# SLEEP PROBLEMS

## THE PEMF SOLUTION

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Medical authority on Magnetic Field Therapy

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## INTRODUCTION

Sleep problems are common and do not have a single cause. Insomnia, for example, is not a disease. There is no single definition of insomnia that applies to all people with that problem. 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 physical urges like needing to go to the bathroom in the middle of the night, hot flashes, or suffering with pain. Pulsed electromagnetic fields (PEMFs) can help improve the quantity and quality of sleep. Why do we need PEMFs for sleep?

## DANGERS OF LACK OF SLEEP

There are many risks to not sleeping steadily or deeply for 7 or more hours a night. Here is a short list:

- **Sleepiness causes accidents.**
- **Sleep loss dumbs you down.**
- **Lack of sleep leads to serious health problems, including heart problems, high blood pressure, stroke, and diabetes. About 90% of people with insomnia also have another health condition.**
- **Lack of sleep kills your sex drive.**
- **Depression is 5 times more likely in people who don't get enough sleep compared to people who get their 7 hours.**
- **Poor sleeping ages your skin by reducing growth hormone production during deep sleep.**
- **Lack of sleep leads to increased forgetfulness caused by lack of storing long-term memories during deep sleep.**

- **Weight gain is increased in 30% of people who sleep less than 6 hours a day.**
- **The risk of death doubles for those sleeping less than 5 hours a day.**
- **Sleepiness impairs judgment even if you think you're doing fine on less sleep.**

## REASONING FOR USING PEMFS FOR SLEEP

Some of the commonly used medications for helping with sleep have been shown to increase the risk of dementia even after only a few weeks of use. We all need a better safe solution for helping with sleep, this is why we should use PEMFs for sleep.

Brainwave patterns in people without sleep can become abnormal. There are four basic brainwave patterns:

- **BETA**
- **ALPHA**
- **THETA**
- **DELTA**

Beta is awake alertness. Alpha is a relaxed mind. Theta is light sleep or deep meditation and Delta is deep "slow wave" sleep. Deep sleep is essential to health and basic sleep problems are falling asleep and staying asleep, with the most common being staying asleep. One way to help with sleep problems safely and without drugs is to tune the brainwaves, coaxing the brain into Delta sleep using magnetic deep sleep frequencies – 1-4 Hz. A number of research studies have shown that using magnetic fields at sleep frequencies change the brainwaves and help people sleep better.

### STUDIES HAVE SHOWN THAT PULSED ELECTROMAGNETIC THERAPIES CAN SUPPORT BETTER SLEEP

One study using higher intensity magnetic fields even found them to be better than medication or counseling. Other researchers found that continuous magnetic stimulation through the night improves sleep better than irregular stimulation. I use a portable battery-operated PEMF device called the Flex Pulse all night long under my pillow or under my head, set at the deep sleep frequency 3 Hertz. I started using this device because my sleep patterns were not consistent and my ability to stay focused during the day was affected. I have never slept as well as I do now that I use my Flex Pulse every night all night. In addition, other family members even children, can safely use the Flex Pulse for sleep. It's also used for various aches and pains you can read more about the Flex pulse and PEMFs for sleep at [drpawluk.com](drpawluk.com).


So, even though low-frequency pulsed electromagnetic fields (PEMFs) can be very helpful for enhancing and maintaining sleep, these benefits can be easily undone by environmental high-frequency EMFs. Stresses, whether physiologic or emotional, can affect circadian rhythms (the roughly 24-hour cycle of the body).

It's one thing to say that PEMFs can help with sleep, but it's much better if this is supported by research. A number of research studies have been carried out using magnetic fields to help with sleep.

## Some PEMF Sleep Research

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 insomnia 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.

Sleep patterns can also be disrupted significantly by background EMFs in the sleep environment. 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. If this is the common form of router, that is, on all the time, it is even 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 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 near your bed is a definite no-no.

Even a clock radio near your head on a bedstand is still emitting a strong enough 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 and has a power light, is emitting an EMF into the sleep environment.

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 also interfere with sleep.

So, while low frequency PEMFs can be very restorative for enhancing and maintaining sleep, these benefits can be easily undone by extraneous environmental high-frequency EMFs. Stresses, whether physiologic or emotional, can affect circadian rhythms. Research done in Germany in the 1960's through the 1970's, 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. (*Wever*)

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 2 and 6 wks 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. Nevertheless, the people receiving active treatment consistently had better results for sleep whether it was at 2 weeks or 6 weeks. Results were stronger at 6 weeks. (*Fischer*)

In a 4-week double-blind, placebo-controlled study, impulse magnetic-field therapy was tested for insomnia. One hundred patients 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, 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. But, the differences between the 2 groups hugely favored the active treatment group. 70% of the people given active treatment experienced substantial or even complete relief of their complaints; 24% had clear improvement; 6% slight improvement. In the placebo group, only one patient had very 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. (*Pelka*)

PEMF therapy also has positive effects on calming the brain (see “entrainment” in other sections of the book) and on regulating circadian rhythms.

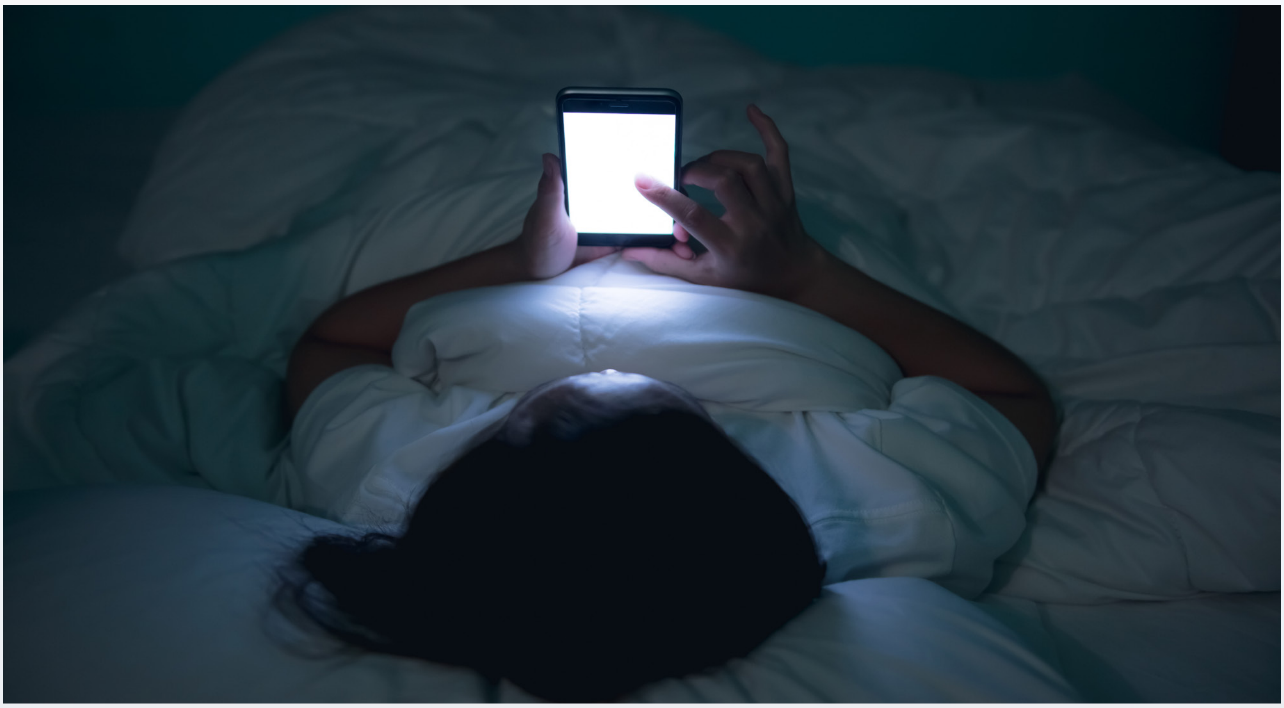
Even very low intensity PEMFs may enhance the effects of sleep medications and psychotropic drugs. This may result in a hangover-like effect in the morning. If this should be happen, the dosing of the medications may be able to be decreased, under appropriate supervision. (*Shtemberg*)

One research laboratory has done an extensive amount of research on magnetic field stimulation and sleep. They discovered that using 20-30 μT magnetic fields at 60 Hz didn’t significantly alter sleep patterns. However, with the magnetic stimulation alternated one hour on/one hour off over 8 hours of sleep, and when on, further switched on and off every 15 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. But, 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 we see disruptions in sleep patterns. This may be useful in considering whether to use PEMFs with intermittent pattern signals during the night with brainwave resonant frequencies or to only use devices with continuous PEMF signals through the night. (Graham)There is an increasing number of 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 boxspring. 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.

## Basic sleep concepts

Sleep is a major issue for people worldwide and in the US, over 50% of people have significant sleep issues. Poor sleep is caused by many issues and is a cause of many health issues. In addition, the causes of poor sleep are often amplified by the poor sleep, in a vicious cycle. Many of the causes of poor sleep have to do with the physical processes associated with aging. For example, anyone who has to get up at night to go to the bathroom has a higher likelihood of having a problem getting back to sleep, at least to some extent. Aches and pains, which are often felt more during the night, create some level of arousal increasing the perception of the need to empty the bladder, even though the bladder is not very full.

Faulty sleep "hygiene" could also be a significant contributor to poor sleep. This includes having your cell phone by your bed, continually emitting an irritating but silent signal. Too much light in the room from a lit clock radio panel, nightlights in the room, especially blue lights, and not pulling the shade, watching TV in bed. Light decreases the production of melatonin which is necessary for deeper sleep. This then exaggerates any underlying melatonin production problems already present. Watching TV before bedtime may overstimulate the brain and emotions, making it harder to wind down.



If sleep hygiene is not controlled, then no matter what techniques are used to help with sleep, this would be fighting an uphill battle. Many people have upper respiratory issues, including nasal congestion, sinuses or coughing that often feel worse at night, causing difficulty getting comfortable and falling asleep.

Drinks with caffeine, even decaffeinated ones, create arousal making it hard to fall asleep. The body's ability to eliminate or metabolize caffeine varies significantly. Some people will tolerate caffeine and sleep well, but others may have significant issues even with small amounts of caffeine. For some people, the elimination of even 50% of their caffeine from their bodies may take upwards of 12 hours. So, about 50% of the caffeine taken in the morning may still be in the body or affecting the brain at bedtime. Caffeine suppresses adenosine, which the body uses to alert us that we are getting sleepier.

Another common culprit for creating sleep problems, especially early waking is alcohol. Alcohol may facilitate falling asleep but when it is metabolized, 2 to 3 hours later, there is rebound alertness.

There is much helpful information on the Internet about sleep hygiene. But, even with the best sleep hygiene techniques, there are still many other factors that lead to poor sleep. All of these have to be dealt with individually. Common factors are sleep deprivation due to getting up to feed newborns, attending to sick children, and pet issues. Pets can create numerous problems such as sleeping on the bed, tossing and turning, or even trying to get into the bedroom.

Daytime stress can spillover into the night. Stress raises cortisol levels. High cortisols increase alertness and contribute to more significant variation in blood sugar levels. Individuals with reactive hypoglycemia may be aroused during sleep by the urge to snack, particularly carbohydrates. Having high glycemic carbs before bedtime may contribute to this problem.

Sleep apnea is a major sleep disruptor, creating physiologic stress throughout the night because of low oxygen levels. Sleep apnea requires controlled pressure breathing, using continuous airway pressure (CPAP) devices. PEMFs will not resolve sleep apnea but will help the body absorb the oxygen levels better.

Chronic pain is a major cause of disrupted sleep. In addition, disrupted sleep amplifies the perception of any pain present at night. Even milder levels of pain, itching, discomforts are more noticeable at night because of a generally decreased background of sensory information. In other words, the nervous system that is less distracted notices these milder discomforts more than during the day.

## Common sleep problem solutions

Most people with sleep issues use chemical solutions because they are simple, quick and easy. These include medications and herbs/ supplements. Most of the time if someone goes to a medical doctor the solution will be a prescription medication. These medications usually include hypnotics, sedatives, tranquilizers, antihistamines and antidepressants/SSRIs. Hypnotics include medications like Ambien. Sedatives include medications like Valium, Librium, and Xanax, especially when there is also anxiety. Tranquilizers include medications like barbiturates, with names ending in barbital. Antihistamines used for sleep include Benadryl. Benadryl can be long-lasting and lead to daytime sleepiness. It can be considered a cause of driving while "intoxicated." Also, the Harvard Health Blog discussed a study linking higher levels of use of Benadryl to increased dementia risk. SSRIs are antidepressant medications, some of which have sedative properties, and include paroxetine (Paxil), trazodone, amitriptyline and doxepin. This is not an exhaustive list. Almost all these medications are very hard to get off once started. Recent studies suggest many of these may contribute to the development of dementia and suppression of natural killer cell activity. Suppressing natural killer cell activity increases risk for cancer and lowers the body's ability to fight viruses.

There are numerous herbs and supplements used for sleep. A minimal list includes melatonin, CBD, valerian, lavender, passionflower, glycine, 5HTP, ginkgo, L theanine, chamomile, kava, niacinamide and PEA. All of these are variably potent or useful on their own or in combinations. Most of these are primarily useful for helping with falling asleep. Extended-release formulations may be helpful to maintain sleep for longer periods. It's rare that any one supplement will help the vast majority of people. Frequently it's necessary to "stack" multiple supplements/herbs to achieve the best benefits. Huge variability exists in effectiveness in individuals and across time.

### Miscellaneous sleep aids

There are numerous alternative approaches to facilitating sleep. Earthing mats, ionizers, humidifiers, white noise, binaural beat sound, cooling blankets, magnetic pads/necklaces, metronomes or pendulum clocks, microcurrent pods, cranial vibration, and redlight stimulation. They all have varying degrees of effectiveness, and few have had adequate research studies.

## Stages of sleep

Sleep "structure" has been defined as having four stages, based on electroencephalogram (EEG) brainwave patterns. These stages can last variable time and repeat frequently. The sleep patterns can be broadly classed as non-REM (REM - rapid eye movement) and REM. REM sleep is primarily the dream state.

### Stage 1 Sleep

NREM stage 1 sleep is a transitional sleep-stage. This stage usually lasts 1 to 7 minutes in the initial cycle, being 2-5% of total sleep. It is easily interrupted by a disruptive noise. The EEG transitions from wakefulness alpha waves to mixed-frequency waves.

### Stage 2 Sleep

Lasts about 10-25 minutes in the first cycle, lengthening with each successive cycle, eventually being 45-55% of total sleep. An individual in stage 2 sleep requires more intense stimuli than in stage 1 to induce awakening. The EEG shows mixed-frequency activity. It includes sleep spindles that are important for memory consolidation. Those who learn a new task have higher density of sleep spindles.

### Stages 3 and 4, Slow-Wave Sleep

Sleep stages 3 and 4 are collectively called slow-wave sleep (SWS), most of which is in the first third of the night. Stage 3 lasts only a few minutes, about 3-8% of sleep. The EEG shows increased high wave, slow activity. The last NREM stage is stage 4, lasting about 20-40 minutes in the first cycle, making up about 10-15% of sleep. This stage requires the most amount of stimulation for arousal.

Arousal threshold is highest for all NREM stages in stage 4. This stage has tall, slow-wave activity on the EEG. Growth hormone secretion typically takes place during the first few hours after sleep onset, mostly during SWS. As a result SWS sleep (especially Delta) is considered the most regenerative part of sleep. Sympathetic nerve activity decreases with deeper sleep.

**REM sleep** shows low wave, mixed-frequency brain wave activity, loss of muscle tone and bursts of rapid eye movements. “Sawtooth” wave forms, theta activity (3-7 Hz), and slow alpha activity are also seen in REM sleep. Initially, a REM cycle may last only 1-5 minutes, becoming progressively longer as sleep progresses. Dreaming happens mostly in REM sleep. Loss of muscle tone and reflexes prevents the person from “acting out” their dreams or nightmares while sleeping. About 80% of vivid dream recall happens after arousal from this stage of sleep.

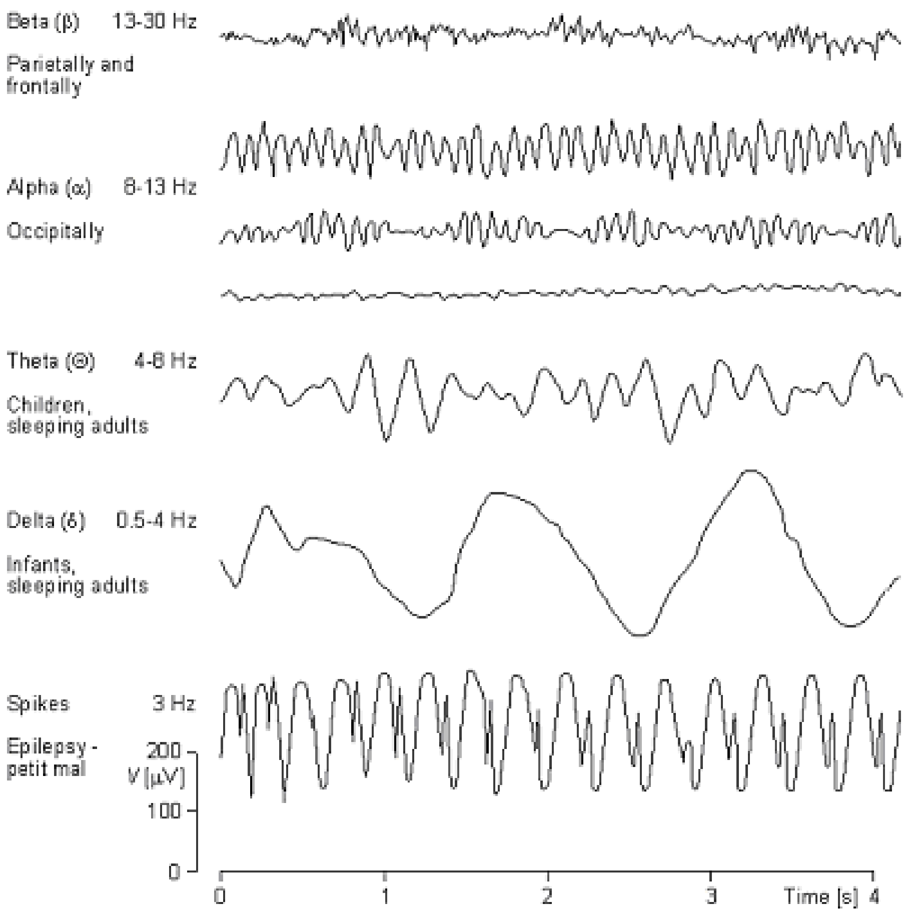
Sleep generation results from the shutdown of brain arousal. The neurons that control this are found in the hypothalamus and the reticular activating system (RAS) in the brainstem of the brain. The hypothalamus takes inputs from the lower brainstem. These inputs can be from the sleep-inducing effects of a full stomach, from the emotional and cognitive areas of the front of the brain and from the circadian hormonal system that synchronizes the sleep-wake cycle with the day-night cycle. This is why hypothalamic control affects sleep so much, depending on input from the emotional and cognitive areas of the higher levels of the brain.

## Sleep changes with age

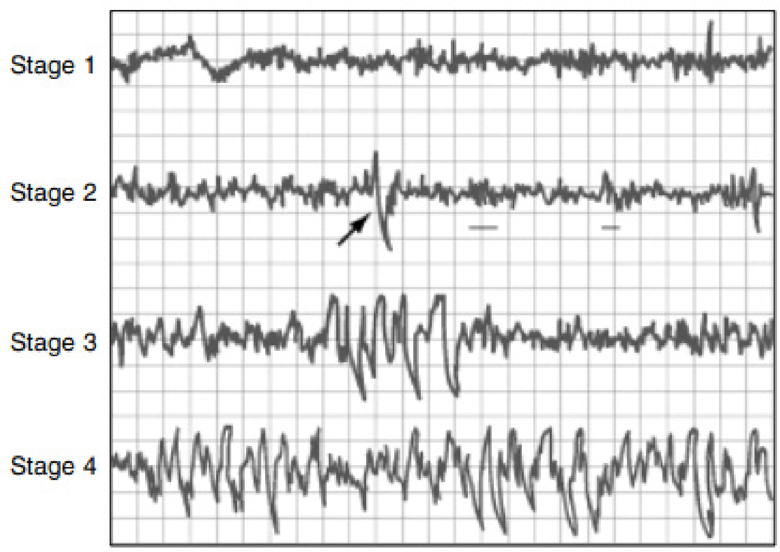
Sleep structure continues to change with age across the range of adulthood. These sleep changes include earlier wake time and reduced memory consolidation. With increasing age comes a tendency toward earlier bedtimes and wake times. Older adults (about ages 65-75) typically awaken 1.33 hours earlier, and go to bed 1 hour earlier, than younger adults at ages 20-30. Between ages 20-60, slow-wave sleep (SWS) decreases by about 2% per decade of age. Even though it takes more to be aroused from SWS, the amount of SWS declines with age. So, older adults experience more frequent awakenings during sleep.

## Typical EEG patterns

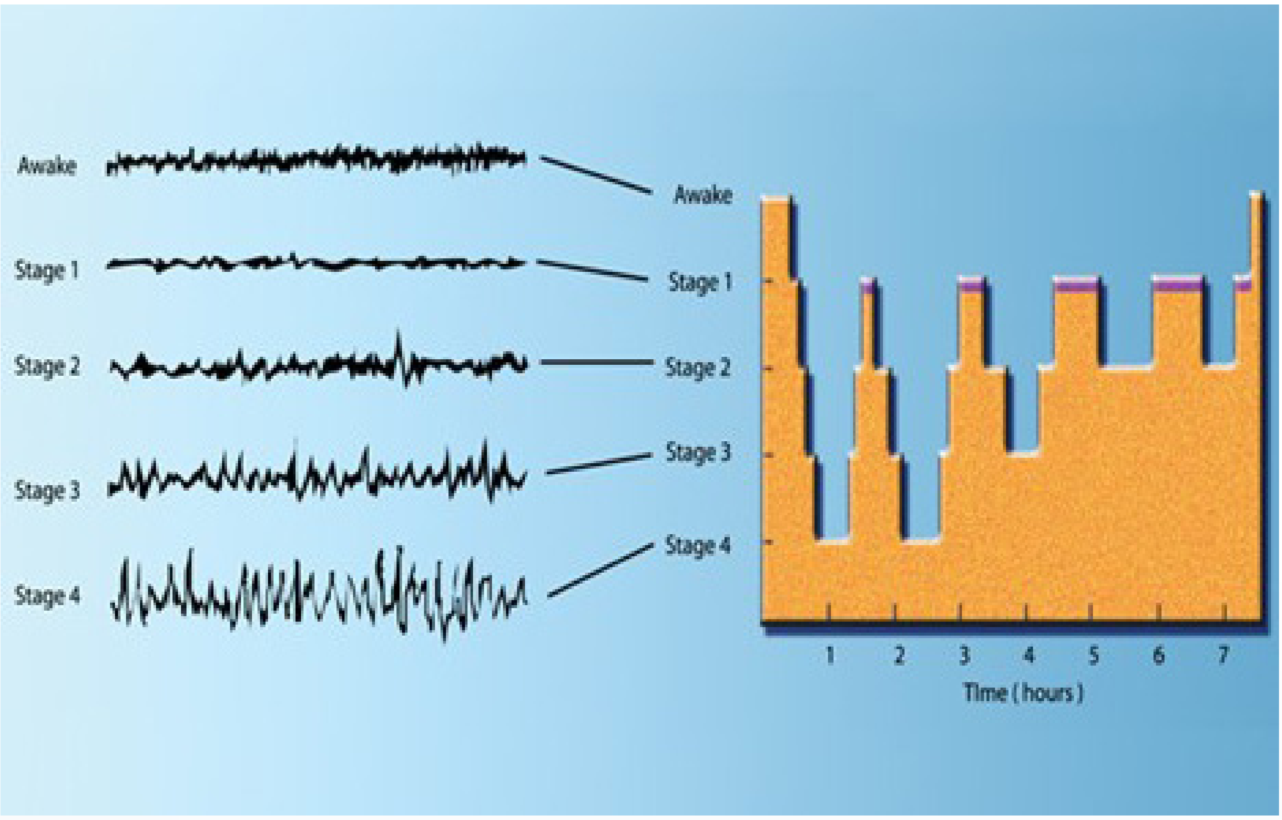
The image below shows the typical EEG patterns for each of the brainwave states, beta, alpha, theta, and delta. Most of sleep is in the Theta and Delta EEG range.




This image below shows the EEG patterns for each of the stages.



This next image shows the EEG patterns and the distribution of the different stages of sleep over time in an average situation.




In the 1st hour to hour and ½ of falling asleep, the sleeper descends through the stages from 1 to 4, followed by arousal backup to stage I, without being awake. Between 1 ½ to 2 hours a similar pattern is seen with stage IV sleep (SWS) lasting 30 to 45 minutes each time it occurs. From that point forward after about 3 hours, sleep never goes deeper than stage III. After about 5 hours it doesn't go deeper than stage II, again, with excursions backup to stage I until final arousal to being awake.

## Brainwave entrainment

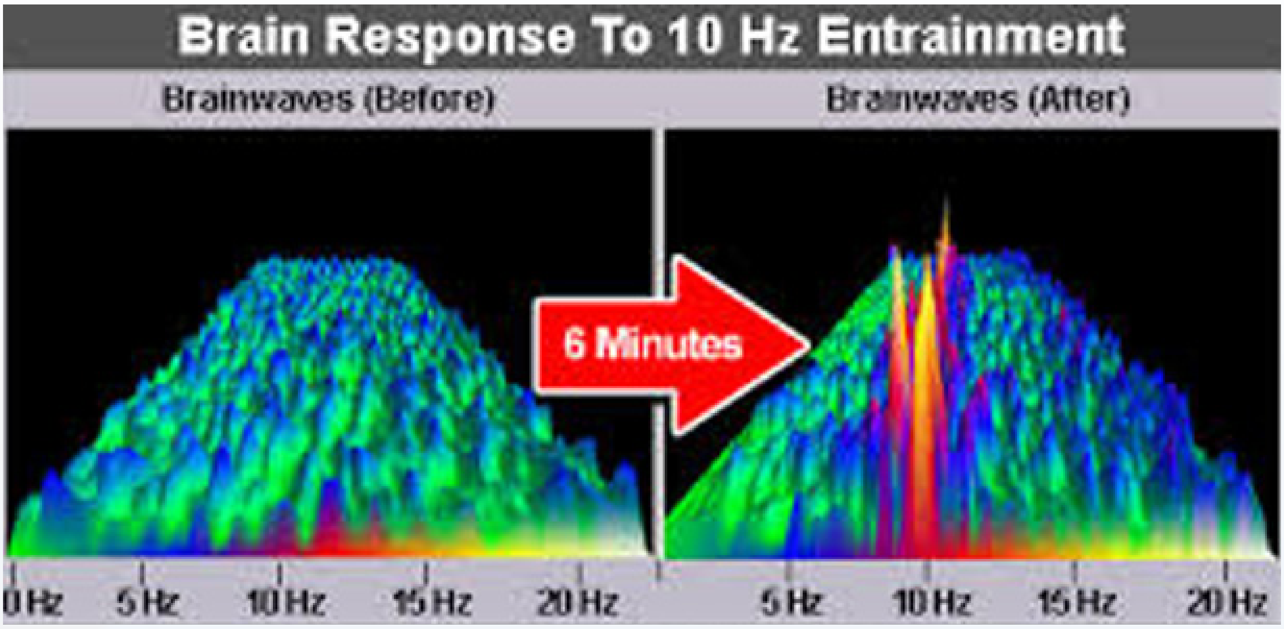
The frequency chosen for the PEMF sleep device, that is, 3Hz, has been selected based on its effect of inducing the SWS brainwave frequency bands in the brain through a process called brainwave entrainment.

### Brainwave entrainment history

Brainwave entrainment is nothing new. Ancient ceremonial chambers, acoustically tuned to specific brainwave frequencies, have been found dating back to the Bronze Age, and the ancient Greeks used flickering sunlight shining through a spinning wheel to induce altered states. Since the 1970's, a multitude of brainwave entrainment techniques have been developed using computer encoded audio beats, strobe lights, or low-energy electromagnetic fields.

### What is Brainwave entrainment?

Brainwave entrainment has been well studied scientifically. One of the earliest descriptions of this was found from scientific research into the effects of rhythmic light and sound stimulation in the mid-1930s. Scientists discovered that the electrical rhythms of the brain, or brainwaves, tended to assume the rhythm of a flashing light stimulus. This process was called entrainment. For example, when a strobe light was flashed at a frequency of 10 Hz into the eyes of a person monitored by an EEG, the EEG pattern tended to follow into a 10 Hz frequency. This is depicted in this image below:



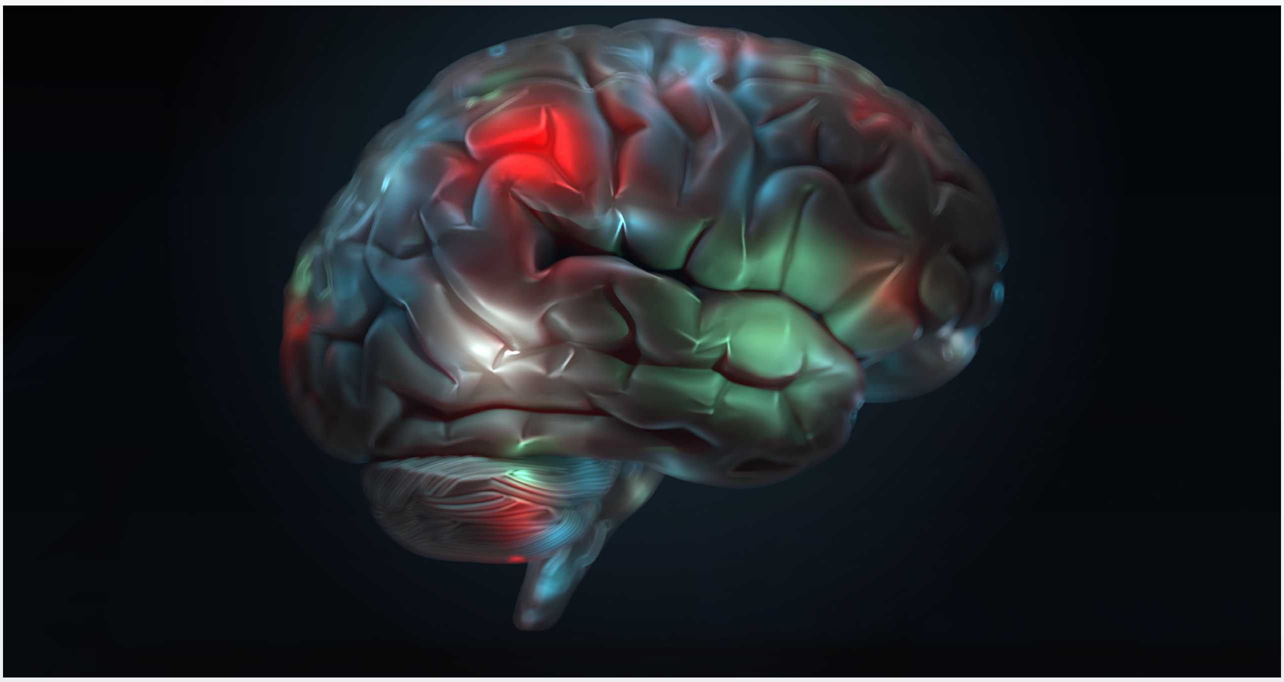

This color encoded image shows the increase in brainwave activity (from the small peaks and valleys before) into a sharp spiking activity at the simulation frequency of 10 Hz – even after only 6 minutes.

Various scientists discovered that such strobe light entrainment stimulation could have a variety of beneficial effects, such as increasing IQ scores, enhancing intellectual functioning, greater synchronization between the two hemispheres of the brain, relaxation, improved sleep, pain relief, and enhanced immune function. Since these early studies, a whole new branch of science has developed called neuroscience, which includes neurofeedback. Neurofeedback is based almost completely on rebalancing the brain using entrainment techniques.

### Radio and TV as entrainment

A way to understand entrainment is how radios and TVs work. Each radio or TV station is assigned a frequency within which it must broadcast its signals. This way the signals from all the different stations do not overlap. The signals are produced by the broadcast station transmitters. At the receiving end, our TVs and radios have tuners in them. When we change the station in the radio or TV tuner, we expect the tuner to begin to resonate in synchrony with the broadcast signal frequency. Once the signal is locked in (called phase locking) and refined by the tuner a clear sound and/or picture is produced. If resonance synchronization does not happen, the picture will be blurry, or the sound will be static noise.

The human brain, nervous system, and for that matter all the cells in the body, act like tuners to receive signals from outside the body. Once the signal is tuned properly, the body begins to "resonate" synchronously with the signal. Healing PEMFs operate with this entraining, signal synchronization process to perform the desired actions in the body. Even weak signals, once entrained, are then amplified by the body to affect larger areas of the brain.



### Electrical and magnetic entrainment

Just as sound and light can produce effects on the body through entrainment, so too can electrical stimulation and PEMF stimulation. Generally, whatever we can do with electrical stimulation can be done better, more deeply and more safely with PEMF stimulation. PEMF stimulation can be more effective because complete penetration of the entire brain with more uniform magnetic field intensity can be achieved safely with PEMF signals.

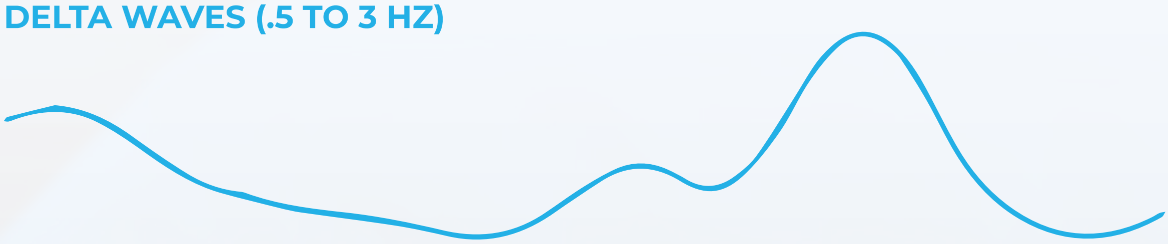
While pulsing sound, light, electrical or electromagnetic fields may have specific actions on the brain, or parts of the brain, the commonality among them is the frequencies used. So, frequencies used by stimulation with other technologies, other than PEMFs, will still have significant stimulation overlap between them as far as their actions are concerned. So, research or experience in using specific stimulation frequencies with sound, light, or electrostimulation show significant comparability in reactions or even synergies among them, including PEMFs. This is in addition to all the other benefits of PEMF stimulation.

So, how are the signals chosen for the FlexPulse and what is the scientific evidence to support their intended purpose?

## Brainwave frequency band basics

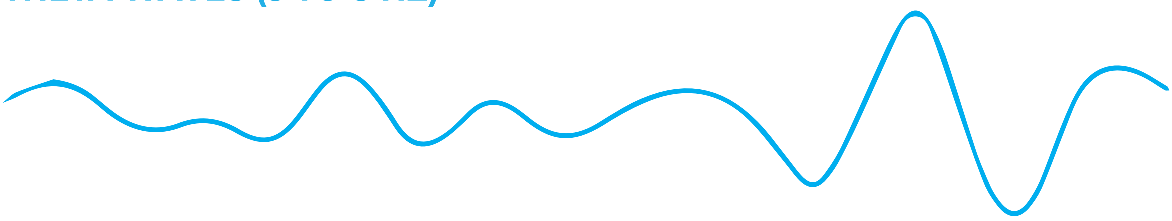
Brainwave frequencies, measured on EEG, range from .5 Hz to above 100 Hz. Delta, theta, and alpha waves will be discussed in greater detail here.

### DELTA WAVES (.5 TO 3 HZ)



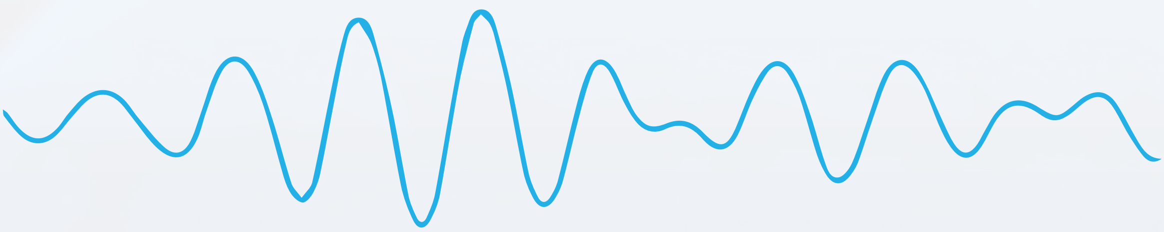
Delta brainwaves are the slowest but tallest brainwaves (low frequency and deeply penetrating, like a drumbeat). They are generated in deepest sleep and are dreamless. Most delta or slow wave sleep happens in the 1st 3 to 4 hours of sleep. The amount of delta decreases gradually as the night goes on. Delta waves suspend external awareness. Healing and regeneration are stimulated in this state, and that is why this deep restorative sleep is so essential to the healing process. Excess delta in an awake person can be associated with a low pain threshold and seen in traumatic brain injury. High delta activity in the frontal area of the brain is often associated with chronic pain disorders such as fibromyalgia. Excess delta on the top of the head is associated with attention deficit disorders and learning problems.

## THETA WAVES (3 TO 8 HZ)



Theta brainwaves occur most often in sleep but are also dominant in deep meditation and hypnotic states. It is our gateway to learning and memory. In theta, our senses are withdrawn from the external world and focused on signals originating from within. High theta activity reflects the overall quiescence of the central nervous system. It is that twilight state which we normally only experience fleetingly as we wake or drift off to sleep. In theta we are in a dream, with vivid imagery, intuition and information beyond our normal conscious awareness. Theta activity in the back of the brain is associated with the mind's ability to quiet itself. Deficient theta activity in the back of the brain is often associated with sleep disturbance, low stress tolerance, and predisposition to addiction. People with poor theta production in this area often cannot "shut the brain off" and suffer from anxiety -related disorders. Severe theta deficiency can be associated with behavioral problems that respond poorly to most psychoactive medications unless the theta deficiency can be corrected.

## ALPHA WAVES (8 TO 12 HZ)



Alpha brainwaves are dominant during quietly flowing thoughts, and in some meditative states. Alpha is "the power of now", that is, being fully here, in the present. Alpha is the lower end of the resting or idling state for the brain. Alpha waves aid overall mental coordination, calmness, alertness, mind/body integration, learning and visual memory. Alpha is relaxed attentiveness. It is used by many neurofeedback practitioners to help clients learn relaxation. Faster alpha (at or over 10 Hz) facilitates intellectual performance, with the potential to increase IQ scores by upwards of 10 points. Just as deficiencies in alpha can be associated with cognitive problems, excess alpha can be problematic as well. Too much alpha in the front of the brain can be associated with attention problems and difficulties planning, organizing, sequencing, and following through on activities, being over talkative and having sleep disturbances. When left frontal alpha is greater than right, depressed mood and negative reactions to emotional situations are more likely.

## More on brainwave entrainment

One of the goals of PEMF therapy is to stimulate the nervous system, in addition to all the other cells and tissues of the body, to produce desired health benefits.

Any stable frequency, optimally a strong signal, presented to the body, especially the brain, evokes a brain tissue response. The brain synchronizes its own natural dominant brainwave frequency with that of the external stimulus, becoming entrained.

Brainwave entrainment (aka. brainwave music or sound) causes the brain to enter specific states by using pulses of sound, light, electrical or electromagnetic fields. The pulses elicit the brain's 'frequency following" response, encouraging the brainwaves to align or "lock-step" to the frequency of a given beat. This "frequency following" response of brainwave entrainment can be seen in action with those prone to epilepsy. This concept is used in neurology to see if seizures may be triggered by flashing lights. If a strobe flashes at the person's seizure frequency, the brain's frequency will "entrain" to the flashing light frequency resulting in a seizure. Not all strobe lights cause seizures, just in those prone to them.

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 and maintenance. The brainwave entrainment effectively pushes most of the activity of the brain or even the entire brain from its resting or then current state into a certain desired state.

Brainwave entrainment works for almost everyone. It is a great way to lead your mind into states that one wants to be in, whether it's being more alert, relaxed, focused, or into sleep.

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

EEGs suggest that different regions of the human brain tend to engage in electrical oscillations at different frequencies. For example, when a person lays eyes closed in a state of relaxation, the back of the brain (occipital areas) typically oscillates at a frequency of 10 Hz rhythm, whereas the part of the brain just above the ears (sensory-motor cortex) often displays faster rhythms, for example, at 20 Hz rhythm. Spontaneous natural EEG rhythms are variable, and their location in the brain can change radically in the space of a second. This is commonly seen during EEG testing, if a person, for instance, opens their eyes or plans a simple body part movement.

Clear-cut resonance frequencies are common in specific parts of the brain - 10 Hz in the visual cortex (the back of the brain, occiput) and 40 Hz in the auditory cortex (the side of the brain, around the bone prominence – mastoid – just behind the ear).

People are very seldom deficient in a certain brainwave type in all areas of their brain. Usually the distribution is much spottier, with an excess being possible in one area and a deficiency in another. We are all different, especially when it comes to the distribution of our brainwaves, depending on the state of our consciousness at the time. This is why the whole brain cannot be put into one frequency with entrainment.

The frequency tuning of a brain area can be directly determined by stimulating it and by watching the rate of the ensuing oscillations on EEG.

This resonance approach is used, for example, in physics, in geology, and also when one tunes a musical instrument.

Higher intensity magnetic brain stimulation tends to produce stronger stimulation responses. High intensity stimulation studies (Rosanova) found dominant oscillations in various brain areas - alpha-band (8-12 Hz) in the occipital brain cortex (back of the brain), beta-band oscillations (13-20 Hz) in the parietal cortex (side of the brain around the ear), and fast beta/gamma-band oscillations (21-50 Hz) in the frontal cortex (frontal lobes).

Half the useful brainwave frequencies (0.3-40 Hz) are below the hearing range of the human ear (20 Hz-20,000 Hz). Most PEMF treatments within the brainwave frequency bands are not usually audible, except for the beating of the magnetic field within the coils, depending on the intensity the magnetic field used.

## Audio magnetic entrainment (AME)

Electromagnetic entrainment (EME) does not use sound or light. It uses small pulsing electromagnetic fields (often at about the same intensity as a large headphone speaker) to directly interact with the neurons. The coils in some electromagnetic devices emit an audible clicking sound. This audible sound serves as another source of entrainment, audio entrainment. In this case, this form of entrainment may be considered ***audio magnetic entrainment*** (AME). The addition of the clicking sound strengthens the value of the magnetic entrainment.

Brainwaves themselves are electromagnetic in nature. As EME uses the same method of stimulation as the brain itself, it is very fast acting (the brain responds in milliseconds). Most importantly, EM entrainment is region specific, meaning that you can entrain brainwave frequencies in any desired area of the brain. Sound or auditory entrainment tends to most strongly affect the auditory brain area , and from there spreads into other parts of the brain. Visual entrainment tends to affect the visual cortex of the brain most strongly. Audiovisual entrainment (AVE) will affect both areas of the brain. In addition, AME has all the other stimulatory benefits of PEMFs, giving it more complex and robust value.

The vast majority of people have no ill- effects from brainwave entrainment. The most common side-effect is simply feeling a little “unusual” for a while. For any unwanted effects, temporarily discontinued use will have the effects return to normal.

## Stimulation intensity

Higher intensity stimulation signals induce stronger frequency following/ entrainment responses. Lower intensity signals are more likely to be offset, distracted or overwhelmed by other types of stronger signals presented to or in the body, such as pain, light, sound, temperature, sensory changes, etc. This may be understood by the intensities of sounds, for example, whispers, versus common speech, versus loud noises. The highest intensity PEMFs have been found to produce the strongest and more lasting benefits in the treatment of insomnia (Sun). Lower intensity PEMFs may not induce enough physiologic or cellular change in the brain, after a course of treatment and, therefore, need more repeated use. Higher intensity PEMFs are bulkier and more expensive, often needing to be provided in a professional setting. When a PEMF signal is combined with AME, the entrainment benefits are stronger. However, they are not so strong as to have the body ignore biologic signals, such as the need to go to the bathroom or change body position.

## Brainwave “tethering” with all night PEMF entrainment

Sleep disturbance is often caused by lowered thresholds for arousal. In other words, sleep over time, like with age, may be disturbed more and more with lower intensity signals, such as a partner snoring, the need to empty the bladder, aches and pains, etc. In later stages of sleep, we are often aware of our dreams. This lower threshold for arousal happens when we are in higher theta frequencies. If we can keep the brain in lower frequencies, that is, lower theta frequencies or, even better, in Delta frequencies, there is less conscious awareness of sleep, aches or pains, undesirable weaker urges for the bathroom, minor movements in the bed from a partner, etc. With continuous all-night stimulation, a higher intensity PEMF, will entrain the brain better into deeper brainwave patterns. This will not allow higher frequency brainwave patterns (theta) to intrude which may facilitate undesirable sensory or conscious awareness, i.e., wakefulness or semi-wakefulness. Early arousals, especially frequent arousals, also often lead to frustration and anxiety. Lower EEG brain frequencies decrease those intrusions/arousals from happening. Also, these lower brainwave frequencies decrease but not eliminate awareness of physical sensations, which also lead to the increased arousals.

Other than becoming awake, one often knows one is in lighter stages of sleep (higher theta) when one is aware of dreams. Awareness of dreams is at a higher level of consciousness than deeper sleep. Lack of awareness of dreaming happens during non-REM sleep. Dreaming happens in REM sleep, mostly later at night in the higher levels of theta, for example, at 10 Hz – 13 Hz.

Staying more consistently and continuously in lower levels of sleep means that you would be in the delta brainwave frequency range. Staying in this range throughout the night without entering theta is desirable for having more restful, continuous and deeper sleep. This process is called "tethering." That means the brain will tend to be tethered into lower frequency patterns, preferably delta frequencies. Tethering does not allow the brain to move as easily up into higher brainwave frequencies associated with arousals or lowered thresholds for arousal.

An image that can be used, is that of a swimmer, swimming on the surface of the water. Swimming on the surface of the water is like very light sleep. If one wants to swim deeper in the water, that is, being in deeper sleep, this is more likely to happen more easily with a weight attached to the belt of the swimmer. This would make it more challenging to swim at the surface, that is, the sleeper is less likely to move into lighter (higher) stages of sleep. This means the brain would not have the opportunity to go to faster brainwave patterns associated with higher stages of sleep. Using Delta entrainment effectively functions as the weight around the body during swimming, making it less likely to reach up into more conscious levels of sleep. This therefore induces deeper, more satisfying, more consistently relaxing and healing sleep.

## Why we don’t recommend ramping

Some sleep PEMF systems use ramping techniques. Ramping means using various frequencies to emulate what the brain might normally do. For example, ramping for sleep might include starting at 10 Hz and decreasing gradually down to 3 Hz. Ramping up may be used for waking up. Experience has shown that ramping preempts the brain from doing what it does naturally. We are effectively trying to be smarter than the body itself. That is, we are trying to produce a “normal” sleep pattern artificially. With a relatively gentle stimulation, the brain will still be allowed to function as it needs to, for example, for arousal for trips to the bathroom. By doing only one frequency, Delta 3 Hz, the brain effectively does its own ramping. Artificial ramping is usually done with preset frequencies. The brain may be at a lower frequency than the PEMF signal starts at, potentially effectively increasing the alertness of the brain. Or oppositely, the brain may want to ramp up more slowly, but with ramping up frequencies the brain may be ramped up too fast. Second-guessing the natural ramping of the brain, up or down is frequently likely to be at odds with what the brain wants to do. That's less natural and is more likely to end up with sleep disruption.

Experience has shown that the single frequency, delta, works better for inducing sleep, maintaining sleep and not allowing awakening too quickly. The brain does its own ramping as it wants to, naturally.

## The value of AME

The audio portion aspect of a PEMF sleep device comes from the normal clicking of the magnetic field in the coils. When these are placed under the head, they can be heard, although not normally disturbingly so. It is important for users to remind themselves that this sound pattern is desirable and additive to entrainment. So, there is a dual benefit from both the magnetic entrainment as well as the audio entrainment.

In addition, the clicking sound serves as a "homing beacon" for the sleeper's brain. Since movement of the body during the night will cause the head to move away from the central part of the magnetic field, listening for the sound will allow repositioning of the head to maximize the magnetic signal. Occasionally this can take some getting used to, but very quickly it becomes part of the therapy process. The clicking of the coils is reassuring that the magnetic system is there doing its work. The magnetic field itself is typically not able to be felt.

## PEMF device selection criteria

PEMF devices are available that consider all of the above information. The requirements for an adequate sleep enhancing device include:

- **Safe** - as safe as most PEMFs.
- **Effective** - based on entrainment research
- **Inexpensive** - $600-$1290
- **Can be used all night long** - runs on a rechargeable battery

- **Ease-of-use** - easily placed on or under the pillow
- **Reusable** - runs as long as the battery lasts, which can be replaced or recharged
- **Useful for all sleep stages** - deepens all sleep stages
- **Sleep inducing** - begins to affect brain stages from the first stage; speeds the initiation of the deep sleep stage. Very noticeable effects
- **Sleep maintaining** - because it runs all night long will maintain sleep through the night until waking
- **Lack of tolerance development** - unlike medication or supplements there is no risk of development of tolerance
- **Combinable with other approaches** - can easily be combined with other techniques or approaches depending on circumstances and needs
- **Affects causes of sleep problems** - besides working on sleep, can be used during the day for aches and pains, arthritis, etc. This would decrease the likelihood of these problems causing waking.
- **Usefulness other than for sleep** - may be useful for aches and pains, healing, daytime relaxation, etc.
- **Lack of side effects** - unlike medication or supplements or other therapies there is an absence of side effects.
- **Research evidence** - there is significant research evidence for the use of PEMFs for entrainment.
- **Significant history of experience** - PEMFs have a long history of research and experience for a vast range of needs.
- **Works directly on sleep-inducing brain waves** - directly stimulates the induction of slow wave sleep oscillations, since the magnetic field passes completely through the brain
- **Effects wear off rapidly** - when stimulation is removed from the brain, the brain will revert back to its normal natural rhythms. There is virtually no “hangover” effect.
- **Enhance napping** - Can even be used to enhance napping.
- **Generalized brain effects vs local** - the magnetic field penetrates the brain completely and is not location specific, such as the auditory cortex or the visual cortex. Can be targeted specifically to the brain stem and the hypothalamus, the areas of the brain that induce sleep.

## The intensity of the magnetic field stimulation

Most of the time, for most people, the highest intensity setting will work best. This setting will also produce the best clicking sound for AME. One knows the battery is depleting when the sounds produced in the coils are significantly less intense. For devices that use 9 V batteries, the use of a 9 V USB rechargeable battery, connected to power throughout the night will allow the best and most consistent intensity levels through the night. If the USB battery charging is not connected at the same time the battery is running, the battery should be recharged before the next time it's used, to allow it to maintain adequate intensity levels through the night.

## Positioning of the coils

For best AME effects, it is recommended to position the coils on top of the pillow, under the pillow cover. Placement under the pillow cover keeps the coils positioned so that they don't move during the night. Alternatively, the coils may be placed inside the pillow cover under the pillow, but this will move the coils farther away from the head producing less strength of AME. So, if the sound from the coils is disturbing, placement under the pillow may be better tolerated. Obviously, the thicker the pillow the more distance it will be away from the head and the lower the AME effectiveness. It's important to remember that the magnetic field needs to go into the brain as deeply as possible to have its strongest benefit.

It is almost never recommended to place the coils under the mattress or under a 2nd bottom pillow because of the extra distance the coils will be away from the head. This may be an option in individuals who are extra sensitive, but, again, the magnetic field intensity will be much, much lower at the level of the brain.

While positioning the coils under the top of the neck will impact the reticular activating system the best, unless somebody is a back sleeper, this may be hard to maintain. Experience shown that stimulation to the side of the head will still produce a significant benefit. There is no hard and fast rule about where the positioning should be. Again, this going to be a matter of personal preference and personal trial and error. Placement at the back of the neck may be heard louder than under the side of the head.

## Running the unit all night long

The best results are going to be obtained by running the sleep PEMF device all night long, from the moment the head hits the pillow. If there is a need to get up during the night, the entrainment process will kick in much faster to allow someone to fall back to sleep faster than would happen normally without AME.

## Combining AME with other modalities

AME may not always be a complete solution to enhance and improve sleep. "Sleep stacking" may be needed by adding other approaches to helping with sleep. Sleep hygiene is always important. Adding melatonin, CBD, theanine, chamomile or other supplements may also be needed. AME will not interfere with these, but, in fact, will be additive to their benefits. Many people who begin to use the AME will have already used other approaches to help with sleep. Adding or subtracting any other modalities can be tried once AME begins to be used.

## Battery charging

Battery should be maintained in a fully charged state as much as possible. If it has to be replaced, replacement should be with a similar strength rechargeable battery. A 9 V battery has a light on it indicating charging status. When using a 9 V battery device, if for some reason a 9 V USB battery is not used, standard 9 will batteries of similar amperage may be used. Recall, that using batteries at the maximum level will deplete them faster. If other types of 9V batteries are used, it would be better to have rechargeable batteries.

## Using the PEMF for other health issues

PEMF devices used primarily for sleep are still PEMF systems and have all the other possible uses of PEMFs applied locally. These include treatment for aches and pains, injuries, burns, insect bites, etc. More can be learned about the overall use of PEMFs at drpawluk.com and from the book **Supercharge Your Health with PEMF Therapy** by Dr. William Pawluk.

# Appendix A

## Research evidence for entrainment

Entrainment effects have been studied in both humans and animals.

Shifts in the distribution of brainwave frequencies seen on EEG that occur with stimulation suggest helpful changes in mental state would be expected. Behavioral and neurophysiological changes have been reported after exposure to extremely low frequency PEMFs in both animals and in humans. Using EEG, it was found that adult rabbits assumed the 5-8-Hz rhythm of the PEMF stimulator. This was less pronounced for 1-2-Hz. (Volynskii). PEMFs increase neurotransmission even in nerve cell cultures.

Noninvasive transcranial brain stimulation of healthy volunteers (Capone) produced changes similar to that seen with pharmaceuticals, enhancing brain glutamine production by about 20%. The PEMF signal was 75 Hz at peak intensity of 1.8 mT. Sham field exposure produced no effects.

EMFs at 2-12 Hz have been reported to affect behavior in man and animals (Hamer; Wever, 1987) and several animal studies suggest that EMFs can specifically alter brain electrical activity. A relative peak in EEG was seen in monkeys at the frequency of the EMF (Gavalas), and EMFs amplitude-modulated at 3-14 Hz were reported to reinforce the occurrence of spontaneous rhythms in cats when the EMF frequency was tuned to the frequency of the intrinsic rhythm (Bawin). EMFs at 5-10 Hz altered intrinsic EEG power in rabbits at the frequency of stimulation (Bell). EMFs at 35-40 Hz and 60 Hz can non-specifically alter human brain activity.

Even brief exposure to weak 100 microT, 60 Hz extremely low frequency (ELF) magnetic fields (up to 5 min) significantly improved performance in mice. (Kavaliers) These facilitatory effects involved reduction of related anxiety related behaviors, probably mediated by stimulation of endogenous brain opioid activity. The same group found similar exposures and benefits even in snails. The degree of analgesic benefit was related to the duration of exposure to the 60 Hz magnetic fields (Kavaliers, 1990). This is yet another reason we support the use of battery-operated PEMFs, which can be used for extended periods of time, to achieve greater analgesic benefit.

A patient was studied (Persinger) who had been experiencing complex partial epileptic-like experiences and disturbances in sleep patterns for four years following a closed head injury. A weak (1 microT) magnetic field was applied across both sides of the head. During the PEMF exposure EEG changes were significantly correlated with the onset of the PEMF transmitted at <1 Hz. These results suggest that some states of consciousness may be more sensitive to entrainment or "synchronization" by weak complex magnetic fields designed to simulate natural brain activity.

Interactions between the hippocampus and the cortex are required for memory formation. Using functional magnetic resonance imaging and electrophysiology measurements, specific frequencies were found to propagate in brain-wide networks. (Moreno) Activity increased with frequency to a maximum at 20-40 Hz. Robust propagation outside the hippocampus was seen specifically at theta-beta frequencies (10-20 Hz), reaching a network of midline neural brain structures. Another study (Rangel) suggests 20-40 Hz brain oscillations in the hippocampus and upstream cortex support learning.

Oscillations in brain activity have been known for a long time. New insights into these issues are emerging from application of non-invasive brain stimulation approaches. Such stimulation led to rapid, periodic fluctuations in behavioral performance, which co-cycle with underlying brain oscillations. (Thut)

There is renewed interest in the functional role of oscillatory brain activity in specific frequency bands, investigated in humans through EEG and MEG recordings. In parallel, there is a growing body of research on non-invasive direct stimulation of the human brain via repetitive (rhythmic) transcranial magnetic stimulation (TMS), in general, and specifically on those frequencies that have the strongest behavioral impact. The research indicates that brain rhythms affect cognitive functions. (Thut, 2009)

High-frequency (9 Hz) photic stimulation for 120 s decreases human occipital alpha activity for about 1 hour. (Aydin-Abidin) rTMS applied at a low repetition frequency (0.5–1 Hz) lowered the mean EEG frequency, while high frequency rTMS (15 Hz) enhanced the high frequencies in the power spectrum of EEG.

There is also information that indicates that the type of input or stimulation into the brain is very important. For example, stimulation using light affects the visual cortex more than other parts of the brain. Sound stimulation affects the auditory cortex more than other parts of the brain. (Dinse) So, more generalized stimulation using pulsed electromagnetic fields will affect all regions of the brain in a different fashion than these other forms of stimulation and is likely to be less susceptible to the perceptual functions of the brain. This is another reason why PEMFs could be the preferred nonspecific method of brain stimulation, by using specific frequencies.

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