Bulletin de veille
Champs électromagnétiques
N°2 - Mai 2023

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS.

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

Exposition professionnelle

RF-EMF Exposure near 5G NR Small Cells,

AERTS S., K. DEPREZ, L. VERLOOCK, R. G. OLSEN, L. MARTENS, P. TRAN and W. JOSEPH,

Sensors 23, no. 6 (Mar 2023),

Of particular interest within fifth generation (5G) cellular networks are the typical levels of radiofrequency (RF) electromagnetic fields (EMFs) emitted by 'small cells', low-power base stations, which are installed such that both workers and members of the general public can come in close proximity with them. In this study, RF-EMF measurements were performed near two 5G New Radio (NR) base stations, one with an Advanced Antenna System (AAS) capable of beamforming and the other a traditional microcell. At various positions near the base stations, with distances ranging between 0.5 m and 100 m, both the worst-case and time-averaged field levels under maximized downlink traffic load were assessed. Moreover, from these measurements, estimates were made of the typical exposures for various cases involving users and non-users. Comparison to the maximum permissible exposure limits issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) resulted in maximum exposure ratios of 0.15 (occupational, at 0.5 m) and 0.68 (general public, at 1.3 m). The exposure of non-users was potentially much lower, depending on the activity of other users serviced by the base station and its beamforming capabilities: 5 to 30

times lower in the case of an AAS base station compared to barely lower to 30 times lower for a traditional antenna. https://doi.org/10.3390/s23063145

Can extremely low frequency magnetic field affect human sperm parameters and male fertility?,

DELLI MUTI N., G. SALVIO, A. CIARLONI, M. PERRONE, G. TOSSETTA, R. LAZZARINI, M. BRACCI and G. BALERCIA,

Tissue & Cell 82 (Jun 2023),

Exposure to extremely low frequency magnetic fields (ELF-MF) may have different effects on spermatozoa depending on the waveform, magnetic flux density, frequency of ELF-MF, and duration of exposure. In this study, we investigated the possible role of ELF-MF (50 Hz; 1 mT) exposure in altering sperm parameters. In this study we found that exposure to ELF-MF at the frequency of 50 Hz (1 mT) for two hours induces statistically significant alterations in progressive motility, morphology and reactive oxygen species (ROS) production of human sper-matozoa, suggesting a role of ELF-MF in altering reproductive function of spermatozoa. Our results represent an important discovery in the field since occupational exposure to the sine waveform 1 mT 50 Hz ELF-MF used in our study is possible in workplace. Moreover, these electromagnetic fields are product by many electronic de-vices and household appliances. Thus, alterations of progressive motility and morphology of spermatozoa would be important consequences of human exposures to ELF-MF. https://doi.org/10.1016/j.tice.2023.102045

Relationship between parental exposure to radiofrequency electromagnetic fields and primarily hematopoietic neoplasms (lymphoma, leukemia) and tumors in the central nervous system in children: a systematic review,

MORALES-SUAREZ-VARELA M., A. LLOPIS-MORALES, C. DOCCIOLI and G. DONZELLI,

Reviews on Environmental Health (Low-frequency electromagnetic fields have grown exponentially in recent years due to technological development and modernization. The World Health Organization (WHO)/International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields (RF-EMFs) as possibly carcinogenic to humans (Group 2B), and recent studies have investigated the association between exposure to electromagnetic fields in parents and possible health effects in children, especially the development of tumours of the central nervous system (CNS). The objective of this systematic review was to collate all evidence on the relationship between parental occupational exposure to electromagnetic fields and the development of CNS cancer in children and to evaluate this association. This review was prepared according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. PubMed, Embase, and Web of Science were searched from January 1990 to April 2021. The search was conducted using the following search string: "occupational" AND "child" AND "electromagnetic" AND "cancer". Seventeen articles met our inclusion criteria: 13 case-control studies, two cohort studies, and 2 meta-analyses. Most of the studies showed several methodological weaknesses that limited their results. Due to a lack of consistency regarding the outcome as well as the heterogeneity in the reviewed studies, the body of evidence for the effects of parental exposure to electromagnetic fields is not clear. Methodological heterogeneity in the way that studies were conducted could be responsible for the lack of consistency in the findings. Overall, the body of evidence allows no conclusion on the question of whether parental exposure to electromagnetic. https://doi.org/10.1515/reveh-2022-0248

Toxicité

3.5 GHz radiofrequency radiation may affect biomechanics of bone and muscle of diabetics,

BEKTAS H., S. DASDAG, A. NALBANT, M. B. AKDAG, C. DEMIR and S. KAVAK,

Biotechnology & Biotechnological Equipment 37, no. 1 (Dec 2023),

With the developments in wireless technologies, living beings are increasingly exposed to electromagnetic fields (EMFs). EMFs are known to affect bone metabolism and muscle tissue. However, their effects on bones and skeletal muscles are controversial, as some studies have reported positive effects while others have reported adverse effects. In this study, the effects of radiofrequency radiation (RFR) on bone biomechanics and skeletal muscle tissues were investigated in diabetic and healthy rats. Rats were exposed to 3.5 GHz RFR for 2 h per day for 30 days. Bone biomechanics measurements were taken to evaluate the effects of RFR on bone quality, flexibility and durability. The whole-body specific absorption rate (SAR) was found to be 37 mW/kg. The results showed that RFR exposure had adverse effects on bone biomechanics, including decreased elasticity coefficient and Young's modulus, increased maximum displacement and decreased maximum force. However, oxidative stress parameters in diabetics were also altered by 3.5 GHz RFR to a greater extent than in healthy rats. In conclusion, 3.5 GHz RFR may have potential to alter bone quality and structural integrity including muscle oxidative stress parameters in rats. It should be emphasized that the observed changes were more obvious in diabetic rats. In addition, the changes observed in healthy and diabetic rats exposed to RFR showed a statistically significant difference according to the sham groups. https://doi.org/10.1080/13102818.2023.2199096

Statistical Amplification of the Effects of Weak Magnetic Fields in Cellular Translation,

BINHI V. N.,

Cells 12, no. 5 (Mar 2023),

We assume that the enzymatic processes of recognition of amino acids and their addition to the synthesized molecule in cellular translation include the formation of intermediate pairs of radicals with spin-correlated electrons. The mathematical model presented describes the changes in the probability of incorrectly synthesized molecules in response to a change in the external weak magnetic field. A relatively high chance of errors has been shown to arise from the statistical enhancement of the low probability of local incorporation errors. This statistical mechanism does not require a long thermal relaxation time of electron spins of about 1 mu s-a conjecture often used to match theoretical models of magnetoreception with experiments. The statistical mechanism allows for experimental verification by testing the usual Radical Pair Mechanism properties. In addition, this mechanism localizes the site where magnetic effects originate, the ribosome, which makes it possible to verify it by biochemical methods. This mechanism predicts a random nature of the nonspecific effects caused by weak and hypomagnetic fields and agrees with the diversity of biological responses to a weak magnetic field. https://doi.org/10.3390/cells12050724

Preliminary Study on the Effect of a Single High-Energy Electromagnetic Pulse on Morphology and Free Radical Generation in Human Mesenchymal Stem Cells,

CZWARTOS J., B. DOBOSZ, W. KASPRZYCKA, P. N. OSUCHOWSKA, M. STEPINSKA, E. A. TRAFNY, J. STARZYNSKI and Z. MIERCZYK,

International Journal of Molecular Sciences 24, no. 8 (Apr 2023),

The effect of nanosecond electromagnetic pulses on human health, and especially on forming free radicals in human cells, is the subject of continuous research and ongoing discussion. This work presents a preliminary study on the effect of a single high-energy electromagnetic pulse on morphology, viability, and free radical generation in human mesenchymal stem cells (hMSC). The cells were exposed to a single electromagnetic pulse with an electric field magnitude of similar to 1 MV/m and a pulse duration of similar to 120 ns generated from a 600 kV Marx generator. The cell viability and morphology at 2 h and 24 h after exposure were examined using confocal fluorescent microscopy and scanning electron microscopy (SEM), respectively. The number of free radicals was investigated with electron paramagnetic resonance (EPR). The microscopic observations and EPR measurements showed that the exposure to the high-energy electromagnetic pulse influenced neither the number of free radicals generated nor the morphology of hMSC in vitro compared to control samples. https://doi.org/10.3390/ijms24087246

50 Hz Magnetic Field Exposure Inhibited Spontaneous Movement of Zebrafish Larvae through ROS-Mediated syn2a Expression,

GUO Y. X., Y. T. FU and W. J. SUN,

International Journal of Molecular Sciences 24, no. 8 (Apr 2023),

Extremely low frequency electromagnetic field (ELF-EMF) exists widely in public and occupational environments. However, its potential adverse effects and the underlying mechanism on nervous system, especially behavior are still poorly understood. In this study, zebrafish embryos (including a transfected synapsin IIa (syn2a) overexpression plasmid) at 3 h post-fertilization (hpf) were exposed to a 50-Hz magnetic field (MF) with a series of intensities (100, 200, 400 and 800 mu T, respectively) for 1 h or 24 h every day for 5 days. Results showed that, although MF exposure did not affect the basic development parameters including hatching rate, mortality and malformation rate, yet MF at 200 mu T could significantly induce spontaneous movement (SM) hypoactivity in zebrafish larvae. Histological examination presented morphological abnormalities of the brain such as condensed cell nucleus and cytoplasm, increased intercellular space. Moreover, exposure to MF at 200 mu T inhibited syn2a transcription and expression, and increased reactive oxygen species (ROS) level as well. Overexpression of syn2a could effectively rescue MF-induced SM hypoactivity in zebrafish. Pretreatment with N-acetyl-L-cysteine (NAC) could not only recover syn2a protein expression which was weakened by MF exposure, but also abolish MF-induced SM hypoactivity. However, syn2a overexpression did not affect MF-increased ROS. Taken together, the findings suggested that exposure to a 50-Hz MF inhibited spontaneous movement of zebrafish larvae via ROS-mediated syn2a expression in a nonlinear manner. https://doi.org/10.3390/ijms24087576

An overview of the biological effects of extremely low frequency electromagnetic fields combined with ionizing radiation,

HAMEDANI B. G., B. GOLIAEI, S. P. SHARIATPANAHI and M. NEZAMTAHERI,

Progress in Biophysics & Molecular Biology 172 (Aug 2022): 50-59,

By growing the electrical power networks and electronic devices, electromagnetic fields (EMF) have become an inseparable part of the modern world. Considering the inevitable exposure to a various range of EMFs, especially at extremely low frequencies (ELF-EMF), investigating the biological effects of ELF-EMFs on biological systems became a global issue. The possible adverse consequences of these exposures were studied, along with their potential therapeutic capabilities. Also, their biological impacts in combination with other chemical and physical agents, specifically ionizing radiation (IR), as a co-carcinogen or as adjuvant therapy in combination with radiotherapy were explored. Here, we review the results of several in-vitro and in-vivo studies and discuss some proposed possible mechanisms of ELF-EMFs' actions in combination with IR. The results of these experiments could be fruitful to develop more precise safety standards for environmental ELF-EMFs exposures. Furthermore, it could evaluate the therapeutic capacities of ELF-EMFs alone or as an improver of radiotherapy. https://doi.org/10.1016/j.pbiomolbio.2022.04.008

Effect of prenatal stress and extremely low-frequency electromagnetic fields on anxiety-like behavior in female rats: With an emphasis on prefrontal cortex and hippocampus,

HOSSEINI E. and D. KIANIFARD,

Brain and Behavior 13, no. 4 (Apr 2023),

ObjectivePrenatal stress (PS) is a problematic situation resulting in psychological implications such as social anxiety. Ubiquitous extremely low-frequency electromagnetic fields (ELF-EMF) have been confirmed as a potential physiological stressor; however, useful neuroregenerative effect of these types of electromagnetic fields has also frequently been reported. The aim of the present study was to survey the interaction of PS and ELF-EMF on anxiety-like behavior. MethodA total of 24 female rats 40 days of age were distributed into four groups of 6 rats each: control, stress (their mothers were exposed to stress), EMF (their mothers underwent to ELF-EMF), and EMF/stress (their mothers concurrently underwent to stress and ELF-EMF). The rats were assayed using elevated plus-maze and open field tests. ResultsExpressions of the hippocampus GAP-43, BDNF, and caspase-3 (cas-3) were detected by immunohistochemistry in Cornu Ammonis 1 (CA1) and dentate gyrus (DG) of the hippocampus and prefrontal cortex (PFC). Anxiety-like behavior increased in all treatment groups. Rats in the EMF/stress group presented more serious anxiety-like behavior. In all treatment groups, upregulated expression of cas-3 was seen in PFC, DG, and CA1 and downregulated expression of BDNF and GAP-43 was seen in PFC and DG and the CA1. Histomorphological study showed vast neurodegenerative changes in the hippocampus and PFC. ConclusionThe results showed ,female rats that underwent PS or/and EMF exhibited critical anxiety-like behavior and this process may be attributed to neurodegeneration in PFC and DG of the hippocampus and possibly decreased synaptic plasticity so-called areas. https://doi.org/10.1002/brb3.2949

Relationship between low-frequency electromagnetic field and computer vision syndrome,

KOSEK O., B. METE, I. OCAL, K. YAR, H. DEMIRHINDI and M. TOKUS,

European Review for Medical and Pharmacological Sciences 27, no. 5 (2023): 1801-1807,

- OBJECTIVE: This study aimed to determine the prevalence of computer vi-sion syndrome (CVS) among secretaries work-ing in different departments of a universi-ty hospital in Turkey and its relationship with low-frequency electromagnetic field (LF-EMF) exposure. SUBJECTS AND METHODS: This cross-sectional study included 143 secretaries work-ing in different departments of the hospital. Be-sides eye examinations, CVS Syndrome Ques-

tionnaire (CVS-Q) Scale and Ocular Surface Disease Index Scale (OSDI) were applied to the participants. LF-EMF of the work environment were measured with a 6010 Gauss/Teslameter device and the light intensity with an LX-1102 Device. RESULTS: The mean age of participants was 39.6 years, with a male-to-female ratio of 25.2% to 74.8%. CVS-Q scale revealed 83.9% of com-puter vision syndrome among participants. A weak positive correlation was found between CVS-Q and LF-EMF, while a moderately strong, negative correlation was found between LF-EMF and Schirmer test of both eyes. The work environment LF-EMF values were significantly higher among the participants diagnosed with CVS ($p<0.05$). The risk of CVS was found to in-crease 3.27 times when the ambient LF-EMF was >1,725 mu T and an increase of 0.004 units in the CVS-Q score was calculated for each one -unit increase in the LF-EMF of the environment. CONCLUSIONS: A relationship between CVS, dry eye and EMF was observed among people exposed to LF-EMF. Regular measurement of EMF in work environments, and developing pro-tective behaviours (work-break intervals, 20-20-20 rule, etc.) can be recommended. https://doi.org/

Physiological and Psychological Stress of Microwave Radiation-Induced Cardiac Injury in Rats,

LI D. Y., X. P. XU, Y. YIN, B. W. YAO, J. DONG, L. ZHAO, H. Y. WANG, H. WANG, J. ZHANG and R. Y. PENG,

International Journal of Molecular Sciences 24, no. 7 (Apr 2023),

Electromagnetic waves are widely used in both military and civilian fields, which could cause long-term and high-power exposure to certain populations and may pose a health hazard. The aim of this study was to simulate the long-term and high-power working environment of workers using special electromagnetic radiation occupations to clarify the radiation-induced stress response and cardiac damage and thus gain insights into the mechanisms of injuries caused by electromagnetic radiation. In this study, the combination of microwave and stress was an innovative point, aiming to broaden the research direction with regard to the effect and mechanism of cardiac injury caused by radiation. The myocardial structure was observed by optical and transmission electron microscope, mitochondrial function was detected by flow cytometry, oxidative-stress markers were detected by microplate reader, serum stress hormone was detected by radioimmunoassay, and heart rate variability (HRV) was analyzed by multichannel-physiological recorder. The rats were weighed and subjected to an open field experiment. Western blot (WB) and immunofluorescence (IF) were used to detect the expressions and distributions of JNK (c-Jun N-terminal kinase), p-JNK (phosphorylated c-Jun N-terminal kinase), HSF1 (heat shock factor), and NFATc4 (nuclear factor of activated T-cell 4). This study found that radiation could lead to the disorganization, fragmentation, and dissolution of myocardial fibers, severe mitochondrial cavitation, mitochondrial dysfunction, oxidative-stress injury in myocardium, increase to stress hormone in serum, significant changes in HRV, and a slow gain in weight. The open field experiment indicated that the rats experienced anxiety and depression and had decreased exercise capacity after radiation. The expressions of JNK, p-JNK, HSF1, and NFATc4 in myocardial tissue were all increased. The above results suggested that 30 mW/cm(2) of S-band microwave radiation for 35 min could cause both physiological and psychological stress damage in rats; the damage was related to the activation of the JNK pathway, which provided new ideas for research on protection from radiation. https://doi.org/10.3390/ijms24076237

Effects of extremely low frequency electromagnetic field at 50 Hz on myofibrillar protein from grass carp (Ctenopharyngodon idellus) during chilled storage at 4?C,

MAHATO S., Z. W. ZHU and D. W. SUN,

Lwt-Food Science and Technology 174 (Jan 2023),

Biological interaction with extremely low-frequency electromagnetic fields (ELF-EMF) is complex and the 50 and 60 Hz frequencies are among a few 'window' frequency ranges reported with a stimulating effect. In the current study, ELF-EMF at frequencies from 40 to 70 Hz were examined for their possible significance in inducing biological effects during chilled storage of grass carp (Ctenopharyngodon idellus) at 4 degrees C for 4 and 6 h. The myofibrillar protein extracted from the grass carp was analyzed and the results indicate significant ($p < 0.05$) increases in Ca2+ATPase activity and pH, and a reduction in the total sulfhydryl content during the treatment of 50 and 60 Hz frequencies for both storage durations, in particular, the treatment of 50 Hz had pronounced effects with higher correlations. Therefore, the 50 Hz might be associated with the 'window' effect, enhancing myofi-brillar protein quality during chilled storage. https://doi.org/10.1016/j.lwt.2022.114397

Influence of electromagnetic fields on the circadian rhythm: Implications for human health and disease,

MARTEL J., S. H. CHANG, G. CHEVALIER, D. M. OJCIUS and J. D. YOUNG,

Biomedical Journal 46, no. 1 (Feb 2023): 48-59,

Living organisms have evolved within the natural electromagnetic fields (EMFs) of the earth which comprise the global atmospheric electrical circuit, Schumann resonances (SRs) and the geomagnetic field. Research suggests that the circadian rhythm, which controls several physiological functions in the human body, can be influenced by light but also by the earth's EMFs. Cyclic solar disturbances, including sunspots and seasonal weakening of the geomagnetic field, can affect human health, possibly by disrupting the circadian rhythm and downstream physiological functions. Severe disruption of the circadian rhythm in-creases inflammation which can induce fatigue, fever and flu-like symptoms in a fraction of the population and worsen existing symptoms in old and diseased individuals, leading to periodic spikes of infectious and chronic diseases. Possible mechanisms underlying sensing of the earth's EMFs involve entrainment via electrons and electromagnetic waves, light-dependent radical pair formation in retina cryptochromes, and paramagnetic magnetite nanoparticles. Factors such as electromagnetic pollution from wireless devices, base antennas and low orbit internet satellites, shielding by non-conductive materials used in shoes and buildings, and local geomagnetic anomalies may also affect sensing of the earth's EMFs by the human body and contribute to circadian rhythm disruption and disease development. https://doi.org/10.1016/j.bj.2023.01.003

Effects of long-term exposure to 50 Hz magnetic fields on cell viability, genetic damage, and sensitivity to mutagen-induced damage,

NGUYEN H., S. SEGERS, M. LEDENT, R. ANTHONISSEN, L. VERSCHAEVE, M. HINSENKAMP, J. F. COLLARD, V. FEIPEL and B. MERTENS,

Heliyon 9, no. 3 (Mar 2023),

Until today, it remains controversial whether long-term exposure to extremely low-frequency magnetic fields (ELF-MF) below the legislative exposure limits could result in adverse human health effects. In the present study, the effects of long-term in vitro MF exposure on three different study endpoints (cell viability, genetic damage, and sensitivity to damage induced by known mutagens) were investigated in the human B lymphoblastoid (TK6) cell line. Cells were exposed to 50 Hz MF at three selected magnetic flux densities (i.e., 10, 100, and 500 mu T) for different exposure periods ranging from 96h up to 6 weeks. Cell

viability following MF exposure was assessed using the ATP-based cell viability assay. Effects of MF exposure on cell genetic damage and cell sensitivity to mutagen-induced damage were evaluated using the in vitro alkaline comet assay and the in vitro cytokinesis block micronucleus assay. The results showed that long-term exposure up to 96h to 50 Hz MF at all tested flux densities could significantly increase TK6 cell viability. In contrast, long-term MF exposure did not affect cell genetic damage, and long-term pre-exposure to MF did not change cell sensitivity to damage induced by known muta-gens. At certain time points, statistically significant difference in genotoxicity test results were observed between the MF-exposed cells and the control cells. However, these observations could not be confirmed in the repeat experiments, indicating that they are probably not biologically significant. https://doi.org/10.1016/j.heliyon.2023.e14097

Large-area mobile measurement of outdoor exposure to radio frequencies,

PANIAGUA-SANCHEZ J. M., F. J. GARCIA-COBOS, M. RUFO-PEREZ and A. JIMENEZ-BARCO,

Science of the Total Environment 877 (Jun 2023),

A rapid outdoor sampling technique was tested to measure human exposure to radio frequencies in a city of 96,000 inhabitants. The technique consisted of taking measurements with a personal exposure meter inside a moving vehicle. Tests were carried out to quantify the alteration produced by the vehicle's structure and obtain correction factors order to minimize this alteration. Data were collected at 3065 points where signals in the FM radio and mobile phone wavebands were detected. The coefficients of exposure to sources with multiple frequencies due to thermal ef-fects were calculated from the measured values of the electric field. Kriging was used to generate maps of these coef-ficients, and these maps were then merged with aerial photographs of the city to readily identify the areas with greater or lesser exposure. The results indicated that the vehicle increased the FM broadcasting radiation readings by a factor of 1.66, but attenuated those of mobile telephony by factors of 0.54-0.66. The mean electric field levels detected throughout the city were 0.231, 0.057, 0.140, 0.124, and 0.110 V/m for the frequency bands FM, LTE 800 (DL), GSM + UMTS 900(DL), GSM 1800(DL), and UMTS 2100(DL), respectively. The mean coefficient of exposure to sources with multiple frequencies was 2.05 x 10-4, and the maximum was 9.81 x 10-3. It can be concluded from the study that it is possible to assess radio frequency exposure using this method, and that the technique is scalable to different sized cities. It also allows measurement at different times so as to analyse the temporal variation of radio frequency levels.
https://doi.org/10.1016/j.scitotenv.2023.162852

Combined effects of EMP and RF field on emotional behavior in mice,

QIN T. Z., L. Y. LIU, X. WANG, L. GUO, J. J. LIN, J. Z. DU, Y. Z. XUE, P. P. LAI, Y. T. JING and G. R. DING,

Frontiers in Public Health 11 (Mar 2023),

BackgroundRecently, concerns about the combined effects of electromagnetic field (EMF) in daily living and occupational environment are rapidly growing. MethodsIn this study, we investigated the combined effects of 1-week exposure to electromagnetic pulse (EMP) at 650 kV/m for 1,000 pulses and 4.9 GHz radiofrequency (RF) at 50 W/m(2) for 1 h/d in male mice. Open field test, tail suspension test and Y-maze were applied to evaluate anxiety, depression-like behaviors and spatial memory ability, respectively. ResultsIt was found that compared with Sham group, combined exposure to EMP and RF induced anxiety-like behavior, increased the level of serum S100B and decreased the level of serum 5-HT. The

results of quantitative proteomic and KEGG analysis showed that the differentially expressed proteins in hippocampus were enriched in Glutamatergic and GABAergic synapse after combined exposure group, which were verified by western blot. In addition, an obvious histological alteration and autophagy-associated cell death were observed in amygdala instead of hippocampus after combined exposure to EMP and 4.9 GHz RF. ConclusionCombined exposure to EMP and 4.9 GHz RF could induce emotional behavior alteration, which might be associated with Glutamatergic and GABAergic synapse system of hippocampus and autophagy in amygdala. https://doi.org/10.3389/fpubh.2023.1087161

Evaluation of the Effects of Power-Frequency Magnetic Field Exposure on B-Cell Differentiation From Human Hematopoietic Stem/Progenitor Cells,

TAKAHASHI M. and N. FURUYA,

Bioelectromagnetics (The causal relationship between exposure to power-frequency magnetic fields (MFs) and childhood leukemia has long been controversial. The most common type of childhood leukemia is acute B-lymphoblastic leukemia caused by abnormal proliferation of B cells in the early differentiation process. Here, we focused on B-cell early differentiation and aimed to evaluate the effects of exposing cells to power-frequency MF. First, we optimized an in vitro differentiation protocol of human hematopoietic stem/progenitor cells (HSPCs) to B-cell lineages. Following validation of the responsiveness of the protocol to additional stimulations and the uniformity of the experimental conditions, human HSPCs were continuously exposed to 300 mT of 50 Hz MF for 35 days of the differentiation process. These experiments were performed in a blinded manner. The percentages of myeloid or lymphoid cells and their degree of differentiation from pro-B to immature-B cells in the MF-exposed group showed no significant changes compared with those in the control group. Furthermore, the expression levels of recombination-activating gene (RAG)1 and RAG2 in the B cells were also similar to those in the control group. These results indicate that exposure to 50 Hz MF at 300 mT does not affect the human B-cell early differentiation from HSPCs. (c) 2023 The Authors. Bioelectromagnetics published by Wiley Periodicals LLC on behalf of Bioelectromagnetics Society. https://doi.org/10.1002/bem.22447

The need for consensus guidelines to address the mixed legacy of genetic damage assessments for radiofrequency fields,

VIJAYALAXMI and K. R. FOSTER,

International Journal of Radiation Biology (Purpose: This review considers issues related to interpreting the mixed legacy of >300 papers published during the past three decades on possible genotoxic effects of exposure of human and animal tissues to radiofrequency electromagnetic fields (RF-EMF). The main paper reviews the evolution of consensus guidelines for genotoxicity testing and the increasing emphasis on systematic reviews for evaluation of scientific studies for use in health risk assessments. An Appendix considers some issues in assessing the bioeffects literature by examining a subset of genotoxicity publications that employed the comet assay. While most studies found no statistically significant effects of exposure, a significant minority of studies (chiefly, in vivo studies) reported statistically significant effects of exposure. The quality of the studies was highly variable; while several studies were meticulously done and documented, none of these studies were compliant with currently accepted guidelines such as those of the Organization for Economic Cooperation and Development (OECD). Evaluation of the studies using risk of bias (RoB) criteria showed that, in this sample of studies, higher quality studies were less likely to find statistically significant results than those of lower

quality.Conclusion: The authors conclude that statistical significance should be only one consideration in evaluation of bioeffects studies. Simply listing 'statistically' significant effects identified using null hypothesis testing and the criterion $p < 0.05$ for statistical significance is misleading and uninformative in assessing health risks of exposure. A careful synthesis of evidence is needed, including assessment of study validity, biological significance of reported effects, and coherence of study results with those of other related studies.The authors recommend that all future RF genotoxicity studies intended for use in human health risk assessments and evaluations of the literature should be done in compliance with accepted quality guidelines, i.e. OECD or equivalent guidelines for genotoxicity screening studies and PRISMA or other accepted guideline for reviews of the literature. The positive studies in this group should be redone with tighter quality control to establish the reliability of the findings. https://doi.org/10.1080/09553002.2023.2188936

Theta band brainwaves in human resting EEG modulated by mobile phone radiofrequency,

WALLACE J., W. D. SHANG, C. GITTON, L. HUGUEVILLE, L. YAHIA-CHERIF and B. SELMAOUI,

International Journal of Radiation Biology (PurposeWireless communication has become an integral part of our lives. The growing number of antennas in our environment and the expanding use of mobile phones (MPs) are increasing the population's exposure to electromagnetic fields. The present study aimed to examine the potential impact of MPs radiofrequency electromagnetic fields (RF-EMF) exposure on the brainwaves of the resting electroencephalogram (EEG) in humans.Materials and MethodsTwenty-one healthy volunteers were exposed to Global System for Mobile communications (GSM) signal at 900 MHz MP RF-EMF. The maximum specific absorption rate (SAR) of the MP averaged on 10 g tissue and 1 g tissue were measured at 0.49 W/kg, 0.70 W/kg, respectively.ResultsResults showed that while delta and beta rhythms of resting EEG were not affected, theta brainwaves were significantly modulated during exposure to RF-EMF related to MPs. For the first time, it was shown that this modulation is dependent on the eye condition, i.e. closed or open.ConclusionsThis study strongly suggests that acute exposure to RF-EMF alters the EEG theta rhythm at rest. Long-term exposure studies are required to explore the effect of this disruption in high-risk or sensitive populations. https://doi.org/10.1080/09553002.2023.2187477

Effects of Terahertz Radiation on the Aggregation of Alzheimer's A beta 42 Peptide,

WANG L., Y. Y. CHENG, W. X. WANG, J. W. ZHAO, Y. S. WANG, X. M. ZHANG, M. WANG, T. H. SHAN and M. X. HE,

International Journal of Molecular Sciences 24, no. 5 (Mar 2023),

The pathophysiology of Alzheimer's disease is thought to be directly linked to the abnormal aggregation of beta-amyloid (A beta) in the nervous system as a common neurodegenerative disease. Consequently, researchers in many areas are actively looking for factors that affect A beta aggregation. Numerous investigations have demonstrated that, in addition to chemical induction of A beta aggregation, electromagnetic radiation may also affect A beta aggregation. Terahertz waves are an emerging form of non-ionizing radiation that has the potential to affect the secondary bonding networks of biological systems, which in turn could affect the course of biochemical reactions by altering the conformation of biological macromolecules. As the primary radiation target in this investigation, the in vitro modeled A beta 42 aggregation system was examined using fluorescence spectrophotometry, supplemented by cellular simulations and transmission electron

microscopy, to see how it responded to 3.1 THz radiation in various aggregation phases. The results demonstrated that in the nucleation aggregation stage, 3.1 THz electromagnetic waves promote A beta 42 monomer aggregation and that this promoting effect gradually diminishes with the exacerbation of the degree of aggregation. However, by the stage of oligomer aggregation into the original fiber, 3.1 THz electromagnetic waves exhibited an inhibitory effect. This leads us to the conclusion that terahertz radiation has an impact on the stability of the A beta 42 secondary structure, which in turn affects how A beta 42 molecules are recognized during the aggregation process and causes a seemingly aberrant biochemical response. Molecular dynamics simulation was employed to support the theory based on the aforementioned experimental observations and inferences.
https://doi.org/10.3390/ijms24055039

The effect of magnetic fields on tumor occurrence and progression: Recent advances,

ZHANG G., X. L. LIU, Y. L. LIU, S. L. ZHANG, T. Y. YU, X. X. CHAI, J. L. HE, D. C. YIN and C. Y. ZHANG,

Progress in Biophysics & Molecular Biology 179 (May 2023): 38-50,

Malignancies are the leading human health threat worldwide. Despite rapidly developing treatments, poor prognosis and outcome are still common. Magnetic fields have shown good anti-tumoral effects both in vitro and in vivo, and represent a potential non-invasive treatment; however, the specific underlying molecular mechanisms remain unclear. We here review recent studies on magnetic fields and their effect on tumors at three different levels: organismal, cellular, and molecular. At the organismal level, magnetic fields suppress tumor angiogenesis, microcirculation, and enhance the immune response. At the cellular level, magnetic fields affect tumor cell growth and biological functions by affecting cell morphology, cell membrane structure, cell cycle, and mitochondrial function. At the molecular level, magnetic fields suppress tumors by interfering with DNA synthesis, reactive oxygen species level, second messenger molecule delivery, and orientation of epidermal growth factor receptors. At present, scientific experimental evidence is still lacking; therefore, systematic studies on the biological mechanisms involved are urgently needed for the future application of magnetic fields to tumor treatment.
https://doi.org/10.1016/j.pbiomolbio.2023.04.001

Méthodes

Comparison of Low-Cost 5G Electromagnetic Field Sensors,

DEPREZ K., L. COLUSSI, E. KORKMAZ, S. AERTS, D. LAND, S. LITTEL, L. VERLOOCK, D. PLETS, W. JOSEPH and J. BOLTE,

Sensors 23, no. 6 (Mar 2023),

This paper compares different low-cost sensors that can measure (5G) RF-EMF exposure. The sensors are either commercially available (off-the-shelf Software Defined Radio (SDR) Adalm Pluto) or constructed by a research institution (i.e., imec-WAVES, Ghent University and Smart Sensor Systems research group ((SR)-R-3), The Hague University of Applied Sciences). Both in-lab (GTEM cell) and in-situ measurements have been performed for this comparison. The in-lab measurements tested the linearity and sensitivity, which can then be used to calibrate the sensors. The in-situ testing confirmed that the low-cost hardware sensors and SDR can be used to assess the RF-EMF radiation. The variability between the

sensors was 1.78 dB on average, with a maximum deviation of 5.26 dB. Values between 0.09 V/m and 2.44 V/m were obtained at a distance of about 50 m from the base station. These devices can be used to provide the general public and governments with temporal and spatial 5G electromagnetic field values. https://doi.org/10.3390/s23063312

Uncertainty quantification in the assessment of human exposure to pulsed or multi-frequency fields,

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Physics in Medicine and Biology 68, no. 9 (May 2023),

Objective: pulsed fields or waveforms with multi-frequency content have to be assessed with suitable methods. This paper deals with the uncertainty quantification associated to these methods.Approach: among all possible approaches, the weighted peak method (WPM) is widely employed in standards and guidelines, therefore, in this paper, we consider its implementation both in time domain and frequency domain. For the uncertainty quantification the polynomial chaos expansion theory is used. By means of a sensitivity analysis, for several standard waveforms, the parameters with more influence on the exposure index are identified and their sensitivity indices are quantified. The output of the sensitivity analysis is used to set up a parametric analysis with the aim of evaluating the uncertainty propagation of the analyzed methods and, finally, also several measured waveforms generated by a welding gun are tested.Main results: it is shown that the time domain implementation of the weighted peak method provides results in agreement with the basilar mechanisms of electromagnetic induction and electrostimulation. On the opposite, the WPM in frequency domain is found to be too sensitive to parameters that should not influence the exposure index because its weight function includes sharp variations of the phase centered on real zeros and poles. To overcome this issue, a new definition for the phase of the weight function in frequency domain is proposed.Significance: it is shown that the time domain implementation of the WPM is the more accurate and precise. The standard WPM in frequency domain has some issues that can be avoided with the proposed modification of the phase definition of the weight function. Finally, all the codes used in this paper are hosted on a GitHub and can be freely accessed at https://github.com/giaccone/wpm_uncertainty. https://doi.org/10.1088/1361-6560/acc924

Hybrid deep learning model for efficient prediction of telecom data using EMF radiation,

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Journal of Intelligent & Fuzzy Systems 44, no. 3 (2023): 4257-4272,

EMF has a variety of biological impacts and has an impact on the metabolic process in the human body. Antenna towers, anechoic chambers, and other sources can all produce this. Some of the human populations live very close to the EMF-emitting antenna towers. We can make humans aware of the EMF radiation and protect from diseases if there is a proper method to anticipate the EMF radiation of antennas installed in different places. For the study of telecom data and EMF emission, many machine learning and deep learning techniques have been developed in recent years. Predictive analytics played a bigger part in this. For prediction, it comprises advanced statistics, modeling and more machine learning methodologies. However, the appropriate hyper parameters must be established for the model's effective prediction, but this cannot be guaranteed in a dynamic environment where the data is always changing. The learning model's performance improves when these parameters are optimized. The goal of this study is to use the Telecom dataset to create a novel hybrid deep learning model for forecasting the trend of

EMF radiations. The patterns were first discovered using Artificial Neural Networks (ANN) and Multilayer Perceptron (MLP) combined with the Particle Swarm Optimization method (PSO). Later to boost its performance the hybrid approach (MLP-RFD-PSO) was developed and 98.8% accuracy was achieved. https://doi.org/10.3233/jifs-220408

Advances in Wearable Piezoelectric Sensors for Hazardous Workplace Environments,

MOKHTARI F., Z. X. CHENG, C. H. WANG and J. FOROUGHI,

Global Challenges (Recent advances in wearable energy harvesting technology as solutions to occupational health and safety programs are presented. Workers are often exposed to harmful conditions-especially in the mining and construction industries-where chronic health issues can emerge over time. While wearable sensors technology can aid in early detection and long-term exposure tracking, powering them and the associated risks are often an impediment for their widespread use, such as the need for frequent charging and battery safety. Repetitive vibration exposure is one such hazard, e.g., whole body vibration, yet it can also provide parasitic energy that can be harvested to power wearable sensors and overcome the battery limitations. This review can critically analyze the vibration effect on workers' health, the limitations of currently available devices, explore new options for powering different personal protective equipment devices, and discuss opportunities and directions for future research. The recent progress in self-powered vibration sensors and systems from the perspective of the underlying materials, applications, and fabrication techniques is reviewed. Lastly, the challenges and perspectives are discussed for reference to the researchers who are interested in self-powered vibration sensors. https://doi.org/10.1002/gch2.202300019

Acoustic and Magnetic Stimuli-Based Three-Dimensional Cell Culture Platform for Tissue Engineering,

SEO J. Y., S. B. PARK, S. Y. KIM, G. J. SEO, H. K. JANG and T. J. LEE,

Tissue Engineering and Regenerative Medicine (In a conventional two-dimensional (2D) culture method, cells are attached to the bottom of the culture dish and grow into a monolayer. These 2D culture methods are easy to handle, cost-effective, reproducible, and adaptable to growing many different types of cells. However, monolayer 2D cell culture conditions are far from those of natural tissue, indicating the need for a three-dimensional (3D) culture system. Various methods, such as hanging drop, scaffolds, hydrogels, microfluid systems, and bioreactor systems, have been utilized for 3D cell culture. Recently, external physical stimulation-based 3D cell culture platforms, such as acoustic and magnetic forces, were introduced. Acoustic waves can establish acoustic radiation force, which can induce suspended objects to gather in the pressure node region and aggregate to form clusters. Magnetic targeting consists of two components, a magnetically responsive carrier and a magnetic field gradient source. In a magnetic-based 3D cell culture platform, cells are aggregated by changing the magnetic force. Magnetic fields can manipulate cells through two different methods: positive magnetophoresis and negative magnetophoresis. Positive magnetophoresis is a way of imparting magnetic properties to cells by labeling them with magnetic nanoparticles. Negative magnetophoresis is a label-free principle-based method. 3D cell structures, such as spheroids, 3D network structures, and cell sheets, have been successfully fabricated using this acoustic and magnetic stimuli-based 3D cell culture platform. Additionally, fabricated 3D cell structures showed enhanced cell behavior, such as differentiation potential and tissue regeneration. Therefore, physical

stimuli-based 3D cell culture platforms could be promising tools for tissue engineering. https://doi.org/10.1007/s13770-023-00539-8

Proof of Concept of an ELF Magnetic Field Exposure System with Biphasic Magnetic Pulses: Effects on Human Dermal Fibroblast Proliferation,

VIVES L. A., M. IELPI, M. T. SOSA, M. RISK and O. PATINO,

Ieee Latin America Transactions 21, no. 1 (Jan 2023): 175-180,

The aim of this work was to validate the usefulness of an Extremely Low Frequency (ELF) magnetic field exposure system with a magnetotherapy device of common use in clinical practice that generates Biphasic Magnetic Pulses (BMP), in order to study the effects of the BMP on the proliferation of Human Dermal Fibroblasts (HDF). In that regard, HDF were exposed 2h in the morning and 2h in the afternoon for 2 days to BMP of 1.41mT peak value at 5, 10, 25Hz continuous and 50Hz intermittent (2s on/1.5s off). MTT assay was performed to assess proliferation. The 10Hz BMP showed a significant decrease in proliferation of 6.6% ($p = 0.001$) with respect to controls, but no significant changes in proliferation were seen with the other BMP. In order to analyze whether these results could be related to the exposure protocol, a 50Hz power line intermittent signal (1s on/ 1s off) was generated and tested but exposure time was increased to 48h to cover the complete cells doubling time. A significant increase in proliferation of 9% ($p < 0.001$) was found in this case. The results validate the in vitro exposure system for its use with the BMP. Though the MTT proliferation assay alone is not enough to make definitive claims, the results might indicate that exposure time plays a key role in the outcome of the experiments. Therefore, special attention should be paid to the exposure time on in vitro protocols and how they relate to in vivo experiments and current treatments. https://doi.org/10.1109/tla.2023.10015145

Moyens de prévention

An Out-of-Phase Wireless Power Transfer System for Implantable Medical Devices to Reduce Human Exposure to Electromagnetic Field and Increase Power Transfer Efficiency,

AHN J., S. WOO, H. KIM, K. SONG, S. HUH, S. E. HONG, J. KIM, H. D. CHOI and S. AHN,

Ieee Transactions on Biomedical Circuits and Systems 16, no. 6 (Dec 2022): 1166-1180,

For the wireless power transfer (WPT) system in implantable medical devices (IMDs), human tissue is positioned between the transmitting and receiving coils which are different from general WPT systems. Because this space is where the strongest electromagnetic field (EMF) occurs, it is essential to reduce the EMF at the interspace to reduce human exposure to the EMF. In this paper, an out-of-phase coupled WPT system for IMDs is proposed to reduce human exposure to EMF. Considering the EMF exposure and power transfer efficiency (PTE) of the proposed system, a design procedure for determining the phase difference of each capacitor is analyzed and presented. Based on the equivalent circuit model analysis of the proposed system, the EMF and PTE characteristics of the WPT system depending on the design variables are comprehensively analyzed. The proposed system is compared with conventional systems through simulation and measurements. It is verified that the proposed system can reduce the EMF by 41.05% and increase the PTE by 9.62% compared to the conventional system. In addition, through simulation, human exposure to EMFs is assessed considering the exposure environment and electrical properties of human tissues. As a result, the current density, induced electric field, and specific absorption rate were reduced by 44.10%, 38.90%, and 63.82%, respectively. https://doi.org/10.1109/tbcas.2022.3222011

Washable and breathable ultrathin copper-coated nonwoven polyethylene terephthalate (PET) fabric with chlorinated poly-para-xylylene (parylene-C) encapsulation for electromagnetic interference shielding application,
HU S., D. WANG, D. KREMANAKOVA and J. MILITKY,
Textile Research Journal (Electromagnetic interference shielding clothing has been developed for people who is sensitive to electromagnetic radiation or workers working under extremely high electromagnetic radiation circumstances. The challenge was developing the fabric with good washability, durability, and air permeability. After three machine washing cycles, the electromagnetic interference shielding effectiveness can drop more than 99% for untreated copper-coated fabric. In this research, the chlorinated poly-para-xylylene (parylene C) encapsulating technology was used to protect the fiber's copper particles. The result shows that the treated sample's washing ability will significantly improve after processing 15 g parylene-C on the copper-coated fabrics. The electromagnetic interference shielding effectiveness can remain at 39.93 dB and 25 dB on average from 30 MHz to 3 GHz after 10 hand washing cycles and 10 machine washing cycles, respectively. The air permeability remains around 1043.6 mm/s for a 15 g parylene-C encapsulated sample. The chemical resistance property was also improved significantly after encapsulation of 15 g parylene-C. For the 15 g parylene-C encapsulated samples, there is less than 3% loss of electromagnetic interference shielding effectiveness after 8 h of immersing into pH = 2 and pH = 12 solution. The overall structure of the 15 g parylene-C encapsulated fabric remains intact after 6000 abrasion cycles. The study presents an effective method for fabricating highly durable, comfortable electromagnetic interference shielding fabric, guaranteeing reliability for technical clothing applications and showing great potential for further development. https://doi.org/10.1177/00405175231168418