M, Giavaresi G, et al. Effects of pulsed electromagnetic stimulation on patients undergoing hip revision prostheses: a randomized prospective double-blind study. Bioelectromagnetics 2009 30:423-430.

97. Danilova AI and Peleshchuk EA. Alternating magnetic fields in the complex treatment of various endocrine ophthalmopathies. Oftalmol Zh (4):207-210, 1986.

98. de Carvalho ML, Motta R, Konrad G, et al. A randomized placebo-controlled cross-over study using a low frequency magnetic field in the treatment of fatigue in multiple sclerosis. Mult Scler. 2012 Jan;18(1):82-9.

99. De Gennaro M, Capitanucci ML, Mosiello G, et al. (2011) Current state of nerve stimulation technique for lower urinary tract dysfunction in children. J Urol 185(5):1571-1577

100. de Oliveira LF, de Oliveira DM, Da Silva de Paula LI, et al. (2013) Transcutaneous parasacral electrical neural stimulation in children with primary monosymptomatic enuresis: a prospective randomized clinical trial. J Urol 190(4):1359-1363

101. Del Re B, Bersani F, Agostini C, et al. Various effects on transposition activity and survival of Escherichia coli cells due to different ELF-MF signals. Radiat Environ Biophys. 2004 Dec;43(4):265-70.

102. Del Re B, Bersani F, Mesirca P, et al. Synthesis of DnaK we have helped and GroEL in Escherichia coli cells exposed to different magnetic field signals. Bioelectrochemistry. 2006 Sep;69(1):99-103.

103. Demetskii, AM, Surganova, SF, Nikolskii, MA. Magnetic therapy for traumatic injuries to the extremities. Electromagnetic Therapy of Injuries and Diseases of the Support-Motor Apparatus; International collection of papers I. Detlav, ed., Riga, Latvia: Riga Medical Inst., p. 103-109, 1987.

104. Detlavs I, Karklinsch E, Murniece M, et al. Effects of electromagnetic fields in treatment patients with diseases of nervous system (meeting abstract). European Bioelectromagnetics Assoc. (EBEA), 4th International Congress, 19-21 November, Zagreb, Croatia, 1998.

105. Detlavs I, Turauska A, Veliks V. Effects of low intensity modulated electromagnetic fields on patients with diseases of support-motor apparatus, cardiovascular and nervous systems. European Bioelectromagnetics Assoc. (EBEA), 5th International Congress, 6-8 September, Helsinki, Finland, P-51, p. 285-286, 2001.

106. Dhuna A, Gates J, Pascual-Leone A. Transcranial magnetic stimulation in patients with epilepsy. Neurology 1991 Jul;41(7):1067-71.

107. Di Carlo AL, Farrell, JM, Litovitz TA. Myocardial protection conferred by electromagnetic fields. Circulation 99(6):813-816, 1999.

108. Di Carlo AL, White NC, Litovitz TA. Mechanical and electromagnetic induction of protection against oxidative stress. Bioelectrochemistry. 2001 Jan;53(1):87-95.

109. Di Loreto S, Falone S, Caracciolo V, et al. Fifty hertz extremely low-frequency magnetic field exposure elicits redox and trophic response in rat-cortical neurons. J Cell Physiol. 2009 May;219(2):334-43.

110. Diamond MC, Tenforde TS, Liburdy RP, et al. The influence of ultrahigh magnetic fields on cerebral cortical morphological development: a preliminary study (meeting abstract). Bioelectromagnetics Society, 11th Annual Meeting, 18-22 June, Tucson, AZ, Abstract No. P-1-20, p. 62-63, 1989.

111. Dinur-Klein L, Dannon P, Hadar A, et al. Smoking cessation induced by deep repetitive transcranial magnetic stimulation of the prefrontal and insular cortices: a prospective, randomized controlled trial. Biol Psychiatry. 2014 Nov 1;76(9):742-9.

112. Dostrovsky JO, Hutchison WD, Lozano AM. The globus pallidus, deep brain stimulation, and Parkinson's disease. Neuroscientist 8(3):284-290, 2002.

113. Du L, Fan H, Miao H, et al. Extremely low frequency magnetic fields inhibit adipogenesis of human mesenchymal stem cells. Bioelectromagnetics. 35(7): 519–530, 2014.

114. Durmaz O and Ates D. A Review of Repetitive Transcranial Magnetic Stimulation Use in Psychiatry. Dis Mol Med. 2013; 1(4): 77-86.

115. Dwyer ME, Vandersteen DR, Hollatz P, et al. Sacral neuromodulation for the dysfunctional elimination syndrome: a 10-year single-center experience with 105 consecutive children. Urology. 2014 Oct;84(4):911-7.

116. Ebert U and Ziemann U. Altered seizure susceptibility after high-frequency transcranial magnetic stimulation in rats. Neurosci Lett 1999 Oct 8;273(3):155-8.

117. Efanov OI, Djafarova AD, Zilberman UV, et al. Treatment of periodontitis with the help of a constant magnetic field. Vopr Kurortol Fizioter Lech Fiz Kult (3):28-30, 1992.

118. Eftekhar T, Teimoory N, Miri E, et al. Posterior tibial nerve stimulation for treating neurologic bladder in women: a randomized clinical trial. Acta Med Iran. 2014;52(11):816-21.

119. Ellis WV. (1993) Pain control using high-intensity pulsed magnetic stimulation. Bioelectromagnetics. 14(6): 553-556.

120. Esposito M, Lucariello A, Riccio I, et al. Differentiation of human osteoprogenitor cells increases after treatment with pulsed electromagnetic fields. In Vivo. 2012 Mar-Apr;26(2):299-304.

121. Eyres KS, Saleh M, Kanis JA. Effect of pulsed electromagnetic fields on bone formation and bone loss during limb lengthening. Bone 1996 Jun;18(6):505-9.

122. Fadakar K, Saba V, Farzampour S. Effects of extremely low frequency electromagnetic field (50 Hz) on pentylenetetrazol-induced seizures in mice. Acta Neurol Belg. 2013 Jun;113(2):173-7.

123. Fischer G and Kokoschinegg PJ. The treatment of sleep disturbances and meteorosensitivity by pulsed magnetic fields of low intensity. Bioelectr 9(2):243 Third Symposium on Magnetotherapy and Magnetic Stimulation, 12-14 October 1989, Hungary, 1990.

124. Fitzsimmons RJ, Baylink DJ. Growth factors and electromagnetic fields in bone. Clin Plast Surg 1994 Jul;21(3):401-6.

125. Fleischmann A, Hirschmann S, Dolberg OT, et al. Chronic treatment with repetitive transcranial magnetic stimulation inhibitsseizure induction by electroconvulsive shock in rats. Biol Psychiatry 1999 Mar 15;45(6):759-63.

126. Forgacs Z, Thuroczy G, Paksy K, et al. Effect of sinusoidal 50 Hz magnetic field on the testsosterone production of mouse primary Leydig cell culture. Bioelectromagnetics 19:429–431, 1998.

127. Foulds IS and Barker AT. Human skin battery potentials and their possible role in wound healing. Br J Dermatol 109(5):515-522, 1983.

128. Frolov VE, Bakhmutskii NG, Sinitskii DA, et al. Morphology of breast tumor in patients after combined therapy using pre-operation treatment with a magnetic eddy field. All-Union Symposium: Laser and Magnetic Therapy in Experimental and Clinical Studies, Tsyb A and Kaplan M, eds., 16-18 June, Obninsk, Kaluga Region, Russia, p. 204-206, 1993.

129. Fu YC, Lin CC, Chang JK, et al. A novel single pulsed electromagnetic field stimulates osteogenesis of bone marrow mesenchymal stem cells and bone repair. PLoS One. 2014 Mar 14;9(3):e91581.

130. Fujishiro T, Enomoto H, Ugawa Y, et al. Magnetic stimulation of the sacral roots for the treatment of stress incontinence: an investigational study and placebo controlled trial. J Urol. 2000 Oct;164(4):1277-9.

131. Fujishiro T, Takahashi S, Enomoto H, et al. Magnetic stimulation of the sacral roots for the treatment of urinary frequency and urge incontinence: an investigational study and placebo controlled trial. J Urol. 2002 Sep;168(3):1036-9.

132. Gandaglia G, Zaffuto E, Fossati N, et al. The role of prostatic inflammation in the development and progression of benign and malignant diseases. Curr Opin Urol. 2017 Mar;27(2):99-106.

133. Gao, L-S. The effect of magnetized water on digestive enzymes. Bioelectromagnetics Society, 17th Annual Meeting, 18-22 June, Boston, MA, Abstract No. P-171C, p. 221-222, 1995.

134. Garcia-Toro M, Mayol A, Arnillas H, et al. Modest adjunctive benefit with transcranial magnetic stimulation in medication-resistant depression. J Affect Disord 64(2-3):271-275, 2001.

135. Garland DE, Adkins RH, Matsuno NN, et al. The effect of pulsed electromagnetic fields on osteoporosis at the knee in individuals with spinal cord injury. J Spinal Cord Med 1999 Winter;22(4):239-45

136. Gaspard L, Tombal B, Opsomer RJ, et al. Physiotherapy and neurogenic lower urinary tract dysfunction in multiple sclerosis patients: a randomized controlled trial. Prog Urol. 2014 Sep;24(11):697-707.

137. Gaziev G, Topazio L, Iacovelli V, et al. Percutaneous Tibial Nerve Stimulation (PTNS) efficacy in the treatment of lower urinary tract dysfunctions: a systematic review. BMC Urol. 2013 Nov 25;13:61.

138. Ghersetich I, Teofoli P, Benci M, et al. Ultrastructural study of hyaluronic acid before and after the use of a pulsed electromagnetic field, electrorydesis, in the treatment of wrinkles. Int J Dermatol. 1994 Sep;33(9):661-3.

139. Giannakopoulos XK, Giotis C, Karkabounas SCh, et al. Effects of pulsed electromagnetic fields on benign prostate hyperplasia. Int Urol Nephrol. 2011 Dec;43(4):955-60.

140. Giczi J and Guseo A. Treatment of headache by pulsating electromagnetic field a preliminary report. Hungarian Symposium on Magnetotherapy (with International Participation), 2nd symposium, 16-17 May, Szekesfehervar, Hungary, p. 74-76, 1987.

141. Golbach LA, Scheer MH, Cuppen JJ, et al. Low-Frequency Electromagnetic Field Exposure Enhances Extracellular Trap Formation by Human Neutrophils through the NADPH Pathway. J Innate Immun. 2015;7(5):459-65.

142. Goodwin T. Physiological and molecular genetic effects of time-varying electromagnetic fields on human neuronal cells. NASA Johnson Space Center, Houston, TX, United States. NASA/TP-2003-212054.

143. Gorelick DA, Zangen A, George MS. Transcranial magnetic stimulation in the treatment of substance addiction. Ann N Y Acad Sci. 2014 Oct;1327:79-93.

144. Gorgun SS. Studies on the interaction between electromagnetic fields and living matter. Front Perspect 7(2):44-59, 1998.

145. Goritskaya I, Vinokurov V, Uritsky V, et al. The treatment effect of elf magnetic fields on patients with ovarian tumours. Bioelectromagnetics Society, 17th Annual Meeting, 18-22 June, Boston, MA, Abstract No. P-16A, p. 99, 1995.

146. Gorpinchenko II. The use of magnetic devices in treating sexual disorders in men. Lik Sprava (3-4):95-97, 1995.

147. Govoni E, Abatangelo G, Criscuolo M, et al. The interactions between pulsed electromagnetic fields and hyaluronic acid during skin wound healing. Bioelectrical Repair and Growth Society (BRAGS), Vol. IX, 9th Annual Meeting, 17-20 September, Cleveland, OH, p. 47, 1989.

148. Graham C and Cook MR. Human sleep in 60 hz magnetic fields. Bioelectromagnetics 20(5):277-283, 1999.

149. Graham C, Cook MR, Cohen HD, et al. Dose response study of human exposure to 60 Hz electric and magnetic fields. Bioelectromagnetics 15(5):447-463, 1994.

150. Graham C, Cook MR, Sastre A, et al. Cardiac autonomic control mechanisms in power-frequency magnetic fields: a multistudy analysis. Environ Health Perspect 108(8):737-742, 2000.

151. Grant DM. Detoxification pathways in the liver. J Inherit Metab Dis. 1991;14(4):421-30.

152. Grant G, Cadossi R, Steinberg G. Protection against focal cerebral ischemia following exposure to a pulsed electromagnetic field. Bioelectromagnetics. 1994;15(3):205-16.

153. Greenfield DS, Suñer IJ, Miller MP, et al. Endophthalmitis after filtering surgery with mitomycin. Arch Ophthalmol. 1996;114:943–949.

154. Greenspan JD, Craft RM, LeResche L, et al. Studying sex and gender differences in pain and analgesia: A consensus report. Pain. 2007 Nov; 132(Suppl 1): S26–S45.

155. Grisaru N, Amir M, Cohen H,et al. Effect of transcranial magnetic stimulation in posttraumatic stress disorder: a preliminary study. Biol Psychiatry 44(1):52-55, 1998.

156. Grunner O. Cerebral use of a pulsating magnetic field in neuropsychiatry patients with long-term headache. EEG EMG Z Elektroenzephalogr Verwandte Geb (1985) Dec;16(4):227-230.

157. Grunner O. Electromagnetic field and psychobiologic information. Cas Lek Cesk 118(40/41):1221-1226, 1979.

158. Gungor Ugurlucan F, Onal M, Aslan E, et al. Comparison of the effects of electrical stimulation and posterior tibial nerve stimulation in the treatment of overactive bladder syndrome. Gynecol Obstet Invest. 2013;75(1):46-52.

159. Guseo A and Hosszu Z. Effects of pulsing electromagnetic field of the GB device (meeting abstract). First World Congress for Electricity and Magnetism in Biology and Medicine, 14-19 June, Lake Buena Vista, FL, Abstract No. P-86, p. 96, 1992.

160. Guseo A. Pulsing electromagnetic field effects small intestine motility. European Bioelectromagnetics Assoc. (EBEA), 2nd Congress, 9-11 December, Bled, Slovenia, p. 33, 1993.

161. Guseo A. Pulsing electromagnetic field therapy of multiple sclerosis by the Gyuling–Bordacs device: Double-blind, cross-over and open studies. J Bioelectr 1987; 6: 23–25.

162. Gyuk I. Bio-electromagnetic computation in the low frequency range: an introduction. Progress in Applied Computational Electromagnetics, 9th Annual Review, 22-26 March, Naval Postgraduate Sch., Monterey, CA, p. 400-402, 1993.

163. Haddad JB, Obolensky AG, Shinnick P (2007) The biologic effects and the therapeutic mechanism of action of electric and electromagnetic field stimulation on bone and cartilage: new findings and a review of earlier work. J Altern Complement Med 13:485–90.

164. Hambly MF and Mooney V. Effect of smoking and pulsed electromagnetic fields on intradiscal pH in rabbits. Spine 17(6S):S83-S85, 1992.

165. Han JQ, Liu Q, Sun CT, et al. Efficacy and safety of low-frequency rotary magnetic fields in the treatment of patients with advanced malignant tumors. Zhonghua Zhong Liu Za Zhi. 2013 Jun;35(6):468-71.

166. Hardt JV. Alpha brain-wave neurofeedback training reduces psychopathology in a cohort of male and female Canadian aboriginals. Adv Mind Body Med. 2012 Fall;26(2):8-12.

167. Hart RA and Gandhi OP. Comparison of cardiac-induced endogenous fields and power frequency induced exogenous fields in an anatomical model of the human body. Phys Med Biol 43(10):3083-3099, 1998.

168. Hartmann KE, McPheeters ML, Biller DH, et al. Treatment of overactive bladder in women. Evid Rep Technol Assess (Full Rep). 2009 Aug;(187):1-120.

169. Health Quality Ontario. Repetitive Transcranial Magnetic Stimulation for Treatment-Resistant Depression: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Ont Health Technol Assess Ser. 2016 Mar 1;16(5):1-66.

170. Hedendahl L, Carlberg M, Hardell L. Electromagnetic hypersensitivity--an increasing challenge to the medical profession. Rev Environ Health. 2015;30(4):209-15.

171. Hei WH, Byun SH, Kim JS, et al. Effects of electromagnetic field (PEMF) exposure at different frequency and duration on the peripheral nerve regeneration: in vitro and in vivo study. Int J Neurosci. 2016 Aug;126(8):739-48.

172. Hei WH, Kim S, Park JC, et al. Schwann-like cells differentiated from human dental pulp stem cells combined with a pulsed electromagnetic field can improve peripheral nerve regeneration. Bioelectromagnetics. 2016 Apr; 37(3): 163–174.

173. Herbst E, Bryant GC, Sisken BF. Increased skin flap survival in rats subjected to low frequency electromagnetic fields. Bioelectrical Repair and Growth Society (BRAGS), Seventh Annual Meeting 11-14 October 1987, Toronto, Ontario, Canada, p. 72, 1987.

174. Heusser K, Tellschaft D, Thoss F. Influence of an alternating 3Hz magnetic field with an induction of 0.1 millitesla on chosen parameters of the human occipital EEG. Neurosci Lett 1997; 239: 57–60.

175. Hodaj H, Alibeu JP, Payen JF, et al. Treatment of Chronic Facial Pain Including Cluster Headache by Repetitive Transcranial Magnetic Stimulation of the Motor Cortex With Maintenance Sessions: A Naturalistic Study. Brain Stimul. 2015 Jul-Aug;8(4):801-7.

176. Hofmann GA. 1985. Deactivation of microorganisms by an oscillating magnetic field. U.S. Patent 4,524,079. http://www.patentgenius.com/patent/4524079.html.

177. Huang TL, Charyton C. A comprehensive review of the psychological effects of brainwave entrainment. Altern Ther Health Med. 2008 Sep-Oct;14(5):38-50.

178. Il'inskii IA, Syzdykov MS, Zhumanbaev KA, et al. Experience with the use of glucocorticosteroids and magnetic fields in the intensive therapy of severe forms of viral hepatitis. Sov Med (9):72-74, 1978.

179. Indulski JA, Bortkiewicz A, Zmyslony M. The present state of knowledge concerning the effect of electromagnetic fields of 50/60 Hz on the circulatory system and the autonomic nervous system. Med Pr 48(4):441-451, 1997.

180. Ingram DA, Thompson AJ, Swash M. Central motor conduction in multiple sclerosis: evaluation of abnormalities revealed by transcutaneous magnetic stimulation of the brain. J Neurol Neurosurg Psychiatry 51(4):487-[494], 1988.

181. Iorio R, Monache SD, Bennato F, et al.Involvement of mitochondrial activity in mediating ELF-EMF stimulatory effect on human sperm motility. Bioelectromagnetics 32:15–27, 2011.

182. Ishikawa N, Suda S, Sasaki T, et al. Development of a non-invasive treatment system for urinary incontinence using a functional continuous magnetic stimulator (FCMS). Med Biol Eng Comput. 1998 Nov;36(6):704-10.

183. Jacobs G, Zborowski M, Atkinson M, et al. Effects of pulsed electromagnetic fields (pemf) on organelle velocities in rat sciatic nerve axons. Bioelectrical Repair and Growth Society (BRAGS), Transactions, Vol. X, Tenth Annual Meeting, 14-17 October 1990, Philadelphia, PA, p. 18, 1990.

184. Jacobson JI. Pineal-hypothalamic tract mediation of picoTesla magnetic fields in the treatment of epilepsy and parkinson's disease (meeting abstract). Bioelectromagnetics Society, 16th Annual Meeting, 12-17 June, Copenhagen, Denmark, Abstract No. P-69, p. 100, 1994.

185. Jadidi M, Biat SM, Sameni HR, et al. Mesenchymal stem cells that located in the electromagnetic fields improves rat model of Parkinson's disease. Iran J Basic Med Sci. 2016 Jul;19(7):741-8.

186. Jahanshahi M and Rothwell J. Transcranial magnetic stimulation studies of cognition: an emerging field. Exp Brain Res 131(1):1-9, 2000.

187. Jang J, Park EY, Seo SI, et al. Effects of intravesical instillation of cyclooxygenase-2 inhibitor on the expression of inducible nitric oxide synthase and nerve growth factor in cyclophosphamide-induced overactive bladder. BJU Int. 2006 Aug;98(2):435-9.

188. Janicak PG, O'Reardon JP, Sampson SM, et al. Transcranial magnetic stimulation in the treatment of major depressive disorder: a comprehensive summary of safety experience from acute exposure, extended exposure, and during reintroduction treatment. J Clin Psychiatry. 2008 Feb;69(2):222-32.

189. Janssen DA, Farag F, Heesakkers JP. Urgent-SQ implant in treatment of overactive bladder syndrome: 9-year follow-up study. Neurourol Urodyn. 2013 Jun;32(5):472-5.

190. Jerabek, J and Pawluk, W. Magnetic therapy in Eastern Europe: a review of 30 years of research. Publ. Advanced Magnetic Research of the Delaware Valley, Chicago, 1996.

191. Jin Y, Phillips B. A pilot study of the use of EEG-based synchronized Transcranial Magnetic Stimulation (sTMS) for treatment of Major Depression. BMC Psychiatry. 2014 Jan 18;14:13.

192. Johnson MT, Vanscoy-Cornett A, Vesper DN, et al. Electromagnetic fields used clinically to improve bone healing also impact lymphocyte proliferation in vitro. Biomed Sci Instrum. 2001;37:215-20.

193. Jung I, Kim H, Noh R, et al. Effects of extremely low frequency magnetic fields on NGF induced neuronal differentiation of PC12 cells. Bioelectromagnetics. 35:459–469, 2014.

194. Kajbafzadeh AM, Sharifi-Rad L, Mozafarpour S, et al. Efficacy of transcutaneous interferential electrical stimulation in treatment of children with primary nocturnal enuresis: a randomized clinical trial. Pediatr Nephrol. 2015 Jul;30(7):1139-45.

195. Kakuda W, Abo M, Shimizu M, et al. A multi-center study on low-frequency PEMF combined with intensive occupational therapy for upper limb hemiparesis in post-stroke patients. J Neuroeng Rehabil. 2012 Jan 20;9(1):4.

196. Kakuda W, Momosaki R, Yamada N, et al. High-frequency rTMS for the Treatment of Chronic Fatigue Syndrome: A Case Series. Intern Med. 2016;55(23):3515-3519.

197. Kalkan MT, Korpinar MA, Seker S, et al. The effect of the 50 Hz frequency sinusoidal magnetic field on the stress-related behavior of rats. Proceedings of the 2nd International Conference Biomedical Engineering Days, 20-22 May, Istanbul, Turkey, p.78-81, 1998.

198. Kang SH, Bae JH, Shim KS, et al. Extracorporeal magnetic innervation therapy in children with refractory monosymptomatic nocturnal enuresis. Urology. 2007 Sep;70(3):576-80.

199. Karpukhin IV and Bogomol'nii VA. Local vacuum-magnetotherapy of impotency patients. Vopr Kurortol Fizioter Lech Fiz Kult (2):38-40, 1996.

200. Keck ME, Welt T, Post A, et al. Neuroendocrine and behavioral effects of repetitive transcranial magnetic stimulation in a psychopathological animal model are suggestive of antidepressant-like effects. Neuropsychopharmacology 24(4):337-349, 2001.

201. Kennedy WF, Roberts CG, Zuege RC, et al. 1993. Use of pulsed electromagnetic fields in treatment of loosened cemented hip prostheses. Clin Orthop 286:198–205.

202. Khedr EM, Abo-Elfetoh N, Elbeh KA, et al, Transcranial magnetic stimulation identifies cortical excitability changes in monosymptomatic nocturnal enuresis. Neurophysiol Clin. 2015 May;45(2):151-8.

203. Kim EC, Leesungbok R, Lee SW, et al. Effects of moderate intensity static magnetic fields on human bone marrow-derived mesenchymal stem cells. Bioelectromagnetics. 2015 Apr;36(4):267-76.

204. Kim HJ, Jung J, Park JH, et al. Extremely low-frequency electromagnetic fields induce neural differentiation in bone marrow derived mesenchymal stem cells. Exp Biol Med (Maywood). 2013 Aug 1;238(8):923-31.

205. Kim SB, Lee NR, Park SW, et al. Electromagnetic acupuncture to enhance the effects of manual acupuncture on recovery from muscle fatigue of the quadriceps. J Acupunct Meridian Stud. 2014 Oct;7(5):250-7.

206. Kiselev AV and Grushina TI. Use of artificial magnetic field for rehabilitation of children with malignant tumors. Vopr Onkol 46(4):469-472, 2000.

207. Klawansky S, Yeung A, Berkey C, et al. Meta-analysis of randomized controlled trials of cranial electrostimulation. Efficacy in treating selected psychological and physiological conditions. J Nerv Ment Dis 183(7):478-484, 1995.

208. Klemenov, AV. Magnetotherapy of arrhythmia. Sov Med (10):119, 1989.

209. Koch G, Rossi S, Prosperetti C, et al. Improvement of hand dexterity following motor cortex rTMS in multiple sclerosis patients with cerebellar impairment. Mult Scler. 2008 Aug;14(7):995-8.

210. Kokoschinegg P, Kokoschinegg M, et al. Weak electromagnetic pulses can improve breathing. European Bioelectromagnetics Assoc. (EBEA), 2nd Congress, 9-11 December, Bled, Slovenia, p. 40-41, 16993.

211. Kolomietz A, Suslova TE, Savina EV, et al. Clinical-immunological effects of magnetotherapy. All-Union Symposium: Laser and Magnetic Therapy in Experimental and Clinical Studies, Tsyb A and Kaplan M, eds., 16-18 June, Obninsk, Kaluga Region, Russia, p. 208-209 1993.

212. Konrad K, Sevcic K, Folde K, et al. 1996. Therapy with pulsed electromagnetic fields in aseptic loosening of total hip prostheses. A prospective study. Clin Rheumatol 15:325–328.

213. Kovalchuk VI, Ahtirskii VI, Dubovoi LV. Use of weak extremely-low-frequency magnetic fields in treatment of oncological diseases. Fizicheskaia Meditzina 4(1-2):93-95. Abstracts of All-Russian Conference "Use of Low-Level Laser Radiation and Magnetic Fields in Biology and Medicine," Obninsk, Russia, 21-23 June 1994.

214. Koziarin IP. Structure of the internal organs of animals after short-term exposure to an electromagnetic field of industrial frequency. Vrach Delo (5):93-94, 1988.

215. Kraus W. The causality of elastic, electrical and magnetic forces in the healthy and defective bone. European Society of Biomechanics, 2nd Meeting and first Symposium of the Groupe d'Etudes de Biomecanique Oste-Articulaire de Strasbourg, 13-15 September, 1979, Strasbourg, France:C-1, 1979.

216. Kravtsova T Iu, Rybolovlev EV, Kochurov AP. The use of magnetic puncture in patients with duodenal peptic ulcer. Vopr Kurortol Fizioter Lech Fiz Kult (1):22-24, 1994.

217. Kuliev RA and Babaev RF. A magnetic field in the combined treatment of suppurative wounds in diabetes mellitus. Vestn Khir 148(1):33-36, 1993.

218. Kumar VS, Kumar DA, Kalaivani K, et al. Optimization of pulsed electromagnetic field therapy for management of arthritis in rats. Bioelectromagnetics. 2005 Sep;26(6):431-9.

219. Kusaka C, Seto A, Nagata T, et al. (1995) Pulse magnetic treatment and whole-body, alternating current magnetic treatment for post-herpetic neuralgia. J Jpn Biomagnetism Bioelectromagnetics Soc. 8(2): 29-38.

220. Lagroye I, Bersani F, Billaudel B, et al. Effects of ELF- and RF-EMF on the apoptotic process. Bioelectromagnetics Society, 25th Annual Meeting, 22-27, Wailea, Maui, HI, Abstract No. 13-8, p. 134, 2003.

221. Laitl-Kobierska A, Cieslar G, Sieron A, et al. Influence of alternating extremely low frequency elf magnetic field on structure and function of pancreas in rats. Bioelectromagnetics 23(1):49-58, 2002.

222. Lamusuo S, Hirvonen J, Lindholm P, et al. Neurotransmitters behind pain relief with transcranial magnetic stimulation - positron emission tomography evidence for release of endogenous opioids. Eur J Pain. 2017 May 11.

223. Lappin MS, Lawrie FW, Richards TL et al. Effects of a pulsed electromagnetic therapy on multiple sclerosis fatigue and quality of life: A double-blind, placebo controlled trial. Altern Ther Health Med 2003; 9: 38–48.

224. Laugier R, Bernard JP, Berthezene P, et al. Changes in pancreatic exocrine secretion with age: pancreatic exocrine secretion does decrease in the elderly. Digestion. 1991;50(3-4):202-11.

225. Law SK, Nguyen AM, Coleman AL, et al. Severe loss of central vision in patients with advanced glaucoma undergoing trabeculectomy. Arch Ophthalmol. 2007;125:1044–1055.

226. Lazar L and Farago A. Experiences of patients suffering from migraine-type headache treated with magnetotherapy. Hungarian Symposium on Magnetotherapy (with International Participation), 2nd symposium, 16-17 May, Szekesfehervar, Hungary, p. 137-140, 1987.

227. Lee NR, Kim SB, Heo H, et al. Comparison of the Effects of Manual Acupuncture, Laser Acupuncture, and Electromagnetic Field Stimulation at Acupuncture Point BL15 on Heart Rate Variability. J Acupunct Meridian Stud. 2016 Oct;9(5):257-263.

228. Lefaucheur JP, Drouot X, Ménard-Lefaucheur I, et al. Neuropathic pain controlled for more than a year by monthly sessions of repetitive transcranial magnetic stimulation of the motor cortex. Neurophysiol Clin. 2004 Apr;34(2):91-5.

229. Lefaucheur JP. Use of repetitive transcranial magnetic stimulation in pain relief. Expert Rev Neurother. 2008 May;8(5):799-808.

230. Lena Fortuna R, Friol González JE. Fibromialgia y Magnetoterapia. Revista Cubana de Reumatologa. 2002;IV(1):56.

231. Leoci R, Aiudi G, Silvestre F, et al. Effect of pulsed electromagnetic field therapy on prostate volume and vascularity in the treatment of benign prostatic hyperplasia: A pilot study in a canine model. Prostate. 2014 Aug;74(11):1132-41.

232. Letiagin VP, Dobrynin YV, Rybakov YL, et al. Application of the turbulent magnetic field (TMF)-influence for decrease of the postoperative lymphorrhea after surgical treatment of the locally spread breast cancer. Bioelectromagnetics Society, 24th Annual Meeting, 23-27 June, Quebec City, QC, Canada, Abstract (poster) No. P-26, p. 162, 2002.

233. Leuchter AF, Cook IA, Feifel D, et al. Efficacy and Safety of Low-field Synchronized Transcranial Magnetic Stimulation (sTMS) for Treatment of Major Depression. Brain Stimul. 2015;8(4):787-94.

234. Leuchter AF, Cook IA, Jin Y, et al. The relationship between brain oscillatory activity and therapeutic effectiveness of transcranial magnetic stimulation in the treatment of major depressive disorder. Front Hum Neurosci. 2013 Feb 26;7:37.

235. Leuchter AF, Hunter AM, Krantz DE, et al. Rhythms and blues: modulation of oscillatory synchrony and the mechanism of action of antidepressant treatments. Ann N Y Acad Sci. 2015 May;1344:78-91.

236. Li Y, Yan X, Liu J, Let al. Pulsed electromagnetic field enhances brain-derived neurotrophic factor expression through L-type voltage-gated calcium channel- and Erk-dependent signaling pathways in neonatal rat dorsal root ganglion neurons. Neurochem Int. 2014 Sep;75:96-104.

237. Li Y, Zhao L, Xing X, et al. Effects of different frequency electromagnetic fields on the differentiation of midbrain neural stem cells. Space Med Med Eng (Beijing). 2002 Oct;15(5):374-6.

238. Liao X, Li G, Wang A, et al. Repetitive Transcranial Magnetic Stimulation as an Alternative Therapy for Cognitive Impairment in Alzheimer's Disease: A Meta-Analysis. J Alzheimers Dis. 2015 Sep 9;48(2):463-72.

239. Liburdy RP, Vanek PF, Kemski MH, et al. Influence of pulsed electromagnetic fields on soft tissue wound healing: in vivo and in vitro studies. Bioelectrical Repair and Growth Society (BRAGS), Vol. VIII, 8th Annual Meeting, 9-12 October, Washington, DC, p. 49, 1988.

240. Liepert J, Tegenthoff M. Transcranial magnetic stimulation of patients with a single epileptic seizure. Nervenarzt 1992 Aug;63(8):492-4.

241. Lindholm P, Lamusuo S, Taiminen T, et al. The analgesic effect of therapeutic rTMS is not mediated or predicted by comorbid psychiatric or sleep disorders. Medicine (Baltimore). 2016 Nov;95(44):e5231.

242. Lipiec J, Janas P, Barabasz W. 2004. Effect of oscillating magnetic field pulses on the survival of selected microorganisms. Int Agrophysics 18:325–328.

243. Lisanby SH, Kinnunen LH, Crupain MJ. Applications of TMS to therapy in psychiatry. J Clin Neurophysiol 19(4):344-360, 2002.

244. Lisanby SH, Luber B, Schlaepfer TE, et al. Safety and feasibility of magnetic seizure therapy (MST) in major depression: randomized within-subject comparison with electroconvulsive therapy. Neuropsychopharmacology. 2003 Oct;28(10):1852-65.

245. Liu HF, Yang L, He HC, et al. Pulsed electromagnetic fields on postmenopausal osteoporosis in Southwest China: a randomized, active-controlled clinical trial. Bioelectromagnetics. 2013 May;34(4):323-32.

246. Longo FM, Yang T, et al. Electromagnetic fields influence NGF activity and levels following sciatic nerve transection. J Neurosci Res 55(2):230-237, 1999.

247. Lopes AD, Hespanhol Júnior LC, Yeung SS, et al. What are the main running-related musculoskeletal injuries? A Systematic Review. Sports Med. 2012 Oct 1;42(10):891-905.

248. Löwik CW, Nibbering PH, van de Ruit M, et al. Inducible production of nitric oxide in osteoblast-like cells and in fetal mouse bone explants is associated with suppression of osteoclastic bone resorption. J Clin Invest. 1994 Apr;93(4):1465-72.

249. Lubennikov VA, Lazarev AF, Golubtsov VT. First experience in using a whole-body magnetic field exposure in treating cancer patients. Vopr Onkol 41(2):140-141, 1995.

250. Lundsberg LS, Bracken MB, Belanger K. Occupationally related magnetic field exposure and male subfertility. Fertil Steril 63(2):384-391, 1995.

251. Luzi L, Ferrulli A, Drago L, et al. Deep Transcranial Magnetic Stimulation (dTMS) Exerts Anti-Obesity Effects Via Microbiota Modulation. Endocrine Society 2017 Annual Conference, Orlando FL. Abstract: LB SUN 72.

252. Lyskov EB, Juutilainen J, Jousmaki V, et al. Effects of 45 Hz magnetic fields on the functional state of the human brain. Bioelectromagnetics (1993)14: 87–95.

253. Ma J, Zhang Z, Su Y, et al. Magnetic stimulation modulates structural synaptic plasticity and regulates BDNF-TrkB signal pathway in cultured hippocampal neurons. Neurochem Int. 2013 Jan;62(1):84-91.

254. Ma SM, Ni JX, Li XY. et al. High-Frequency Repetitive Transcranial Magnetic Stimulation Reduces Pain in Postherpetic Neuralgia. Pain Med. 2015 Nov;16(11):2162-70.

255. MacFarlane MP, Glenn TC. Neurochemical cascade of concussion. Brain Inj. 292:139-53, 2015.

256. Machado S, Paes F, Velasques B, et al. Is rTMS an effective therapeutic strategy that can be used to treat anxiety disorders? Neuropharmacology. 2012 Jan;62(1):125-34.

257. Maestú C, Blanco M, Nevado A, et al. Reduction of pain thresholds in fibromyalgia after very low-intensity magnetic stimulation: a double-blinded, randomized placebo-controlled clinical trial. Pain Res Manag. 2013 Nov-Dec;18(6):e101-6.

258. Mahapokai W, Van Sluijs FJ, Schalken JA. Models for studying benign prostatic hyperplasia. Prostate Cancer Prostatic Dis. 2000 Jul;3(1):28-33.

259. Maisch D, Rapley B, Rowland RE, et al. Chronic fatigue syndrome--is prolonged exposure to environmental level powerline frequency electromagnetic fields a co-factor to consider in treatment? J Australasian Coll Nutr Environ Med 17(2):29-35, 1998.

260. Makhni EC, Buza JA, Byram I, et al. Sports reporting: a comprehensive review of the medical literature regarding North American professional sports. Phys Sportsmed. 2014 May;42(2):154-62.

261. Maksimov VIu, Zakharova NV, Maksimova IS, et al. Laser magnetotherapy after cataract extraction with implantation of intraocular lens. Vestn Oftalmol. 2002 May-Jun;118(3):15-7.

262. Mally J and Stone TW. Therapeutic and "dose-dependent" effect of repetitive microelectroshock induced by transcranial magnetic stimulation in Parkinson's Disease. J Neurosci Res 57(6):935-940, 1999.

263. Mandolini G, Santantonio M, Zucchini P, et al. The association of PEMF and 60co irradiation for the treatment of patients suffering from brain metastases not surgically removable. Electromagnetics in Biology and Medicine. Brighton CT, Pollack SR, eds. San Francisco, CA: San Francisco Press, p. 343-346, 1991.

264. Manganotti P, Zaina F, Vedovi E, et al. Repetitive magnetic stimulation of the sacral roots for the treatment of stress incontinence: a brief report. Medicophys. 2007 Sep;43(3):339-44.

265. Manzella N, Bracci M, Ciarapica V, et al. Circadian gene expression and extremely low-frequency magnetic fields: An in vitro study Bioelectromagnetics. 36:294–301, 2015.

266. Marchesi N, Osera C, Fassina L, et al. Autophagy is modulated in human neuroblastoma cells through direct exposition to low frequency electromagnetic fields. J Cell Physiol. 2014 Nov;229(11):1776-86.

267. Martinson M, MacDiarmid S, Black E. Cost of neuromodulation therapies for overactive bladder: percutaneous tibial nerve stimulation versus sacral nerve stimulation. J Urol. 2013 Jan;189(1):210-6.

268. Martiny K, Lunde M, Bech P: Transcranial low voltage pulsed electromagnetic fields in patients with treatment-resistant depression. Biol Psychiatry 2010, 68:163–169.

269. Massimini M, Ferrarelli F, Esser SK, et al. Triggering sleep slow waves by transcranial magnetic stimulation. Proc Natl Acad Sci U S A. 2007, May 15;104(20):8496-501.

270. Massot O, Grimaldi B, Bailly J-M, et al. Magnetic field desensitizes 5-HT(1B) receptor in brain: pharmacological and functional studies. Brain Res 858(1):143-150, 2000.

271. Mavranezouli I, Meader N, Cape J, et al. The cost effectiveness of pharmacological treatments for generalized anxiety disorder. Pharmacoeconomics. 2013 Apr;31(4):317-33.

272. Mayer-Wagner S, Passberger A, Sievers B, et al. Effects of low frequency electromagnetic fields on the chondrogenic differentiation of human mesenchymal stem cells. Bioelectromagnetics. 2011 May;32(4):283-90.

273. Mayo-Wilson E, Dias S, Mavranezouli I, et al. Psychological and pharmacological interventions for social anxiety disorder in adults: a systematic review and network meta-analysis. Lancet Psychiatry. 2014 Oct;1(5):368-76.

274. McCann, UD, Kimbrell TA, Morgan CM, et al. Repetitive transcranial magnetic stimulation for posttraumatic stress disorder. Arch Gen Psychiatry 55(3):276-279, 1998.

275. McEver RP and Zhu C. Rolling cell adhesion. Annu Rev Cell Dev Biol. 2010;26:363-96.

276. McKay JC, Prato FS, Thomas AW. A literature review: the effects of magnetic field exposure on blood flow and blood vessels in the microvasculature. Bioelectromagnetics. 2007 Feb;28(2):81-98.

277. Meehan WP 3rd. Medical therapies for concussion. Clin Sports Med. 2011 Jan;30(1):115-24, ix.

278. Menkes DL and Gruenthal M. Slow-frequency repetitive transcranial magnetic stimulation in a patient with focal cortical dysplasia. Epilepsia 2000 Feb;41(2):240-2.

279. Merkulova IU and Mikhel'son ML. The therapeutic action of magnetized water on the quality of health at a sanatorium. Vopr Kurortol Fizioter Lech Fiz Kult (2):37-39, 1994.

280. Messer K, Trinidad DR, Al-Delaimy WK, et al. Smoking Cessation Rates in the United States: A Comparison of Young Adult and Older Smokers. Am J Public Health. 2008 February; 98(2): 317–322.

281. Miasoedov DV, Biniashevskii EV, Bundiuk LS, et al. Experience with the use of microwave resonance therapy as a modifying factor in oncological therapy. Fundamental and Applied Aspects of the Use of Millimeter Electromagnetic Radiation in Medicine. Abstracts of the first All-Union Symposium with International Participation. 10-13 May, 1989, Kiev, Ukraine, p. 313-315, 1989.

282. Mikhailova RI, Komarova ZA, Semkin VA, et al. Magnetotherapy in fractures of the lower jaw. Stomatologiia (Mosk) 61(1):41-42, 1982.

283. Mikhel'son ML and Merkulova IU. The biological and bactericidal actions of magnetized water. Vopr Kurortol Fizioter Lech Fiz Kult (2):35-37, 1994.

284. Milevskaya TG, Shitikov BD, Prohorova VI, et al. Eddy magnetic field therapy as a part of combined therapy for breast cancer. Mammologia (2):51-55, 1997.

285. Mills KR. Magnetic brain stimulation: a tool to explore the action of the motor cortex on single human spinal motoneurones. Trends Neurosci 1991 Sep;14(9):401-5.

286. Mirtskhulava MB. Regularities of the biological action of magnetic fields of sound frequency. Regularity of Biological Action of Magnetic Fields of Sound Frequency. Bulletin of Dissertation. 47 pp. 1993.

287. Mishima S. The effect of long-term pulsing electromagnetic field stimulation on experimental osteoporosis of rats. J UOEH 1988 Mar 1;10(1):31-45

288. Mitbreit IM, Savchenko AG, Volkova LP, et al. (1986) Low-frequency magnetic field in the complex treatment of patients with lumbar osteochondrosis. Ortop Travmatol Protez. (10): 24-27.

289. Mittenzwey R, Sussmuth R, Mei W. Effects of extremely low-frequency electromagnetic fields on bacteria -- the question of a co-stressing factor. Bioelectrochem Bioenerg 40(1):21-27, 1996.

290. Mix E, Henssen HL, Lehmitz R, et al. Pulsing electromagnetic field (PEMF) treatment of patients with multiple sclerosis (MS) and migraine. Effect on cell volume and phagocytic activity of blood cells and clinical results (meeting abstract). J Bioelectr 9(2):242 Third Symposium on Magnetotherapy and Magnetic Stimulation, 12-14 October 1989, Szekesfehervar, Hungary, 1990.

291. Moisset X, de Andrade DC, Bouhassira D, et al. From pulses to pain relief: an update on the mechanisms of rTMS-induced analgesic effects. Eur J Pain. 2016 May;20(5):689-700.

292. Montagnani AM. Effects of pulsed magnetic fields in the therapy of osteoporosis induced by ovariectomy in the rat. Boll Soc Ital Biol Sper 1993 Jul-Aug;69(7-8):469-75.

293. Moore RL. Biological effects of magnetic fields: studies with microorganisms. Can J Microbiol 25(10):1145-1151, 1979.

294. Moratti A and Jeran M. Electromagnetic stimulation of skin lesions of venous origin in humans: a double-blind study. J Bioelectr 8(2):312 International Symposium in Honor of Luigi Galvani, 14-16, April, Bologna, Italy, 1989.

295. Mosaed S, Dustin L, Minckler DS. Comparative Outcomes between Newer and Older Surgeries for Glaucoma. Trans Am Ophthalmol Soc. 2009 Dec; 107: 127–133.

296. Mosimann UP, Rihs TA, Engeler J, et al. Mood effects of repetitive transcranial magnetic stimulation of left prefrontal cortex in healthy volunteers. Psychiatry Res. 2000 Jul 17;94(3):251-6.

297. Mostert S and Kesselring J. Effect of pulsed magnetic field therapy on the level of fatigue in patients withmultiple sclerosis – a randomized controlled trial. Mult Scler 2005; 11: 302–305.

298. Muehsam D, Lalezari P, Lekhraj R, et al. Non-thermal radio frequency and static magnetic fields increase rate of hemoglobin deoxygenation in a cell-free preparation. PLoS One. 2013 Apr 12;8(4):e61752.

299. Nadiga DN, Hensley PL, Uhlenhuth EH. Review of the long-term effectiveness of cognitive behavioral therapy compared to medications in panic disorder. Depress Anxiety. 2003;17(2):58-64.

300. Nahas Z, Bohning DE, Molloy MA, et al. Safety and feasibility of repetitive transcranial magnetic stimulation in the treatment of anxious depression in pregnancy: a case report. J Clin Psychiatry 60(1):50-52, 1999.

301. Nakajima H, Kishi T, Tsuchiya Y, et al. Exposure of fibroblasts derived from keloid patients to low-energy electromagnetic fields: preferential inhibition of cell proliferation, collagen synthesis, and transforming growth factor beta expression in keloid fibroblasts in vitro. Ann Plast Surg 39(5):536-541, 1997.

302. Nakasono S, Ikehata M, Koana T, et al. A 50 Hz, 14 mT magnetic field is not mutagenic or co-mutagenic in bacterial mutation assays. Mutat Res 471(1-2):127-134, 2000.

303. Negoro H, Kanematsu A, Yoshimura K, Ogawa O. Chronobiology of micturition: putative role of the circadian clock. J Urol. 2013 Sep;190(3):843-9.

304. Neumüller J, Tohidast-Akrad M, Partsch G, et al. Changes in phagocytosis and the percentage of lymphocyte subsets during therapy with pulsed magnetic fields (PMF). Journal of Bioelectricity 8(1), 29-45 (1989).

305. Niedermeyer, E. (1999) The Normal EEG of the Waking Adult. Electroencephalography. Lippincott Williams and Wilkins, Baltimore.

306. Nielsen JF, Sinkjaer T and Jakobsen J. Treatment of spasticity with repetitive magnetic stimulation; a double-blind placebo-controlled study. Mult Scler 1996; 2: 227–232.

307. Nikolic LM, Rokic MB, Todorovic NV, et al. Effect of alternating the magnetic field on phosphate metabolism in the nervous system of Helix pomatia. Biol Res. 2010;43(2):243-50.

308. Nikolova L, Popov A, Klouchek E. Effect of interference current and low-frequency magnetic field on tissue regeneration. Vopr Kurortol Fizioter Lech Fiz Kult(3):19-23, 1984.

309. NIMH. https://www.nimh.nih.gov/health/publications/stress/index.shtml/index.shtml

310. Nindl G, Spandau DF, Vesper DN, et al. Therapeutic potential of elf magnetic fields in inflammatory skin diseases. Bioelectromagnetics Society, 22nd Annual Meeting, 11-16 June, Munich, Germany, Abstract No. 13-1, p. 73-74, 2000.

311. Ning JT, Gajendran V, Porter C, et al. Potential clinical application of taxol and power frequency electromagnetic fields exposure on human prostate disorders. Second World Congress for Electricity and Magnetism in Biology and Medicine, 8-13 June, Bologna, Italy, Abstract No. I-7, p. 136-137.

312. Novickij V, Grainys A, Švedienė J, et al. Microsecond pulsed magnetic field improves efficacy of antifungal agents on pathogenic microorganisms. Bioelectromagnetics 35(5): 347–353, 2014.

313. Nuccitelli R, Erickson CA (1983): Embryonic cell motility can be guided by physiological electric fields. Exp Cell Res 147:195–198.

314. Ober C, Sinatra ST, and Zucker M. Earthing: the most important health discovery ever? Basic Health Publications; 1st edition, 2010.

315. Oda T, Koike T. Magnetic field exposure saves rat cerebellar granule neurons from apoptosis in vitro. Neurosci Lett. 2004 Jul 22;365(2):83-6.

316. Ogorodnikova LS, Gairabed'iants NG, Ratner ON, et al. Morphological criteria of lung cancer regression under the effect of magnetotherapy. Vopr Onkol 26(1):28-34, 1980.

317. Omar AS, Awadalla MA, El-Latif MA. Evaluation of pulsed electromagnetic field therapy in the management of patients with discogenic lumbar radiculopathy. Int J Rheum Dis. 2012 Oct;15(5): 101-8.

318. Ongaro A, Pellati A, Bagheri L, et al. Pulsed electromagnetic fields stimulate osteogenic differentiation in human bone marrow and adipose tissue derived mesenchymal stem cells. Bioelectromagnetics. 2014 Sep;35(6):426-36.

319. Ossenkopp KP, Cain DP. Inhibitory effects of acute exposure to low-intensity 60-Hz magnetic fields on electrically kindled seizures in rats. Brain Res 1988 Mar 1;442(2):255-60.

320. Ossenkopp KP, Kavaliers M. Clinical and applied aspects of magnetic field exposure: a possible role for the endogenous opioid system. J Bioelectr 7(2):189-208, 1989.

321. Otpushchennikova TV, Kazanskaia IV, Volkov SV, et al. Optimization of enuresis therapy in children using transcranial magnetotherapy. Urologiia. 2010 Jan-Feb;(1):61-2, 64-5.

322. Ottani V, Monti MG, Morocutti M, et al. Influence of pulsed electromagnetic fields on regenerating rat liver after partial hepatectomy. J Anat 139(2):253-263, 1984.

323. Ozinkovskii VV. The use of low frequency alternating and constant magnetic fields in otolaryngology. Zh Ushn Nos Gorl Bolezn (6):74-77, 1981.

324. Pape TL, Rosenow J, Lewis G. Transcranial magnetic stimulation: a possible treatment for TBI. J Head Trauma Rehabil. 2006 Sep-Oct;21(5):437-51.

325. Park JE, Seo YK, Yoon HH, et al. Electromagnetic fields induce neural differentiation of human bone marrow derived mesenchymal stem cells via ROS mediated EGFR activation. Neurochem Int. 2013 Mar;62(4):418-24.

326. Pasche B. Low energy emission therapy (leet) for the treatment of insomnia and anxiety. Bioelectromagnetics Society, 22nd Annual Meeting, 11-16 June, Munich, Germany, Abstract No. P-151, p. 240-241, 2000.

327. Pascual-Leone A, Valls-Sole J, Brasil-Neto JP, et al. Akinesia in Parkinson's disease. Ii. Effects of subthreshold repetitive transcranial motor cortex stimulation. Neurology 44(5):892-898, 1994.

328. Pastore A, Curr SB, Spinelli M. Interpretation of low-frequency pulsating magnetic field effects on patients affected by peripheral arteriopathy. Bioelectrochem Bioenerg 14(1-3):207-213 Presented at the first international A.B.A.EM. Meeting, Venice, February 23-25, 1984, 1985.

329. Patino O, Grana D, Bolgiani A, et al. Effect of electromagnetic fields on skin wound healing. Experimental study. Medicina (B Aires) 56(1):41-44, 1996.

330. Pawluk W, Dennis R, Tommerdahl M. Tracking the effects of pulsed electro-magnetic field (PEMF) on individuals with a history of traumatic brain injury with the Brain Gauge. Cortical Metrics Magazine – Vol. 1, pages 1-4. 2017. https://www.corticalmetrics.com/publications.

331. Pawluk W. Clinical dosimetry of extremely low-frequency pulsed electromagnetic fields. Chapter 17. *In* Dosimetry in Bioelectromagnetics, CRC Press, publication Jan 2017, Markov M, Editor.

332. Pawluk W. Magnetic fields for pain control, chapter 17. In Electromagnetic Fields in Biology and Medicine, CRC Press, publication Jan 2015, Markov M, Editor.

333. Pelka RB, Jaenicke C, Gruenwald J. Impulse magnetic-field therapy for migraine and other headaches: a double-blind, placebo-controlled study. Adv Ther 18(3):101-109, 2001.

334. Pelka RB, Jaenicke C, Gruenwald J. Impulse magnetic-field therapy for insomnia: a double-blind, placebo-controlled study. Adv Ther Jul-Aug; 18(4):174-180, 2001.

335. Persinger MA, Hoang V, Baker-Price L. Entrainment of stage 2 sleep spindles by weak, transcerebral magnetic stimulationin an "epileptic" woman. Electromagn Biol Med. 2009; 28(4):374-82.

336. Persinger MA, Saroka KS. Comparable proportions of classes of experiences and intracerebral consequences for surgical stimulation and external application of weak magnetic field patterns: implications for converging effects in complex partial seizures. Epilepsy Behav. 2013 Apr;27(1):220-4.

337. Piatkowski J, Kern S and Ziemssen T. Effect of BEMER magnetic field therapy on the level of fatigue in patients with multiple sclerosis: a randomized double – blind controlled trial. J Altern Complement Med 2009; 15: 507–511.

338. Pica F, Serafino A, Divizia M, et al. Effect of extremely low frequency electromagnetic fields (ELF-EMF) on Kaposi's sarcoma-associated herpes virus in BCBL-1 cells. Bioelectromagnetics. 2006 Apr;27(3):226-32.

339. Pilla AA, Markov MS. Bioeffects of weak electromagnetic fields. Rev Environ Health. 1994 Jul-Dec;10(3-4):155-69.

340. Piruzian LA and Kuznetsov AN. Influence of static and low-frequency magnetic fields on biological systems. Izv Akad Nauk SSSR (Biol) (6):805-821, 1983.

341. Plewnia C, Rilk AJ, Soekadar SR, et al. Enhancement of long-range EEG coherence by synchronous bifocal transcranial magnetic stimulation. Eur J Neurosci. 2008 Mar;27(6):1577-83.

342. Polk C. Electric and magnetic fields for bone and soft tissue repair. Chapter 5 in Handbook of biologic effects of electromagnetic fields, 2nd edition, editors Polk and Postow, CRC press, 1995.

343. Ponomarenko GN, Bin'iash TG, Raĭgorodskiĭ IuM, et al. Transcranial magneto- and electrostimulation in patients with obesity and erectile dysfunction. Vopr Kurortol Fizioter Lech Fiz Kult. 2009 Sep-Oct;(5):30-3.

344. Popa T, Russo M, Vidailhet M, et al. Cerebellar rTMS stimulation may induce prolonged clinical benefits in essential tremor, and subjacent changes in functional connectivity: an open label trial. Brain Stimul. 2013 Mar;6(2):175-9.

345. Potschka H, Thun-Battersby S, Loscher W. Effect of low-intensity 50-Hz magnetic fields on kindling acquisition and fullykindled seizures in rats. Brain Res 1998 Nov 2;809(2):269-76.

346. Price J and and Budzynski T. Anxiety, EEG patterns, and neurofeedback. In Introduction to QEEG and Neurofeedback, Second Edition, 2009. Budzynski TH, et al, Editors. Elsevier.

347. Prusinski A, Wielka J, Durko A. (1987) Pulsating electromagnetic field in the therapy of headache. Second Symposium on Magnetotherapy, Szekesfehervar, Hungary, May, 1987. J Bioelectr. 7(1):127-128.

348. Quittan M, Schuhfried O, Wiesinger GF, et al. Clinical effectiveness of magnetic field therapy a review of the literature. Acta Med Austriaca 2000; 27: 61–68.

349. Radić B, Radić P, Duraković D. Sports and health: equivalence or contrariety. Acta Clin Croat. 2014 Dec;53(4):430-6.

350. Rai S, Singh UP, Awasthi M, et al. Physiological response of the cyanobacterium anacystis nidulans to a magnetic field. Electro Magnetobiol 17(2):145-160, 1998.

351. Rai S, Singh UP, Mishra GD, et al. Additional evidence of stable EMF-induced changes in water revealed by fungal spore germination. Electro Magnetobiol 13(3):253-259, 1994. (b)

352. Rai S, Singh UP, Singh KP, et al. Germination responses of fungal spores to magnetically restructured water. Electro Magnetobiol 13(3):237-246, 1994. (a)

353. Randelli P, Menon A, Ragone V, et al. Effects of the pulsed electromagnetic field PST® on human tendon stem cells: a controlled laboratory study. BMC Complement Altern Med. 2016 Aug 18;16:293.

354. Randoll UG and Pangan RM. The role of complex biophysical-chemical therapies for cancer. Bioelectrochem Bioenerg 27(3):341-346, 1992.

355. Rasouli J, Lekhraj R, White NM, et al. Attenuation of interleukin-1beta by pulsed electromagnetic fields after traumatic brain injury. Neurosci Lett. 2012 Jun 21;519(1):4-8.

356. Rauscher E, Van Bise WL. Pulsed magnetic field treatment of chronic back pain. Bioelectromagnetics Society, 23rd Annual Meeting, St. Paul, MN, June, 2001.

357. Ravnborg M, Knudsen GM, Blinkenberg M. No effect of pulsed magnetic stimulation on the bloodbrain barrier in rats. Neuroscience 38(1):277-280, 1990.

358. Reeder MT, Dick BH, Atkins JK, et al. Stress fractures. Current concepts of diagnosis and treatment. Sports Med 1996 Sep;22(3):198-212

359. Reichmanis M, Marino AA, Becker RO. Electrical correlates of acupuncture points. IEEE Trans Biomed Eng. 1975 Nov;22(6):533-5.

360. Rein G.; Poponin V.; McCraty R. The effects of cardiac EMF simulated using an ECG wave form on human fibroblast cells in culture. Bioelectromagnetics Society, 17th Annual Meeting, 18-22 June, Boston, MA, Abstract No. P-32B, p. 147-148, 1995.

361. Richards TL, Lappin MS, Acosta-Urquidi J, et al. Double-blind study of pulsing magnetic field effects on multiple sclerosis. J Altern Complement Med 1997; 3: 21–29.

362. Rispoli FP, Corolla FM, Mussner R. 1988. The use of low frequency pulsing electromagnetic fields in patients with painful hip prostheses. J Bioelectricity 7:181–187.

363. Robles Bayón A, Gude Sampedro F. Inappropriate treatments for patients with cognitive decline. Neurologia. 2014 Nov-Dec;29(9):523-32.

364. Rodemann HP, Wecke P, Jaeschke M. Low-frequency electromagnetic fields induce premature terminal differentiation of in-vitro cultured human skin and lung fibroblasts. Bioelectrochem Bioenerg 27(3):269-280, 1992.

365. Rohan ML, Yamamoto RT, Ravichandran CT, et al. Rapid mood-elevating effects of low field magnetic stimulation in depression. Biol Psychiatry. 2014 Aug 1;76(3):186-93.

366. Rollman GB, Lautenbacher S (2001) Sex differences in musculoskeletal pain. Clinical Journal of Pain 17:20-24.

367. Romani GL. Fundamentals on neural magnetism. In Advances in biomagnetism. Editors, Williamson SJ, et al. Plenum Press, 1989.

368. Ronchetto F, Barone D, Cintorino M, et al. Static and extremely low frequency (ELF) magnetic fields to treat cancer: a pilot study on patients with advanced neoplasm to assess safety and acute toxicity. Bioelectromagnetics Society, 25th Annual Meeting, 22-27 June, Wailea, Maui, HI, Abstract No. 14-1, p. 137, 2003.

369. Rosendahl K, Strouse PJ. Sports injury of the pediatric musculoskeletal system. Radiol Med. 2016 May;121(5):431-41.

370. Rossi S, Hallett M, Rossini PM, et al. Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research. Safety of TMS Consensus Group. Clin Neurophysiol. 2009 Dec;120(12):2008-39.

371. Rossia S, Hallett M, Rossini, PM, Pascual-Leone A. The Safety of TMS Consensus Group1. Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research. Clin Neurophysiol. 2009 December ; 120(12): 2008–2039.

372. Rubin CT, McLeod KJ, Lanyon LE. Prevention of osteoporosis by pulsed electromagnetic fields. J Bone Joint Surg Am 1989 Mar;71(3):411-7.

373. Rusin MN and Fatkhutdinova LM. Exposure to 50 Hz and heart rhythm in power plant personnel. Med Tr Prom Ekol (11):5-9, 2001.

374. Ryan JJ and Souheaver GT. Effects of transcerebral electrotherapy (electrosleep) on state anxiety according to suggestibility levels. Biol Psychiatry 11(2):233-237, 1976.

375. Rybakov YL, Kazanov AN, Gerasimenko VN. The effect of the turbulent magnetic field (TMF) in the preoperative combined therapy of human breast cancer. Bioelectromagnetics Society, 23rd Annual Meeting, 11-14 June, St. Paul, MN, Abstract No. P-77, p. 164-165, 2001.

376. Saeed SA, Bloch RM, Antonacci DJ. Herbal and dietary supplements for treatment of anxiety disorders. Am Fam Physician. 2007 Aug 15;76(4):549-56.

377. Sakakibara R, Hamano S, Uchiyama T, et al. Do BPH patients have neurogenic detrusor dysfunction? A uro-neurological assessment. Urol Int. 2005;74(1):44-50.

378. Salford LG, Brun A, Eberhardt JL, et al. Development of rat brain tumours during exposure to continuous and pulsed 915 MHz electromagnetic radiation (meeting abstract). First World Congress for Electricity and Magnetism in Biology and Medicine, 14-19 June, Lake Buena Vista, FL, Abstract No. I-1, p. 27-28, 1992.

379. Salvatore S, Serati M, Origoni M, et al. Is overactive bladder in children and adults the same condition? ICI-RS 2011 Neurourol Urodyn. 2012 Mar;31(3):349-51.

380. Sandyk R and Anninos PA. Magnetic fields alter the circadian periodicity of seizures. Int J Neurosci. Apr;63(3-4):265-7, 1992.

381. Sandyk R and Anninos PA. Attenuation of epilepsy with application of external magnetic fields: a case report. Int J Neurosci. Sep;66(1-2):75-85, 1992.

382. Sandyk R. The influence of the pineal gland on migraine and cluster headaches and effects of treatment with picoTesla magnetic fields. Int J Neurosci. Nov-Dec;67(1-4):145-71, 1992.

383. Sandyk R and Dann LC. Weak electromagnetic fields attenuate tremor in multiple sclerosis. Int J Neurosci. 79 (3-4): 199-212, 1994.

384. Sandyk, R. Premenstrual exacerbation of symptoms in multiple sclerosis is attenuated by treatment with weak electromagnetic fields. Int J Neurosci. 83 (3-4): 187-198, 1995.

385. Sandyk R. Treatment with weak electromagnetic fields improves fatigue associated with multiple sclerosis. IntJ Neurosci. Feb;84: 177–186, 1996.

386. Sandyk R. Application of weak electromagnetic fields facilitates sensory–motor integration in patients with multiple sclerosis. Int J Neurosci. Mar; 85:101 – 110, 1996.

387. Sandyk R. Freezing of gait in Parkinson's disease is improved by treatment with weak electromagnetic fields. Int J Neurosci. Mar;85(1-2):111-24, 1996.

388. Sandyk R. Weak electromagnetic fields potentiate the effects of 4-aminopyridine in multiple sclerosis. Int J Neurosci. Mar; 85:125 – 129, 1996.

389. Sandyk, R. Immediate recovery of cognitive functions and resolution of fatigue by treatment with weak electromagnetic fields in a patient with multiple sclerosis. Int J Neurosci Aug;90(1-2):59-74, 1997.

390. Sandyk R. Resolution of sleep paralysis by weak electromagnetic fields in a patient with multiple sclerosis. Int J Neurosci. Aug;90(3-4):145-57, 1997.

391. Sandyk R. Treatment with electromagnetic fields reverses the long-term clinical course of a patient with chronic progressive multiple sclerosis. Int J Neurosci. Aug;90(3-4):177-85, 1997.

392. Sandyk R. Reversal of cognitive impairment in an elderly parkinsonian patient by transcranial application of picoTesla electromagnetic fields. Int J Neurosci. Sep;91(1-2):57-68, 1997.

393. Sandyk R. Treatment with AC pulsed electromagnetic fields improves the response to levodopa in Parkinson's disease. Int J Neurosci. Oct;91(3-4):189-97, 1997.

394. Sandyk R. Speech impairment in Parkinson's disease is improved by transcranial application of electromagnetic fields. Int J Neurosci. Nov;92(1-2):63-72, 1997.

395. Sandyk R. Reversal of a body image disorder (macrosomatognosia) in Parkinson's disease by treatment with AC pulsed electromagnetic fields. Int J Neurosci. Feb;93(1-2):43-54, 1998.

396. Sandyk R. Transcranial AC pulsed applications of weak electromagnetic fields reduces freezing and falling in progressive supranuclear palsy: a case report. Int J Neurosci. May;94(1-2):41-54, 1998.

397. Sandyk R. Yawning and stretching--a behavioral syndrome associated with transcranial application of electromagnetic fields in multiple sclerosis. Int J Neurosci. Jul;95(1-2):107-13, 1998.

398. Sandyk R. Serotonergic neuronal atrophy with synaptic inactivation, not axonal degeneration, are the main hallmarks of multiple sclerosis. Int J Neurosci. Jul;95(1-2):133-40, 1998.

399. Sandyk R. Yawning and stretching induced by transcranial application of AC pulsed electromagnetic fields in Parkinson's disease. Int J Neurosci. Mar;97(1-2):139-45, 1999

400. Sandyk R. Treatment with AC pulsed electromagnetic fields improves olfactory function in Parkinson's disease. Int J Neurosci. Apr;97(3-4):225-33, 1999.

401. Sato E, Ueda Y, Imai Y, et al. Pulsed magnetic stimulation with a high-frequency continuous magnetic stimulator (SMN-X) does not exert an adverse effect on genital organs and the estrous cycle in female Iar:Wistar-Imamichi rats. Neurourol Urodyn. 2011 Nov;30(8):1675-80.

402. Sauerwein W, Heselman I, Olthoff K, et al. Can low frequency, low intensity magnetic fields be used in cancer treatment? Bioelectrochem Bioenerg 27(3):347-359, 1992.

403. Scardino MS, Swaim SF, Sartin EA, et al. Evaluation of treatment with a pulsed electromagnetic field on wound healing, clinicopathologic variables, and central nervous system activity of dogs. Am J Vet Res. 1998 Sep;59(9):1177-81.

404. Scherlag BJ, Yamanashi WS, Hou Y, et al. Magnetism and cardiac arrhythmias. Cardiol Rev. 2004 Mar-Apr;12(2):85-96.

405. Schmitt R, Capo T, Boyd E. Cranial electrotherapy stimulation as a treatment for anxiety in chemically dependent persons. Alcohol Clin Exp Res 10(2):158-160, 1986.

406. Schreiner L, dos Santos TG, de Souza AB, et al. (2013) Electrical stimulation for UI in women: a systematic review. Braz J Urol 39(4):4564.

407. Schulze-Bonhage A, Scheufler K, Zentner J, et al. Safety of single and repetitive focal transcranial magnetic stimuli as assessed by intracranial EEG recordings in patients with partial epilepsy. J Neurol 1999 Oct;246(10):914-9.

408. Schwartz J-L, House DE, Mealing GAR. Exposure of frog hearts to CW or amplitude-modulated VHF fields: selective efflux of calcium ions at 16 Hz. Bioelectromagnetics 11(4):349-358, 1990.

409. Scicinski J, Oronsky B, Ning S, et al. NO to cancer: The complex and multifaceted role of nitric oxide and the epigenetic nitric oxide donor, RRx-001. Redox Biol. 2015 Dec;6:1-8.

410. Selitskii GV, Karlov VA, Sorokina ND. Mechanisms of magnetic field reception in the human brain. Fiziol Cheloveka 22(4):66-72, 1996.

411. Semenova TP, Medvinskaia NI, Bliskovka GI, et al. Influence of electromagnetic fields on the emotional behavior of rats. Radiats Biol Radioecol 40(6):693-695, 2000.

412. Shalom DF, Pillalamarri N, Xue X, et al. Sacral nerve stimulation reduces elevated urinary nerve growth factor levels in women with symptomatic detrusor overactivity. Am J Obstet Gynecol. 2014 Nov;211(5):561.e1-5.

413. Sharma K, Chakrapani H. Site-directed delivery of nitric oxide to cancers. Nitric Oxide. 2014 Dec 1;43:8-16.

414. Shehata HS, Esmail EH, Abdelalim A, et al. Repetitive transcranial magnetic stimulation versus botulinum toxin injection in chronic migraine prophylaxis: a pilot randomized trial. J Pain Res. 2016 Oct 7;9:771-777.

415. Sherman RA, Acosta NM, Robson L. Treatment of migraine with pulsing electromagnetic fields: a double-blind, placebo-controlled study. Headache. 1999 Sep;39(8):567-75.

416. Shi Z, Yu H, Sun Y, et al. The Energy Metabolism in Caenorhabditis elegans under The Extremely Low-Frequency Electromagnetic Field Exposure. Sci Rep. 2015 Feb 16;5:8471.

417. Shlygin VV, Arnautov, LN, Maksimov GV. A possible mechanism of retina dystrophy treatment by electromagnetic field. Biofizika 38(3):507-510, 1993.

418. Shtemberg AS, Bazian AS, Shikhov SN, et al. Modulation by ultralow intensity electromagnetic fields on pharmacologic effects of psychotropic drugs. Zh Vyssh Nerv Deiat Im I P Pavlova 51(3):373-377, 2001.

419. Shupak NM, McKay JC, Nielson WR, et al. (2006) Exposure to a specific pulsed low-frequency magnetic field: a double-blind placebo-controlled study of effects on pain ratings in rheumatoid arthritis and fibromyalgia patients. Pain Res Manag. Summer; 11(2): 85–90.

420. Siemens DR, Heaton JP, Adams MA, et al. Phase II study of nitric oxide donor for men with increasing prostate-specific antigen level after surgery or radiotherapy for prostate cancer. Urology. 2009 Oct;74(4):878-83.

421. Sieron A, Cieslar G, Zmudzinski J. The therapeutical effect of variable magnetic field in patients with multiple sclerosis (meeting abstract). European Bioelectromagnetics Assoc. (EBEA), 2nd Congress, 9-11 December, Bled, Slovenia, p. 39, 1993.

422. Sieron A, Labus L, Nowak P, Cieslar G, Brus H, Durczok A, Zagzil T, Kostrzewa RM, Brus R. Alternating extremely low frequency magnetic field increases turnover of dopamine and serotonin in rat frontal cortex. Bioelectromagnetics 25:426– 430, 2004.

423. Sieron A, Cieslar G, Jochan K, et al. The therapeutic effect of variable magnetic fields in patients with diabetic retinopathy. Balneol Pol 37(2):44-47, 1995.

424. Sieron A, Cieslar G, Adamek, M, et al. The variable magnetic fields in the complex treatment of neurological diseases (meeting abstract). European Bioelectromagnetics Association (EBEA), 3rd International Congress, 29 February-3 March, Nancy, France, 1996.

425. Singh G. Recent considerations in nonsteroidal anti-inflammatory drug gastropathy. Am J Med 1998;105:31S-38S.

426. Singh NN, Rai KK, Rai S. Magnetically altered water enhances endosulfan insecticidal efficacy in mustard aphids. Electro Magnetobiol 17(3):415-419, 1998.

427. Singh S, Khanduja KL, Mittal PK. Influence of 50-hz sinusoidal electromagnetic field on hepatic and pulmonary phase I and II drug-metabolizing enzymes in mice. Electro Magnetobiol 17(3):343-350, 1998.

428. Skorik VI, Zhernovoi AI, et al. Effect of prolonging the periods of endurance of mortal hypoxia during extracorporeal exposure of the blood to a magnetic field. Biull Eksp Biol Med 115(1):17-20, 1993.

429. Skrinnik AV and Kovalchuk AS. The impulse electromagnetic field in the treatment of dystrophic lesions of the retina. Oftalmol Zh(8):459-462, 1989.

430. Song M, Zhao D, Wei S, et al. The effect of electromagnetic fields on the proliferation and the osteogenic or adipogenic differentiation of mesenchymal stem cells modulated by dexamethasone. Bioelectromagnetics. 35:479–490, 2014.

431. Sriram S, Ljunggren-Rose A, Yao SY, et al. Detection of chlamydial bodies and antigens in the central nervous system of patients with multiple sclerosis. J Infect Dis. 2005 Oct 1;192(7):1219-28.

432. Staroverov AT, Vil'yanov VB, Raigorodskii YM, et al. Transcranial magnetotherapy in the complex treatment of affective disorders in patients with alcoholism. Neurosci Behav Physiol. 2009 Jun;39(5):507-11.

433. Steffensen, B, Caffesse RG, Hanks CT, et al. Clinical effects of electromagnetic stimulation as an adjunct to periodontal therapy. J Periodontol 59(1):46-52, 1988.

434. Steinberg GG. 1995. Reversible osteolysis. J Arthroplasty 10:556–559.

435. Steinhoff BJ, Stodieck SR, Zivcec Z, et al. Transcranial magnetic stimulation (TMS) of the brain in patients with mesiotemporal epileptic foci. Clin Electroencephalogr 1993 Jan;24(1):1-5.

436. Straaso B, Lauritzen L, Lunde M, et al. Dose-remission of pulsating electromagnetic fields as augmentation in therapy-resistant depression: a randomized, double blind controlled study. Acta Neuropsychiatrica 2014.

437. Strafella AP, Paus T, Barrett J, et al. Repetitive transcranial magnetic stimulation of the human prefrontal cortex induces dopamine release in the caudate nucleus. J Neurosci 21(15):RC157, 2001.

438. Strasak L, Vetterl V, Smarda J. Effects of low-frequency magnetic fields on bacteria escherichia coli. Bioelectrochemistry 55(1-2):161-164, 2002.

439. Streit A, Watson BC, Granata JD, et al. Effect on Clinical Outcome and Growth Factor Synthesis With Adjunctive Use of Pulsed Electromagnetic Fields for Fifth Metatarsal Nonunion Fracture: A Double-Blind Randomized Study. Foot Ankle Int. 2016 Sep;37(9):919-23.

440. Sueiro Blanco F, Estévez Schwarz I, Ayán C, et al. Potential Benefits of Non-Pharmacological Therapies in Fibromyalgia. Open Rheumatol J. 2008; 2: 1–6.

441. Sun HD, Chung SD. Could overactive bladder be a chronic inflammatory disorder? Incont Pelvic Floor Dysfunct 2009; 3(Suppl 1):17-19.

442. Sun J, Kwan RL, Zheng Y, et al. Effects of pulsed electromagnetic fields on peripheral blood circulation in people with diabetes: A randomized controlled trial. Bioelectromagnetics. 2016 Jul;37(5):290-7.

443. Sun L, Hsieh D, Lin P, et al Pulsed electromagnetic fields accelerate proliferation and osteogenic gene expression in human bone marrow mesenchymal stem cells during osteogenic differentiation Bioelectromagnetics 31:209–219, 2010.

444. Sun LY, Hsieh DK, Yu TC, Effect of pulsed electromagnetic field on the proliferation and differentiation potential of human bone marrow mesenchymal stem cells. Bioelectromagnetics 2009 May;30(4):251-60.

445. Sutbeyaz ST, Sezer N, Koseoglu F, et al. (2009) Low-frequency pulsed electromagnetic field therapy in fibromyalgia: a randomized, double-blind, sham-controlled clinical study. Clin J Pain. Oct;25(8): 722-8.

446. Suzuki T, Yasuda K, Yamanishi T, et al. Randomized, double-blind, sham-controlled evaluation of the effect of functional continuous magnetic stimulation in patients with urgency incontinence. Neurourol Urodyn. 2007;26(6):767-72.

447. Swanson C. Life force, the Scientific Basis: Breakthrough Physics of Energy Medicine, Healing, Chi and Quantum Consciousness. Poseidia Press, 2010.

448. Szuba MP, O'Reardon JP, Rai A, et al. Acute mood and thyroid stimulating hormone effects of transcranial magnetic stimulation in major depression. Biol Psychiatry 50(1):22-27, 2001.

449. Tabrah F, Hoffmeier M, Gilbert F Jr, et al. Bone density changes in osteoporosis-prone women exposed to pulsed electromagnetic fields (PEMFs). J Bone Miner Res 1990 May;5(5):437-42.

450. Tassinari CA, Michelucci R, Forti A, et al. Transcranial magnetic stimulation in epileptic patients: usefulness and safety. Neurology 1990 Jul;40(7):1132-3.

451. Tchoukalova Y, Koutsari C, Jensen M. 2007. Committed subcutaneous preadipocytes are reduced in human obesity. Diabetologia 50:151–157.

452. Tenforde TS. Interaction of extremely-low-frequency electric and magnetic fields with humans. Phys Soc 19(4):7-10, 1990.

453. Terlaki, G.; Gyorgy, B.; Payer, A. Clinical experiences by magnetotherapy. Hungarian Symposium on Magnetotherapy (with International Participation), 2nd symposium, 16-17 May, Szekesfehervar, Hungary, p. 175-179, 1987.

454. Thomas AW, Drost DJ, Prato FS. (2001) Human subjects exposed to a specific pulsed (200 μT) magnetic field: effects on normal standing balance. Neurosci Lett. 297(2): 121-124.

455. Thomas AW, Prato FS. Magnetic field based pain therapeutics and diagnostics. Bioelectromagnetics Society, 24th Annual Meeting, Quebec City, PQ, Canada, June, 2002

456. Thuile C, Walzl M. (2002) Evaluation of electromagnetic fields in the treatment of pain in patients with lumbar radiculopathy or the whiplash syndrome. Neuro Rehabilitation.17: 63-7.

457. Thut G, Veniero D, Romei V, et al. Rhythmic TMS causes local entrainment of natural oscillatory signatures. Curr Biol. 2011 Jul 26;21(14):1176-85.

458. Toroptsev IV and Taranov SV. Morphological characteristics and the mechanism of biological effects of magnetic fields. Arkh Patol 44(12):3-12, 1982.

459. Trevizol AP, Barros MD, Silva PO, et al. Transcranial magnetic stimulation for posttraumatic stress disorder: an updated systematic review and meta-analysis. Trends Psychiatry Psychother. 2016 Jan-Mar;38(1):50-5.

460. Trock DH. Electromagnetic fields and magnets. Investigational treatment for musculoskeletal disorders. Rheum Dis Clin North Am 2000 Feb;26(1):51-62, viii.

461. Tsisel'skiĭ IuV. The effect of a pulsed electromagnetic field on ocular hydrodynamics in open-angle glaucoma. Oftalmol Zh. 1990;(2):89-92.

462. Tsvetkov D, Vergieva T, Penkov A, et al. Investigation of some biological effects of food and water treated by a magnetic field. Gig Sanit (9):57-60, 1993.

463. Tworoger SS, Davis S, Emerson SS, et al. Effect of a nighttime magnetic field exposure on sleep patterns in young women. Am J Epidemiol. 2004 Aug 1;160(3):224-9.

464. Tyagi P, Tyagi V, Qu X, et al. Association of inflammaging (inflammation + aging) with higher prevalence of OAB in elderly population. Int Urol Nephrol. 2014 May;46(5):871-7.

465. Vannoni D, Albanese A, Battisti E, et al. In vitro exposure of human osteoarthritic chondrocytes to ELF fields and new therapeutic application of musically modulated electromagnetic fields: biological evidence. J Biol Regul Homeost Agents. 2012 Jan-Mar;26(1):39-49.

466. Vasilev IuM, Iakovleva SD. Magnetotherapy in cardiology (a review of the literature). Vrach Delo (3):42-47, 1990.

467. Veith I and Rose K. *The Yellow Emperor's Classic of Internal Medicine.* University of California Press, 2002.

468. Veronesi F, Torricelli P, Giavaresi G, et al. In vivo effect of two different pulsed electromagnetic field frequencies on osteoarthritis. Orthop Res. 2014 May;32(5):677-85.

469. Verzin AA, Kolesnikova LN. Changes in the hydrodynamic parameters of the eye after exposure to a constant magnetic field. Vestn Oftalmol (1):13-15, 1981.

470. Verzin AA. Action of gentamycin against a background of magnetotherapy of the anterior chamber in a traumatic infected erosion of the cornea. Antibiotiki. 1982 Oct;27(10):774-5.

471. Veselova EV, Kamenskikh TG, Raĭgorodkiĭ IuM, et al. Magnetotherapy designed to affect cervical sympathetic ganglia for the treatment of patients with primary open-angle glaucoma. Vopr Kurortol Fizioter Lech Fiz Kult. 2010 Sep-Oct;(5):21-4.

472. Vievskii NA, Prokopenko SV, Reshetnik IL, et al. Effect of high-intensity electromagnetic fields of industrial frequency on myocardial function. Hygiene of Physical Factors of Environmental and Industrial Surroundings, 1st International Congress, 16-18 November, Kiev, Ukraine, p. 23, 1993.

473. Viktorov VA and Malkov IuV. Equipment design for magnetic therapy and Polius devices. Med Tekh (3):26-32, 1994.

474. Vincenzi F, Ravani A, Pasquini S, et al. Pulsed Electromagnetic Field Exposure Reduces Hypoxia and Inflammation Damage in Neuron-Like and Microglial Cells. J Cell Physiol. 2016 Sep 17.

475. Volynskii AM. Changes in the nervous and cardiac activities in animals of different ages after exposure to low-frequency low-intensity electromagnetic fields. Probl Kosm Biol 43:98-108, 1982.

476. Wallis MC, Davies EA, Thalib L, et al. Pelvic static magnetic stimulation to control urinary incontinence in older women: A randomized controlled trial. Clin Med Res. 2011 Aug 4.

477. Warnke U. Survey of some working mechanisms of pulsating electromagnetic fields (PEMF). Bioelectrochem Bioenerg 27(3):317-320, 1992.

478. Wassermann EM and Lisanby SH. Therapeutic application of repetitive transcranial magnetic stimulation: a review. Clin Neurophysiol 112(8):1367-1377, 2001.

479. Watt DL, Rosenfelder C, Sutton CD. The effect of oral irrigation with a magnetic water treatment device on plaque and calculus. J Clin Periodontol 20(5):314-317, 1993.

480. Webb CY, Lo SSL, Evans JH. 2003. Prevention of diabetic foot using low frequency magnetotherapy. The Diabetic Foot 6:138–150.

481. Weintraub MI. Chronic submaximal magnetic stimulation in peripheral neuropathy: is there a beneficial therapeutic relationship? Am J Pain Manage 8(1):12-16, 1998.

482. Werhahn KJ, Lieber J, Classen J, et al. Motor cortex excitability in patients with focal epilepsy. Epilepsy Res 2000 Sep;41(2):179-89.

483. Wever R. Effects of low-level, low-frequency fields on human circadian rhythms; Neurosci-ResProgram-Bull. 1977 Jan; 15(1): p. 39-45.

484. Wever, RA. (1987) The electromagnetic environment and the circadian rhythms of human subjects. In: M. Grandolfo, SM. Michaelson and A. Rindi (Eds.), *Biological Effects and Dosimetry of Static and ELF Electromagnetic Fields*, Plenum Press, New York, NY.

485. Wieczorek V, Schock G. Our experience with the pulsing electromagnetic field therapy of neurologic diseases. Third Symposium on Magnetotherapy and Magnetic Stimulation, October 1989, Szekesfehervar, Hungary. J Bioelectr 1990; 9(2):242.

486. Wing VC, Barr MS, Wass CE, et al. Brain stimulation methods to treat tobacco addiction. Brain Stimul. 2013 May;6(3):221-30.

487. Winters WD, Brune JL, Darnell B. Virus suppressor factors induced in cultured cells by exposure in vitro to 60 Hz AC magnetic fields. Bioelectromagnetics Society, 8th Annual Meeting, 1-5 June 1986, Madison, WI, p. 31, 1986.

488. Wu H, Ren K, Zhao W, et al. Effect of electromagnetic fields on proliferation and differentiation of cultured mouse bone marrow mesenchymal stem cells. J Huazhong Univ Sci Technolog Med Sci. 2005;25(2):185-7.

489. Wu S, Wang Y, Guo J, et al. Nanosecond pulsed electric fields as a novel drug free therapy for breast cancer: An in vivo study. Cancer Lett. 2013 Oct 4. S0304-3835(13)00701-5.

490. Wu T, Qi X, Su Y, et al. Electroencephalogram characteristics in patients with chronic fatigue syndrome. Neuropsychiatr Dis Treat. 2016 Jan 28;12:241-9.

491. Yamamoto D, Campbell JD. Cost-effectiveness of multiple sclerosis disease-modifying therapies: a systematic review of the literature. Autoimmune Dis. 2012;2012:784364.

492. Yamamoto T, Sakakibara R, Uchiyama T, et al. Neurological diseases that cause detrusor hyperactivity with impaired contractile function. Neurourol Urodyn. 2006;25(4):356-60..

493. Yamanishi T, Homma Y, Nishizawa O, et al. Multicenter, randomized, sham-controlled study on the efficacy of magnetic stimulation for women with urgency urinary incontinence. Int J Urol. Apr;21(4):395-400, 2014.

494. Yamanishi T, Kamai T, Yoshida K. Neuromodulation for the treatment of urinary incontinence. Int J Urol. Aug;15(8):665-72, 2008.

495. Yamanishi T, Sakakibara R, Uchiyama T, et al. Comparative study of the effects of magnetic versus electrical stimulation on inhibition of detrusor overactivity. Urology. Nov 1;56(5):777-81, 2000.

496. Yamanishi T, Yasuda K, Sakakibara R, et al. Induction of urethral closure and inhibition of bladder contraction by continuous magnetic stimulation. Neurourol Urodyn. 18(5):505-10, 1999.

497. Yamanishi T, Yasuda K, Suda S, et al. Effect of functional continuous magnetic stimulation for urinary incontinence. J Urol. Feb;163(2):456-9, 2000.

498. Yang Y, Tao C, Zhao D, et al. EMF acts on rat bone marrow mesenchymal stem cells to promote differentiation to osteoblasts and to inhibit differentiation to adipocytes. Bioelectromagnetics. 2010 May;31(4):277-85.

499. Yu HG, McLaughlin S, Newman M, et al Altering calcium influx for selective destruction of breast tumor. BMC Cancer. 2017 Mar 4;17(1):169.

500. Yung KT. A birdcage model for the Chinese Meridian System: part I. A channel as a transmission line. Am J Chin Med. 2004;32(5):815-28.

501. Yurina NA, Radostina AI, Savin BM, et al. Mast cells as a test of body state during electromagnetic exposure of varying intensity. Aviakosm Ekolog Med 31(2):43-47, 1997.

502. Zagorskaia EA, Klimovitskii Via, Mel'nichenko VP, et al. Effect of low-frequency electromagnetic fields on the individual functional systems of the body. Kosm Biol Aviakosm Med 24(3):3-11, 1990.

503. Zecca,L, Margonato V, Esposti G, et al. Brain transmitters in rats exposed to 50 hz pulsed magnetic fields. (meeting abstract) J Bioelectr 8(2):269, 1989. International Symposium in Honor of Luigi Galvani, 14-16, April, Bologna, Italy.

504. Zeitzer JM, Ayas NT, Shea SA, et al. Absence of detectable melatonin and preservation of cortisol and thyrotropin rhythms in tetraplegia. J Clin Endocrinol Metab. 2000 Jun;85(6):2189-96.

505. Zhang J, Xu C, Wan Y, et al. Effects of extremely low frequency magnetic field on production of mannatide by α-hemolytic Streptococcus. Bioelectromagnetics. 37:331–337, 2016.

506. Zhang X, Zhang J, Qu X, et al. Effects of different extremely low-frequency electromagnetic fields on osteoblasts. Electromagn Biol Med. 2007;26(3):167-77.

507. Zhou J, Wang JQ, Ge BF, et al. Different electromagnetic field waveforms have different effects on proliferation, differentiation and mineralization of osteoblasts in vitro. Bioelectromagnetics. 2014 Jan;35(1):30-8.

508. Zimmerman J, Pennison M, Brezovich I, et al. Cancer cell proliferation is inhibited by specific modulation frequencies. British Journal of Cancer 2012, 106:307 – 313.

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