Micro-Pulse

12 Things you need to know about PEMF - UPDATED July 2018

Posted on 6 Jul 12:19

12 things you need to know about PEMF and ICES® technology by R.G. Dennis, PhD

You can also see this information on YouTube. Just search YouTube or Google for the terms "PEMF clearing up confusion Bob Dennis", and start with Part 1 of the multi-part video series, or visit Bob's YouTube channel

Disclaimer: The following is the scientific opinion of Robert Dennis, PhD. It is not to be viewed as established scientific fact or clinical advice. Bob Dennis also clearly points out his financial interest and potential for scientific bias in the matter under discussion, so, please, use good sense and healthy skepticism when considering his opinions.

(1) **The most important thing to know about PEMF** is that, based upon the reports of physicians and health care providers with many years of clinical experience using a wide range of different products, PEMF clearly has beneficial effects on chronic pain as well as a wide range of other medical conditions that are difficult or impossible to treat by conventional means. These were recently reviewed in a CRC handbook: Electromagnetic Fields in Biology and Medicine. Setting the extensive theories and other content of the book aside for the moment, the many recognized clinical benefits of PEMF are discussed in the CRC Handbook chapters contributed by William Pawluk and Arthur Pilla. Speaking on CSPAN2 in May 2017, NPR biomedical research reporter Richard Harris, also author of Rigor Mortis, pointed out that that there are about 7000 known medical conditions, but mainstream medical science has only produced treatments for about 500 of these, and many of those treatments are not really very good. He did not point out that the remaining 6500 medical conditions without treatments are not just small concerns with few afflicted. Chief among these “untreatable” conditions is chronic pain, which is by far the most prevalent medical condition, and one for which PEMF is reported by progressive clinicians to be uniquely effective. One would think that any potentially effective alternative approach that showed promise for otherwise untreatable diseases would be given very serious consideration for detailed scientific research and clinical evaluation. But PEMF has been marginalized for many decades by mainstream science and medicine, and academic scientists who choose to study PEMF do so at risk of losing their careers. To decide whether or not you think PEMF is a credible technology, you have to understand your own tolerance for risk and uncertainty. But the fact is that even in the most conservative discussions, PEMF is admittedly, grudgingly, accepted as effective, because there are a very small number of FDA-approved PEMF devices, though these generally require a prescription and have very limited medical claims. Consider this: even the existence of a single FDA-approved PEMF device means that the FDA views PEMF as safe and effective, at least in one form, at least for one medical condition. However, even with FDA approval of PEMF as safe and effective for human use, and after thousands of scientific papers reporting efficacy

Recent Articles

12 Things you need to know about PEMF - UPDATED July 2018
Posted on 6 Jul 12:19

12 things you need to know about PEMF and ICES® technology
Posted on 5 Jan 09:43

New Science and New Products from Micro-Pulse - April 29, 2017
Posted on 29 Apr 15:09

ICES - RESEARCH PLANS 2016 (with a review of 2015)
Posted on 18 Jan 07:55

Wholesale Pricing
Posted on 20 Aug 20:39

Micro-Pulse LLC
Posted on 11 Jan 13:06

ICES - PEMF RESEARCH PLANS 2015: diabetes, spinal cord injury, arthritis, inflammation, chronic pain, underlying cell signalling mechanisms
Posted on 2 Jan 17:30

Tags

All blog crowd source ICES gen 6.0 model B5 research plans

of PEMF for a very wide range of health conditions, including most recently cancer, and the recent upsurge in individual scientific and clinical reports showing the many benefits of PEMF, which have swelled in number from hundreds to thousands, nonetheless mainstream medicine still views PEMF as fringe quackery, not worthy of serious consideration. This makes no sense. However, it is also important to point out that some scientific reports and reviews show that PEMF has no significant beneficial effects, and some scientists report that the safety of PEMF has not been adequately established. These scientific opinions are conveniently ignored by PEMF enthusiasts. In a world savaged by alternative facts, an intelligent person will read and consider contradictory viewpoints and not just brainwash themselves by selective reading. Finally, one should keep in mind that scientific controversy remains even in well-established mainstream fields. *Bob's opinion: Good-quality scientific literature on PEMF is hard to find but good papers are beginning to emerge. Biases are many and prevalent, but in balance it is clear that PEMF can work well for several conditions that are difficult or impossible to treat otherwise, and PEMF has few side effects, if any.*

(2) **Why is there so much disagreement in the scientific and clinical literature on PEMF?** There are many reasons for this. I will summarize just a few: (1) PEMF is not just one thing, it is very many different things with potentially very different effects, so it is not correct to make blanket statements about whether or not "PEMF works", just as it makes no sense to say "chemicals work" because different chemicals do different things, (2) within this large range of possibilities some PEMF devices may have the wrong waveforms or other parameters to have significant biological effects, so scientific study of only these forms of PEMF will "prove" incorrectly that PEMF does not work, (3) some studies are poorly designed, so they can easily show either a false positive or false negative outcome. (4) some studies are conducted by researchers with a strong bias either for or against PEMF, (5) some of the loudest disagreement is between people who have no scientific credentials, creating a "fake news" problem in the PEMF field, especially on the Internet, driven largely by PEMF marketers and profiteers versus amateur debunkers, and (6) some scientists point out that most of the findings of published scientific studies are false , so even individual peer-reviewed scientific papers cannot be trusted. Science requires multiple, independent verification before a result is generally accepted. Richard Harris, mentioned above, in his book *Rigor Mortis* notes that the repeatability of peer-reviewed scientific work in the field of cancer research was studied carefully by large private firms, Amgen and Bayer, and they found that the most important recent research was only 11% to 25% repeatable. Repeatability is the core foundation of science. And it's not really clear which 11% - 25% of the cancer literature can be repeated until you try to repeat it. That implies that taken as a whole, the scientific literature in cancer research may have value, but that independent papers are not reliable. Only those findings that have been repeated many times can be trusted. Science is not a peaceful endeavor. Scientists tend to argue all the time anyway, and when you factor in the very low repeatability in some medical-scientific disciplines, the perverse incentives in academia focusing only on the number of grants and publications, and the disruptive effects of working in a fringe area such as PEMF that is also highly controversial and has a strong financial bias, the potential is there for a very confusing situation with no clear answers. Without clear answers from the scientific community on the topic of PEMF, non-scientists tend to cherry-pick the papers and images they like that report the results they want to see. But keep in mind, the FDA has cleared more than one PEMF device for more than one medical indication, so it is very likely that there is a real scientific basis to the clinical effectiveness of PEMF. This leaves open the questions of how well PEMF may or may not work for the many other unapproved uses for which people have made claims. *Bob's opinion: looking at the science as a whole, and many clinical anecdotal reports, it is very clear that PEMF, if the proper type is properly applied, can have very significant beneficial biological effects. It took years to allow myself to see this because I started working in PEMF in 1996 as a strong skeptic, as a consultant attempting to prove to NASA scientists that PEMF was bunk. But the data consistently proved me wrong. Since then I have visited many labs, talked to many colleagues, conducted many experiments, and studied thousands of scientific papers. Following the overwhelming data, I must conclude that at least some forms of PEMF can have significant beneficial effects. I feel it would be scientific misconduct to conclude otherwise.*

(3) **When should PEMF be considered as a viable option for treatment?** There does not seem to have been a very deep or mature discussion on this important topic, probably because most mainstream clinicians would not even consider the use of PEMF. And mainstream scientific consensus has not yet been reached on whether or not PEMF can be effective. As a result, PEMF is generally relegated to the last option, reserved mainly for people who have tried everything else and have had no success, those at the end-of-the-line or those who have been pushed out of the mainstream medical system as untreatable, crazy, or drug-seeking. This situation may have been self-

inflicted by the PEMF community, because having reviewed over 1000 scientific papers on the topic of PEMF and related fields, I do not say this lightly: PEMF science is generally very sketchy and of poor quality, so you can't believe PEMF will work for something specific just because someone has dug up a paper or two that suggest PEMF works for this or that. Science does not work that way. Scientific confidence requires replication and verification of results, many times, using strict controls, and unfortunately the scientific literature on PEMF is sorely lacking in quality, methodological detail, replication and verification. However, in my scientific opinion when you look at the total body of published scientific literature, factor in some healthy skepticism to counterbalance scientific bias, publication bias, fraud and error, talk to many clinicians who use PEMF in their practice, conduct your own scientific experiments as I have done, and talk to/visit the scientists who conduct research on PEMF in various academic laboratories across the globe, there is quite enough mass of clinical data and scientific evidence to strongly suggest that many forms of PEMF have a very useful biological and clinical benefit, and that these effects may be profoundly good in many cases where no other treatment helps. The beneficial effects of PEMF are broad (able treat many different problems) and safe (it is very rare to find any reports of side effects, almost none). In many cases the use of PEMF is much safer than mainstream treatments, and the reported effects are often much better, faster, and have few if any side effects. One must also remember that most people turn to PEMF as a last resort, after having tried all mainstream and many alternative approaches, including surgery and radical and damaging procedures before trying PEMF, yet PEMF very often rises to the top even after maximum damage has been heaped upon an already horrible condition. *Bob's opinion: Clinical reports suggest that PEMF is quite safe, and the fact that PEMF often helps under the most extreme and challenging conditions suggests to me that PEMF should be considered a treatment of first resort, not one of last resort, because it is among the most effective, fastest, safest, least costly and if necessary reversible treatment options available.*

(4) **How does PEMF work?** This question is at the heart of the PEMF debate between scientists, because even now we really do not understand fundamentally how PEMF works. Scientifically, there is a big difference between "what something does" versus "how it works". There is a growing consensus that PEMF has a lot of clinical benefits (what it does), but we remain largely in the dark about how it works, the nuts-and-bolts of how pulsed magnetic fields cause biomolecules to react. This question falls under the field of *molecular biophysics*, which is the study of how cells and molecules interact with the forces of nature. In the case of PEMF, the main question is this: how do cells detect *magnetic* fields? We do know several ways cells can detect *electrical* fields, but it remains unclear how cells should be able to detect *magnetic* fields. No part of a normal cell in a human should be able to detect magnetic fields directly. There is a lot of debate on this topic, but unfortunately the debate seems to be largely a marketing battle between PEMF salesmen, whereas most respectable scientists stay out of the debate because the risk of professional stigma by association with "fringe science" is just too great. The fact is, for the past century, most scientists who have worked seriously in the field of PEMF have not come out of the endeavor smelling like roses. Taking a different perspective on our lack of knowledge might be helpful: The fact that we do not yet understand exactly *how* PEMF works at the molecular level should not pose a major problem because this is true of some mainstream drugs and medical procedures: they seem to work, but honestly, no one is certain why they work. One example of a whole class of drugs that seem to work safely, but we really don't know how or why they work, is anesthetics. This is a good example because almost everyone reading this either has or will undergo a procedure that requires anesthetics at some point in their lives. Would you really trust a drug that no one understands? If not, your only remaining options are: go ahead and try your surgery without anesthetics, or never have a surgical procedure. Most people just opt for the anesthesia, and for the vast majority of people it works safely. Because of experience, we know that anesthesia works safely and effectively for most people, but the exact mechanisms by which these chemicals alter our consciousness and perception of pain remains mysterious. We don't even know what consciousness is, but we all have it. We know many drugs are safe and effective for the same reason we know many foods are safe and nutritious, because lots of people have tried them and the overall consensus is that they are safe, nutritious and (sometimes) tasty. In the case of food additives, the FDA even has a specific term for this: GRAS, which means "Generally Regarded As Safe". Keep in mind that absolutely nothing is 100% safe. The fact that some people have specific food allergies does not make that type of food unsafe for everyone. So even a few reports of adverse reactions to drugs and devices should be viewed carefully in this light. But still, it's hard to find a single report of harm caused by properly applied PEMF. Overall a brief summary of the current state of knowledge of PEMF is: clinical experience shows that PEMF really seems to work, it has helped countless people with otherwise untreatable conditions, but we really do not know why PEMF works. And that's OK. Nonetheless, many PEMF marketers and profiteers claim to have the scientific "secret", which they publicize in an attempt to increase their share of the PEMF market. Since their claims of secret knowledge do not bear close scrutiny, their contribution to the overall mainstream acceptability of

PEMF is generally negative. The practical question for the consumer of PEMF technology is this: How should you navigate this confusion? First, don't waste a lot of time trying to find the secret document that describes exactly how PEMF works because it does not exist. Second, your skepticism should snap ON when someone tells you they know the secret. Remain open minded but skeptical. Third, you can safely decline their offer if they propose to sell the secret to you. Finally, try not to confuse a marketing demonstration with a scientific study. These are very different things, and in the world of PEMF, some marketers will do a demonstration but presented their cherry-picked images and data as a "scientific study". For example, consider the videos of the effects of PEMF on "blood clumping". Note that they do not say blood "clotting" which is a very different thing. I have some expertise in this area, having invented a prototype for a commercial blood coagulation testing device in my laboratory which was later developed under contract with the US Army. So, in my opinion what you see in most of these "blood clumping" videos is a marketing demonstration, not a scientific study. While blood clumping has been carefully studied, most of what you see on the Internet is for marketing purposes, not scientific purposes. The same is true for "User testimonials". This would all be useful information if it were reliable, but these types of reports lack all of the important controls that scientists impose on their experiments to assure the reliability of their results. That is why the scientific method employs scientific controls: to control, identify and exclude sources of error and bias from the final results. So, while I consider all of these cool images and user testimonials to be anecdotal reports that are potentially useful and interesting, I do not consider them to be scientific. Nor should you. *Bob's opinion: It is OK if we don't know exactly why PEMF works. The argument that we must understand the detailed biophysics of PEMF for it to be credible is misplaced. That detailed level of knowledge would be useful for nerd scientists and product developers like me, but just as is the case for many drugs and foods, the long history and wide-spread clinical experience with the safe and effective use of PEMF should dominate the discussion of whether or not to use PEMF.*

(5) **Is there any plausible mechanism for magnetism to influence cells and molecules in the body?** Yes. This discussion is within the realm of scientific hypotheses, not proven fact. Also, this is not essential to the discussion of the clinical value of PEMF, as discussed above, but it's a reasonable question, so let's head down the rabbit hole. Keep in mind that explanations such as "PEMF increases blood circulation" are a description of what PEMF *does*, not *how it works*. In the past decade there have been a growing number of studies to elucidate the mechanisms of PEMF, but in most cases these seem to me to be just descriptions of what PEMF does, not how it works at the most fundamental biophysical level. Very few scientists openly speculate on how PEMF might work at a molecular level, so most of the debate is among non-scientists, who are increasingly putting forward non-scientific "theories" which include mystical effects, numerology, and other things I consider to be nonsense (but I have been wrong in the past so I remain open minded). In an attempt to understand the biophysics of PEMF, I begin with my first and most fundamental observation: at NASA and in all subsequent studies we found that only rapidly changing magnetic fields had a significant and repeatable biological effect. My hypothesis, briefly, is that the effect arises from electro-magnetism, not just magnetism *per se*. In fact, it is impossible to have a changing magnetic field without also having an induced electric field. This is well known from classical electro-magnetism of the 19th century. Very briefly, I hypothesize that cells do not respond directly to magnetic fields, and that most tissues are transparent to magnetic fields, so magnetic fields can easily penetrate deeply into tissues. Then, when you change the magnetic field rapidly, it will induce an electric current in the range of nano- to pico-amperes in the deep tissues of the body by Faraday Induction. These very small electrical currents are detected by cells because they emulate the streaming currents (selective movement of unbound ions through tissues) caused by the application of mechanical stress to tissues, which were hypothesized in the 1960's as a mechanism for the body to detect exercise and motion. Though first proposed in the 1960's, the cellular/molecular detectors for these very small currents have not yet been discovered (this discovery will result in a Nobel Prize for someone), but it is at least plausible because unlike magnetism, it is well established that electrical signals have many different mechanisms by which they can influence cells and molecules in the body, as described by the well-accepted scientific field of research called *electrophysiology*. I propose only that there is one more mechanism that we have not yet discovered, whereby cells detect very low-level currents of unbound ions moving along (not across) cell and organelle membranes. This isn't so farfetched because, as mentioned above, the presence of such receptors was first proposed in the 1960's as a mechanism by which musculo-skeletal tissues could detect low-level daily activity and normal movement. Based on this hypothesis, I have published the general approach for inductively stimulating this cellular response in the form of a set of patented design specifications (patents: 1, 2, 3, 4). I call this specific form of PEMF *I.C.E.S.* (Inductively Coupled Electrical Stimulation). *Bob's opinion: I base my design of ICES technology upon a working hypothesis based firmly in established science, while incorporating as-yet undiscovered cell receptors that seem biophysically plausible. This means that I focus on very low-energy, trapezoidal pulses of magnetism with very rapid rise times but*

relatively low pulse frequency, generally at or below 100 pulses per second. Many modern PEMF systems use this same approach whether or not they know it. I am not saying that other forms of PEMF do not work. Honestly, they may work by entirely different biophysical mechanisms and they may have different biological effects. But I could not get them to work in any of my experiments. So I remain skeptical.

(6) **What does PEMF do?** While the mechanism of action of PEMF remains unknown, and it is possible that different forms of PEMF have different mechanisms of action at the molecular and cellular level, it is clear that at least some forms of PEMF do not just "block pain". Considering the bulk of clinical evidence, it is likely that PEMF acts to allow the body to correct the underlying problems that have lead to a condition of chronic pain. Because the effects of PEMF can persist for a very long time after the use of PEMF has stopped, it is logical to conclude that PEMF is acting to correct the problem that has been causing the pain, not just blocking the pain signal. This is in stark contrast to most mainstream and many alternative treatments for chronic pain, especially narcotics. The beneficial effects of PEMF can last days, weeks, months or even years after treatment. For example, the effects of PEMF on blood flow in rabbits was shown to last as long as 3 years after cessation of treatment. Clinical reports and independent laboratory testing indicate that certain types of PEMF appear to quickly reduce swelling and inflammation in deep tissues. At the time of this writing, several scientific studies are ongoing to try to determine which inflammatory pathways are influenced by different forms of PEMF. But clinically the effects of PEMF are very broad, almost certainly because PEMF works to reduce chronic inflammation, which is at the root of several hundred known diseases and chronic injuries, and is thought to be at least partially responsible for almost all diseases of aging. So, while PEMF seems to be effective at treating a dazzling range of medical conditions(1, 2, 3, 4, 5) without any side effects, which should immediately raise in your mind the red flags of skepticism because there is no such thing as a perfect cure-all, it may be that PEMF really only does one thing effectively; it seems to reduce chronic inflammation by mechanisms unlike any known drug, and by doing this one thing in one unique way it may be able to reduce or eliminate a very wide range of ostensibly unrelated medical conditions, all of which are actually caused by chronic inflammation, but they just manifest as different problems in different tissues. Another interesting thing about PEMF is that, unlike narcotics or other chemical pain killers, people do not seem to experience a reduction in effectiveness of PEMF over time. To the contrary, many people report that over time they can use lower doses of PEMF to still get the same beneficial effects. PEMF seems to have especially good benefits for chronic pain, which constitutes the single largest human health issue, in total affecting about double the total of all the people suffering from “The Big 5”: cancer, diabetes, cardiovascular disease, dementia and stroke, combined , according to painmed.org . According to a paper in The Journal of Pain, it is estimated that about one third of adults in the USA suffer from some form of chronic pain, primarily lower back pain or osteoarthritis pain. Even though chronic pain has more sufferers than any other disease, inexplicably it has been marginalized by society as an unfortunate but rare condition, which certainly it is not, as pointed out by the US Institute of Medicine (Relieving Pain in America, 2011, page 19), where the total cost in the USA from lost productivity from chronic pain is estimated to be over half a trillion dollars per year, or about 3% of the total US GDP, which is also approximately the same as the total annual US budget for Defense. So, from both a social and an economic perspective, chronic pain is not exactly a small problem. For treating chronic pain, PEMF compares favorably when compared against a wide range of other alternative and complimentary treatments, according to a 2007 report in the Journal of Rehabilitation Research & Development. The findings for PEMF in this study were primarily limited by the lack of reliable studies included in this review paper. The authors conclude by saying that if there were a greater number of reliable studies, that "PEMF is probably efficacious for treatment of knee OA and possibly efficacious for treatment of cervical spine OA. Moreover, the device is relatively inexpensive, appears to have no short-term side effects, and can be easily applied by patients or technicians.". Similar statements appear again and again in the PEMF scientific literature, and have done so for decades. One more thing to consider is that there has been an explosion of PEMF products since the publication of this paper in 2007, and many of the new PEMF products are much more technically refined, more energy efficient, safer, less expensive, and portable/wearable. To the extent that PEMF was reported to be "probably" effective for chronic pain ten years ago, and many times before that, in subsequent years with improved technology, greater competition in the PEMF market, wider clinical adoption and more extensive clinical experience, it is likely that PEMF has evolved to become even more effective. And most interestingly, new and mounting clinical evidence is beginning to show that PEMF may have significant benefits for treatment of “The Big 5” as well as chronic pain. The question remains: …

(7) **Why has PEMF been scientifically and clinically marginalized for so long?** PEMF in the context of the broader field of electro-medicine has been marginalized, both scientifically and clinically for over a century, principally as a result of the Flexner Report of 1910. While the Flexner Report has benefitted society through the sharp improvement in the training of medical doctors and the focus on science in medical research and clinical practice, unfortunately, it also had the effect of forcing the closure of medical schools that offered training in various disciplines including electromagnetic field therapy, phototherapy, eclectic medicine, physiomedicalism, naturopathy, and homeopathy, who were told either to drop these courses from their curriculum or lose their accreditation and underwriting support. The Flexner report also had the effects of sharply reducing the number of doctors, reverting back to a system where women and African Americans were largely excluded from the medical profession, and the stigmatization of academic researchers who tried to do research in alternative medicine, to the point where they were marginalized and often lost their careers because their research was regarded as "quackademic medicine". As such, most PEMF researchers could not win research funding or maintain their academic appointments. The many decades of low-quality scientific research in the field of PEMF, as discussed above, have made matters worse, and as a result the clinical and scientific and regulatory bias against PEMF is now well established and is usually regarded as a matter of "common sense". But the potential of this underdeveloped technology may have found a new non-academic route for development. While mainstream federal research programs have shown only a very modest renewed interest in electro-medicine, for example DARPA, recently there has been a tremendous surge in private interest in the potential development of electro-medicine. In 2016, Google and GSK created a $714 joint venture in bioelectronic medicine, following earlier and much more modest investments in "electroceuticals" technology made by GSK, which started in 2014 with a very modest challenge competition and a prize of $5000, to root out new technologies. But the more recent investment of nearly a billion dollars into the "new" field of electroceuticals clearly indicates that the corporate leaders in Big Pharma see real potential in the field of electro-medicine, which they helped to marginalize to the brink of extinction over a century ago. Publicly their stated interest is limited to sending electrical impulses through nerves to treat some forms of nerve-related disease, but the publicity and scope of the initiative suggests they have larger plans. They are unlikely to tip their hand until they have the intellectual property locked down and under control. But just as clearly, they no longer view electro-medicine as simple "quackery". *Bob's opinion: It is very likely that the safe and effective potential for PEMF is much more widely appreciated than anyone will admit. Many decades of marginalization have set a stigma in place that will be difficult to overcome. But I believe a grass roots acceptance of PEMF has already been well established, and it is only a matter of time before the mainstream either accepts it, violently tries to crush it, or suffers the consequences of having missed the boat entirely. My prediction is that when the economics are favorable, PEMF will suddenly become mainstream, and everyone who benefits financially will act as though it is a miraculous new discovery.*

(8) **How many different forms of PEMF are there?** The confusion about PEMF may stem from the fact that there are a lot of different types of PEMF and many different PEMF protocols, but these have not been formally systematized and there is a lot of disagreement about what forms of PEMF are similar, which are different, how to group them, and even which forms of PEMF are "legitimate" and which forms are not. Depending on how you define a PEMF protocol, PEMF can take one of many different forms. If you consider that most PEMF practitioners view many of the parameters as important, when you consider the precision they require, for example, say 10 Hz is really different from 11 Hz, and most PEMF practitioners would say it is, then you can calculate the number of different forms of PEMF. This has been done and is available on the Internet as an Excel spreadsheet (you need Microsoft Excel to open and work with it). If you use tight standards, you get about 1 quadrillion different PEMF protocols (1,000,000,000,000,000). Even with low precision of frequencies and very broad ranges (example, say 10 Hz is about the same as 12 or 13 Hz), you can still easily get millions or billions of different protocols, at least equivalent to the total number of known chemicals in the universe. And different chemicals have very different biological effects: consider water vs testosterone vs arsenic, for example, so perhaps this is true for different forms of PEMF. And then there is the debate between “High-Power” and “Low-Power” PEMF. While this may or may not impact the effectiveness of PEMF, it certainly has a direct bearing on the safety of PEMF. For PEMF, safety is more an issue of peak energy exposure, whereas effectiveness is more a function of total dosage above the minimum necessary threshold. In the case of energy exposure safety, consideration is often given to both the peak exposure (maximum intensity) as well as the total dosage: intensity multiplied by exposure time. But biological systems often have an upper limit to their response to a stimulus, so increasing stimuli over a certain intensity level will not elicit a greater response. Many of my colleagues believe that it is possible that the primary effect of high-power PEMF is "pain masking", whereas low-power PEMF, because it is safer and can be applied for longer periods of time, may more directly address the source of pain rather than just blocking or masking pain. Thus, the excess

energy of high-power PEMF may not have an optimal effect, or the energy is just wasted, or it may even cause harm. *Bob's opinion: In terms of power, if low-power can work approximately as well as high-power, and there is every indication that this is the case, then safety is the primary concern, and preference should be given to low-power PEMF systems. As for differences in pulse pattern (waveform and frequency), while technically there are many different PEMF pulse patterns, it is likely they fall into a few broad ranges based on their biological effects. Some may be optimal for inflammation, some for orthopedic injury, some will be able to influence brain function, some may have special effects on pathologic cells such as cancers and tumors, and a few may have tissue specific effects. Or all forms of PEMF may just have one fundamental effect that is common to many diseases, such as the reduction of inflammation. But there are probably not special precise frequencies for each type of clinical condition. Essentially, I think it is likely that when grouped by clinical effects, there are only a few different kinds of PEMF.*

(9) **Does PEMF have special, precise frequencies?** There is not nearly enough scientific evidence to suggest that there are "special", specific, precise therapeutic frequencies. I believe the misconception of "special frequencies" is both theoretically unlikely and scientifically unsupported. For example, just because someone shows that a PEMF frequency of 7.83 Hz works, this DOES NOT mean that 7.83 Hz is a special frequency that works significantly better than all other frequencies. To make that assertion, there would need to be numerous studies to show that very close but different frequencies have different effects. For example, you would need to show:

7.83 Hz WORKS, but...

7.82 Hz DOES NOT WORK

7.84 Hz DOES NOT WORK

and... NO OTHER FREQUENCIES WORK.

But there has never been such a precise study done on PEMF. Just because one study may show a certain frequency works does not mean that it is any different from other similar frequencies unless they SHOW IT, then REPEAT IT several times in an independent laboratory, with full scientific controls against experimenter error and bias. No study of this type on the effects of PEMF has ever been done. At most, a study may look at two or three different pulse patterns, and they may suggest that one pattern is somewhat better than the others. But for PEMF, differences in clinical effectiveness between even very dissimilar frequencies are difficult to show. Studies which carefully compare different PEMF patterns against one another have only been done rarely, and the findings are very general, such as "frequencies below 5 Hz seemed to be more effective than higher frequencies." But no study has ever cut a finer distinction than that. It is also important to remember that changing signals can have important biological effects. Some biological receptors are more sensitive to a changing signal than a steady signal. This is true in vision and hearing, for example, and with many hormone receptors, so a PEMF system that changes frequency within an effective range can have better long-term efficacy. There is an effect known as *neuro-accommodation* or *habituation*, where cells and tissues of the body tends over time to ignore monotonic signals after a while, so it is best to vary the signal a bit over time to keep the tissues from becoming less sensitive to it.

And finally, NASA did not "discover" or "prove" that there are special secret frequencies for medical PEMF. This is an urban myth. Some people violently claim there are "thousands" of papers published by NASA on this topic, supposedly "proving" such things as the impact of Schumann resonances or frequencies on human health. But when I challenge them, no one has ever been able to produce a single paper that actually proves any such thing. During the time of this mythical NASA PEMF research (~1995-2002), I was actually working as a consultant with real people in real laboratories at NASA - JSC and at major universities. The main people were Dr. David Wolf, astronaut, medical doctor and electrical engineer, who was the director of the lab I was consulting for at NASA - JSC, and Kathy Clark, PhD, who was Senior Visiting Scientist for the soon-to-be-launched International Space Station (ISS), and a scientist at the University of Michigan. She was a colleague of mine while I was at UM, where we collaborated on skeletal muscle tissue research and tissue bioreactor research using NASA-developed rotating wall bioreactors to simulate micro-gravitty. None of the three of us had ever heard of this mythical PEMF research being done at NASA at JSC and on shuttle flights. The only work in PEMF that any of us knew of at the time was the work I was doing as a consultant for NASA - JSC. If anyone at NASA would have been conducting any research on the biological effects of PEMF, we certainly would have been aware of it. And no real person who worked at NASA and claims to have done this research has ever emerged. In June 2018, I gave three scientific talks at SOPMed (June 2018). In attendance was Dr. Roger Billica, MD, who had been

Chief of Medical Operations at NASA - Johnson Space Center during the 1990's, at the same time when I was doing consulting work for scientists at NASA - JSC. In my first talk at SOPMed I dispelled the urban myths about "special secret frequencies" that were never actually discovered by NASA. We had never met before, so Dr. Billica approached me after my first talk to thank me for being the first person he knew of to tell the truth about the PEMF work from NASA in the late 1990's. We compared notes on the history and the people we knew, and had a good laugh about the lingering urban myths that had developed around the work that had been done at NASA two decades ago. This persistent urban myth does nothing more than undermine the entire field of PEMF just to allow low-integrity uneducated PEMF marketers to dazzle potential customers with the credibility of NASA and make-believe pseudo-science. Hey, if I'm wrong, just send me any one of the reputedly thousands of scientific papers that prove it.

Bob's opinion: So far as I can tell, PEMF frequencies fall into a few broad bands, and precise frequency is not really important. It may be more important to change frequency within the effective range over time than to use just one specific magical frequency. The truth of this is obscured by decades of urban myth and pseudo-science that is promulgated by low-integrity PEMF marketers.

(10) **If we know so little about PEMF, how can we tell which PEMF product works best?** The good news for you the consumer from all of this is that for the many different PEMF systems out there, broad ranges of frequencies are likely to be equivalently effective. There is no need for you to become a biophysicist in your spare time or to hire a scientific Indiana Jones to find the "Special Secret Frequency" just suited to your problem, nor is there a need to pay a king's ransom for access to someone's "special" frequency. I could be wrong about this, but all available evidence favors my opinion; not just the lack of compelling scientific evidence to the contrary, but also the fact that most clinicians report that most modern PEMF systems seem to work pretty well for most applications. This in stark contrast to the deafening noise and confusion from competing PEMF marketers, where each is trying to gain a market edge by making special claims. The fact is, most clinicians find that most modern PEMF systems (those using square or trapezoidal waveforms and less than about 300 Hz) generally work very well, and they base their purchasing decisions on such factors as cost to buy, cost to operate, recommendations from colleagues, personal experience, availability of financing (some clinical systems cost $40K or more), and reputation of the PEMF company for after-sale support. There simply is not one secret hidden document that shows conclusively and reliably that one PEMF product is better than all others in terms of its biological or clinical effects. Claims to the contrary should be viewed with extra skepticism. Another problem is that it is simply not possible to compare different PEMF products based on their technical specifications. It is widely known among PEMF manufacturers that many companies publish performance specifications for their products that are off by a factor of 10 or more. I have directly measured the output of several PEMF devices in my laboratory, using scientific-grade, calibrated, NIST-traceable test equipment, and I find that there are almost always huge differences between what PEMF manufacturers claim in their product literature and what their devices actually do. The frequency can easily be off by 10% or more, and the peak magnetic fields are often over-stated by a factor of 10 to 100. And many PEMF manufacturers do not know how to test their own products. I have been asked by several of my competitors to test and calibrate their devices, which I do for them confidentially and for free to help promote honest competition and technical integrity in the entire field. *Bob's opinion: when looking for a PEMF system, focus on choosing a reputable PEMF company, not on a futile attempt to decode the science of PEMF, or to compare products based on manufacturers specifications which are often incorrect, incomplete, or intentionally inflated.*

(11) **If many different PEMF systems work, how can you decide which is the best PEMF system?** That might not be the best question. The best way to frame the question might be "which system is best for you personally?" or “Which PEMF product has the best value, the best bang-for-the-buck?” Begin by considering your needs. You may have a true systemic problem that requires a whole body system. I think this is the case only for a small percentage of people, maybe 5% to 10% of people who need PEMF. In most cases the problem stems from a single injury that may be years or decades old. This original persistent injury needs to be treated thoroughly, and when you do so, most non-specific systemic problems, such as "*now I have pain all over my body!!!*", usually disappear within a few weeks of treating the site of the original injury. But sometimes people do need to treat their whole body, or several different areas simultaneously, so that should inform your first main decision: do you need a large whole body PEMF system, or a small wearable one for localized treatment. Keep in mind that large "whole body" systems are large by necessity, so they are very expensive and are not wearable or easily portable, and they draw a lot of power, so you need to stay

put, plugged in to the wall, during treatment. If you need localized treatment, you can consider the portable PEMF systems which are much more reasonably priced, are battery powered so you do not need to be plugged in to the wall socket, and are small enough to wear around all day. In my experience this is the best option for most people. But effective low-cost PEMF systems were not available when I began making PEMF systems, so bringing small, affordable, effective PEMF systems to the market has been my focus in the development of Micro-Pulse ICES® technology. Since I sell this technology you should view everything I say with healthy skepticism. I am trying to be honest, but I am human, so I will invariably have a bias in favor of my own technology. I strongly believe that for the vast majority of PEMF users, the smaller wearable PEMF systems are a more practical and affordable choice. That still leaves open the question: overall which is best, a large or small PEMF system? The answer I hear from almost all clinicians I have talked to who have carefully studied the clinical outcomes from both approaches is this: BOTH. First they begin treatment with a few sessions using a larger very expensive system in clinic, followed by daily use of a much smaller, wearable system that the patient owns and uses every day at home and at work. This strategy seems to give the best short-term and long-term clinical benefits. While I would like to be able to say my ICES technology is best hands-down and that no other products are better, I cannot honestly say that is true. If you have access to the large clinical PEMF systems and can also afford a portable (wearable) system for daily use, you very well might get the best long-term benefit from using both. As a general rule, when I talk to people about their experiences with PEMF they almost always tell me that their results were very good. This seems to be true for pretty much all of the reputable PEMF companies and their products. I do see one pattern though: the vast majority of negative reports about PEMF products can be traced back to one common trait: the company selling the device makes claims about mystical effects, supernatural powers, or they evoke pseudo-scientific jargon to try to get you to buy their product. Examples of mystical or supernatural effects are self evident, but many intelligent (non-scientific) people are taken in by the use of pseudo-scientific jargon. Common examples include any claims of the use of zero-point energy, dark energy, anti-matter, dark matter, quantum coupling, quantum entanglement, quantum computing, action-at-a-distance, gene scanning, epigenetic scanning, energy frequencies of DNA, and creative combinations of that kind of stuff. PEMF machines just can't do that. Anyone doing anything like that with any PEMF machine will be getting a Nobel Prize before too long. While it is possible that I could be wrong, I find such claims to be extremely implausible, and I also note that at least 90% of the time when people tell me that a PEMF product does not work, the company they bought it from sold their products on the basis of such claims. So, even if I am wrong about the science of these wonderful new devices, to me this is a very clear pattern of user feedback: people tell me they just don't work. *Bob's opinion: Large or small, PEMF devices from most reputable manufacturers seem to work pretty well. Consider combining large clinical PEMF treatment with daily use of portable PEMF. You can find clinics that offer occasional treatment with large systems, but you will probably have to buy or rent a smaller portable PEMF system for daily use. Limit your search to reputable PEMF companies that will support their products after the sale. Avoid products based on sketchy claims or pseudo-science.*

(12) **Can PEMF be used with other treatments?** Many people ask whether PEMF can be used with other clinical interventions, or whether the use of PEMF is contraindicated in such cases. While I was initially quite cautious, I have come to believe that PEMF is perhaps the ultimate adjunct therapy. Every clinician I have talked to, without exception, who has tried PEMF along with any other therapy has reported to me that the benefits are strongly synergistic. Thus, while using large and small PEMF systems together during treatment seems to give better clinical results than just the use of one type of PEMF system, so too does it seem very clear that using PEMF enhances the effectiveness of almost any treatment, mainstream or alternative. Clinicians emphatically report to me that this is true for everything they have tried, including chiropractic adjustment, nutritional and naturopathic strategies, acupuncture, laser and LED therapy, exercise therapy, stem cell therapy, and even surgery. Once again I would like to be able to say that it is my technology alone that seems to have such favorable uses as an adjunct therapy, but that would not be the truth. So far as I can tell, all types and forms of PEMF have synergistic beneficial effects as adjunct treatments, enhancing the effectiveness of any other therapy with which they are combined. This is a major observation, but there is scant scientific evidence for this because it is strongly advantageous to limit the number of variables in any scientific experiment. This explains why you will always tend to see only one therapy at a time being tested in a scientific study. Very few studies include large numbers of different interventions unless they are attempting to compare and contrast each one in isolation from the others. Combining therapies to show synergistic effects is vastly more time consuming and expensive than simpler, one-variable studies, so studies of treatment synergy are very rare indeed. And this is unfortunate, because it is perhaps by combining PEMF with other interventions and therapies that the best benefits of PEMF can be achieved. *Bob's opinion: the use of PEMF as an adjunct therapy seems to have great promise. I have never heard or seen a report with an adverse reaction or negative consequence of combining*

PEMF with other treatments, but I have heard many reports from clinicians of improved effectiveness when they combine PEMF with their other treatments. This area would really benefit from more research, both when combining PEMF with alternative as well as mainstream treatments.

(And one more for good measure…) **What is the future of PEMF?** I hope the future is bright for PEMF. I want my children and grandchildren (and yours) to have unrestricted access to this technology. While I think the market for the large PEMF machines is fairly mature, there is still a lot of room for technological improvement. The main barrier is a lack of widespread mainstream acceptance. Because of regulatory barriers, it may be that most PEMF innovation needs to occur outside of the United States and countries with similar regulatory barriers, which are known to stifle innovation and prolong the delays before new products can reach the market. I think the market for portable PEMF devices is much less well developed than the market for large PEMF systems, and is undergoing much more rapid innovation compared to the development of the larger PEMF systems. Innovation should be understood to refer to the core technology inside the PEMF system, not the outside: the wireless tablet interfaces or other superficial bells and whistles. These do not enhance the effectiveness of the core PEMF technology and should be viewed as marketing refinements, but not technological innovation. Portable PEMF technology is undergoing rapid innovation, with new products being introduced to the market every few months. Most of these are pirate copies of existing systems, or are ineffective for technical reasons. But effective portable PEMF systems are available. My technological push has been to sharply reduce the power while increasing electrical efficiency while also maintaining or improving the biological effectiveness. This means smaller and safer systems with lower unit cost that can be battery powered, freeing you from the tether of the wall plug. I have been able to reduce the system power requirement of ICES technology by 99.8% since the first prototypes in the late 1990's, while retaining or improving the biological effects. And I am trying to challenge competing PEMF developers to do the same; to pick up the pace, to increase the efficiency and safety and effectiveness while reducing size and cost. I have been introducing a new portable PEMF architecture to the market every 18 months or so for the past 7 or 8 years. This began with the early AllevaWave, Magnafix and several other similar systems, followed by ICES gen 4.0 sold through reputable physicians in 2013-14, and then by our direct-to-consumer ICES gen 5.0 "Model A9" in 2015, and the newer gen 6.0 Models M1, C5, and B5 introduced in 2017. My focus on the gen 6.0 architecture was to build a system that was optimal for my ongoing scientific work with PEMF, while also providing a very flexible product for anyone who wants a personal, portable PEMF system for a very wide range of uses. The gen 6.0 products have dozens of different PEMF protocols to allow experimentation with different biological effects, and they represent the needs and interests of our customers and colleagues, who have requested many different PEMF protocols for scientific research, personal use, clinical use, and self-hacking. The new gen 6.0 systems have all of the original ICES protocols, plus many new protocols requested by clinicians and self-hackers for brain entrainment, Schumann harmonics, and others. You can compare the currently available ICES products on our web page at this link. Hopefully the entire PEMF market will broaden and evolve to include many inexpensive, safe and effective portable PEMF products. Everyone in the PEMF market, especially the consumers, will benefit from competition in a fierce, high-integrity, and fair PEMF market. *Bob's opinion: right now I think my portable PEMF technology is the best on the market, but I look forward to the day when it is blown away by better products. Then I can retire.*

About the Author

Bob Dennis is a Professor of Biomedical Engineering at the University of North Carolina at Chapel Hill. He is a medical scientist and tissue engineer, and also has an active consultancy in medical device design and product development. He has worked in the aerospace and defense industries, the automotive industry, and the medical device industry. Early in his career he developed components and processes for the guidance and targeting systems for the Strategic Missile Defense System and the first generation of electronic automatic transmissions for Ford Motor Company. He has consulted for many private corporations as well as NASA. He co-founded the Biomechatronics Group in the Harvard-MIT HST program in the original MIT Artificial Intelligence Laboratory, where he developed the world's first hybrid (living + synthetic) swimming robot for DARPA. As a professor at U-Michigan and UNC, he has lead multi-institutional research projects to develop new tissue engineering technologies for the United States Department of Defense. Currently an Associate Professor of Biomedical Engineering at UNC Chapel Hill, he also owns a private laboratory facility for advanced product development where he has developed and collaborated on the development of devices and

products for a wide range of applications including measuring blood viscosity and coagulation, pulmonary research, neuroscience, bioreactors for tissue engineering cardiovascular, neural, musculoskeletal and pulmonary tissues, measurement of physiological and biophysical properties of cells and tissues, the non-invasive control of the human autoimmune system by means of ultra-low power electromagnetic fields, and measurement of brain function and health.

Development of ICES-PEMF technology

Bob is working to spread the word about PEMF technology after 2 decades in the field. He has developed ICES® Advanced PEMF technology to drive the value and portability of PEMF to the next level, with ultra-low power, safe, and scientifically-based PEMF for the control of chronic pain, inflammation, and to accelerate tissue recovery from injury. His objective is to bring PEMF technology mainstream, with solid science, high integrity, rapid innovation, and affordable products. This will cause a major revolution in medicine and human health, and will contribute to the solution of many of today's major health challenges, including chronic pain, inflammatory disease, head injury, the opioid addiction crisis (by eliminating the need for narcotics to manage chronic pain in most cases), and many diseases of aging. Bob entered this field more than 20 years ago as a consultant for NASA, reluctantly, because he was a very skeptical of PEMF and other fringe medical "pseudo-science". Believing PEMF did not have biological effects, he did everything scientifically possible to debunk it. He designed and built equipment to run several carefully controlled scientific studies to disprove PEMF once-and-for-all, but the data were clear and repeatable: certain forms of PEMF had very clear effects on cell behavior and gene expression. This resulted in the original TVEMF (PEMF) research published by NASA in 2003, which since has been incorporated into most modern PEMF systems available on the Internet today. Though none of these competing PEMF products have official license to use the NASA technology, most of these systems do seem to confer clinical benefits because almost all of these systems share the same basic core technology developed for NASA two decades ago.

Since then Bob has had DARPA funding (contract #: N00173-01-1-G020) to study PEMF, and has run several private studies, all of which have allowed him to refine a specific type of PEMF called ICES (Inductively Coupled Electrical Stimulation). "ICES" is now trademarked, so the quality of the technology can be protected against cheap imitation. Bob has initiated many academic studies of PEMF, and has several ongoing studies. The over-arching objective is to find the scientific truth, and thereby to refine ICES technology, so that everyone everywhere can afford a safe PEMF technology that gives them control of their pain and their healing, without drugs. While many PEMF companies still base their unlicensed products on the original NASA technology developed by Bob two decades ago, it is Bob's opinion that society benefits from a competitive market in PEMF, and for the time being he does not intend to press his competitors with their violations of NASA patents and his own later and more comprehensive IP. Rather, he provides advice and technical support for many of his competitors in the spirit of accelerating PEMF innovation and technology development, fostering competition in the marketplace, increasing the honesty and integrity of the entire field of PEMF, and providing a diverse range of products and technologies for people with a wide range of needs.

Bob's personal journey with PEMF and ICES® technology

Bob focused the development of Micro-Pulse ICES® technology over the past decade to help him recover from a lower back injury sustained as a volunteer firefighter on a rescue in Hillsborough, NC. Though initially minor, the injury resulted in a progressive spinal degenerative process that caused a severe disability over a period of months, eventually causing Bob to lose most of his ability to stand and walk, and left him in untreatable chronic pain that was only partially responsive to narcotic prescription medications. After being abandoned by the mainstream medical system, Bob optimized the technology from his ongoing PEMF research for the treatment of severe orthopedic injury and chronic pain, with a special emphasis on back injuries. With a focus on developing a safe, affordable, wearable PEMF technology based on science and clinical feedback, he has developed the Micro-Pulse ICES® technology. Having developed the technology initially for himself, Bob now makes this technology available for anyone, at an affordable price, with highly responsive and individualized customer support. Micro-Pulse ICES® technology in its earlier forms (generations 2.0 through 4.0) have been incorporated into many products. Beginning with generation 5.0 ICES® technology, Bob has decided to cut out the middle man, sell directly to consumers, reduce prices, and vastly improve customer support. The price drop with the introduction of ICES® gen 5.0 technology (the Model A9a) was more than 72% lower than the previous gen 4.0 technology sold through a network of distributors

and marketers. This price drop was accompanied by greatly improved customer support, especially after sale, as well as an increase in power efficiency, a reduction in system complexity, and a wide range of product improvements that resulted in improved reliability, portability, and biological effectiveness.

Quick Links

Studies and Research Data

Sign up for Newsletter and Promos

Enter email

Subscribe