PULSED ELECTROMAGNETIC FIELD THERAPY (PEMF)

Alzheimer's

http://hindawi.com/journals/jhe/2017/2530270 Low-Frequency Pulsed Electromagnetic Field Is Able to Modulate miRNAs in an Experimental Cell Model of Alzheimer's Disease

These results suggest that the electromagnetic fields at low frequencies, if properly used, **may be useful for the treatment of patients with AD**, as suggested by the results of pilot experiments with deep brain stimulation via EMFs, which were reported to produce clinical benefits [15].

https://onlinelibrary.wiley.com/doi/10.1002/ana.22089 A phase I trial of deep brain stimulation of memory circuits in Alzheimer's disease

PET scans showed an early and striking reversal of the impaired glucose utilization in the temporal and parietal lobes that was maintained after 12 months of continuous stimulation. Evaluation of the Alzheimer's Disease Assessment Scale cognitive subscale and the Mini Mental State Examination suggested **possible improvements and/or slowing in the rate of cognitive decline** at 6 and 12 months in some patients. There were **no serious adverse events**.

https://content.iospress.com/articles/journal-of-alzheimers-disease/jad01228 Electromagnetic Field Treatment Protects Against and Reverses Cognitive Impairment in Alzheimer's Disease Mice

Although caution should be taken in extrapolating these mouse studies to humans, we conclude that EMF exposure may represent a non-invasive, non-pharmacologic **therapeutic against Alzheimer's disease** and an effective memory-enhancing approach in general.

https://bmcneurol.biomedcentral.com/articles/10.1186/1471-2377-7-13 A case-control study of occupational magnetic field exposure and Alzheimer's disease: results from the California Alzheimer's Disease Diagnosis and Treatment Centers

Elevated occupational MF exposure was associated with an **increased risk of AD**. Based on previous published studies, the results likely pertain to the general population.

https://pubmed.ncbi.nlm.nih.gov/30880541/ Effects of pulsed electromagnetic fields on learning and memory abilities of STZ-induced dementia rats

PEMF, 10 mT at 20 Hz Our findings indicate that the pulsed EMF exposure **can improve the ability of learning and memory** in STZ-induced dementia rats and this effect may be related to the process of IGF signal transduction, suggesting a potential role for the pulsed EMF for the amelioration of cognition impairment.

https://pubmed.ncbi.nlm.nih.gov/25118893/ Short-term effects of extremely low frequency electromagnetic fields exposure on Alzheimer's disease in rats

The present study indicated that short-term exposure of **100 μT/50** Hz ELF-EMF had **no effects on cognition and memory** of rats

https://pubmed.ncbi.nlm.nih.gov/29185809/ Spatial memory recovery in Alzheimer's rat model by electromagnetic field exposure

Therefore, this study aimed to investigate the effect of ELF-EMF exposure (**50 Hz, 10 mT**) on spatial learning and memory changes in AD rats. Our results showed that application of ELF-MF not only has **improving effect on different cognitive disorder** signs of AD animals, but also disrupts the processes of AD rat model formation.

https://pubmed.ncbi.nlm.nih.gov/7960477/ Alzheimer's disease: improvement of visual memory and visuoconstructive performance by treatment with picotesla range magnetic fields

Recently, I reported that external application of electromagnetic fields (EMF) of extremely low intensity (in the **picotesla** range) and of low frequency (in the range of **5Hz-8Hz**) improved visual memory and visuoperceptive functions in patients with Parkinson's disease. The rapid improvement in cognitive functions in response to EMF suggests that s**ome of the mental deficits of AD are reversible** being caused by a functional (i.e., synaptic transmission) rather than a structural (i.e., neuritic plaques) disruption of neuronal communication in the central nervous system.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5434238/ Low-Frequency Pulsed Electromagnetic Field Is Able to Modulate miRNAs in an Experimental Cell Model of Alzheimer's Disease

suggest that the electromagnetic fields at low frequencies, if properly used, **may be useful for the treatment of patients with AD**, as suggested by the results of pilot experiments with deep brain stimulation via EMFs, which were reported to produce clinical benefits [15

https://pubmed.ncbi.nlm.nih.gov/20061638/ Electromagnetic field treatment protects against and reverses cognitive impairment in Alzheimer's disease mice

To the contrary, this report presents the first evidence that long-term EMF exposure directly associated with cell phone use (918 MHz; 0.25 w/kg) provides cognitive benefits.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5292622/ A Pulsed Electromagnetic Field Protects against Glutamate-Induced Excitotoxicity by Modulating the Endocannabinoid System in HT22 Cells

These results suggest that **PEMF exposure leads to neuroprotective effects against excitotoxicit**y by facilitating the eCB/CB1R/ERK signaling pathway. Therefore, PEMF may be a **potential physical therapeutic technique for preventing and treating neurological diseases.**

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3938248/pdf/f1000research-2-3188.pdf Long term delivery of pulsed magnetic fields does not alter visual discrimination learning or dendritic spine density in the mouse CA1 pyramidal or dentate gyrus neurons

Our negative results highlight the lack of deleterious side effects in normal subjects and are consistent with previous studies suggesting that rTMS has a bigger effect on abnormal or injured brain substrates than on normal/control structures.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7764106/pdf/molecules-25-05789.pdf Comprehensive Review on Alzheimer's Disease: Causes and Treatment

Aging and genetic risk factors cannot explain all cases of AD. Environmental risk factors including air pollution, diet, metals, infections, and many others may induce oxidative stress and **inflammation** and increase the risk for developing AD

The **brain inflammation** causes an increase in microglia and results in reduced synaptic plasticity and impaired neurogenesis.

Alzheimer's Sundowners Effect

https://pubmed.ncbi.nlm.nih.gov/11329390/ Sundowning and circadian rhythms in Alzheimer's disease

These data indicate that Alzheimer's disease causes disturbances of circadian rhythms and that sundowning is related to a phase delay of body temperature caused by Alzheimer's disease.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5187352/pdf/fmed-03-00073.pdf Sundowning in Dementia: Clinical Relevance, Pathophysiological Determinants, and Therapeutic Approaches

Accordingly, no randomized controlled trial specifically investigating the effectiveness of pharmacological and non-pharmacological strategies in managing this condition among demented patients has been yet conducted. In the present narrative review, we present and discuss available evidence concerning sundowning occurring in people with dementia.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3246134/pdf/pi-8-275.pdf Sundown Syndrome in Persons with Dementia: An Update

Neurophysiologically, it appears to be mediated by degeneration of the suprachiasmatic nucleus of the hypothalamus and **decreased production of melatonin.** A variety of treatment options have been found to be helpful to ameliorate the neuropsychiatric symptoms associated with this phenomenon: **bright light therapy**, **melatonin**, ace-tylcholinesterase **inhibitors**, N-methyl-d-aspartate receptor antagonists, antipsychotics, and behavioral modifications.

https://pubmed.ncbi.nlm.nih.gov/11260364/ Effects of extremely low frequency magnetic fields on pain thresholds in mice: roles of melatonin and opioids

Exposure of MFs (24 h, 20 gauss (G)) inhibited the increase of pain thresholds at night time and even produced hyperalgesia at daytime. 3. The increase of pain thresholds induced by melatonin at daytime was inhibited by exposure to MFs (24 h, 20 G) or opioid antagonist naloxone. The MFs and naloxone synergically inhibited hypoalgesia produced by melatonin. The hyperalgesia at daytime after MFs exposure was potentiated by the benzodiazepine agonist, diazepam, and inhibited by the benzodiazepine antagonist, flumazenil. There was no significant difference in all rotarod performance we tested. 4. From these results, it is suggested that exposure to MFs inhibits the increase of pain thresholds at night time and produces hyperalgesia at daytime with the involvement of opioid and benzodiazepine systems.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5405617/ Melatonin: Pharmacology, Functions and Therapeutic Benefits

Measures of melatonin are considered the best peripheral indices of human circadian timing based on an internal 24-hour clock.

https://pubmed.ncbi.nlm.nih.gov/9855367/ The effects of pulsing magnetic fields on pineal melatonin synthesis in a teleost fish (brook trout, Salvelinus fontinalis)

Fields were generated by Helmholtz coils (maximum flux density 40 microT, frequency 1 Hz, 200 ms on, 800 ms off). Melatonin concentrations were estimated by a specific radioimmunoassay. **MF exposure significantly increased night-time pineal (P < 0.001) and serum (P < 0.01) melatonin levels, as compared with the controls**.

https://pubmed.ncbi.nlm.nih.gov/16219483/ Melatonin

Melatonin regulates the sleep/wake cycle, other circadian and seasonal rhythms, and acts as an immunostimulator and cytoprotective agent. Findings are encouraging to use melatonin as a sleep promoter and in preventing progression of neurodegenerative diseases.

https://pubmed.ncbi.nlm.nih.gov/12019347/ The use of melatonin in Alzheimer's disease

About 45% of Alzheimer's disease (AD) patients have disruptions in their sleep and sundowning agitation. Since **melatonin secretion is greatly inhibited in AD patients** we have used melatonin to treat sleep disorders in AD patients since 1995. In a first study [21] we reported, in 7 out of 10 dementia patients treated with melatonin (3 mg p.o. at bed time), a decreased sundowning. In a second study [22] we examined 14 AD patients who received 9 mg melatonin daily for 22 to 35 months, observing a significant improvement of sleep quality with stabilization of behavioral and cognitive parameters. In a third study [23] we reported two monozygotic twins with AD and similar cognitive impairment, one of them receiving 6 mg melatonin at bedtime daily for 3 years. Melatonin treatment improved sleep quality and suppressed sundowning. We now report the effect of melatonin (4-month-long treatment with 6 mg/day) in 45 AD patients with sleep disturbances. Melatonin improved sleep and suppressed sundowning, an effect seen regardless of the concomitant medication employed to treat cognitive or behavioral signs of AD. Melatonin treatment seems to constitute a selection therapy to ameliorate sundowning and to slow evolution of cognitive impairment in AD patients.
https://pubmed.ncbi.nlm.nih.gov/11455329/ Melatonin treatment stabilizes chronobiologic and cognitive symptoms in Alzheimer's disease
Clinically, the patients exhibited lack of progression of the cognitive and behavioral signs of the disease during the time they received melatonin. Sundowning was no longer detectable in 12 patients and persisted, although attenuated, in 2 patients. CONCLUSION. The results suggest that melatonin can be useful for treatment of Alzheimer's disease.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1395802/ The Therapeutic Potential of Melatonin: A Review of the Science
some studies have demonstrated **improvements in sleep disturbances and "sundowning" in patients with Alzheimer's disease**.
https://pubmed.ncbi.nlm.nih.gov/9084867/ Human melatonin during continuous magnetic field exposure
We conclude that the intermittent and continuous exposure conditions used in our laboratory to date are **not effective in altering nocturnal blood levels of melatonin in human volunteer**s.

Parkinson's

https://www.pemf-tech.com
https://pubmed.ncbi.nlm.nih.gov/26347217/ Mechanisms and therapeutic applications of electromagnetic therapy in Parkinson's disease
In this review, we discuss the mechanisms and therapeutic applications of electromagnetic therapy to alleviate motor and non-motor deficits that characterize Parkinson's disease.
https://pubmed.ncbi.nlm.nih.gov/30252895/ Effect of transcranial pulsed electromagnetic fields (T-PEMF) on functional rate of force development and movement speed in persons with Parkinson's disease: A randomized clinical trial
Treatment with transcranial pulsed electromagnetic fields was superior to placebo regarding functional rate of force development during chair rise among high-performers. Active treatment tended to increase functional rate of force development while placebo did not. Our **results suggest that mildly affected persons with Parkinson's disease have a larger potential for neural rehabilitation** than more severely affected persons and indicate that early treatment initiation may be beneficial.
https://pubmed.ncbi.nlm.nih.gov/33909634/ Long-term treatment with transcranial pulsed electromagnetic fields improves movement speed and elevates cerebrospinal erythropoietin in Parkinson's disease
Long-term treatment with transcranial bipolar pulsed electromagnetic fields increased movement speed markedly and elevated erythropoietin levels. We hypothesize that treatment with transcranial bipolar pulsed electromagnetic fields improved functional performance by increasing dopamine levels in the brain, possibly through erythropoietin induced neural repair and/or protection of dopaminergic neurons.
https://pubmed.ncbi.nlm.nih.gov/30704504/ The effect of 8 weeks of treatment with transcranial pulsed electromagnetic fields on hand tremor and inter-hand coherence in persons with Parkinson's disease
The T-PEMF treatment decreased the inter-hand coherence in the PD group with unilateral postural tremor. The PD group with unilateral postural tremor was less clinically affected by the disease than the PD group with bilateral postural tremor.
https://pemfinfo.com/wp-content/uploads/2018/12/004_PARKINSONS_art3A10.11862Fs12993-015-0070-z-1.pdf Mechanisms and therapeutic applications of electromagnetic therapy in Parkinson's disease
In conclusion, electromagnetic therapy represents a non-invasive, **safe and promising approach** that can be used alone or combined with conventional therapies for the challenging treatment of PD motor and non-motor symptoms.
https://pubmed.ncbi.nlm.nih.gov/7989159/ Improvement in word-fluency performance in Parkinson's disease by administration of electromagnetic fields
The present communication concerns five fully medicated Parkinsonian patients in whom application of a series of treatments with electromagnetic fields (EMF) of extremely low intensity **(in the picotesla range) and frequency (5-8Hz) produced a dramatic improvement in performance on Thurstone's World-Fluency Test,** a sensitive marker of frontal lobe functions.
https://www.nature.com/articles/s41598-022-21093-8 High risk of developing dementia in Parkinson's disease: a Swedish registry-based study
PwP had approximately f**our times higher risk of developing dementia**
https://www.frontiersin.org/articles/10.3389/fneur.2022.904796/full Frequency of Neurological Diseases After COVID-19, Influenza A/B and Bacterial Pneumonia
Compared to COVID-negative outpatients, COVID-19 positive outpatients had an increased RR of **Alzheimer's disease** (RR = 3.5; 95%CI: 2.2–5.5) and **Parkinson's disease** (RR = 2.6; 95%CI: 1.7–4.0), ischemic stroke (RR = 2.7
https://pubmed.ncbi.nlm.nih.gov/33682730/ Decreased Risk of Parkinson's Disease After Rheumatoid Arthritis Diagnosis: A Nested Case-Control Study with Matched Cases and Controls
Individuals with a previous diagnosis of RA had a **decreased risk of later developing PD by 30-50% compared to individuals without an RA diagnosis**. This relationship was strongest in our conservative analysis, where the first PD diagnosis occurred close to the earliest PD symptoms (odds ratio 0.47 (CI 95% 0.28-0.75, p = 0.0006); with the greatest risk reduction in females (odds ratio 0.40 (CI 95% 0,19-0.76, p = 0.002). Our findings provide evidence that **individuals diagnosed with RA have a significantly lower risk of developing PD than the general population**. Our data should be considered when developing or repurposing therapies aimed at modifying the course of PD.
https://pubmed.ncbi.nlm.nih.gov/35645965/ Association Between Rheumatoid Arthritis and Risk of Parkinson's Disease: A Meta-Analysis and Systematic Review
Four population-based studies involving 353,246 patients and one Mendelian randomized study were included in our study. The pooled result showed a significantly reduced risk of PD in patients with RA than in the general population This study supports that people with RA had a lower PD risk than those without RA.

Alzheimer's and Parkinson's LINKS

https://clinicaltrials.gov/ct2/show/NCT05268770 Inflammation in Tinnitus (INFLATIN)
"In the past decade, **inflammation has been implicated in the pathophysiology of tinnitus**. In animal models of tinnitus, the expression of proinflammatory cytokines Tumor Necrosis Factor-α (TNF-α) and interleukine-1β (IL-1β) was increased throughout the whole auditory tract. Only two studies evaluated cytokine concentrations in tinnitus patients."

https://clinicaltrials.gov/ct2/show/NCT05268770#:~:text=In%20the%20past%20decade%2C%20inflammation%20has%20been%20implicated,two%20studies%20evaluated%20cytokine%20concentrations%20in%20tinnitus%20patients.
https://www.audiology-worldnews.com/research/3554-is-treatable-neuroinflammation-the-trigger-for-tinnitus
In recent years, **inflammation in the body has become a major focus of researchers investigating a long list of conditions from arthritis to heart disease, diabetes, and even cancer.** Such research tends to point to the host immune response creating inflammation as part of our defence process against a wide range of factors.

https://pubmed.ncbi.nlm.nih.gov/33675261/#:~:text=A%20pulsed%20electromagnetic%20field%20%28PEMF%29%20has%20been%20used,studies%20have%20shown%20that%20PEMF%20may%20affect%20angiogenesis.
A pulsed electromagnetic field **(PEMF) has been used to treat inflammation-based diseases** such as osteoporosis, neurological injury, and osteoarthritis. Numerous animal experiments and in vitro studies have shown that PEMF may affect angiogenesis. For ischemic diseases, in theory, blood flow may be richer by increasing the number of blood vessels which supply blood to ischemic tissue.

https://pubmed.ncbi.nlm.nih.gov/22737171/
Hydrogen peroxide in inflammation: messenger, guide, and assassin

https://pubmed.ncbi.nlm.nih.gov/21734470/
Hydrogen peroxide fuels aging, inflammation, cancer metabolism and metastasis: the seed and soil also needs "fertilizer"

https://studyfinds.org/hydrogen-peroxide-gut-bacteria-inflammation/
Hydrogen peroxide keeps your gut bacteria from causing inflammation, scientists discover

https://pubmed.ncbi.nlm.nih.gov/34183724/ Risk of early-onset dementia among persons with tinnitus: a retrospective case-control study
Our findings showed that pre-existing tinnitus was associated with a 68% increased risk of developing early-onset dementia among young and middle-aged adults. The results call for greater awareness of tinnitus as a potential harbinger of future dementia in this population.

https://psoriatic-arthritis.com/clinical/tinnitus
Tinnitus And Its Connection to Psoriatic Arthritis

https://pubmed.ncbi.nlm.nih.gov/30042382/
Association between Open-Angle **Glaucoma and the Risks of Alzheimer's and Parkinson's Diseases** in South Korea: A 10-year Nationwide Cohort Study
. Patients diagnosed with OAG have a higher risk of developing AD, but not PD, and the risk differed according to age and sex

https://pubmed.ncbi.nlm.nih.gov/23768921/
The role of inflammation in the pathogenesis of glaucoma
We review recent studies elucidating a possible role of **low-grade inflammation as a causal factor in the pathogenesis of glaucoma**.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4568617/#:~:text=Abstract.%20Dementia%20and%20glaucoma%20are%20both%20neurodegenerative%20conditions,structural%20signs%2C%20specifically%20degenerative%20changes%20within%20ganglion%20cells.
Dementia and glaucoma are both neurodegenerative conditions characterized by neuronal loss leading to cognitive and visual dysfunction, respectively. **A variety of evidence exists linking the two diseases** including structural signs, specifically degenerative changes within ganglion cells. Both diseases become more prevalent with increased age, but that alone is unlikely to account for the increased co-prevalence of the diseases found in various studies.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4998642/
This study demonstrated that patients with POAG but not those with PACG were associated with an **increased risk of dementia** compared with the general population.

https://pubmed.ncbi.nlm.nih.gov/33192461/
Association Between Psoriasis and Dementia: Current Evidence
Conclusions: The patients with **psoriasis and psoriatic arthritis show high prevalence of different types of dementia**. Based on the findings of this study, dementia may not be considered a high-risk factor of death from severe psoriasis.

https://pubmed.ncbi.nlm.nih.gov/33771384/
Association between psoriasis and dementia: A systematic review
: Most studies included in this review supported the hypothesis that **psoriasis constitutes a risk factor for dementia**

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6079596/pdf/BN2018-5315098.pdf Increased Risk of Dementia in Patients with Antidepressants: A Meta-Analysis of Observational Studies
These studies also mentioned that several factors like **stroke, diabetes mellitus, hypertension, head trauma, and hyperlipidemia** might be associated with dementia [4, 5].

https://pubmed.ncbi.nlm.nih.gov/19358976/ Meta-analysis of Alzheimer's disease risk with obesity, diabetes, and related disorders
Obesity and diabetes significantly and independently increase risk for AD.

https://pubmed.ncbi.nlm.nih.gov/15118167/ Dementia after stroke: the Framingham Study
Stroke increases a subject's risk of dementia as compared with age- and sex-matched controls. Primary and secondary prevention of stroke should significantly decrease the risk of all dementia. . Baseline stroke **doubled the risk of dementia** (hazard ratio [HR]: 2.0;

https://www.brown.edu/news/2022-07-13/thyroid-dementia Thyroid problems linked to increased risk of dementia, study finds
When researchers looked only at people who took medication for hypothyroidism, they found they were three times more likely to develop dementia than those who did not take medication.

https://pubmed.ncbi.nlm.nih.gov/26061317/ Increased Risk of Dementia in Patients With Chronic Obstructive Pulmonary Disease
This nationwide cohort study demonstrates that the risk of dementia, including AD and PD, is significantly increased in patients with COPD compared with individuals in the general population.

https://pubmed.ncbi.nlm.nih.gov/27373322/ Inflammatory mechanisms in patients with chronic obstructive pulmonary disease
Chronic obstructive pulmonary disease (COPD) is associated with chronic inflammation affecting predominantly the lung parenchyma and peripheral airways that results in largely irreversible and progressive airflow limitation.

https://pubmed.ncbi.nlm.nih.gov/26705224/ Increased Risk of Dementia Among Sleep-Related Movement Disorders: A Population-Based Longitudinal Study in Taiwan
Our data revealed that patients with SRMD had a 3.952 times (95% CI = 1.124-4.767) higher risk to develop all-cause dementia compared with individuals without SRMD.

https://pubmed.ncbi.nlm.nih.gov/21965313/ Dyslipidemia and dementia: current epidemiology, genetic evidence, and mechanisms behind the associations
The aim of this review is to summarize the findings of epidemiological and cell biological studies to elucidate the role of **cholesterol** in AD etiology.

https://pubmed.ncbi.nlm.nih.gov/21068429/ The 32-year relationship between cholesterol and dementia from midlife to late life
Higher cholesterol level in 1968 was not associated with an increased risk of AD (highest vs lowest quartile: hazard ratio [HR] 2.82, 95% confidence interval [CI] 0.94-8.43) among those who survived to and participated in the 2000-2001 examination. While there was no association between cholesterol level and dementia when considering all participants over 32 years, a time-d**ependent decrease in cholesterol over the follow-up was associated with an increased risk of dementia** (HR 2.35, 95% CI 1.22-4.58). These data suggest that midlife cholesterol level is not associated with an increased risk of AD. However, there may be a slight risk among those surviving to an age at risk for dementia. **Declining cholesterol levels from midlife to late life may better predict AD** risk than levels obtained at one timepoint prior to dementia onset.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4107296/pdf/nihms598564.pdf Dietary fat composition and dementia risk
The CHAP study found an **increased risk of AD with higher consumption of saturated and trans fatty acids and decreased risk with higher consumption of monounsaturated and polyunsaturated fatty acids**. A similar pattern emerges from the review of the studies that investigated the relationship of dietary fatty acid composition to cognitive decline. However, many more of these studies adjusted statistically for other fatty acids. Of all the different types of fatty acids, the findings are most consistent for an increased risk of **cognitive decline with a higher intake of saturated fatty acids**

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3024452/pdf/nihms236984.pdf Statins and serum cholesterol's associations with incident dementia and mild cognitive impairment
Statin users had **two to three-fold lower risk of developing dementia** (HR=0.41
https://pubmed.ncbi.nlm.nih.gov/20421792/ Statins and inflammation: an update
Statins have anti-inflammatory properties that are clinically important in lowering cardiovascular risk. It is probable, but not definitely proven, that some of the benefits of statins are due to their nonlipid effects.

Multiple Sclerosis

https://pubmed.ncbi.nlm.nih.gov/7829292/ Improvement by picoTesla range magnetic fields of perceptual-motor performance and visual memory in a patient with chronic progressive multiple sclerosis
We now report a 58 year old man with a 37 year history of chronic progressive MS in whom external application of MF in the **picoTesla** range produced rapid improvement of neurologic symptoms including walking, balance, sensory symptoms, and bladder functions.
https://pubmed.ncbi.nlm.nih.gov/1305621/ Successful treatment of multiple sclerosis with magnetic fields
The present communication concerns a 50 year-old woman with a 15 year history of chronic-progressive multiple sclerosis (MS) in whom extracranial application of picoTesla magnetic fields (MF) produced a **dramatic and sustained improvement** in disability. It is hypothesized that the therapeutic effects of **picoTesla MF** involve the mediation of the pineal gland which is known to act as a magnetosensor.
https://pubmed.ncbi.nlm.nih.gov/7814217/ Rapid normalization of visual evoked potentials by picoTesla range magnetic fields in chronic progressive multiple sclerosis
This communication concerns a 55 year old woman with a 5 year history of chronic progressive multiple sclerosis (MS) in whom a single external application of extremely low magnetic fields (MF) (**7.5 picoTesla; 5 Hz frequency**) of 20 minutes duration resulted in a rapid improvement in symptoms including vision, cerebellar symptomatology (ataxia and dysarthria), bladder functions, mood, sleep, cognitive functions and fatigue. Improvement in the patient's symptoms was associated with normalization of the pretreatment abnormal visual evoked potential (VEP) latencies within 24 hours after magnetic treatment. The rapid normalization of the VEP latencies suggests that recovery did not occur as a result of remyelination but probably was related to enhancement of neurotransmitter functions.
https://pubmed.ncbi.nlm.nih.gov/8746748/ Long term beneficial effects of weak electromagnetic fields in multiple sclerosis
A 39 year-old severely disabled woman with a 19 year history of chronic relapsing-remitting multiple sclerosis (MS) began to experience improvement in symptoms within 24 hours after she received experimental treatment with **picotesla** electromagnetic fields (EMFs). Pattern reversal visual evoked potential (VEP) study obtained three weeks after the initiation of the first magnetic treatment showed a return to normal of the P100 latencies in each eye. The patient continued to receive 1-2 EMFs treatments per week and during the following 32 months she made a dramatic recovery with resolution of diplopia, blurring of vision, dysarthria, ataxia of gait, and bladder dysfunction as well as improvement in fatigue, heat tolerance, mood, sleep, libido, and cognitive functions. VEP studies, which were repeated in April of 1995 more than 2 1/2 years after the initiation of magnetic treatment, showed that P100 latencies remained normal in each eye providing objective documentation that continued application of these EMFs may sustain normal conduction in the damaged optic pathways over a long period of time. This is the first case report documenting the dramatic long term beneficial effects of treatment with picotesla range EMFs in a patient with MS.

Stroke (Cerebral Ischemia)

https://pubmed.ncbi.nlm.nih.gov/34480781/ Pulsed Electromagnetic Fields: A Novel Attractive Therapeutic Opportunity for Neuroprotection After Acute Cerebral Ischemia
Altogether, these **data demonstrate the efficacy of PEMFs** against several mechanisms underlying ischemic damage and suggest that PEMFs might represent a novel noninvasive adjunctive treatment for acute ischemic stroke, providing neuroprotection and reducing functional deficits following ischemia.
https://pubmed.ncbi.nlm.nih.gov/24549571/ Effect of pulsed electromagnetic field (PEMF) on infarct size and inflammation after cerebral ischemia in mice
PEMF application **significantly downregulated** genes encoding members of the major pro-apoptotic tumor necrosis factor (TNF) superfamily indicating that the treatment could have **both anti-inflammatory and anti-apoptotic effects**. Both reduction of infarct size and influence on neuroinflammation could have a potentially important **positive impact on the poststroke recovery process**, implicating PEMF as a possible adjunctive therapy for stroke patients.
https://pubmed.ncbi.nlm.nih.gov/25343187/ Increases in microvascular perfusion and tissue oxygenation via pulsed electromagnetic fields in the healthy rat brain
This is the first demonstration of the acute effects of PEMF on cerebral cortical microvascular perfusion and metabolism. Thirty minutes of PEMF treatment induced cerebral arteriolar dilation leading to an **increase in microvascular blood flow** and tissue oxygenation that persisted for at least 3 hours. The effects of PEMF were mediated by NO, as we have shown in NOS inhibition experiments. These results suggest that PEMF may be an **effective treatment for patients after traumatic or ischemic** brain injury.
https://pubmed.ncbi.nlm.nih.gov/35831547/ Pulsed Electromagnetic Fields Protect Against Brain Ischemia by Modulating the Astrocytic Cholinergic Anti-inflammatory Pathway
Pulsed electromagnetic fields (PEMFs) **protect against brain ischemia**, but their role in regulating neuroinflammation remains unclear. In the present study, we investigated the biological effects of PEMF exposure on brain ischemia-induced neuroinflammation through the astrocytic cholinergic anti-inflammatory pathway. PEMF exposure reduced the activation of astrocytes and neuroinflammation following brain ischemia by directly modulating astrocytic injury and inflammatory cytokine release. Inhibition of nicotinic acetylcholine receptor alpha 7 subunit (α7nAChR) by a specific antagonist reversed the regulatory effects of PEMF on astrocytes. Furthermore, negative regulation of signal transducer and activator of transcription 3 (STAT3) by α7nAChR was found to be an important downstream mechanism through which PEMF regulates astrocyte-related neuroinflammation. PEMF suppressed STAT3 phosphorylation and nuclear translocation by activating α7nAChR. These results **demonstrate that PEMF exerts anti-inflammatory effects in the context of brain ischemia by modulating astrocytic α7nAChR/STAT3 signaling**.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8453690/ Electromagnetic Field as a Treatment for Cerebral Ischemic Stroke
As can be appreciated from this review, there is **increasing evidence that supports the idea that therapeutic effects can be achieved from EMF in ischemic stroke**.
https://pubmed.ncbi.nlm.nih.gov/8074737/ Protection against focal cerebral ischemia following exposure to a pulsed electromagnetic field
Preliminary data suggest that exposure to a PEMF of short duration may have implications for the treatment of acute stroke.
https://pubmed.ncbi.nlm.nih.gov/34557522/ Electromagnetic Field as a Treatment for Cerebral Ischemic Stroke
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6320690/pdf/nihms-1002390.pdf Increases in microvascular perfusion and tissue oxygenation via pulsed electromagnetic fields in the healthy rat brain
This is the first demonstration of the acute effects of PEMF on cerebral cortical microvascular perfusion and metabolism. Thirty minutes of PEMF treatment induced cerebral arteriolar dilation leading to an **increase in microvascular blood flow** and tissue oxygenation that persisted for at least 3 hours. The effects of PEMF were **mediated by NO**, as we have shown in NOS inhibition experiments. These results suggest that PEMF **may be an effective treatment for patients after traumatic or ischemic brain injury**. Studies on the effect of PEMF on the injured brain are in progress

Cardiac

https://pubmed.ncbi.nlm.nih.gov/24936220/ Pulsed electromagnetic field improves cardiac function in response to myocardial infarction
In conclusion, PEMF therapy preserves cardiac systolic function, inhibits apoptosis and trigger postnatal neovascularization in ischemic myocardium.
https://pubmed.ncbi.nlm.nih.gov/31915323/ Pulsed Electromagnetic Fields Increase Angiogenesis and Improve Cardiac Function After Myocardial Ischemia in Mice
PEMF treatment could **promote angiogenesis** of the infarct border zone and improve cardiac function in MI mice. A treatment parameter of **30 Hz 3.0 mT is remarkably effective** in MI mice.

Bone repair, osteoporosis

https://pubmed.ncbi.nlm.nih.gov/29694967/ Underlying Signaling Pathways and Therapeutic Applications of Pulsed Electromagnetic Fields in Bone Repair

Considerable research progresses have been made in exploring the underlying cellular and subcellular mechanisms of **PEMF promotion effect in bone repair.** Moreover, the promotion effect has shown strikingly positive benefits in the treatment of various skeletal diseases.

https://pubmed.ncbi.nlm.nih.gov/30603841/ Pulsed electromagnetic fields: promising treatment for osteoporosis

Although **PEMFs stimulate osteoblastogenesis, suppress osteoclastogenesis, and influence the activity of bone marrow mesenchymal stem cells (BMSCs) and osteocytes, ultimately leading to retention of bone mass and strength**. However, whether PEMFs could be taken into clinical use to treat OP is still unknown.

https://pubmed.ncbi.nlm.nih.gov/32251502/ Effects of Pulsed Electromagnetic Field Therapy on Pain, Stiffness, Physical Function, and Quality of Life in Patients With Osteoarthritis: A Systematic Review and Meta-Analysis of Randomized Placebo-Controlled Trials

Compared with placebo, there was a **beneficial effect of PEMF therapy on pain, stiffness, and physical function** in patients with OA.

https://pubmed.ncbi.nlm.nih.gov/16224674/ Adjuvant treatment of knee osteoarthritis with weak pulsing magnetic fields. Results of a placebo-controlled trial prospective clinical trial

Predominantly, on the one hand, pain relief in osteoarthritis patients was confirmed by a double-blind trial, on the other hand, increases in mobility could be proven

https://pubmed.ncbi.nlm.nih.gov/22504115/ Effects of pulsed electromagnetic field on knee osteoarthritis: a systematic review

The present study provided suggestive **evidence supporting PEMF efficacy** in the management of knee OA.

https://pubmed.ncbi.nlm.nih.gov/24106421/ Pulsed electromagnetic field therapy for management of osteoarthritis-related pain, stiffness and physical function: clinical experience in the elderly

The present study shows that **PEMF therapy improves pain, stiffness and physical function in** elderly patients affected by knee osteoarthritis.

https://pubmed.ncbi.nlm.nih.gov/26705327/ Pulsed electromagnetic fields in knee osteoarthritis: a double blind, placebo-controlled, randomized clinical trial

Sixty-six patients were included, and 60 completed the study. After 1 month, PEMF induced a **significant reduction in VAS pain and WOMAC scores** compared with placebo. These results suggest that PEMF therapy is effective for pain management in knee OA patients and also affects pain threshold and physical functioning.

https://pemfinfo.com/wp-content/uploads/2018/12/003_EXERCISE_cia-10-539-BMD.pdf Electromagnetic field versus circuit weight training on bone mineral density in elderly women

It is possible to conclude that LFLIPMF and CWT programs are effective modalities in increasing BMD but L**FLIPMF is more effective** in elderly women.

https://pubmed.ncbi.nlm.nih.gov/19670410/ Pulsed electromagnetic fields stimulation affects BMD and local factor production of rats with disuse osteoporosis

The results found demonstrate that **PEMF stimulation can efficiently suppress bone mass loss**.

https://pubmed.ncbi.nlm.nih.gov/6143039/ Pulsed electromagnetic field therapy of persistent rotator cuff tendinitis. A double-blind controlled assessment

At the end of the study 19 (65%) of the 29 patients were symptomless and 5 others much improved. PEMF therapy may thus be **useful in the treatment of severe and persistent rotator cuff** and possibly other chronic tendon lesions.

https://pubmed.ncbi.nlm.nih.gov/24501089/ In vivo effect of two different pulsed electromagnetic field frequencies on osteoarthritis

At **75 Hz**, PEMFs counteracted cartilage thinning as demonstrated by a **significantly higher cartilage thickness values** than either those of the SHAM or 37 Hz PEMF-treated groups. Although in severe OA both PEMF frequencies were able to limit its progression, 75 Hz PEMF stimulation achieved the better results.

https://pubmed.ncbi.nlm.nih.gov/26480822/ Experimentally induced cartilage degeneration treated by pulsed electromagnetic field stimulation; an in vitro study on bovine cartilage

Making a comparison with control cartilage, IL1β-treated explants showed a decrease in cartilage matrix, structure and cellularity parameters. PEMFs were able to counteract the progression of OA acting on both cartilage cellularity and ECM in cartilage previously treated with IL1β. These results, obtained by culturing and treating cartilage explants from two different joints, confirmed that PEMF stimulation can be used as adjuvant therapy to preserve cartilage from detrimental effects of high inflammatory cytokine levels during OA.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8302368/pdf/BMRI2021-4650057.pdf Pulsed Electromagnetic Field Affects the Development of Postmenopausal Osteoporotic Women with Vertebral Fractures

As a result of changes in bone microstructure, pulsed electromagnetic field treatment can **significantly improve the bone microstructure** of the radius and tibia three months after vertebral fractures. Conclusion. Pulsed electromagnetic field therapy has positive significance for improving pain, body functional changes, and bone loss after vertebral fracture surgery.

https://pubmed.ncbi.nlm.nih.gov/1608864/ Treatment of ununited tibial fractures: a comparison of surgery and pulsed electromagnetic fields (PEMF)

In general, PEMF treatment of ununited fractures has proved to be more successful than noninvasive traditional management and at least as effective as surgical therapies. Given the costs and potential dangers of surgery, PEMF should be considered an effective alternative. Experience supports its role as a successful method of treatment for ununited fractures of the tibia.

https://f1000research.com/articles/10-649 Long-term effect of full-body pulsed electromagnetic field and exercise protocol in the treatment of men with osteopenia or osteoporosis: A randomized placebo-controlled trial

PEMF combined with exercise protocol exerts a potent role for treating OP, is more effective than exercise and PEMF alone for increasing BMD and enhancing bone formation, and suppresses bone-resorption markers after 12-weeks of treatment with the impact lasting up to 6 months.

https://link.springer.com/article/10.1007/s00296-005-0600-3 The effect of pulsed electromagnetic fields in the treatment of cervical osteoarthritis: a randomized, double-blind, sham-controlled trial

During the treatment, the patients lay on the mat for 30 min per session, twice a day for 3 weeks. Pain levels in the PEMF group decreased significantly after therapy (p<0.001), but no change was observed in the placebo group. The active ROM, paravertebral muscle spasm and neck pain and disability scale (NPDS) scores improved significantly after PEMF therapy (p<0.001) but no change was observed in the sham group. The results of this study are promising, in that PEMF treatment may offer a potential therapeutic adjunct to current COA therapies in the future.

Pain

https://pemfinfo.com/wp-content/uploads/2018/12/008_PAIN_TOLERANCE_pone.0061926-pain-tolerance.pdf A Novel Magnetic Stimulator Increases Experimental Pain Tolerance in Healthy Volunteers A Double-Blind Sham-Controlled Crossover Study

As expected PEMF stimulation of the brain with this device caused **increased pain tolerance** in healthy subjects. At the same time, sensitivity to non-noxious thermal stimuli remained unchanged. We found **no evidence for changes in emotional state** and motor parameters that correlate with dopaminergic tone, thus it is unlikely that these would have mediated the changes in pain sensation.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2670735/pdf/prm12249.pdf A randomized, double-blind, placebo-controlled clinical trial using a low-frequency magnetic field in the treatment of musculoskeletal chronic pain

PEMF may be a novel, safe and effective therapeutic tool for use in at least certain subsets of patients with chronic, nonmalignant pain. Clearly, however, a larger randomized, double-blind clinical trial with just FM patients is warranted

Standing Balance

https://pubmed.ncbi.nlm.nih.gov/11121885/ Human subjects exposed to a specific pulsed (200 microT) magnetic field: effects on normal standing balance

Analysis of the data shows a **significant improvement of normal standing balance** or center of pressure, with eyes open or eyes closed, by a specific pulsed 200 microT(pk) magnetic field (PEMF).

Blood pressure

https://pubmed.ncbi.nlm.nih.gov/32401418/ Impact of pulsed electromagnetic field therapy on vascular function and blood pressure in hypertensive individuals

After therapy, the PEMF group demonstrated **significant improvements in FMD and FMD**$_{NOR}$ (normalized to hyperemia), but the control group did not (P = .05 and P = .04, respectively).

https://pubmed.ncbi.nlm.nih.gov/23675619/ Influence of pulsing electromagnetic field therapy on resting blood pressure in aging adults

The results include statistically **significant reductions in systolic and pulse blood pressure, while no significant difference in diastolic pressure** or the index of arterial stiffness was observed. These findings suggest that the PEMF treatment

might be **linked to improvements in peripheral resistance or circulation**.

https://pubmed.ncbi.nlm.nih.gov/21248759/ A 1-μT extremely low-frequency electromagnetic field vs. sham control for mild-to-moderate hypertension: a double-blind, randomized study

Our results suggest that repeated exposure to an ELF-EMF **has a BP-lowering effect on humans** with mild-to-moderate hypertension.

https://pubmed.ncbi.nlm.nih.gov/31394939/ The impact of pulsed electromagnetic field therapy on blood pressure and circulating nitric oxide levels: a double blind, randomized study in subjects with metabolic syndrome

PEMF may **increase plasma NO availability and improve BP at rest and during exercise**. However, this beneficial effect appears to be more pronounced in subjects with existing hypertension.

Microcirculatory

https://pubmed.ncbi.nlm.nih.gov/14656663/ Microcirculatory effects of pulsed electromagnetic fields

These results support the hypothesis that local application of a specific PEMF waveform can elicit **significant arteriolar vasodilation**.

Arthritis

https://pubmed.ncbi.nlm.nih.gov/30886614/ Targeting Mesenchymal Stromal Cells/Pericytes (MSCs) With Pulsed Electromagnetic Field (PEMF) Has the Potential to Treat Rheumatoid Arthritis

Extremely-low frequency pulsed electromagnetic field (PEMF), a biophysical form of stimulation, has an **anti-inflammatory effect** by causing differentiation of MSCs. PEMF has also been reported to increase the functional activity of MSCs to **improve differentiation to chondrocytes and osteocytes**. Moreover, PEMF has been demonstrated to **accelerate cell differentiation, increase deposition of collagen, and potentially return vascular dysfunction back to homeostasis**.

https://pubmed.ncbi.nlm.nih.gov/32014064/ Pulsed electromagnetic fields potentiate the paracrine function of mesenchymal stem cells for cartilage regeneration

The findings reported here demonstrate that PEMF stimulation is capable of modulating the paracrine function of MSCs for the enhancement and **re-establishment of cartilage regeneration** in states of cellular stress. The PEMF-induced modulation of the MSC-derived paracrine function for directed biological responses in recipient cells or tissues has **broad clinical and practical ramifications** with high translational value across numerous clinical applications.

https://pubmed.ncbi.nlm.nih.gov/29887943/ Coupling of pulsed electromagnetic fields (PEMF) therapy to molecular grounds of the cell

Concerted in the right way, these reactions can cause a kind of cell protection and ultimately lead to a **dampening of inflammatory signals** like interleukins.

https://pubmed.ncbi.nlm.nih.gov/20329696/ Low frequency pulsed electromagnetic field--a viable alternative therapy for arthritis

The analysis of various studies (animal models of arthritis, cell culture systems and clinical trials) reporting the use of PEMF for arthritis cure has conclusively shown that PEMF not only **alleviates the pain** in the arthritis condition but it also affords chondroprotection, exerts **antiinflammatory actio**n and h**elps in bone remodeling** and this could be developed as a **viable alternative for arthritis therapy**.

https://pubmed.ncbi.nlm.nih.gov/15887257/ Optimization of pulsed electromagnetic field therapy for management of arthritis in rats

A magnetic field of **5 Hz x 4 muT x 90 min** was found to be optimal in lowering the paw edema volume and decreasing the activity of lysosomal enzymes. Soft tissue **swelling was shown to be reduced** as evidenced by radiology. Histological studies confirmed **reduction in inflammatory cells infiltration, hyperplasia, and hypertrophy of cells lining synovial membrane**. PEMF was also shown to have a **membrane stabilizing actio**n by significantly inhibiting the rate of release of beta-glucuronidase from lysosomal rich and sub-cellular fractions. The results indicated that **PEMF could be developed as a potential therapy in the treatment of arthritis in humans**.

https://pubmed.ncbi.nlm.nih.gov/17537462/ Low frequency and low intensity pulsed electromagnetic field exerts its antiinflammatory effect through restoration of plasma membrane calcium ATPase activity

Exposure of arthritic rats to PEMF at **5 Hzx4 microT x 90 min**, produced significant antiexudative effect resulting in the restoration of the altered parameters. The **antiinflammatory** effect could be partially mediated through the stabilizing action of PEMF on membranes as reflected by the restoration of PMCA and intracellular Ca(2+) levels in blood lymphocytes subsequently inhibiting PGE(2) biosynthesis. The results of this study indicated that **PEMF could be developed as a potential therapy for RA in human beings.**

https://pemfinfo.com/wp-content/uploads/2018/12/009_ARTHRITIS_RU-54-28372.pdf The use of magnetic fields in treatment of patients with rheumatoid arthritis. Review of the literature

Despite the numerous reports showing an impact of magnetic field in subjects with RA, the effectiveness of magnetotherapy has **not been explicitly confirmed**. Given the above, further research appears to be necessary to clarify the impact of magnetic fields on biological systems, and the relationship between magnetic field intensity and the obtained results as well as their durability. The majority of clinical trials have failed to identify any undesirable outcomes or side effects of this physical therapeutic factor

In summary, the magnetic field is a useful physical factor used in modern and comprehensive rehabilitation implemented in numerous dysfunctions and symptomatic syndromes. Magnetic fields and magnetic stimulation are effective in promoting the treatment of inflammatory diseases and musculoskeletal injuries, diseases of the nervous system, muscle tone disorders, and diseases of the digestive and urogenital system [10]. Rehabilitation of people with rheumatic diseases **reduces pain and improves the functions of the musculoskeletal system**, while reduction of stress has a positive effect on the psyche of the patient and improves quality of life [36, 49].

https://pubmed.ncbi.nlm.nih.gov/1293548/ Therapeutic effects of pulsed magnetic fields on joint diseases

3,014 patients were treated by means of MF at extremely low frequencies and intensities. A general average value of 78.8% of good results and 21.2% of poor results was obtained. Higher (82%) percentages of good results were observed when single joint diseases were considered with respect to multiple joint diseases (polyarthrosis); conclusion that magnetic field treatment is an e**xcellent physical therapy in cases of joint diseases**. A hypothesis is advanced that external magnetic fields influence transmembrane ionic activity.

Inflamation

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3617815/pdf/jir-6-045.pdf Effect of pulsed electromagnetic field on inflammatory pathway markers in RAW 264.7 murine macrophages

The **anti-inflammatory applications of pulsed electromagnetic field (PEMF) are well known.**[1–3] Immunological studies show that PEMF, even low-intensity PEMF, can interact with cells and tissues.[2,4] For example, the effect of PEMF on the immune system in phagocytic cells alone has attracted attention because of the role that extremely- low frequency electromagnetic field (ELF-EMF) plays in decreasing the growth rate of bacteria.[3] Interest in PEMF therapy has increased rapidly in recent years due to its advantages over other treatments.[5]

https://pubmed.ncbi.nlm.nih.gov/35118946/ Post-COVID-19 arthritis: is it hyperinflammation or autoimmunity?

The **strong association observed with inflammatory markers** (ESR and CRP) and the insignificant association with serologic markers of autoimmunity (ANA and anti-CCP) in our study support the notion that the underlying mechanism of post-COVID-19 arthritis is primarily due to the hyperinflammatory process associated with COVID-19 infection, and not the result of an autoimmune reaction.

Tinnitus

https://pubmed.ncbi.nlm.nih.gov/16419692/ Pulsed magnetic-field therapy: a new concept to treat tinnitus?

We conclude that pulsed magnetic-field therapy induces changes of the electroencephalography pattern that correlated with a decrease in tinnitus symptoms.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7376045/pdf/41598_2020_Article_69243.pdf Tinnitus and risk of Alzheimer's and parkinson's disease: a retrospective nationwide population-based cohort study

Tinnitus has been implied as a "soft" sign of neurodegenerative disease, which is characterized by progressive loss of neuronal function, such as Alzheimer's disease (AD) and Parkinson's disease (PD).

Compared with controls, patients with tinnitus were **1.54 times more likely to develop AD** (95% confidence interval (CI) 1.34–1.78, P < 0.001) and **1.56 times more likely to develop PD** (95% CI 1.29–1.89, P < 0.001), after adjusting confounding factors. Our results indicate an association between tinnitus and higher risk of developing AD and PD.

https://pubmed.ncbi.nlm.nih.gov/25234771/ Seasonal trends in tinnitus symptomatology: evidence from Internet search engine query data

Our findings indicate that there are significant seasonal trends for Internet search queries for tinnitus, with a zenith in winter months

https://www.remaudiology.com/seasonal-tinnitus-spikes/ SEASONAL TINNITUS SPIKES

Cancer

https://pubmed.ncbi.nlm.nih.gov/34858847/ Baskin

Rotating Magnetic Fields Inhibit Mitochondrial Respiration, Promote Oxidative Stress and Produce Loss of Mitochondrial Integrity in Cancer Cells 2021

Electromagnetic fields (EMF) raise intracellular levels of reactive oxygen species (ROS) that can be toxic to cancer cells. Because weak magnetic fields influence spin state pairing in redox-active radical electron pairs, we hypothesize that they disrupt electron flow in the mitochondrial electron transport chain (ETC). We tested this hypothesis by studying the effects of oscillating magnetic fields (sOMF) produced by a new noninvasive device involving permanent magnets spinning with specific frequency and timing patterns. We studied the effects of sOMF on ETC by measuring the consumption of oxygen (O_2) by isolated rat liver mitochondria, normal human astrocytes, and several patient derived brain tumor cells, and O_2 generation/consumption by plant cells with an O_2 electrode. We also investigated glucose metabolism in tumor cells using ^{1}H and ^{13}C nuclear magnetic resonance and assessed mitochondrial alterations leading to cell death by using fluorescence microscopy with MitoTracker™ and a fluorescent probe for Caspase 3 activation. We show that sOMF of appropriate field strength, frequency, and on/off profiles completely arrest electron transport in isolated, respiring, rat liver mitochondria and patient derived glioblastoma (GBM), meningioma and diffuse intrinsic pontine glioma (DIPG) cells and can induce loss of mitochondrial integrity. These changes correlate with a decrease in mitochondrial carbon flux in cancer cells and with cancer cell death even in the non-dividing phase of the cell cycle. Our findings suggest that rotating magnetic fields could be therapeutically efficacious in brain cancers such as GBM and DIPG through selective disruption of the electron flow in immobile ETC complexes.

https://pubmed.ncbi.nlm.nih.gov/34367992/ Baskin

Case Report: End-Stage Recurrent Glioblastoma Treated With a New Noninvasive Non-Contact Oncomagnetic Device 2021

Alternating electric field therapy has been approved for glioblastoma (GBM). We have preclinical evidence for anticancer effects in GBM cell cultures and mouse xenografts with an oscillating magnetic field (OMF) generating device. Here we report OMF treatment of end-stage recurrent glioblastoma in a 53-year-old man who had undergone radical surgical excision and chemoradiotherapy, and experimental gene therapy for a left frontal tumor. He experienced tumor recurrence and progressive enlargement with leptomeningeal involvement. OMF for 5 weeks was well tolerated, with 31% reduction of contrast-enhanced tumor volume and reduction in abnormal T2-weighted Fluid-Attenuated Inversion Recovery volume. Tumor shrinkage appeared to correlate with treatment dose. These findings suggest a powerful new noninvasive therapy for glioblastoma.

https://pubmed.ncbi.nlm.nih.gov/34477946/ Baskin

Selective induction of rapid cytotoxic effect in glioblastoma cells by oscillating magnetic fields 2021

Purpose: The mechanisms underlying anticancer effects of electromagnetic fields are poorly understood. An alternating electric field-generating therapeutic device called Optune™ device has been approved for the treatment of glioblastoma (GBM). We have developed a new device that generates oscillating magnetic fields (OMF) by rapid rotation of strong permanent magnets in specially designed patterns of frequency and timing and have used it to treat an end-stage recurrent GBM patient under an expanded access/compassionate use treatment protocol. Here, we ask whether OMF causes selective cytotoxic effects in GBM and whether it is through generation of reactive oxygen species (ROS).

Methods: We stimulated patient derived GBM cells, lung cancer cells, normal human cortical neurons, astrocytes, and bronchial epithelial cells using OMF generators (oncoscillators) of our Oncomagnetic Device and compared the results to those obtained under unstimulated or sham-stimulated control conditions. Quantitative fluorescence microscopy was used to assess cell morphology, viability, and ROS production mechanisms.

Results: We find that OMF induces highly selective cell death of patient derived GBM cells associated with activation of caspase 3, while leaving normal tissue cells undamaged. The cytotoxic effect of OMF is also seen in pulmonary cancer cells. The underlying mechanism is a marked increase in ROS in the mitochondria, possibly in part through perturbation of the electron flow in the respiratory chain.

Conclusion: Rotating magnetic fields produced by a new noninvasive device selectively kill cultured human glioblastoma and non-small cell lung cancer cells by raising intracellular reactive oxygen species, but not normal human tissue cells.

https://pubmed.ncbi.nlm.nih.gov/37446167/

Molecular Biological Effects of Weak Low-Frequency Magnetic Fields: Frequency-Amplitude Efficiency Windows and Possible Mechanisms 2023

This review covers the phenomenon of resonance-like responses of biological systems to low-frequency magnetic fields (LFMF). The historical development of this branch of magnetobiology, including the most notable biophysical models that explain the resonance-like responses of biological systems to LFMF with a specific frequency and amplitude, is given. Two groups can be distinguished among these models: one considers ion-cofactors of proteins as the primary targets for the LFMF influence, and the other regards the magnetic moments of particles in biomolecules. Attention is paid to the dependence of resonance-like LFMF effects on the cell type. A radical-pair mechanism of the magnetic field's influence on biochemical processes is described with the example of cryptochrome. Conditions for this mechanism's applicability to explain the biological effects of LFMF are given. A model of the influence of LFMF on radical pairs in biochemical oscillators, which can explain the frequency-amplitude efficiency windows of LFMF, is proposed.

https://www.sciencedirect.com/science/article/abs/pii/S0079610722001341

Biological effects of rotating magnetic field: A review from 1969 to 2021

As one of the common variable magnetic fields, rotating magnetic field (RMF) plays a crucial role in modern human society. The biological effects of RMF have been studied for over half a century, and various results have been discovered. Several reports have shown that RMF can inhibit the growth of various types of cancer cells *in vitro* and *in vivo* and improve clinical symptoms of patients with advanced cancer. It can also affect endogenous opioid systems and rhythm in central nerve systems, promote nerve regeneration and regulate neural electrophysiological activity in the human brain. In addition, RMF can influence the growth and metabolic activity of some microorganisms, alter the properties of fermentation products, inhibit the growth of some harmful bacteria and increase the susceptibility of antibiotic-resistant bacteria to common antibiotics. Besides, there are other biological effects of RMF on blood, bone, prenatal exposure, enzyme activity, immune function, aging, parasite, endocrine, wound healing, and plants. These discoveries demonstrate that RMF have great application potential in health care, medical treatment, fermentation engineering, and even agriculture. However, in some cases like pregnancy, RMF exposure may need to be avoided. Finally, the specific mechanisms of RMF's biological effects remain unrevealed, despite various hypotheses and theories. It does not prevent us from using it for our good.

https://pubs.rsc.org/en/content/articlehtml/2022/na/d1na00474c

Magneto-mechanical destruction of cancer-associated fibroblasts using ultra-small iron oxide nanoparticles and low frequency rotating magnetic fields 2022

The destruction of cells using the mechanical activation of magnetic nanoparticles with low-frequency magnetic fields constitutes a recent and interesting approach in cancer therapy. Here, we showed that superparamagnetic iron oxide nanoparticles as small as 6 nm were able to induce the death of pancreatic cancer-associated fibroblasts, chosen as a model. An exhaustive screening of the amplitude, frequency, and type (alternating vs. rotating) of magnetic field demonstrated that the best efficacy was obtained for a rotating low-amplitude low-frequency magnetic field (1 Hz and 40 mT), reaching a 34% ratio in cell death induction; interestingly, the cell death was not maximized for the largest amplitudes of the magnetic field.

https://pubmed.ncbi.nlm.nih.gov/10653622/ Effects of PEMF on a murine osteosarcoma cell line: drug-resistant (P-glycoprotein-positive) and non-resistant cells

Therefore, this study suggests that PEMF **promotes the growth of undifferentiated cells but progressively suppresses the growth of more differentiated cells,** i.e., PEMF controls cell growth depending on the degree of cell differentiation. This study also shows the potentiality of PEMF as an **adjunctive treatment method for malignant tumors.**

https://pubmed.ncbi.nlm.nih.gov/28064222/ Pulsed Electromagnetic Field Stimulation Promotes Anti-cell Proliferative Activity in Doxorubicin-treated Mouse Osteosarcoma Cells

Our results indicate that **combination of PEMF and doxorubicin could be a novel chemotherapeutic strategy**.

https://pubmed.ncbi.nlm.nih.gov/12395412/ Influence of 1 and 25 Hz, 1.5 mT magnetic fields on antitumor drug potency in a human adenocarcinoma cell line

The data indicate that PEMF can induce modulation of cytostatic agents in HCA-2/1(cch), with an **increased effect when PEMF was applied at the same time as the drug**. .

https://pubmed.ncbi.nlm.nih.gov/15376245/ Differences in lethality between cancer cells and human lymphocytes caused by LF-electromagnetic fields

The **efficacy of PEMF on the destruction of cancer cells is further increased by heating** (hyperthermia) of the suspension up to 44 degrees C or by lowering the pH-value (hyperacidity) to pH 6.4. Similar apoptosis and necrosis can be obtained using moderate magnetic fields (B < or = 15 mT 50/60 Hz), but this requires longer treatment of at least over a week. PEMF application combined with anticancer drugs and photodynamic therapy will be very effective.

https://pubmed.ncbi.nlm.nih.gov/9216668/ Enhanced potency of daunorubicin against multidrug resistant subline KB-ChR-8-5-11 by a pulsed magnetic field

In recent years, magnetic fields have been found to **enhance the potency of anticancer drugs**, with favorable modulation of cancer therapy

https://pubmed.ncbi.nlm.nih.gov/10517264 / Growth modification of human colon adenocarcinoma cells exposed to a low-frequency electromagnetic field

In contrast, a **significant decrease in cell growth** was found in those cultures treated with 1 Hz for 360 minutes ($p < 0.02$)

https://pubmed.ncbi.nlm.nih.gov/18821204/ No effect of 50 Hz 2.45 mT magnetic field on the potency of cisplatin, mitomycin C, and methotrexate in S. cerevisiae

The results showed that MF exposures **do not induce alterations in the potency** of cisPt, MMC, and MTX on these cells in relation to untreated controls.
https://pubmed.ncbi.nlm.nih.gov/34741480/ Cellular stress response to extremely low-frequency electromagnetic fields (ELF-EMF): An explanation for controversial effects of ELF-EMF on apoptosis
Indeed, **numerous studies have stated that non-ionizing non-thermal extremely low-frequency magnetic fields** (ELF-MF) can modulate the induction of apoptosis in exposed cells; however, **much controversy** exists in observations. When cells are exposed to ELF-EMF alone, very low or no statistically significant changes in apoptosis are observed
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5119968/pdf/CAM4-5-3128.pdf Mechanisms and therapeutic effectiveness of pulsed electromagnetic field therapy in oncology
presents **several potential advantages** including non-invasiveness, safety, **lack of toxicity for non-cancerous cells**, and the possibility of being combined with other available therapies
https://pubmed.ncbi.nlm.nih.gov/11536283/ Static and ELF magnetic fields induce tumor growth inhibition and apoptosis
The treatment of nude mice bearing WiDr tumors subcutaneously. with daily exposure for 70 min to MF for 4 weeks caused significant **tumor growth inhibition (up to 50%)** by the end of the treatment when modulated MF were used for at least 60% of the whole treatment period and the time-averaged total MF intensity was higher than **3.59 mT**.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2672058/pdf/1756-9966-28-51.pdf Amplitude-modulated electromagnetic fields for the treatment of cancer: Discovery of tumor-specific frequencies and assessment of a novel therapeutic approach
https://pubmed.ncbi.nlm.nih.gov/21554101/ Functionality of natural killer cells from end-stage cancer patients exposed to coherent electromagnetic fields
Data showed that the exposure of the end-stage cancer patients to the coherent electromagnetic fields resulted in a **significant increase of the number and the cytotoxicity of the NK T-lymphocytes against cancer cells, in all patients**. Exposure to coherent EMFs at radiofrequencies increases the number and cytotoxicity of NK T-lymphocytes, which **may contribute to the improvement of cancer patients' status**.
https://pubmed.ncbi.nlm.nih.gov/20001703/ The little explored efficacy of magnetic fields in cancer treatment and postulation of the mechanism of action
In this article, we concentrate on the potential of strong magnetic fields to play a role in cancer treatment.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3770670/ Low Intensity and Frequency Pulsed Electromagnetic Fields Selectively Impair Breast Cancer Cell Viability
We observed a discrete window of vulnerability of MCF7 cells to PEMFs of 20 Hz frequency, **3 mT** magnitude and exposure duration of 60 minutes per day. The cell damage accrued in response to PEMFs increased with time and gained significance after three days of consecutive daily exposure. By contrast, the PEMFs parameters determined to be most cytotoxic to breast cancer MCF-7 cells were **not damaging to normal MCF-10 cells**.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1190196/ Therapeutic Electromagnetic Field (TEMF) and gamma irradiation on human breast cancer xenograft growth, angiogenesis and metastasis
TEMF therapy provided a safe means for retarding tumor vascularization, growth and metastasis.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3261663/ Cancer cell proliferation is inhibited by specific modulation frequencies
These findings uncover a novel mechanism **controlling the growth of cancer cells** at specific modulation frequencies **without affecting normal tissues**, which may have broad implications in oncology.
https://pubmed.ncbi.nlm.nih.gov/19016143/ A 60-Hz sinusoidal magnetic field induces apoptosis of prostate cancer cells through reactive oxygen species
These results demonstrate 60-Hz sinusoidal MF-activated **cell growth inhibition of prostate cancer in vitro**. Apoptosis together with cell cycle arrest were the dominant causes of the MF-elicited cell growth inhibition, mediated by MF-induced ROS. These results suggest that a possibility of **using 60-Hz MF in radiation therapy of prostate cancer could usefully be investigated**.
https://pubmed.ncbi.nlm.nih.gov/11911264/ Therapeutic electromagnetic field effects on angiogenesis and tumor growth
A novel TEMF treatment **safely reduced growth** and vascularization of implanted breast cancers in mice.
https://pubmed.ncbi.nlm.nih.gov/16304693/ Effects of pulsed magnetic stimulation on tumor development and immune functions in mice
These results showed the first evidence of the anti-tumor effect and immunomodulatory effects brought about by the application of repetitive magnetic stimulation and also suggested the possible relationship between anti-tumor effects and the increase of TNF-alpha levels caused by pulsed magnetic stimulation.
https://pubmed.ncbi.nlm.nih.gov/21062126/ Bioelectromagnetic field effects on cancer cells and mice tumors
Our **successful results in killing cancer cells**-analyzed by trypan blue staining or by flow cytometry-and of the inhibition of MX-1 tumors in mice by 15-20 mT, 50 Hz treatment in a solenoid coil also in the presence of bleomycin are presented in comparison to similar experimental results from the literature. In conclusion, the synergistic combinations of PEMF or SEMF with hyperthermia (41.5°C) and/or cancerostatic agents presented in the tables for cells and mice offer a basis for further development of an adjuvant treatment for patients suffering from malignant tumors and metastases pending the near-term development of suitable solenoids of 45-60 cm in diameter, producing >20 mT in their cores.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3155400/pdf/cm2011000339.pdf Effect of Magnetic Fields on Tumor Growth and Viability
In sum, we report that direct exposure of mice to magnetic fields **reduced tumor growth** and progression. Mice exposed to magnetic fields for 360 min daily for as long as 4 wk showed extensive areas of necrosis in their tumors. Mice in the **unexposed control group developed large tumors**. In addition, the time of exposure of these tumors to magnetic fields is critical. Mice exposed for shorter durations (that is, 60 or 180 min daily for wk) did not show a reduction in tumor size or growth. Previous reports[2,3,7,15,17] lead us to **hypothesize that much longer exposure times for multiple months should be attempted**
https://www.researchgate.net/profile/Neveen-Hussein/publication/326199513_Effect_of_low_molecular_weight_iron_dextran_therapy_on_pregnancy_associated_plasma_protein_-A_and_C40_ligand_markers_in_chronic_renal_failure_patients_J_Med_Res_Inst_2009_30_105-10/links/5dee1fe092851c83646e61f8/Effect-of-low-molecular-weight-iron-dextran-therapy-on-pregnancy-associated-plasma-protein-A-and-C40-ligand-markers-in-chronic-renal-failure-patients-J-Med-Res-Inst-2009-30-105-10.pdf Therapeutic Effects of Low Frequency Pulsed Electromagnetic Fields on Rat Liver Cancer.
Normal animals exposed to pulsed magnetic fields from both coil A and coil B showed no histopathological changes and had a nearly normal architecture. Also dielectric properties, OF livers and blood tests were fluctuated within the physiological norms for this species. **Such results suggest the safety of the used magnetic fields**. The lack of adverse reactions in normal cells suggested that the safety of this treatment may be related to its ability to influence prefentially and selectively with the transformed cells. Upon exposure of HCC groups to pulsed magnetic fields, we reported significant decrease in AFP level and other blood tests; also we reported slight improvement in dielectric properties of livers which **suggests the anticancer activity of these magnetic fields.** The exposure system Schumann device; **(coil A; 13-42 gauss, 2-3 Hz)** and Pulsed gradient magnetic field **(coil B; 0.6 Tesla, <1 Hz)** provide a **safety, selective, noninvasive, painless, drug free and low cost therapeutic devices**. The histopathology and ultra-structure of liver tissues suggests a selective anticancer activity of magnetic fields from the exposure system through incorporating three main strategies: apoptosis, necrosis and inflammatory infiltration of the hepatocellular carcinoma.
https://pubmed.ncbi.nlm.nih.gov/24039828/ Low intensity and frequency pulsed electromagnetic fields selectively impair breast cancer cell viability
We observed a discrete window of vulnerability of MCF7 cells to PEMFs of **20 Hz frequency, 3 mT** magnitude and exposure duration of 60 minutes per day. The cell damage accrued in response to PEMFs increased with time and gained significance after three days of consecutive daily exposure. By contrast, the PEMFs parameters determined to be **most cytotoxic to breast cancer MCF-7 cells were not damaging to normal MCF-10 cells**.
https://pemfinfo.com/wp-content/uploads/2019/01/022_CANCER_pone.0039317.pdf The Anti-Tumor Effect of A 3 Adenosine Receptors Is Potentiated by Pulsed Electromagnetic Fields in Cultured Neural Cancer Cells
The effect of the A_3 AR agonist in tumor cells was enhanced in the presence of PEMFs and blocked by using a well-known selective antagonist. Together these results demonstrated that **PEMF exposure significantly increases the anti-tumor effect** modulated by A_3 ARs.
https://pemfinfo.com/wp-content/uploads/2019/01/020_CANCER_Vadal-_et_al-2016.pdf Mechanisms and therapeutic effectiveness of pulsed electromagnetic field therapy in oncology
Several mechanisms of PEMF therapy have been elucidated. For example, PEMFs **inhibit cancer growth by disrupting the mitotic spindle** in a process mediated by interference of spindle tubulin orientation and induction of dielectrophoresis.
In addition, PEMFs **inhibit angiogenesis in tumor tissues**, suppressing tumor vascularization and reducing tumor growth, as shown by in vivo studies [95-99, 104].
However, long-term PEMF treatment in HCC patients is not toxic, **confirming the safety of PEMF therapy** that employs 100,000 times lower frequencies if compared with radiofrequency ablation that is also employed for treatment of HCC [55].
https://pemfinfo.com/wp-content/uploads/2018/12/012_BONE_nihms-695721.pdf The effect of low-frequency electromagnetic field on human bone marrow stem/progenitor cell differentiation
Treatment using EMF could be an auxiliary approach to **enhancing cellular activities for tissue regeneration** by stimulating cells with both EMF and the proper chemical signals (differentiation media and growth factors) to promote cellular responses synergistically.
https://pemfinfo.com/wp-content/uploads/2018/12/006_PROSTATE_CANINE_pros0074-1132.pdf Effect of Pulsed Electromagnetic Field Therapy on Prostate Volume and Vascularity in theTreatment of Benign Prostatic Hyperplasia: A Pilot Study in a Canine Model
The 3 weeks of PEMF produced a significant r**eduction in prostatic volume (average 57%)** without any interference with semen quality, testosterone levels or libido. The efficacy of PEMF on BPH in dogs, **with no side effects**, suggests the suitability of this treatment in humans and supports the hypothesis that impairment of blood supply to the lower urinary tract may be a causative factor in the development of BPH.
https://www.klemenspulsers.com/uploads/5/1/4/7/5147936/breast_cancer_pemf_pubmed_043-pone.0072944.pdf Low Intensity and Frequency Pulsed Electromagnetic Fields Selectively Impair Breast Cancer Cell Viability
We observed a discrete window of vulnerability of MCF7 cells to PEMFs of **20 Hz frequency, 3 mT** magnitude and exposure duration of 60 minutes per day. The cell damage accrued in response to PEMFs increased with time and

gained significance after three days of consecutive daily exposure. By contrast, the PEMFs parameters determined to be m**ost cytotoxic to breast cancer MCF-7 cells were not damaging to normal MCF-10 cells**
https://pubmed.ncbi.nlm.nih.gov/32142642/ Pulsed Low-Frequency Magnetic Fields Induce Tumor Membrane Disruption and Altered Cell Viability

We applied a pulsed 20-millitesla (mT) magnetic field with rate of rise (dB/dt) in the **msec range** to cultured tumor cells to assess whether this affects membrane integrity as measured using cytolytic assays. A 10-min exposure of A549 human lung cancer cells to sequential 50- and 385-Hz oscillating magnetic fields was sufficient to induce intracellular protease release, suggesting altered membrane integrity after the field exposure. The field exposure was also sufficient to **alter proliferation of tumor cells in culture, but not that of normal lymphatic cells**. The proof of concept herein points to a mechanistic basis for **possible applications of pulsed magnetic fields in novel anticancer strategies**.
https://pubmed.ncbi.nlm.nih.gov/31055982/ Effect of pulsed millisecond current magnetic field on the proliferation of C6 rat glioma cells

Our findings provide the theoretical and experimental basis for **clinical applications of electromagnetic fields**.
https://pubmed.ncbi.nlm.nih.gov/36043404/ Extremely Low Frequency Magnetic Fields Induce mTOR and Hsa_Circ_100338 Expression Changes in Gastric Cancer and Normal Fibroblast Cell Lines

In this experimental study, cell lines of AGS and Hu02, were cultured under the exposure of ELFMF with magnetic flux densities (MFDs) of 0.25, 0.5, 1 and 2 millitesla (mT) for 18 hours. **Viability of the normal cells was significantly increased** at MFDs of 0.5, 1 and 2 mT, while **viability of the tumor cells was significantly decreased** at MFD of 0.25 and increased at MFD of 2 mT.
https://pubmed.ncbi.nlm.nih.gov/23781987/ The effects of pulsed magnetic field exposure on the permeability of leukemia cancer cells

Our results show that magnetic field can **efficiently increase permeability**. Among the treatment groups, the system gives the optimal permeabilization when cells are exposed to a train of 28 pulses with 1 Hz frequency.
https://link.springer.com/article/10.1007/BF02881733 Experimental studies on extremely low frequency pulsed magnetic field inhibiting sarcoma and enhancing cellular immune functions

The previous observation with an electron microscope showed that extremely low frequency (ELF) pulsed magnetic field (PMF) (with the maximum intensity of 0.6–2.0T, gradient of 10–100 $T \cdot M^{-1}$, pulse width of 20–200 ms and frequency of 0.16–1.34 Hz) inhibited the growth of S-180 sarcoma in mice and enhanced the ability of immune cell's dissolving sarcoma cells. In this study, the DNA contents of nuclei were assayed by using Faulgen Staining method. With an electron microscope and cell stereoscopy technology it was observed that magnetic field affected the sarcoma cell 's metabolism, lowered its malignancy, and restrained its rapid and heteromorphic growth. The magnetic field enhanced the cellular immune ability and the reaction of lymphocytes and plasma. **Since ELF pulsed magnetic fields can inhibit the growth of sarcomas and enhance the cellular immune ability, it is possible to use it as a new method to treat cancer**.

Seed Enhancement

https://pubmed.ncbi.nlm.nih.gov/22153250/ Pulsed magnetic field: a contemporary approach offers to enhance plant growth and yield of soybean

Seeds were subjected to 20 days with 1500 nT at 10.0 Hz of PMF for 5 h per day. PMF pretreatment **increased the plant height, fresh and dry weight, and protein content** with the changes of protein profile in 8 days old seedlings. The **number of leaves, pods, seeds and length of pods, and weight of seeds were also remarkably higher in PMF treatment** in contrast to controls.
https://pubmed.ncbi.nlm.nih.gov/27859499/ Growth characteristics of maize seeds exposed to magnetic field

From the studies, it may be concluded that exposure of dry seeds to **static** magnetic field of **200 mT for 1 h** improved shoot and root growth. Improved root system and biomass led to increased seed yield. Improved functional root parameters suggested that magnetically treated maize seeds could be used under moisture stress conditions.
https://www.hindawi.com/journals/tswj/2014/369745/ Effects of Presowing Pulsed Electromagnetic Treatment of Tomato Seed on Growth, Yield, and Lycopene Content

Pulsed electromagnetic field was used for 0, 5, 10, and 15 minutes as a presowing treatment of tomato seeds in a field experiment for two years. Papimi device (amplitude on the order of 12.5 mT) has been used. The use of pulsed electromagnetic field as a presowing treatment was found to enhance plant growth in tomato plants at certain duration of exposure. Magnetic field treatments and especially the exposure of 10 and 15 minutes gave the best results in all measurements, except plant height and lycopene content. **Yield per plant** was higher in magnetic field treatments, compared to control. MF-15 treatment yield was **80.93% higher** than control treatment.
https://www.chemijournal.com/archives/2021/vol9issue1/PartP/9-1-58-500.pdf Effect of pulsed magnetic field on seed borne pathogen and germination of tomato

he seeds pre-inoculated with A. solani were **1500nT** PMF treated with frequency of **10 Hz** for 5 h for varied durations of 0, 5, 10, 15, 20 and 25 days. PMF treatment **significantly reduced pathogen incidence** and **increased both germination and plant growth** in comparison with the control. Experimental results indicated that all the treatments were significantly different and the seeds treated for 20 and 25 days showed the minimum percent disease incidence (71%) with highest percent disease inhibition over control (29%). It also recorded the highest plant biometrics viz., germination (81%), speed of germination (7.74), root length (13.37 cm), shoot length (6.45 cm) and vigour index (1606
https://wcpemf.com/wp-content/uploads/2021/01/Effects-of-PEMF-over-plant-seeds.pdf EFFECTS OF PULSED VARIABLE MAGNETIC FIELDS OVER PLANT SEEDS

Pulsed variable magnetic fields, if correctly administered, have a **very high stimulating effect on cell multiplication, growing and development**. Also, the growing of mould was stimulated. The stimulation of mould growing and acceleration of plant development may be used for industrial purposes, production of pharmaceutics and agriculture.
https://chesci.com/wp-content/uploads/2017/08/V6i23_41_CS242048061_Vishwanath_1617-1622.pdf Comparison between Pulsed and Static Magnetic Treatment for Enhancement of Germination Characteristics in Differentially Aged Maize Seeds

Both the magnetic treatments showed positive effect and the enhancement in low vigour lot was more as compared to high vigour lot. The ef**fect of magnetic treatment was more pronounced in pulsed magnetic field treatment** as compared to static magnetic field. It is concluded that both pre-sowing magnetic treatment can be effectively used for improving field performance on low vigour lots of maize
https://www.semanticscholar.org/paper/Pulsed-electromagnetic-field-%E2%80%93-a-cultivation-used-%C4%90uki%C4%87-Miladinov/49e1985050a038ac5d2279292a0be9edc428f723 Pulsed electromagnetic field – a cultivation practice used to increase soybean seed germination and yield

Exposed to the PEMF therapy using the impulse generator and strip. Low-frequency (16, 24, 30 and 72 Hz) PEMF was used in the duration of 0, 30, 60 and 90 minutes. Research results indicate that this method can increase seed germination up to 8.00% and yield by 960.5 kg, or **21%** in field conditions, which is a significant increase and a solid basis to introduce this practice, primarily in organic production with a very limited use of seed treatment preparations. However, the **practice can have an inhibitory effect under an unfavourable combination of exposure duration and frequency**. The longest exposure time gave the best results with 3.81% increase at the lowest frequency.
https://pubag.nal.usda.gov/catalog/7400299 Magnetic-pulse treatment of garden strawberry seeds

Germination energy of the seeds treated by a pulsed magnetic field was changed from 29 to 47 percent, germination was from 34 to 48 percent. The maximum of the increment of germination of irradiated seeds compared to control sample was 14 percent. The best germination corresponds to the **16 Hz** frequency of exposure and **360 seconds** exposure time when **5 mT** induction. A further increase time and frequency of exposure reduced germination energy by 5 percent. The pulsed electromagnetic fields affect positively the linear dimensions of sprouts. The average root length in the experimental variant (16 Hz, 360 seconds) compared to the control was greater by 24 percent; sprouts height increased by 28.2 percent and **weight by 33.3 percent**. The pulsed low frequency electromagnetic fields could be put to good use to improve sowing qualities of the garden strawberry seeds.

Migraine

https://pubmed.ncbi.nlm.nih.gov/11279973/ Treatment of migraine with pulsing electromagnetic fields: a double-blind, placebo-controlled study

In conclusion, exposure of the inner thighs to pulsing electromagnetic fields for at least 3 weeks is an effective, **short-term intervention for migraine**, but not tension headaches.

Nerve Regrowth

https://pubmed.ncbi.nlm.nih.gov/21365664/ Pulsed magnetic fields enhance the rate of recovery of damaged nerve excitability

Consequently, characteristic findings in impulse conduction of recovered nerves under PMF indicate that the observed abnormalities in signaling or aberrant ion channel functions following injury may be restored by PMF application.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4131097/ Does Pulsed Magnetic Field Therapy Influence Nerve Regeneration in the Median Nerve Model of the Rat?

Our results suggest that the pulsed magnetic field therapy has a positive influence on the functional aspects of neural regeneration.

Germicidal Effect – Food Processing

https://www.researchgate.net/publication/354070547_Germicidal_efficacy_of_the_pulsed_magnetic_field_against_pathogens_and_spoilage_microorganisms_in_food_processing_An_overview Germicidal efficacy of the pulsed magnetic field against pathogens

and spoilage microorganisms in food processing: An overview

The findings of our review suggest that PMF itself would be beneficial as a **bacteria inactivation technique** or could be readily combined with other suitable methods. Besides, we recommend conceivable paths to adopt this sustainable technique in the food industry.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8249513/ Impact of pulsed magnetic field treatment on enzymatic inactivation and quality of cloudy apple juice

The findings from this study demonstrated that PMF would be a promising non-thermal technology for **enzyme inactivation in fruit juice** with minor quality changes

https://www.mdpi.com/2076-3417/12/6/3183/html Effect of Magnetic and Electrical Fields on Yield, Shelf Life and Quality of Fruits

Magnetic and electrical fields increase the shelf life of the fruit and improve its quality. Alternating magnetic fields (AMF) with a value of 0.1–200 mT and a power frequency of 50 Hz or 60 Hz **improve plant growth parameters**. MF cause an increase in **firmness**, the **rate of maturation**, the **content of beta-carotene, lycopene, and fructose, sugar concentration**, and a **reduction in acidity and respiration**

https://www.researchgate.net/publication/273216603_Research_on_the_Pulsed_Magnetic_Field_Device_for_Sterilization_of_Fruit_and_Vegetable_Equipment

The experiment shows that the pulsed magnetic field produced by the device can achieve a **better effect in killing bacillus coli, beer yeast and staphylococcus aurous, etc**. Compared with the traditional sterilization device, the bactericidal effect of the pulsed magnetic field sterilization device is more obvious so that it will be the direction of the development of food equipments.

https://www.researchgate.net/publication/291624086_Sterilization_effect_of_pulsed_magnetic_field_and_its_influence_on_milk_nutrient_components

Comparing with heat pasteurization, the losses of protein, lactose and deoxidized vitamin C were less, the color was not significantly affected by pulsed magnetic field.

https://www.researchgate.net/publication/43288346_Efficacy_in_Microbial_Sterilization_of_Pulsed_Magnetic_Field_Treatment

Sterilization effects of the pulsed magnetic field with a maximum intensity of **11.37 Tesla** were investigated . Sensibility of bacteria on the pulsed magnetic field significantly depends on a variety of microorganisms. Sterilization effects of a flowing sample were better than that of static samples.

https://www.semanticscholar.org/paper/Sterilization-test-colostrums-by-pulse-magnetic-Meng-xiang/4712bea86525258a142eec959a7928585b7bfaac Sterilization test colostrums by pulse magnetic field

The pulse magnetic field sterilization test of colostrum was carried out. The test result shows that pulse magnetic field **can kill 99.9 percent bacteriums in colostrum**

https://www.atlantis-press.com/article/25862073.pdf Data Analysis of Sterilization Effect of Low Pressure Pulse Magnetic Field on Fruit Juice Products

The experimental results showed that the pulse magnetic field sterilization method **can effectively kill the bacteria and fungi** in the fruit juice under the premise of retaining the nutritional components of fruit juice compared with high temperature sterilization. The effect of sterilization is proportional to the time of sterilization, and the sterilization effect of bacteria is better than that of the fungus.

https://www.sciencedirect.com/science/article/abs/pii/S0956713519302671 Synergistic efficacy of pulsed magnetic fields and *Litseacubeba* essential oil treatment against *Escherichia coli* O157:H7 in vegetable juices

The optimal synergistic effects were found using PMF (3 times under **8T, 60 pulses**) treatments combined with 1.5 mg/mL of LC-EO.

https://www.semanticscholar.org/paper/Sterilization-Effect-of-High-intensity-Pulsed-Field-Chun-mei/1e491449f980d2f632e547d9f00224bb814a2ffc Sterilization Effect of High-intensity Pulsed Magnetic Field on Saccharomyces cerevisiae,Staphylococcus aureus

With **2.5 T and 4.5 T** magnetic intensity treatment,the survival rate is the lowest when the pulse number is 25.The sterilization effect of Staphylococcus aureus is better and beeter with the increasing of magnetic intensity and the number of pulses.The survival rate of Staphylococcus aureus is only 0.7% which the treatment of **35 pulse number and 4.5 magnetic intensit**y.

https://en.cnki.com.cn/Article_en/CJFDTotal-SPGY200906022.htm Sterilization Effect of High-intensity Pulsed Magnetic Field to Srawberry Juice

When the intensity of magnetic field up to over **17.3 tesla and pulsed number up to over 12** under room temperature(28±1℃), the number of total plate count decreased to below of 100 cfu/mL, molds and yeasts were killed completely and has **satisfied requirements of food business**.

https://patents.google.com/patent/CN2778280Y/en Pulse magnetic sterilizing equipment

The utility model can realize the purpose of high efficiency **sterilization by a few pulses**, and moreover, the utility model has small temperature rising process. Thus, the utility model not only can realize sterilization, but also can keep original flavor, taste, color and sweet, and the quality of the foods, and components of the foods can not be changed.

https://link.springer.com/article/10.1007/s11947-020-02425-w Effect of Combined Pulsed Magnetic Field and Cold Water Shock Treatment on the Preservation of Cucumbers During Postharvest Storage

Cucumbers were immersed into cold water at 0.5 °C with PMF for 40 min and then stored at 6 °C for 13 days. Different levels of the PMF (0.0, 2.0, 4.0, and 6.0 mT) were applied with a frequency of 25 Hz. The results showed that combined pretreatments of PMF and cold water possessed better preservation quality and prolonged their shelf life. When the magnetic flux density of PMF was 4.0 mT, the color change and decay rate of samples were the lowest and decreased by 52.8% and 73% at 13 days. The preservation mechanism of combined PMF and cold water may be ascribed to triggering higher catalase activity, which induced higher membrane integrity that displayed lower malondialdehyde accumulation.

https://www.researchgate.net/publication/289720152_The_effect_of_extremely_low_frequency_ELF_pulsed_electromagnetic_field_PEMF_on_bacteria_staphylococcus_aureus/link/569b5c5b08ae6169e55faa06/download

The results demonstrated that ELF PEMF exposures at 150-500 Hz are more effective than exposures at 3-100 Hz in reducing the viability of S. aureus in broth. The lowest CFU value was achieved with the exposure at 300 Hz and 1.5 mT.

Cellular Level + vessels

https://pubmed.ncbi.nlm.nih.gov/23373613/ Pulsed magnetic field improves the transport of iron oxide nanoparticles through cell barriers

Microscopic observations and biochemical analysis indicated that, in a constant magnetic field, transport of MNPs across the cells was inhibited due to the formation of large (>2 μm) magnetically induced MNP aggregates, which exceeded the size of endocytic vesicles. Thus, a **pulsed magnetic field enhances the cellular uptake and transport of MNPs across cell barriers** relative to a constant magnetic field by promoting accumulation while minimizing magnetically induced MNP aggregation at the cell surface.

https://pubmed.ncbi.nlm.nih.gov/10744227/ Effects of pulsed magnetic energy on a microsurgically transferred vessel

Pulsed magnetic energies of **0.1 and 2.0 gauss** were applied immediately postoperatively and for 4, 8, and 12 weeks, respectively, with a **statistically significant increase in neovascularization** among the treated animals compared with control rats. The study provides a starting point for future study and evaluation of the **stimulation of angiogenesis** with the use of pulsed magnetic energy and suggests a possible use of this modality to **increase the quality of revascularized tissue**.

Cholesterol

https://pubmed.ncbi.nlm.nih.gov/8810100/ Effect of pulsed magnetic fields on cholesterol and tryglyceride levels in rats study of field intensity and length of exposure

In a previous work a **decrease in cholesterol and triglyceride plasma level**s was observed in rats 24 hours after their exposure to a **12 Hz 6 mT** pulsed magnetic field (PMF). This time, a study of intensity effects of a 12 Hz PMF for a sixty-minute exposure and of length of exposure for a 12 Hz 6 mT PMF took place. Non-linear effect-dose relationships were observed for the PMF intensity as well as for the length of exposure used. The highest decreases in cholesterol and triglyceride levels were obtained after to a **sixty-minute exposure with 1.5 mT and 12 mT**.

Water Treatment

https://en.wikipedia.org/wiki/Pulsed-power_water_treatment Pulsed-power water treatment

Several reports have shown that pulse-powered systems yield significantly lower counts of bacteria colony forming units compared to chemically controlled systems.

https://cwt-vulcan.com/wp-content/uploads/Vulcan_Appl_Flyer_Medical_EN.pdf Anti Scale

Vulcan reduces bacterial growth by starving them of nutrients contained in scale. Studies show that Vulcan creates a more sanitary environment while providing healthy water for patients and staff alike.

https://www.achrnews.com/articles/117713-the-professor-chemicalfree-cooling-tower-treatment The Professor: Chemical-Free Cooling Tower Treatment

small suspended particles passes through a water treatment module and is activated by a high-frequency electrical pulse field, the natural electrical static charge on the particle's surface is removed. In removing this surface charge on the suspended particles, they are now the preferred site for precipitation of minerals to occur, instead of the equipment surfaces. The suspended particles now act as seeds for precipitation of dissolved minerals. Thus, the hard scale is prevented from forming on the equipment's surfaces and instead bonds to the tiny suspended particles in the water.

https://www.cwejournal.org/vol9no3/magnetic-water-treatment-in-environmental-management-a-review-of-the-recent-advances-and-future-perspectives

Liver Damage

https://pubmed.ncbi.nlm.nih.gov/25910613/ Effect of long-term pulsed electromagnetic field exposure on hepatic and immunologic functions of rats

Male rats were randomly divided into four groups: a control group and three experimental groups exposed to a **50-Hz PEMF at 5, 10, or 20 mT for 10 weeks**. Compared with the control group, activities of serum alanine aminotransferase and aspartate aminotransferase and concentrations of serum, liver, and spleen Metabolism of lipid peroxidation (MDA) in the **10- and 20-mT** PEMF groups were significantly increased. These results demonstrate **that long-term exposure to PEMF can lead to oxidative damage of the liver and spleen.**

https://pubmed.ncbi.nlm.nih.gov/6490517/ Influence of pulsed electromagnetic fields on regenerating rat liver after partial hepatectomy

Five days after operation the treated rats reach the values found at zero time, while control animals need seven days to reach the same values.

https://pubmed.ncbi.nlm.nih.gov/6463048/ Pulsed electromagnetic fields increase the rate of rat liver regeneration after partial hepatectomy

The recovery to normal glycogen and lipid contents is completed within 5 days after surgery, instead of 7 days as found in control rats.

https://pubmed.ncbi.nlm.nih.gov/3631891/ Tumoricidal cells increased by pulsating magnetic field

Repeated applications of pulsed magnetic fields (right-angle waves, 50 Hz = 135 Gauss, 2 Hz = 262 Gauss) **significantly enhanced the number and the tumoricidal activity of nonparenchymal liver cells**. The transplantable mouse leukemia L1210 used as a tumor model was not significantly influenced, either directly or during Cyclophosphamide treatment.

Hearing Damage

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9442804/pdf/main.pdf The effect of very low dose pulsed magnetic waves on cochlea

The rats at the study group were exposed to Pulsed Magnetic Field (PMF) of the same intensity and frequency **(1.5 mT, 40 Hz) for 1 h a**t the same time of the day for 30 days. According to the results of our study, the very low dose magnetic field, which is considered to be used for various therapeutic purposes recently, can cause both auditory function defects and histopathologic damage in cochlear cells. Histological studies in human cochleas are difficult to obtain. Our study results were in rats and studies in humans, using OAE or ABR are still lacking.

Water Evaporation

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3546730/pdf/ijms-13-16916.pdf Evaporation Rate of Water as a Function of a Magnetic Field and Field Gradient

The evaporation of pure water at simulated gravity positions (0 gravity level (ab. g), 1 g, 1.56 g and 1.96 g) in a superconducting magnet was compared with that in the absence of the magnetic field. The results showed that the **evaporation of water was indeed faster in the magnetic field** than in the absence of the magnetic field. Furthermore, the amount of water evaporation differed depending on the position of the sample within the magnetic field. In particular, the evaporation at 0 g was clearly faster than that at other positions. The results are discussed from the point of view of the evaporation surface area of the water/air interface and the convection induced by the magnetization force due to the difference in the magnetic susceptibility of water vapor and the surrounding air.

https://www.researchgate.net/publication/310447905_Increasing_Water_Evaporation_Rate_by_Magnetic_Field

Enhanced water evaporation in a magnetic field, however, is less disputed. In this paper, we present an investigation of water evaporation through magnetic field of 0.5 T, which was located at different location of tested water height (water-air interface, water mid height and bottom). An increase in evaporation time led to increase the evaporation rate, the **preferred location of magnetic field is at the water-air interface** which gave more evaporation rate (6% more than absence magnetic field) compared with other location

https://www.sciencedirect.com/science/article/abs/pii/S0255270117300156 Increase in water evaporation rate with increase in static magnetic field perpendicular to water-air interface

18% increase in magnetic water evaporation

https://www.researchgate.net/publication/329437740_Influence_of_Magnetic_Field_on_Evaporation_Rate_and_Surface_Tension_of_Water

The evaporated amounts depended partially on which pole of the ring magnet was directed up. The relatively strong MF (0.65 T) caused a slight decrease in surface tension (−2.11 mN/m) which lasted longer than 60 min and the memory effect vanished slowly. The surface tension data reduced by the MF action are reported in the literature, although contrary results can be also found.

https://www.semanticscholar.org/paper/Effects-of-Magnetic-Field-on-Evaporation-of-Water-Shao-yi/085f86c2645e6976d31f4ddcc2ba9c6e053ac232 Effects of Magnetic Field on Evaporation of Distilled Water

The results show that the rate of the water evaporation in the magnetic field is about 1.1 times of that in no magnetic field in the experiment conditions.The rate of the water evaporation increases as the intensities of magnetic induction increase.When the intensitie of magnetic induction is constant,the water vaporization rate increases with the temperature