

Wissenschaft bestätigt Mobilfunk-Schäden

Studien über Schäden hochfrequenter elektromagnetischer Strahlung unterhalb von Grenzwerten

Referenzen zu Diagnose-Funk - Studienliste auf <http://studien.diagnose-funk.org>

(1) **Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes**

International Archives of Occupational and Environmental Health, Springer Berlin / Heidelberg Volume 81, Number 6 / May 2008, Pages 755-767

<http://lib.bioinfo.pl/pmid:18278508>

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UMTS

0,05; 0,1 SAR

OBJECTIVE: Universal Mobile Telecommunication System (UMTS) was recently introduced as the third generation mobile communication standard in Europe. This was done without any information on biological effects and genotoxic properties of these particular high-frequency electromagnetic fields. This is disconcerting, because genotoxic effects of the second generation standard Global System for Mobile Communication have been reported after exposure of human cells in vitro. **METHODS:** Human cultured fibroblasts of three different donors and three different short-term human lymphocyte cultures were exposed to 1,950 MHz UMTS below the specific absorption rate (SAR) safety limit of 2 W/kg. The alkaline comet assay and the micronucleus assay were used to ascertain dose and time-dependent genotoxic effects. Five hundred cells per slide were visually evaluated in the comet assay and comet tail factor (CTF) was calculated. In the micronucleus assay 1,000 binucleated cells were evaluated per assay. The origin of the micronuclei was determined by fluorescence labeled anticentromere antibodies. All evaluations were performed under blinded conditions. **RESULTS:** UMTS exposure increased the CTF and induced centromere-negative micronuclei (MN) in human cultured fibroblasts in a dose and time-dependent way. Incubation for 24 h at a SAR of 0.05 W/kg generated a statistically significant rise in both CTF and MN ($P = 0.02$). At a SAR of 0.1 W/kg the CTF was significantly increased after 8 h of incubation ($P = 0.02$), the number of MN after 12 h ($P = 0.02$). No UMTS effect was obtained with lymphocytes, either unstimulated or stimulated with Phytohemagglutinin. **CONCLUSION:** UMTS exposure may cause genetic alterations in some but not in all human cells in vitro.

(2) **Genotoxic effects of radiofrequency electromagnetic fields: Review**

Pathophysiology. 2009 Aug; 16(2-3):89-102.

<http://www.ntia.doc.gov/broadbandgrants/comments/71B9.pdf>

<http://www.ncbi.nlm.nih.gov/pubmed/19285841>

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101 publications are exploited which have studied genotoxicity of radiofrequency electromagnetic fields (RF-EMF) in vivo and in vitro. **Of these 49 report a genotoxic effect and 42 do not.** In addition, 8 studies failed to detect an influence on the genetic material, but showed that RF-EMF enhanced the genotoxic action of other chemical or physical agents.

The controversial results may in part be explained by the different cellular systems. Moreover, inconsistencies may depend from the variety of analytical methods being used, which differ considerably with respect to sensitivity and specificity. Taking altogether there is ample evidence that RF-EMF can alter the genetic material of exposed cells in vivo and in vitro and in more than one way. This genotoxic action may be mediated by microthermal effects in cellular structures, formation of free radicals, or an interaction with DNA-repair mechanisms.

(3) **Effects of 900 MHz GSM In Vitro Exposure on Gene Expression in Human Fibroblasts**

Davos Congress Center Davos, Switzerland, 2009 June 14 – 19,

<http://bioem2009.org/abstract-collection-pdf/>

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900 MHz GSM

0,4 and 1,0 SAR

RESULTS: We found that 24h electromagnetic field exposure affected the expression levels of BCL2, MAPKP38 e BDNF genes. In particular, BCL2 mRNA levels were reduced both at 0,4 and 1 W/kg (0.72 ± 0.2 , $p=0.039$ and 0.75 ± 0.27 , $p=0.022$ versus sham respectively), MAPK-P38 mRNA levels were reduced in stimulated group but only with a SAR of 0,4 W/kg (0.86 ± 0.14 , $p=0.025$ versus sham), whereas BDNF levels were negatively affected only with a dose of 1 W/kg. After 72 hours of exposure, we found that only BDNF mRNA levels were significant modulated, in particular, the dose of 1 W/kg caused a significant reduction (0.82 ± 0.18 , $p=0.019$ versus sham).

CONCLUSION: A reduction in the expression levels of some genes involved in cell stress response, neuronal differentiation and apoptosis processes were evidenced, at different SAR levels and exposure times, failing to put in evidence a dose-response trend. Further investigation are planned to better define possible effects of exposure to GSM electromagnetic fields on human fibroblasts.

(4) **Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes**

Bioelectromagnetics. 2009 Feb;30(2):129-141.

<http://www.ncbi.nlm.nih.gov/pubmed/18839414?dopt=Abstract>

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GSM, UMTS

0,037 SAR

Abstract: We have recently described frequency-dependent effects of mobile phone microwaves (MWs) of global system for mobile communication (GSM) on human lymphocytes from persons reporting hypersensitivity to electromagnetic fields and healthy persons. Contrary to GSM, universal global telecommunications system (UMTS) mobile phones emit wide-band MW signals. Hypothetically, UMTS MWs may result in higher biological effects compared to GSM signal because of eventual "effective" frequencies within the wideband. Here, we report for the first time that UMTS MWs affect chromatin and inhibit formation of DNA double-strand breaks co-localizing 53BP1/gamma-H2AX DNA repair foci in human lymphocytes from hypersensitive and healthy persons and confirm

that effects of GSM MWs depend on carrier frequency. Remarkably, the effects of MWs on 53BP1/gamma-H2AX foci persisted up to 72 h following exposure of cells, even longer than the stress response following heat shock. The data are in line with the hypothesis that the type of signal, UMTS MWs, may have higher biological efficiency and possibly larger health risk effects compared to GSM radiation emissions. No significant differences in effects between groups of healthy and hypersensitive subjects were observed, except for the effects of UMTS MWs and GSM-915 MHz MWs on the formation of the DNA repair foci, which were different for hypersensitive ($P < 0.02$ [53BP1]/ 0.01 [gamma-H2AX]) but not for control subjects ($P > 0.05$). The non-parametric statistics used here did not indicate specificity of the differences revealed between the effects of GSM and UMTS MWs on cells from hypersensitive subjects and more data are needed to study the nature of these differences.

(5) **Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons.**

Brain Res. 2009 Oct 29.

<http://www.ncbi.nlm.nih.gov/pubmed/19879861?dopt=Abstract>

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1800 MHz GSM modulated

average: 2 SAR

Abstract: Increasing evidence indicates that oxidative stress may be involved in the adverse effects of radiofrequency (RF) radiation on the brain. Because mitochondrial DNA (mtDNA) defects are closely associated with various nervous system diseases and mtDNA is particularly susceptible to oxidative stress, the purpose of this study was to determine whether radiofrequency radiation can cause oxidative damage to mtDNA. In this study, we exposed primary cultured cortical neurons to pulsed RF electromagnetic fields at a frequency of 1800 MHz modulated by 217 Hz at an average special absorption rate (SAR) of 2 W/kg. At 24 h after exposure, we found that RF radiation induced a significant increase in the levels of 8-hydroxyguanine (8-OHdG), a common biomarker of DNA oxidative damage, in the mitochondria of neurons. Concomitant with this finding, the copy number of mtDNA and the levels of mitochondrial RNA (mtRNA) transcripts showed an obvious reduction after RF exposure. Each of these mtDNA disturbances could be reversed by pretreatment with melatonin, which is known to be an efficient antioxidant in the brain. Together, these results suggested that 1800 MHz RF radiation could cause oxidative damage to mtDNA in primary cultured neurons. Oxidative damage to mtDNA may account for the neurotoxicity of RF radiation in the brain.

(6) **Mobile Phone Use and Risk of Tumors: Review**

J Clin Oncol. 2009 Oct 13

<http://www.ncbi.nlm.nih.gov/pubmed/19826127?dopt=Abstract>

Myung SK, Ju W, McDonnell DD, Lee YJ, Kazinets G, Cheng CT, Moskowitz JM.

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PURPOSE: Case-control studies have reported inconsistent findings regarding the association between mobile phone use and tumor risk. We investigated these associations using a meta-analysis. **METHODS:** We searched MEDLINE (PubMed), EMBASE, and the Cochrane Library in August 2008. Two evaluators independently reviewed and selected

articles based on predetermined selection criteria. **RESULTS:** Of 465 articles meeting our initial criteria, 23 case-control studies, which involved 37,916 participants (12,344 patient cases and 25,572 controls), were included in the final analyses. Compared with never or rarely having used a mobile phone, the odds ratio for overall use was 0.98 for malignant and benign tumors (95% CI, 0.89 to 1.07) in a random-effects meta-analysis of all 23 studies. However, a significant positive association (harmful effect) was observed in a random-effects meta-analysis of eight studies using blinding, whereas a significant negative association (protective effect) was observed in a fixed-effects meta-analysis of 15 studies not using blinding. Mobile phone use of 10 years or longer was associated with a risk of tumors in 13 studies reporting this association (odds ratio = 1.18; 95% CI, 1.04 to 1.34). Further, these findings were also observed in the subgroup analyses by methodologic quality of study. Blinding and methodologic quality of study were strongly associated with the research group. **CONCLUSION:** The current study found that there is possible evidence linking mobile phone use to an increased risk of tumors from a meta-analysis of low-biased case-control studies. Prospective cohort studies providing a higher level of evidence are needed.

(7) Pathophysiology of cell phone radiation: oxidative stress and carcinogenesis with focus on male reproductive system: Review

Reproductive Biology and Endocrinology **2009** Aug 13, **7**:114

<http://www.rbej.com/content/7/1/114>

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Conclusion:

We have reviewed the literature to better understand the effects of cell phone radiation on human health, especially on fertility and in relation to cancer. Commercially available cellular phones might affect cell function via non-thermal effects. We hypothesized that the plasma membrane might be the target of cell phone radiation. RF-EMW can increase ROS formation by increasing the activity of plasma membrane NADH oxidase. Prolonged exposure to RF-EMW can also cause DNA damage (by prolonged OS), which may accelerates neuronal and spermatozoal cell death and promote neurodegenerative processes as well as promote brain and testicular carcinogenesis. Any tumor promoting effects of RF-EMW might be due to the effect it has on PKC, ODC, intra cellular calcium spikes and stimulation of stress kinase. Stimulation of plasma membrane NADH oxidase might play central role in above mentioned effects.

OS and changes in PKC activity might lead to the RF-EMW related infertility observed in numerous studies. Hence, RF-EMW from commercially available cell phones might affect the fertilizing potential of spermatozoa. Therefore, the SAR limit (maximum acceptable exposure limit) should be lowered for cellular phones. However, more studies are necessary to provide definitive evidence against cell phone radiation, which can be provided by in vitro studies combined with computational biomodeling.

(8) Epidemiological evidence for an association between use of wireless phones and tumor diseases:

Meta - Analyse von Studien

Pathophysiology. **2009** Aug;16(2-3):113-22

<http://www.ncbi.nlm.nih.gov/pubmed/19268551?dopt=Abstract>

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Handy

Abstract: During recent years there has been increasing public concern on potential cancer risks from microwave emissions from wireless phones. We evaluated the scientific evidence for long-term mobile phone use and the association with certain tumors in case-control studies, mostly from the Hardell group in Sweden and the Interphone study group. Regarding brain tumors the meta-analysis yielded for glioma odds ratio (OR)=1.0, 95% confidence interval (CI)=0.9-1.1. OR increased to 1.3, 95% CI=1.1-1.6 with 10 year latency period, with highest risk for ipsilateral exposure (same side as the tumor localisation), **OR=1.9**, 95% CI=1.4-2.4, lower for contralateral exposure (opposite side) OR=1.2, 95% CI=0.9-1.7. Regarding acoustic neuroma OR=1.0, 95% CI=0.8-1.1 was calculated increasing to OR=1.3, 95% CI=0.97-1.9 with 10 year latency period. For ipsilateral exposure **OR=1.6**, 95% CI=1.1-2.4, and for contralateral exposure OR=1.2, 95% CI=0.8-1.9 were found. Regarding meningioma no consistent pattern of an increased risk was found. Concerning age, highest risk was found in the age group <20 years at time of first use of wireless phones in the studies from the Hardell group. For salivary gland tumors, non-Hodgkin lymphoma and testicular cancer no consistent pattern of an association with use of wireless phones was found. One study on uveal melanoma yielded for probable/certain mobile phone use **OR=4.2**, 95% CI=1.2-14.5. One study on intratemporal facial nerve tumor was not possible to evaluate due to methodological shortcomings. **In summary our review yielded a consistent pattern of an increased risk for glioma and acoustic neuroma after >10 year mobile phone use. We conclude that current standard for exposure to microwaves during mobile phone use is not safe for long-term exposure and needs to be revised.**

(9) Oxidative damage in the kidney induced by 900-MHz-emitted mobile phone: protection by melatonin

Arch Med Res. 2005 Jul-Aug;36(4):350-5.

<http://www.ncbi.nlm.nih.gov/pubmed/15950073>

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900 MHz

10,4 W/m²

BACKGROUND: The mobile phones emitting 900-MHz electromagnetic radiation (EMR) may be mainly absorbed by kidneys because they are often carried in belts. Melatonin, the chief secretory product of the pineal gland, was recently found to be a potent free radical scavenger and antioxidant. The aim of this study was to examine 900-MHz mobile phone-induced oxidative stress that promotes production of reactive oxygen species (ROS) on renal tubular damage and the role of melatonin on kidney tissue against possible oxidative damage in rats. **METHODS:** The animals were randomly grouped as follows: 1) sham-operated control group and 2) study groups: i) 900-MHz EMR exposed (30 min/day for 10 days) group and ii) 900-MHz EMR exposed+melatonin (100 microg kg(-1) s.c. before the daily EMR exposure) treated group. Malondialdehyde (MDA), an index of lipid peroxidation, and urine N-acetyl-beta-d-glucosaminidase (NAG), a marker of renal tubular damage were used as markers of oxidative stress-induced renal impairment. Superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) activities were studied to evaluate the changes of antioxidant status. **RESULTS:** In the EMR-exposed group, while tissue MDA and urine NAG levels increased, SOD, CAT, and GSH-Px activities were reduced. Melatonin

treatment reversed these effects as well. In this study, the increase in MDA levels of renal tissue and in urine NAG and also the decrease in renal SOD, CAT, GSH-Px activities demonstrated the role of oxidative mechanism induced by 900-MHz mobile phone exposure, and melatonin, via its free radical scavenging and antioxidant properties, ameliorated oxidative tissue injury in rat kidney. **CONCLUSIONS:** These results show that melatonin may exhibit a protective effect on mobile phone-induced renal impairment in rats.

(10) **Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies**

Biochem J. 2007 Aug 1;405(3):559-68

<http://www.ncbi.nlm.nih.gov/pubmed/17456048>

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GSM

700.000 MicroW/m²

Abstract: The exposure to non-thermal microwave electromagnetic fields generated by mobile phones affects the expression of many proteins. This effect on transcription and protein stability can be mediated by the MAPK (mitogen-activated protein kinase) cascades, which serve as central signalling pathways and govern essentially all stimulated cellular processes. Indeed, long-term exposure of cells to mobile phone irradiation results in the activation of p38 as well as the ERK (extracellular-signal-regulated kinase) MAPKs. In the present study, we have studied the immediate effect of irradiation on the MAPK cascades, and found that ERKs, but not stress-related MAPKs, are rapidly activated in response to various frequencies and intensities. Using signalling inhibitors, we delineated the mechanism that is involved in this activation. We found that the first step is mediated in the plasma membrane by NADH oxidase, which rapidly generates ROS (reactive oxygen species). These ROS then directly stimulate MMPs (matrix metalloproteinases) and allow them to cleave and release Hb-EGF [heparin-binding EGF (epidermal growth factor)]. This secreted factor activates the EGF receptor, which in turn further activates the ERK cascade. Thus this study demonstrates for the first time a detailed molecular mechanism by which electromagnetic irradiation from mobile phones induces the activation of the ERK cascade and thereby induces transcription and other cellular processes.

(11) **The effects of electromagnetic fields on peripheral blood mononuclear cells in vitro**

Bratisl Lek Listy. 2009;110(9):526-9

<http://www.ncbi.nlm.nih.gov/pubmed/19827334?dopt=Abstract>

Atasoy A, Sevim Y, Kaya I, Yilmaz M, Durmus A, Sonmez M, Omay SB, Ozdemir F, Ovali E

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900, 1784 MHz

48,3 V/m => 6,188 W/m²

OBJECTIVE: A discussion about the adverse effects of electromagnetic waves on the biological life has been ongoing since the discovery of electricity in the 19th century.
MATERIALS AND METHODS: The primary objective of this study was to analyze the changes in the cell viability, rates of apoptosis, proliferation indices and the cell surface antigenic structures resulting from 2-, 6- and 24-hour exposure of mononuclear cells isolated from the peripheral blood to 450, 900 and 1784 MHz electromagnetic waves.
RESULTS: Data obtained showed that electromagnetic waves didn't have any effect on the

cell viability, rates of apoptosis and proliferation index. While electromagnetic waves didn't affect the HLADR and CD11b expression in the peripheral blood mononuclear cells, they decreased the CD11a expression and increased the CD49d expression.

CONCLUSION: These data suggest that electromagnetic signals could affect the functional capacity of the peripheral blood mononuclear cells by changing their adhesion ability.

Maybe these alterations are the sign of the immune system modulation. More comprehensive studies are needed, involving higher number and more lines of cells.

(12) **Blood-brain barrier permeability and nerve cell damage in rat brain 14 and 28 days after exposure to microwaves from GSM mobile phones.**

Electromagn Biol Med. 2008;27(3):215-229.

<http://www.ncbi.nlm.nih.gov/pubmed/18821198>

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GSM 900 MHz

0,00012; 0,0012; 0,012; 0,120 SAR

Abstract: We investigated the effects of global system for mobile communication (GSM) microwave exposure on the permeability of the blood-brain barrier and signs of neuronal damage in rats using a real GSM programmable mobile phone in the 900 MHz band. Ninety-six non-anaesthetized rats were either exposed to microwaves or sham exposed in TEM-cells for 2 h at specific absorption rates of average whole-body Specific Absorption Rates (SAR) of 0.12, 1.2, 12, or 120 mW/kg. The rats were sacrificed after a recovery time of either 14 or 28 d, following exposure and the extravasation of albumin, its uptake into neurons, and occurrence of damaged neurons was assessed. Albumin extravasation and also its uptake into neurons was seen to be enhanced after 14 d (Kruskal Wallis test: $p = 0.02$ and 0.002 , respectively), but not after a 28 d recovery period. The occurrence of dark neurons in the rat brains, on the other hand, was enhanced later, after 28 d ($p = 0.02$). Furthermore, in the 28-d brain samples, neuronal albumin uptake was significantly correlated to occurrence of damaged neurons (Spearman $r = 0.41$; $p < 0.01$).

(13) **Increased blood-brain barrier permeability in mammalian brain 7 days after exposure to the radiation from a GSM-900 mobile phone**

Pathophysiology. 2009 Aug; 16(2-3):103-12.

<http://www.ncbi.nlm.nih.gov/pubmed/19345073?dopt=Abstract>

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GSM 900 MHz

0,12 SAR

Abstract: Microwaves were for the first time produced by humans in 1886 when radio waves were broadcasted and received. Until then microwaves had only existed as a part of the cosmic background radiation since the birth of universe. By the following utilization of microwaves in telegraph communication, radars, television and above all, in the modern mobile phone technology, mankind is today exposed to microwaves at a level up to 10(20) times the original background radiation since the birth of universe. Our group has earlier shown that the electromagnetic radiation emitted by mobile phones alters the permeability of the blood-brain barrier (BBB), resulting in albumin extravasation immediately and 14 days after 2h of exposure. In the background section of this report, we present a thorough review of the literature on the demonstrated effects (or lack of effects) of microwave

exposure upon the BBB. Furthermore, we have continued our own studies by investigating the effects of GSM mobile phone radiation upon the blood-brain barrier permeability of rats 7 days after one occasion of 2h of exposure. Forty-eight rats were exposed in TEM-cells for 2h at non-thermal specific absorption rates (SARs) of 0mW/kg, 0.12mW/kg, 1.2mW/kg, 12mW/kg and 120mW/kg. Albumin extravasation over the BBB, neuronal albumin uptake and neuronal damage were assessed. Albumin extravasation was enhanced in the mobile phone exposed rats as compared to sham controls after this 7-day recovery period (Fisher's exact probability test, $p=0.04$ and Kruskal-Wallis, $p=0.012$), at the SAR-value of 12mW/kg (Mann-Whitney, $p=0.007$) and with a trend of increased albumin extravasation also at the SAR-values of 0.12mW/kg and 120mW/kg. There was a low, but significant correlation between the exposure level (SAR-value) and occurrence of focal albumin extravasation ($r(s)=0.33$; $p=0.04$). The present findings are in agreement with our earlier studies where we have seen increased BBB permeability immediately and 14 days after exposure. We here discuss the present findings as well as the previous results of altered BBB permeability from our and other laboratories.

(14) **Cranial and postcranial skeletal variations induced in mouse embryos by mobile phone radiation**

Pathophysiology. 2009 Oct 23.

<http://www.ncbi.nlm.nih.gov/pubmed/19854628?dopt=Abstract>

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Handy

Abstract: This study focuses on foetal development following mild daily exposure of pregnant mice to near field electromagnetic radiation emitted by a mobile phone. The investigation was motivated by the fact that the potentially hazardous electromagnetic radiation emitted by mobile phones is currently of tremendous public interest. Physically comparable pregnant mice were exposed to radiofrequency radiation GSM 900MHz emitted by a mobile phone. Within 5h after birth most cubs were fixed followed by double staining in toto, and conventional paraffin histology. Other cubs remained with their mothers until teeth eruption. Structural development was assessed by examining newborns for the presence of anomalies and/or variations in soft tissues and skeletal anatomy. Electromagnetic radiofrequency exposed newborns, externally examined, displayed a normal phenotype. Histochemical and histological studies, however, revealed variations in the exposed fetuses with respect to control ones concerning the ossification of cranial bones and thoracic cage ribs, as well as displacement of Meckelian cartilage. Littermates examined after teeth eruption displayed normal phenotypes. It is concluded that mild exposure to mobile phone radiation may affect, although transiently, mouse foetal development at the ossification level. The developmental variations observed could be explained by considering the different embryonic origin and mode of ossification of the affected skeletal elements.

(15) **The effects of microwave emitted by cellular phones on ovarian follicles in rats**

Arch Gynecol Obstet. 2009 Nov; 280(5):729-33.

<http://www.ncbi.nlm.nih.gov/pubmed/19241083?dopt=Abstract>

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Handy

OBJECTIVE: The aim of this study was to investigate whether there were any toxic effects of microwaves of cellular phones on ovaries in rats. **METHODS:** In this study, 82 female pups of rats, aged 21 days (43 in the study group and 39 in the control group) were used. Pregnant rats in the study group were exposed to mobile phones that were placed beneath the polypropylene cages during the whole period of pregnancy. The cage was free from all kinds of materials, which could affect electromagnetic fields. A mobile phone in a standby position for 11 h and 45 min was turned on to speech position for 15 min every 12 h and the battery was charged continuously. On the 21st day after the delivery, the female rat pups were killed and the right ovaries were removed. The volumes of the ovaries were measured and the number of follicles in every tenth section was counted. **RESULTS:** The analysis revealed that in the study group, the number of follicles was lower than that in the control group. The decreased number of follicles in pups exposed to mobile phone microwaves suggest that intrauterine exposure has toxic effects on ovaries. **CONCLUSION:** We suggest that the microwaves of mobile phones might decrease the number of follicles in rats by several known and, no doubt, countless unknown mechanisms.

(16) **Precautions suggested for the use of cell phones, especially for embryos and children, based on a series of bio-electromagnetic experiments**

1st HELLENIC CONGRESS - THE EFFECTS OF ELECTROMAGNETIC RADIATION,
Thessalonica, 24-25 May 2008

http://multimedia.biol.uoa.gr/2008/Seminaria_Diplwmatikes%20k.a/Synedrio_Thess/t_hesaloniki-emf-2008-proceedings-12-05-08-TELIKOeng.pdf

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9350 MHz

50.000 $\mu\text{W}/\text{m}^2$, 88.000 $\mu\text{W}/\text{m}^2$

Abstract: During the last twenty years, a series of experimental works carried out on various experimental animals (mice, rats, quails and chicken) for comparative reasons, to show the sensitivity of their embryos to the radiofrequency radiation. These works were performed and published in cooperation with Prof. Th. Xenos (Department of Electrical and Computer Engineering, A.U.Th).

The first experimental study that took place, about 20 years ago, around the "antenna park" of Hortiatis, arose strong indications on the potential adverse effects from the non ionizing radio-frequency radiation on the prenatal development of the experimental mice. Twelve pairs of mice were placed in locations of different power densities of 168-1053 nW/cm² and repeatedly mated five times. The 118 collected newborns were examined macro- and microscopically. A progressive decrease in the number of newborns per dam was observed, which ended in irreversible infertility. These results were strong indication of the embryotoxicity from radio-frequency radiation sources. The "experiment of Hortiatis", performed in situ, was attended by a series of experimental studies in labo. Some of them are presenting following in brief: (a) Two groups of 12 pregnant rats were continuously irradiated to non thermal pulsed microwaves, to a power density of 5.0 $\mu\text{W}/\text{cm}^2$, at 9.35 GHz. The first group was irradiated during 1st-3rd day after fertilization and the second during 4th-9th day of the gestation. The 58 % of the dams of the first group and 50 % of the second did not give birth. The uteri of these dams presented traces of embryonic absorption. These results support the aspect that very low power density microwaves, applied in pregnant rats, during embryogenesis and organogenesis, may cause adverse effects on their embryos. (b) Six groups of 40 quail embryos, in ovo, were exposed to

different degrees of low power radio-waves radiation at 95 MHz, during the first three incubation days. A 17.91 % of embryonic and fetal deaths were observed among the exposed embryos, in relation to a 3.33 % among the controls. (c) Sixty quail embryos, in ovo, were exposed to a very low power density of 5.0 $\mu\text{W}/\text{cm}^2$ pulse modulated microwave radiation, at 9.31 GHz, during the three incubation days. An abnormally high rate of embryonic and fetal deaths (65 %) was observed among the exposed embryos, in relation to 11.7 % among the controls. (d) Three groups of 54 chicken embryos, in ovo, were exposed, for 16 hours daily, to non thermal low power densities, at 95 MHz, of VHF radio-waves during 3rd-10th day of incubation (the first group in power densities of 30 $\mu\text{W}/\text{cm}^2$ and the second and third group 150 mW/cm^2). Embryonic deaths and congenital malformations have been observed, 27.7 % in the first group, 33.3 % in the second and 38.8 % in the third, instead of 1.7 % in the control group. (e) 380 chicken embryos, in ovo, were exposed to non-thermal very low power density radiation of 8.8 $\mu\text{W}/\text{cm}^2$ at 9.152 GHz (172 embryos in pulse modulated and 208 in non-modulated microwaves), during 3rd-10th incubation day. Developmental retardation, grave malformations, stillborns, embryonic deaths and fetal deaths were found in 62.78 % of the first group, 47.12 % of the second and only 3.44 % of the controls. These results supported the aspect that very low power density microwaves, applied to chicken embryos, in ovo, during organogenesis, cause abnormal development. The high sensitivity of the mouse, rat, chicken and quail embryos to the low power density microwaves is a strong indication of corresponding high sensitivity of higher mammalian or human embryos, because of their similarities on the initial stages of their prenatal development. According to the results from our experimental studies, as well as to the precautionary principle, every possible precaution from the radiofrequency radiation, as those of the cell phones, is suggested for the human embryos as well as for the children.

(17) **Preliminary Study on the Induction of Sperm Head Abnormalities in Mice, *Mus musculus*, Exposed to Radiofrequency Radiations from Global System for Mobile Communication Base Stations**

Bull Environ Contam Toxicol. 2009 Oct 9.

<http://www.ncbi.nlm.nih.gov/pubmed/19816647?dopt=Abstract>

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Basisstation

0,7 V/m => 0,001 W/m²

Abstract: The exposure of male mice to radiofrequency radiations from mobile phone (GSM) base stations at a workplace complex and residential quarters caused 39.78 and 46.03%, respectively, in sperm head abnormalities compared to 2.13% in control group. Statistical analysis of sperm head abnormality score showed that there was a significant ($p < 0.05$) difference in occurrence of sperm head abnormalities in test animals. The major abnormalities observed were knobbed hook, pin-head and banana-shaped sperm head. The occurrence of the sperm head abnormalities was also found to be dose dependent. The implications of the observed increase occurrence of sperm head abnormalities on the reproductive health of humans living in close proximity to GSM base stations were discussed.

(18) **Mobile Phone Radiation Induces Reactive Oxygen Species Production and DNA Damage in Human Spermatozoa In Vitro**

PLoS One. 2009 Jul 31;4(7):e6446

<http://www.plosone.org/article/info:doi/10.1371/journal.pone.0006446>

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GMS 1800 MHz

1,0 SAR

Principal Findings

Purified human spermatozoa were exposed to radio-frequency electromagnetic radiation (RF-EMR) tuned to 1.8 GHz and covering a range of specific absorption rates (SAR) from 0.4 W/kg to 27.5 W/kg. In step with increasing SAR, motility and vitality were significantly reduced after RF-EMR exposure, while the mitochondrial generation of reactive oxygen species and DNA fragmentation were significantly elevated ($P < 0.001$). Furthermore, we also observed highly significant relationships between SAR, the oxidative DNA damage biomarker, 8-OH-dG, and DNA fragmentation after RF-EMR exposure.

Results

High quality spermatozoa selected in discontinuous Percoll gradients displayed a decline in both vitality and motility after exposure to RF-EMR in a dose-dependent manner. The control populations maintained an average vitality of 89%; however, significant reductions in vitality were observed at exposure levels as low as 1.0 W/kg ($p < 0.01$) (Figure 2A). Similarly, the control populations maintained motilities at an average of 86% over the incubation period, however after exposure to RF-EMR at levels of 1.0 W/kg, motility was observed to significantly decrease to 68% ($p < 0.05$) and decreased still further at higher SAR exposures (Figure 2B).

Conclusions

RF-EMR in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring.

(19) Radio frequency electromagnetic radiation(RF-EMR) from GSM(0.9/1.8GHz) mobile phones induces oxidative stress and reduces sperm motility in rats

CLINICS 2009; 64(6):561-5

<http://www.scielo.br/pdf/clin/v64n6/11.pdf>

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Handy

DISCUSSION

In the present study, we have tested the hypothesis that RF-EMR from mobile phones results in oxidative stress and decreases semen quality. We found a striking reduction in the percentage of motile sperm in rats exposed to RF-EMR, as well as a significantly elevated LPO and decreased GSH content in the testis and epididymis.

Several recent epidemiological studies have investigated the effects of RF-EMR from mobile phones on the human body, but results to date have been contradictory and inconclusive. Furthermore, these studies have not addressed questions regarding the thermal effects of mobile phone exposure. Many researchers believe that the effects of mobile phone exposure may be due to the cumulative effects of the heat generated and the RF-EMR emitted from mobile phone; others have suggested that the contribution of the non-thermal component is minimal and that the effects of mobile phone exposure would be negligible if the thermal effect could be eliminated. Certainly, it is widely accepted that temperature increases adversely affect sperm maturity and motility. In the present study, we excluded temperature effects by keeping the mobile phone in a smaller cage within the home cage. Furthermore, animals were allowed to move freely within the home cage in order to reduce their contact with the phone, and both cages were kept in well-ventilated rooms throughout the experiment to further reduce the possibility of heating. Finally, to confirm the lack of thermal effect, we measured the facial temperatures of rats in both groups both before and after exposure to the phone. After 1 hour of exposure, the mean facial temperature did not differ significantly from the initial temperature in either group. This experimental design eliminated mechanical heat influence from the phone and allowed us to conclude that RF-EMR alone affected the reproductive tissue.

Oxidative stress is also a well-established cause of male infertility. Reactive oxygen species (ROS) from spermatozoa and infiltrating leukocytes cause infertility principally by affecting sperm motility. Spermatozoa possess a multiple plasma membrane redox system that is similar to the transmembrane NADH oxidase. NADH oxidase activity is a major source of superoxide anions and, interestingly, RF-EMR has been shown to stimulate NADH oxidase in the plasma membrane of mammalian cells. Normally, ROS is kept at physiologically low levels by intracellular free radical scavengers. GSH, a major thiol in living organisms, is one such scavenger, and plays a central role in coordinating the body's antioxidant defense mechanisms against free radicals. Conditions that perturb intracellular glutathione levels result in significantly altered cellular metabolism. Tissue GSH reflects tissues ability to detoxify, preserve the proper cellular redox balance, and protect cells. GSH also probably plays a role in sperm nucleus condensation and spindle microtubule formation. The depletion of GSH in RF-EMR exposed animals observed here supports our hypothesis that elevated ROS is responsible for low percentages of motile sperm. Similar findings were reported for human ejaculate exposed to RF-EMR from a mobile phone. We also believe that RF-EMR induces oxidative stress that affects testicular function and structure in rabbits exposed to mobile phones. Our study validates recent observational studies showing that mobile phone use may play a role in male infertility. Further research will be required to understand the long-term effects of mobile phone use.

(20) **Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations**

Occup Environ Med. 2006 May; 63(5):307-13.

<http://www.ncbi.nlm.nih.gov/pubmed/16621850?dopt=Abstract>

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Basestation

0,04 mW/m²; 0,23 mW/m²; 1,3 mW/m²

BACKGROUND: The erection of mobile telephone base stations in inhabited areas has raised concerns about possible health effects caused by emitted microwaves. **METHODS:** In

a cross-sectional study of randomly selected inhabitants living in urban and rural areas for more than one year near to 10 selected base stations, 365 subjects were investigated. Several cognitive tests were performed, and wellbeing and sleep quality were assessed. Field strength of high-frequency electromagnetic fields (HF-EMF) was measured in the bedrooms of 336 households. **RESULTS:** Total HF-EMF and exposure related to mobile telecommunication were far below recommended levels (max. 4.1 mW/m²). Distance from antennae was 24-600 m in the rural area and 20-250 m in the urban area. Average power density was slightly higher in the rural area (0.05 mW/m²) than in the urban area (0.02 mW/m²). **Despite the influence of confounding variables, including fear of adverse effects from exposure to HF-EMF from the base station, there was a significant relation of some symptoms to measured power density; this was highest for headaches.** Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels. There was no significant effect on sleep quality. **CONCLUSION:** Despite very low exposure to HF-EMF, effects on wellbeing and performance cannot be ruled out, as shown by recently obtained experimental results; however, mechanisms of action at these low levels are unknown.

(21) **Neurobehavioral effects among inhabitants around mobile phone base stations**

Neurotoxicology. 2007 Mar; 28(2):434-40

<http://www.ncbi.nlm.nih.gov/pubmed/16962663>

Abdel-Rassoul G, El-Fateh OA, Salem MA, Michael A, Farahat F, El-Batanouny M, Salem E. Community, Environmental and Occupational Medicine Department, Faculty of Medicine, Menoufiya University, Shebin El-Kom, Egypt. gaafar17@yahoo.com

Basestation

0,02 W/m²

BACKGROUND: There is a general concern on the possible hazardous health effects of exposure to radiofrequency electromagnetic radiations (RFR) emitted from mobile phone base station antennas on the human nervous system. **AIM:** To identify the possible neurobehavioral deficits among inhabitants living nearby mobile phone base stations. **METHODS:** A cross-sectional study was conducted on (85) inhabitants living nearby the first mobile phone station antenna in Menoufiya governorate, Egypt, 37 are living in a building under the station antenna while 48 opposite the station. A control group (80) participants were matched with the exposed for age, sex, occupation and educational level. All participants completed a structured questionnaire containing: personal, educational and medical histories; general and neurological examinations; neurobehavioral test battery (NBTB) [involving tests for visuomotor speed, problem solving, attention and memory]; in addition to Eysenck personality questionnaire (EPQ). **RESULTS:** The prevalence of neuropsychiatric complaints as headache (23.5%), memory changes (28.2%), dizziness (18.8%), tremors (9.4%), depressive symptoms (21.7%), and sleep disturbance (23.5%) were significantly higher among exposed inhabitants than controls: (10%), (5%), (5%), (0%), (8.8%) and (10%), respectively (P<0.05). **The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory [Paced Auditory Serial Addition Test (PASAT)].** Also, the inhabitants opposite the station exhibited a lower performance in the problem solving test (block design) than those under the station. All inhabitants exhibited a better performance in the two tests of visuomotor speed (Digit symbol and Trailmaking B) and one test of attention (Trailmaking A) than controls. The last available measures of RFR emitted from the first mobile phone base station antennas in Menoufiya governorate were less than the allowable standard level. **CONCLUSIONS AND RECOMMENDATIONS:** **Inhabitants living nearby mobile phone base stations are at risk for developing neuropsychiatric problems and some changes in the performance of neurobehavioral**

functions either by facilitation or inhibition. So, revision of standard guidelines for public exposure to RER from mobile phone base station antennas and using of NBTB for regular assessment and early detection of biological effects among inhabitants around the stations are recommended.

- (22) Am 2. September 2004 liess **Swisscom** eine Erfindung international patentieren, welche bei drahtlosen Computer- Netzwerken vom Typ WLAN den Elektrosmog reduzieren soll: „ Es war somit möglich darzulegen, **dass Mobilfunkstrahlen das Erbmaterial schädigen kann**. Insbesondere bei weißen Blutzellen, bei welchen nicht nur die DNA sondern auch die Anzahl der Chromosomen verändert wurden. Diese Mutation kann folglich zu einem **erhöhten Krebsrisiko führen**. Ebenfalls konnte nachgewiesen werden, dass insbesondere diese Zerstörung nicht von der Erhöhung der Temperatur abhängig ist, d.h. **nicht-thermischen Ursprungs** ist.“

WLAN

Quelle: Patentamt

- (23) **Untersuchung athermischer Wirkungen elektromagnetischer Felder im Mobilfunkbereich**

Forschungsbericht 2009 (ATHEM)

Auftraggeber und Finanzierung: Allgemeine Unfallversicherungsanstalt (AUVA), Wien

Medizinische Universität Wien

Seibersdorf Labor GmbH

Mosgöller

0,1 SAR

Untersuchungen am Menschen

Bei den Untersuchungen an gesunden menschlichen Probanden wurden Auswirkungen von Feldern des GSM-900 und der UMTS-Technologie doppelblind untersucht, durchwegs bei Feldstärken unterhalb der aktuellen Grenzwerte. Einige Ergebnisse bestätigten internationale Untersuchungen; andere waren neu, die wichtigsten sind:

- Zunehmende Veränderungen des **EEG im Alpha-Spektrum**.
- Es war der Effekt ab ca. 5-10 Minuten Exposition, und
- **50 Minuten nach Ende** der Exposition feststellbar.
 - Unter Exposition fand sich eine **schnellere Reaktionszeit**, allerdings auf Kosten der Richtigkeit von Entscheidungen; es fielen insbesondere die Reaktionszeiten **bei falschen** Antworten etwas kürzer aus.

Die Untersuchungen zeigten, dass Reaktionen des Zentralnervensystems auf die Exposition mit schwachen Mikrowellen (0,1 W/kg oder 1 W/kg), wie sie beim Mobilfunk auftreten, möglich sind und die Veränderungen sogar nach Expositionsende anhalten. Die Bedeutung der Befunde liegt aber darüber hinaus darin, dass die Effekte, bei Annahme von nur thermischen Wirkungen - und darauf beruhen die derzeit geltenden Grenzwerte - gar nicht auftreten dürften.

Somit sind diese Effekte ein weiterer Beweis der Existenz athermischer Wirkungen.

Untersuchungen von Proteinen

Für Experimente zur Proteom-Analyse kamen teilweise die gleichen Zellen (Bindegewebszellen und Lymphozyten) wie bei früheren Untersuchungen zu DNA-Schäden zur Anwendung [Diem, et al., Mutation Research, 583, 178-183, (2005); REFLEX, European Union ProjectQLK4-CT-1999-01574, <http://www.verum-foundation.de>, (2004); Schwarz et al., Int.Arch.Occup.Environ.Health 81:755-767, (2008)].

Es bestätigte sich die Annahme, dass es empfindliche und unempfindliche Zellen gibt. Bei den Bindegewebszellen wurden strahlenbedingte Effekte gezeigt, die bei den Lymphozyten

nicht deutlich auftraten. Im Gegensatz zu früheren Untersuchungen wurde nicht nur die Proteinmenge in der Zelle untersucht, sondern die Neubildungsaktivität (Synthese) unter Exposition.

Dabei wurde erstmalig gezeigt, dass die Exposition zu Mobilfunkstrahlen eine deutliche Veränderung im Proteinsynthese-Profil bewirkt. Die gefundenen Effekte sind bei der Exposition mit SAR 2 W/kg reproduzierbar und statistisch hoch signifikant, sie treten bereits bei einer SAR von 0,1 W/kg auf, also bereits bei niedrigen Feldstärken. Die Aktivierung der Proteinsynthese ist ca. 4 Stunden nach Expositionsbeginn messbar vorhanden. Da die Erwärmung von der Anlage konstant gehalten und aufgezeichnet wurde, und in dieser Zeitspanne keine erfassbaren Temperatur Veränderungen auftraten, schließt dies ebenfalls einen thermischen Effekt aus, zumal die Temperaturerhöhung in den bestrahlten Proben extrem niedrig war. Die erhöhte Syntheserate bildet sich nach Expositions-Ende innerhalb von 2 Stunden zurück, die Proteinsynthese erreicht dann den normalen Zustand. Eine Dynamik, die ebenfalls mit „thermischen“ Wirkungen kaum erklärbar ist.

(24) **Survey study of people living in the vicinity of cellular phone base stations.**

Epidemiologische Studie

Electromagn Biol Med **2003**; 22 (1): 41 - 49

<http://www.informaworld.com/smpp/content~content=a713628949>

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France

Basestation

Abstract

A survey study was conducted, using a questionnaire, on 530 people (270 men, 260 women) living or not in proximity to cellular phone base stations. Eighteen different symptoms (Non Specific Health Symptoms-NSHS), described as radiofrequency sickness, were studied by means of the chi-square test with Yates correction. The results that were obtained underline that certain complaints are experienced only in the immediate vicinity of base stations (up to 10 m for nausea, loss of appetite, visual disturbances), and others at greater distances from base stations (up to 100 m for irritability, depressive tendencies, lowering of libido, and up to 200 m for headaches, sleep disturbances, feeling of discomfort). In the 200 m to 300 m zone, only the complaint of fatigue is experienced significantly more often when compared with subjects residing at more than 300 m or not exposed (reference group). For seven of the studied symptoms and for the distance up to 300 m, the frequency of reported complaints is significantly higher ($P < 0.05$) for women in comparison with men. Significant differences are also observed in relation to the ages of subjects, and for the location of subjects in relation to the antennas and other electromagnetic factors.

(25) **Mobile telephone use is associated with changes in cognitive function in young adolescents.** Epidemiologische Studie.

Bioelectromagnetics. **2009** Dec;30(8):678-86.

<http://www.ncbi.nlm.nih.gov/pubmed/19644978>

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Handy

Abstract: As part of the Mobile Radiofrequency Phone Exposed Users' Study (MoRPhEUS), a cross-sectional epidemiological study examined cognitive function in secondary school students. We recruited 317, 7th grade students (144 boys, 173 girls, median age 13 years) from 20 schools around Melbourne, Australia. Participants completed an exposure questionnaire based on the Interphone study, a computerised cognitive test battery, and the Stroop colour-word test. The principal exposure metric was the total number of reported mobile phone voice calls per week. Linear regression models were fitted to cognitive test response times and accuracies. Age, gender, ethnicity, socio-economic status and handedness were fitted as covariates and standard errors were adjusted for clustering by school. The accuracy of working memory was poorer, reaction time for a simple learning task shorter, associative learning response time shorter and accuracy poorer in children reporting more mobile phone voice calls. There were no significant relationships between exposure and signal detection, movement monitoring or estimation. The completion time for Stroop word naming tasks was longer for those reporting more mobile phone voice calls. The findings were similar for total short message service (SMS, also known as text) messages per week, suggesting these cognitive changes were unlikely due to radiofrequency (RF) exposure. Overall, mobile phone use was associated with faster and less accurate responding to higher level cognitive tasks. These behaviours may have been learned through frequent use of a mobile phone.

(26) **Subjective symptoms reported by people living in the vicinity of cellular phone base stations**

Med Pr. 2004; 55(4):345-51.

<http://www.ncbi.nlm.nih.gov/pubmed/15620045>

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Basestation

Abstract: The problem of health effects of electromagnetic fields (EMF) emitted by cellular phone base stations evokes much interest in view of the fact that people living in their vicinity are fated to continuous exposure to EMF. None of the studies carried out throughout the world have revealed excessive values of standards adopted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). A questionnaire was used as a study tool. The results of the questionnaire survey reveal that people living in the vicinity of base stations report various complaints mostly of the circulatory system, but also of sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache and vertigo. The performed studies showed the relationship between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station. This association was observed in both groups of persons, those who linked their complaints with the presence of the base station and those who did not notice such a relation. Further studies, clinical and those based on questionnaires, are needed to explain the background of reported complaints.

(27) **Chronic prenatal exposure to the 900 megahertz electromagnetic field induces pyramidal cell loss in the hippocampus of newborn rats**

Brain Res 2009; 1265 : 178 - 185

<http://www.ncbi.nlm.nih.gov/pubmed/19671630?dopt=Abstract>

Bas O, Odaci E, Mollaoglu H, Ucok K, Kaplan S.

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900 MHz
10 W/m²

Abstract: Widespread use of mobile phones which are a major source of electromagnetic fields might affect living organisms. However, there has been no investigation concerning prenatal exposure to electromagnetic fields or their roles in the development of the pyramidal cells of the cornu ammonis in postnatal life. Two groups of pregnant rats, a control group and an experimental group, that were exposed to an electromagnetic field were used. For obtaining electromagnetic field offspring, the pregnant rats were exposed to 900 megahertz electromagnetic fields during the 1-19th gestation days. There were no actions performed on the control group during the same period. The offspring rats were spontaneously delivered--control group (n = 6) and electromagnetic field group (n = 6). Offspring were sacrificed for stereological analyses at the end of the 4th week. Pyramidal cell number in rat cornu ammonis was estimated using the optical fractionator technique. **It was found that 900 megahertz of electromagnetic field significantly reduced the total pyramidal cell number in the cornu ammonis of the electromagnetic field group (P < 0.001).** Therefore, although its exact mechanism is not clear, it is suggested that pyramidal cell loss in the cornu ammonis could be due to the 900 megahertz electromagnetic field exposure in the prenatal period.

(28) **Endometrial Apoptosis Induced by a 900-MHz Mobile Phone: Preventive Effects of Vitamins E and C**

Adv Ther. 2006 Nov-Dec;23(6):957-73.

<http://www.ncbi.nlm.nih.gov/pubmed/17276964>

Oral B, Guney M, Ozguner F, Karahan N, Mungan T, Comlekci S, Cesur G.

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900 MHz PW

10,4 W/m²

Abstract: Numerous reports have described the effects induced by an electromagnetic field (EMF) in various cellular systems. The purposes of this study were to examine oxidative stress that promotes production of reactive oxygen species induced by a 900-megahertz (MHz) mobile phone and the possible ameliorating effects of vitamins E and C on endometrial tissue against EMF-induced endometrial impairment and apoptosis in rats. Animals were randomly grouped as follows: (1) sham-operated control group (n=8), (2) 900 MHz EMF-exposed group (n=8; 30 min/d for 30 d), and (3) 900 MHz EMF-exposed group, treated with vitamins E and C (n=8; 50 mg/kg intramuscularly and 20 mg/kg body weight intraperitoneally before daily EMF exposure). Malondialdehyde (an index of lipid peroxidation) was used as a marker of oxidative stress-induced endometrial impairment; Bcl-2, Bax, caspase-3, and caspase-8 were assessed immunohistochemically. **In this study, increased malondialdehyde levels in endometrial tissue and apoptosis illustrated the role of the oxidative mechanism induced by exposure to a 900-MHz mobile phone-like device and vitamins E and C; via free radical scavenging and antioxidant properties, oxidative tissue injury and apoptosis were ameliorated in rat endometrium.** In conclusion, exposure to 900-MHz radiation emitted by mobile phones may cause endometrial apoptosis and oxidative stress, but treatment with vitamins E and C can diminish these changes and may have a beneficial effect in preventing endometrial changes in rats.

(29) **Effects of radio frequency magnetic fields on iron release from cage proteins**

Bioelectromagnetics. 2009 Jul;30(5):336-42.

<http://www.ncbi.nlm.nih.gov/pubmed/19274682?dopt=Abstract>

Céspedes O, Ueno S.

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1 MHz, 30 microT

Abstract: Ferritin, the iron cage protein, contains a superparamagnetic ferrihydrite nanoparticle formed from the oxidation and absorption of Fe(2+) ions. This nanoparticle increases its internal energy when exposed to alternating magnetic fields due to magnetization lag. The energy is then dissipated to the surrounding proteic cage, affecting its functioning. In this article we show that the rates of iron chelation with ferrozine, an optical marker, are reduced by up to a factor of 3 in proteins previously exposed to radio frequency magnetic fields of 1 MHz and 30 microT for several hours. The effect is non-thermal and depends on the frequency-amplitude product of the magnetic field.

(30) **Continuous exposure to 900MHz GSM-modulated EMF alters morphological maturation of neural cells**

Neurosci Lett. 2009 May 22;455(3):173-177

<http://www.ncbi.nlm.nih.gov/pubmed/19429115?dopt=Abstract>

Del Vecchio G, Giuliani A, Fernandez M, Mesirca P, Bersani F, Pinto R, Ardoino L, Lovisolo GA, Giardino L, Calzà L.

BioPharmaNet-DIMORFIPA, Bologna University, Bologna, Italy.

GSM 900 MHz

1 SAR

Abstract: The effects of radiofrequency electromagnetic field (RF-EMF) exposure on neuronal phenotype maturation have been studied in two different in vitro models: murine SN56 cholinergic cell line and rat primary cortical neurons. The samples were exposed at a dose of 1W/kg at 900 MHz GSM modulated. The phenotype analysis was carried out at 48 and 72 h (24 and 48 h of SN56 cell line differentiation) or at 24, 72, 120 h (2, 4 and 6 days in vitro for cortical neurons) of exposure, on live and immunolabeled neurons, and included the morphological study of neurite emission, outgrowth and branching. Moreover, cortical neurons were studied to detect alterations in the expression pattern of cytoskeleton regulating factors, e.g. beta-thymosin, and of early genes, e.g. c-Fos and c-Jun through real-time PCR on mRNA extracted after 24h exposure to EMF. We found that RF-EMF exposure reduced the number of neurites generated by both cell systems, and this alteration correlates to increased expression of beta-thymosin mRNA.

(31) **The action of pulse-modulated GSM radiation increases regional changes in brain activity and c-Fos expression in cortical and subcortical areas in a rat model of picrotoxin-induced seizure proneness**

J Neurosci Res. 2009 May 1;87(6):1484-1499.

<http://www.ncbi.nlm.nih.gov/pubmed/19115403>

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GSM 900 MHz PW

0,05 SAR

Abstract: The action of the pulse-modulated GSM radiofrequency of mobile phones has been suggested as a physical phenomenon that might have biological effects on the mammalian central nervous system. In the present study, GSM-exposed picrotoxin-pretreated rats showed differences in clinical and EEG signs, and in c-Fos expression in the brain, with

respect to picrotoxin-treated rats exposed to an equivalent dose of unmodulated radiation. Neither radiation treatment caused tissue heating, so thermal effects can be ruled out. The most marked effects of GSM radiation on c-Fos expression in picrotoxin-treated rats were observed in limbic structures, olfactory cortex areas and subcortical areas, the dentate gyrus, and the central lateral nucleus of the thalamic intralaminar nucleus group. Nonpicrotoxin-treated animals exposed to unmodulated radiation showed the highest levels of neuronal c-Fos expression in cortical areas. These results suggest a specific effect of the pulse modulation of GSM radiation on brain activity of a picrotoxin-induced seizure-proneness rat model and indicate that this mobile-phone-type radiation might induce regional changes in previous preexcitability conditions of neuronal activation.

(32) **Transient DNA damage induced by high-frequency electromagnetic fields (GSM 1.8GHz) in the human trophoblast HTR-8/SVneo cell line evaluated with the alkaline comet assay**

Mutat Res. **2010** Jan 5;683(1-2):35-42.

<http://www.ncbi.nlm.nih.gov/pubmed/19822160>

Franzellitti S, Valbonesi P, Ciancaglini N, Biondi C, Contin A, Bersani F, Fabbri E.

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GSM 1800 MHz PW

2 SAR

Abstract: One of the most controversial issue regarding high-frequency electromagnetic fields (HF-EMF) is their putative capacity to affect DNA integrity. This is of particular concern due to the increasing use of HF-EMF in communication technologies, including mobile phones. Although epidemiological studies report no detrimental effects on human health, the possible disturbance generated by HF-EMF on cell physiology remains controversial. In addition, the question remains as to whether cells are able to compensate their potential effects. We have previously reported that a 1-h exposure to amplitude-modulated 1.8GHz sinusoidal waves (GSM-217Hz, SAR=2W/kg) largely used in mobile telephony did not cause increased levels of primary DNA damage in human trophoblast HTR-8/SVneo cells. Nevertheless, further investigations on trophoblast cell responses after exposure to GSM signals of different types and durations were considered of interest. In the present work, HTR-8/SVneo cells were exposed for 4, 16 or 24h to 1.8GHz continuous wave (CW) and different GSM signals, namely GSM-217Hz and GSM-Talk (intermittent exposure: 5min field on, 10min field off). The alkaline comet assay was used to evaluate primary DNA damages and/or strand breaks due to uncompleted repair processes in HF-EMF exposed samples. The amplitude-modulated signals GSM-217Hz and GSM-Talk induced a significant increase in comet parameters in trophoblast cells after 16 and 24h of exposure, while the unmodulated CW was ineffective. However, alterations were rapidly recovered and the DNA integrity of HF-EMF exposed cells was similar to that of sham-exposed cells within 2h of recovery in the absence irradiation. Our data suggest that HF-EMF with a carrier frequency and modulation scheme typical of the GSM signal may affect the DNA integrity.

(33) **Blood-Brain Barrier Disruption by Continuous-Wave Radio Frequency Radiation**

Electromagn Biol Med **2009**; 28 (2): 215 - 222

<http://www.ncbi.nlm.nih.gov/pubmed/19811403>

Sirav B, Seyhan N

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900 - 1800 MHz CW (continous wave)

12,62 V/m => 0,422 W/m²

Abstract: The increasing use of cellular phones and the increasing number of associated base stations are becoming a widespread source of non ionizing electromagnetic radiation. Some biological effects are likely to occur even at low-level EM fields. This study was designed to investigate the effects of 900 and 1,800 MHz Continuous Wave Radio Frequency Radiation (CW RFR) on the permeability of Blood Brain Barrier (BBB) of rats. **Results have shown that 20 min RFR exposure of 900 and 1,800 MHz induces an effect and increases the permeability of BBB of male rats.** There was no change in female rats. The scientific evidence on RFR safety or harm remains inconclusive. More studies are needed to demonstrate the effects of RFR on the permeability of BBB and the mechanisms of that breakdown.

(34) **Non-thermal DNA breakage by mobile-phone radiation (1800 MHz) in human fibroblasts and in transformed GFSH-R17 rat granulosa cells in vitro**

Mutat Res. 2005 Jun 6;583(2):178-83.

<http://www.ncbi.nlm.nih.gov/pubmed/15869902>

Diem E, Schwarz C, Adlkofer F, Jahn O, Rüdiger H.

1800 MHz

1,2 or 2 SAR

Comment in:

- [Mutat Res. 2006 Jan 31;603\(1\):104-6; author reply 107-9.](#)
- [Mutat Res. 2009 Feb 19;673\(1\):2.](#)
- [Mutat Res. 2009 Feb 19;673\(1\):1.](#)

Abstract: Cultured human diploid fibroblasts and cultured rat granulosa cells were exposed to intermittent and continuous radiofrequency electromagnetic fields (RF-EMF) used in mobile phones, with different specific absorption rates (SAR) and different mobile-phone modulations. **DNA strand breaks were determined by means of the alkaline and neutral comet assay.** RF-EMF exposure (1800 MHz; SAR 1.2 or 2 W/kg; different modulations; during 4, 16 and 24h; intermittent 5 min on/10 min off or continuous wave) induced DNA single- and double-strand breaks. Effects occurred after 16 h exposure in both cell types and after different mobile-phone modulations. The intermittent exposure showed a stronger effect in the comet assay than continuous exposure. **Therefore we conclude that the induced DNA damage cannot be based on thermal effects.**

(35) **Exposure to radiation from global system for mobile communications at 1,800 MHz significantly changes gene expression in rat hippocampus and cortex**

Springer Netherlands, The Environmentalist, Volume 28, Number 4/Dezember 2008, 458-465

<http://www.springerlink.com/content/91885487327u56w5>

Nittby H, Widgren B, Krogh M, Grafström G, Berlin H, Rehn G, Eberhardt J, Malmgren L, Perrson B, Salford L

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Theoretical Physics and Protein Technology, Lund University, the Rausing Laboratory and Lund University Hospital, 22185 Lund, Sweden

Medical Radiation Physics, Lund University, the Rausing Laboratory and Lund University Hospital, 22185 Lund, Sweden

Applied Electronics, Lund University, the Rausing Laboratory and Lund University Hospital, 22185 Lund, Sweden

1800 MHz PW

11,54 V/m => 0,353 W/m²

Abstract We have earlier shown that radio frequency electromagnetic fields can cause significant leakage of albumin through the blood–brain barrier of exposed rats as compared to non-exposed rats, and also significant neuronal damage in rat brains several weeks after a 2 h exposure to a mobile phone, at 915 MHz with a global system for mobile communications (GSM) frequency modulation, at whole-body specific absorption rate values (SAR) of 200, 20, 2, and 0.2 mW/kg. We have now studied whether 6 h of exposure to the radiation from a GSM mobile test phone at 1,800 MHz (at a whole-body SAR-value of 13 mW/kg, corresponding to a brain SAR-value of 30 mW/kg) has an effect upon the gene expression pattern in rat brain cortex and hippocampus—areas where we have observed albumin leakage from capillaries into neurons and neuronal damage. Microarray analysis of 31,099 rat genes, including splicing variants, was performed in cortex and hippocampus of 8 Fischer 344 rats, 4 animals exposed to global system for mobile communications electromagnetic fields for 6 h in an anechoic chamber, one rat at a time, and 4 controls kept as long in the same anechoic chamber without exposure, also in this case one rat at a time. **Gene ontology analysis (using the gene ontology categories biological processes, molecular functions, and cell components) of the differentially expressed genes of the exposed animals versus the control group revealed the following highly significant altered gene categories in both cortex and hippocampus: extracellular region, signal transducer activity, intrinsic to membrane, and integral to membrane. The fact that most of these categories are connected with membrane functions may have a relation to our earlier observation of albumin transport through brain capillaries.**

(36) **Effects of prenatal exposure to a 900 MHz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study**

Brain Res. **2008** Oct 31;1238:224-9.

<http://www.ncbi.nlm.nih.gov/pubmed/18761003>

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900 MHz CW

10 W/m² average

Abstract: Electromagnetic fields (EMFs) inhibit the formation and differentiation of neural stem cells during embryonic development. In this study, the effects of prenatal exposure to EMF on the number of granule cells in the dentate gyrus of 4-week-old rats were investigated. This experiment used a control (Cont) group and an EMF exposed (EMF) group (three pregnant rats each group). The EMF group consisted of six offspring (n=6) of pregnant rats that were exposed to an EMF of up to 900 megahertz (MHz) for 60 min/day between the first and last days of gestation. The control group consisted of five offspring (n=5) of pregnant rats that were not treated at all. The offspring were sacrificed when they were 4 weeks old. The numbers of granule cells in the dentate gyrus were analyzed using the optical fractionator technique. **The results showed that prenatal EMF exposure caused a decrease in the number of granule cells in the dentate gyrus of the rats (P<0.01). This suggests that prenatal exposure to a 900 MHz EMF affects the development of the dentate gyrus granule cells in the rat hippocampus. Cell loss might be caused by an inhibition of granule cell neurogenesis in the dentate gyrus.**

(37) **In vitro testing of cellular response to ultra high frequency electromagnetic field radiation**

Toxicol In Vitro **2008**; 22 (5): 1344 – 1348

<http://www.ncbi.nlm.nih.gov/pubmed/18513921>

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935 MHz CW

0,12 SAR average

Abstract: The aim of this study was to evaluate whether low-level, ultra high frequency (UHF) irradiation of 935 MHz influences the cell structure and growth of V79 cells. UHF field was generated inside a Gigahertz Transversal Electromagnetic Mode cell (GTEM-cell) with a Hewlett-Packard signal generator. The electric field strength was 8.2+/-0.3 V/cm and the average specific absorption rate (SAR) was calculated to be 0.12 W/kg. Cell samples were cultivated in a humidified atmosphere at 37 degrees C with 5% CO2. Prepared cell samples were exposed to a 935 MHz continuous wave frequency field for 1, 2, and 3 h. The structure of microtubule proteins has been determined using the immunocytochemical method. Cell growth was determined by cell counts for each hour of exposure during five post-exposure days. Negative- and positive-cell controls were included into the experimental procedure. In comparison with control cells, the microtubule structure clearly altered after 3h of irradiation (p<0.05). Significantly decreased growth was noted in cells exposed for 3h three days after irradiation (p<0.05). It seems that the 935 MHz, low-level UHF radiation affects microtubule proteins, which consequently may obstruct cell growth.

(38) **Upregulation of specific mRNA levels in rat brain after cell phone exposure**

Electromagn Biol Med. 2008; 27(2):147-54.

<http://www.ncbi.nlm.nih.gov/pubmed/18568932>

Yan JG, Agresti M, Zhang LL, Yan Y, Matloub HS.

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Handy

Abstract: Adult Sprague-Dawley rats were exposed to regular cell phones for 6 h per day for 126 days (18 weeks). RT-PCR was used to investigate the changes in levels of mRNA synthesis of several injury-associated proteins. Calcium ATPase, Neural Cell Adhesion Molecule, Neural Growth Factor, and Vascular Endothelial Growth Factor were evaluated. The results showed statistically significant mRNA up-regulation of these proteins in the brains of rats exposed to cell phone radiation. These results indicate that relative chronic exposure to cell phone microwave radiation may result in cumulative injuries that could eventually lead to clinically significant neurological damage.

(39) **Cellular phone use and risk of benign and malignant parotid gland tumors - a nationwide case-control study**

Am J Epidemiol. 2008 Feb 15;167(4):457-67.

<http://www.ncbi.nlm.nih.gov/pubmed/18063591>

Sadetzki S, Chetrit A, Jarus-Hakak A, Cardis E, Deutch Y, Duvdevani S, Zultan A, Novikov I, Freedman L, Wolf M

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Handy

Abstract: The objective of this nationwide study was to assess the association between cellular phone use and development of parotid gland tumors (PGTs). The methods were based on the international INTERPHONE study that aimed to evaluate possible adverse

effects of cellular phone use. The study included 402 benign and 58 malignant incident cases of PGTs diagnosed in Israel at age 18 years or more, in 2001-2003, and 1,266 population individually matched controls. For the entire group, no increased risk of PGTs was observed for ever having been a regular cellular phone user (odds ratio = 0.87; $p = 0.3$) or for any other measure of exposure investigated. However, analysis restricted to regular users or to conditions that may yield higher levels of exposure (e.g., heavy use in rural areas) showed consistently elevated risks. For ipsilateral use, the odds ratios in the highest category of cumulative number of calls and call time without use of hands-free devices were 1.58 (95% confidence interval: 1.11, 2.24) and 1.49 (95% confidence interval: 1.05, 2.13), respectively. The risk for contralateral use was not significantly different from 1. A positive dose-response trend was found for these measurements. Based on the largest number of benign PGT patients reported to date, our results suggest an association between cellular phone use and PGTs.

(40) **Effects of exposure to a mobile phone on testicular function and structure in adult rabbit**

Int J Androl. 2008 Dec 2.

<http://www.ncbi.nlm.nih.gov/pubmed/19076254>

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Department of Urology, Tokushima School of Medicine, Tokushima, Japan.

800 MHz

Handy

Abstract: The accumulating effects of exposure to electromagnetic radiation emitted by a conventional mobile phone (standby position) on the testicular function and structure are not yet fully investigated. To study these effects longitudinally, a total of 24 adult male rabbits were randomly and equally divided into three groups. Rabbits in the first (phone) group were exposed, in specially designed cages, to radio frequency emitted from the mobile phone (800 MHz) in a standby position opposite to that of testes for 8 h daily for 12 weeks. The second group consisted of the stress controls which were kept in the same kind of cages to appreciate any cage-induced anxiety. The third group included the ordinary controls which were kept in the conventional roomy cages. Semen analysis and sperm function tests (viability, hypo-osmotic swelling and acridine orange) were conducted weekly. Histological testicular sections and serum total testosterone were also evaluated. A drop in the sperm concentration appeared in the phone group at week 6. This became statistically significant at week 8, compared with the two control (stress and ordinary) groups (133, 339 and 356 x 10⁶/mL, respectively) and to the initial sperm count (341 x 10⁶/mL) of this group. Motile sperm population showed similarity amongst the three study groups until week 10 when it declined significantly, and thereafter in the phone and stress control groups, with more significant decline in the phone animals (50, 61 and 72.4%, respectively). Histological examination showed also a significant decrease in the diameter of seminiferous tubules in the phone group vs. the stress and ordinary controls (191 μ m vs. 206 and 226 μ m, respectively). The other study points did not show any difference. In conclusion, low intensity pulsed radio frequency emitted by a conventional mobile phone kept in the standby position could affect the testicular function and structure in the adult rabbit.

(41) **Melatonin Reduces Oxidative Stress Induced by Chronic Exposure of Microwave Radiation from Mobile Phones in Rat Brain**

J Radiat Res (Tokyo). 2008 Nov;49(6):579-86

<http://www.ncbi.nlm.nih.gov/pubmed/18827438>

Sokolovic D, Djindjic B, Nikolic J, Bjelakovic G, Pavlovic D, Kocic G, Krstic D, Cvetkovic T, Pavlovic V.

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900 MHz CW
9,88 – 18,356 V/m => 0,259 – 0,894 W/m²
0,043 – 0,135 SAR

Handy

PURPOSE: The aim of the study was to evaluate the intensity of oxidative stress in the brain of animals chronically exposed to mobile phones and potential protective effects of melatonin in reducing oxidative stress and brain injury. **MATERIALS AND METHODS:** Experiments were performed on Wistar rats exposed to microwave radiation during 20, 40 and 60 days. Four groups were formed: I group (control)- animals treated by saline, intraperitoneally (i.p.) applied daily during follow up, II group (Mel)- rats treated daily with melatonin (2 mg kg(-1) body weight i.p.), III group (MWs)- microwave exposed rats, IV group (MWs + Mel)- MWs exposed rats treated with melatonin (2 mg kg(-1) body weight i.p.). The microwave radiation was produced by a mobile test phone (SAR = 0.043-0.135 W/kg). **RESULTS:** A significant increase in the brain tissue malondialdehyde (MDA) and carbonyl group concentration was registered during exposure. Decreased activity of catalase (CAT) and increased activity of xanthine oxidase (XO) remained after 40 and 60 days of exposure to mobile phones. Melatonin treatment significantly prevented the increase in the MDA content and XO activity in the brain tissue after 40 days of exposure while it was unable to prevent the decrease of CAT activity and increase of carbonyl group contents.

CONCLUSION: We demonstrated two important findings; that mobile phones caused oxidative damage biochemically by increasing the levels of MDA, carbonyl groups, XO activity and decreasing CAT activity; and that treatment with the melatonin significantly prevented oxidative damage in the brain.

(42) Increased frequency of micronucleated exfoliated cells among humans exposed in vivo to mobile telephone radiations

Mutat Res. 2008 Feb 29;650(2):175-80.

<http://www.ncbi.nlm.nih.gov/pubmed/18248768>

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Handy

Abstract: The health concerns have been raised following the enormous increase in the use of wireless mobile telephones throughout the world. This investigation had been taken, with the motive to find out whether mobile phone radiations cause any in vivo effects on the frequency of micronucleated exfoliated cells in the exposed subjects. A total of 109 subjects including 85 regular mobile phone users (exposed) and 24 non-users (controls) had participated in this study. Exfoliated cells were obtained by swabbing the buccal-mucosa from exposed as well as sex-age-matched controls. One thousand exfoliated cells were screened from each individual for nuclear anomalies including micronuclei (MN), karyolysis (KL), karyorrhexis (KH), broken egg (BE) and binucleated (BN) cells. The average daily duration of exposure to mobile phone radiations is 61.26 min with an overall average duration of exposure in term of years is 2.35 years in exposed subjects along with the 9.84+/-0.745 micronucleated cells (MNCs) and 10.72+/-0.889 total micronuclei (TMN) as compared to zero duration of exposure along with average 3.75+/-0.774 MNC and 4.00+/-0.808 TMN in controls. The means are significantly different in case of MNC and TMN at 0.01% level of significance. The mean of KL in controls is 13.17+/-2.750 and in exposed subjects is 13.06+/-1.793. The value of means of KH in exposed subjects (1.84+/-0.432) is slightly higher than in controls (1.42+/-0.737). Mean frequency of broken egg is found to be

more in exposed subjects (0.65+/-0.276) as compared to controls (0.50+/-0.217). Frequency of presence of more than one nucleus in a cell (binucleated) is also higher in exposed (2.72+/-0.374) in comparison to controls (0.67+/-0.231). Although there is a slight increase in mean frequency of KH, BE and BN in exposed subjects but the difference is not found statistically significant. Correlation between 0-1, 1-2, 2-3 and 3-4 years of exposure and the frequency of MNC and TMN has been calculated and found to be positively correlated.

(43) **Electromagnetic noise inhibits radiofrequency radiation-induced DNA damage and reactive oxygen species increase in human lens epithelial cells**

Mol Vis. 2008 May 19;14:964-9.

<http://www.ncbi.nlm.nih.gov/pubmed/18509546?dopt=Abstract>

Yao K, Wu W, Wang K, Ni S, Ye P, Yu Y, Ye J, Sun L.

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1800 MHz PW (217 Hz amplitude-modulated)

1, 2, (3,4) SAR

PURPOSE: The goal of this study was to investigate whether superposing of electromagnetic noise could block or attenuate DNA damage and intracellular reactive oxygen species (ROS) increase of cultured human lens epithelial cells (HLECs) induced by acute exposure to 1.8 GHz radiofrequency field (RF) of the Global System for Mobile Communications (GSM).

METHODS: An sXc-1800 RF exposure system was used to produce a GSM signal at 1.8 GHz (217 Hz amplitude-modulated) with the specific absorption rate (SAR) of 1, 2, 3, and 4 W/kg. After 2 h of intermittent exposure, the ROS level was assessed by the fluorescent probe, 2',7'-dichlorodihydrofluorescein diacetate (DCFH-DA). DNA damage to HLECs was examined by alkaline comet assay and the phosphorylated form of histone variant H2AX (gammaH2AX) foci formation assay. **RESULTS:** After exposure to 1.8 GHz RF for 2 h, HLECs exhibited significant intracellular ROS increase in the 2, 3, and 4 W/kg groups. RF radiation at the SAR of 3 W/kg and 4 W/kg could induce significant DNA damage, examined by alkaline comet assay, which was used to detect mainly single strand breaks (SSBs), while no statistical difference in double strand breaks (DSBs), evaluated by gammaH2AX foci, was found between RF exposure (SAR: 3 and 4 W/kg) and sham exposure groups. When RF was superposed with 2 muT electromagnetic noise could block RF-induced ROS increase and DNA damage. **CONCLUSIONS:** DNA damage induced by 1.8 GHz radiofrequency field for 2 h, which was mainly SSBs, may be associated with the increased ROS production. Electromagnetic noise could block RF-induced ROS formation and DNA damage.

(44) **Exposure to cell phone radiation up-regulates apoptosis genes in primary cultures of neurons and astrocytes**

Neurosci Lett. 2007 Jan 22;412(1):34-8.

<http://www.ncbi.nlm.nih.gov/pubmed/17187929>

Zhao TY, Zou SP, Knapp PE.

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1900 MHz PW

Handy

Abstract: The health effects of cell phone radiation exposure are a growing public concern. This study investigated whether expression of genes related to cell death pathways are dysregulated in primary cultured neurons and astrocytes by exposure to a working Global System for Mobile Communication (GSM) cell phone rated at a frequency of 1900MHz. Primary cultures were exposed to cell phone emissions for 2h. We used array analysis and

real-time RT-PCR to show up-regulation of caspase-2, caspase-6 and Asc (apoptosis associated speck-like protein containing a card) gene expression in neurons and astrocytes. Up-regulation occurred in both "on" and "stand-by" modes in neurons, but only in "on" mode in astrocytes. Additionally, astrocytes showed up-regulation of the Bax gene. The effects are specific since up-regulation was not seen for other genes associated with apoptosis, such as caspase-9 in either neurons or astrocytes, or Bax in neurons. **The results show that even relatively short-term exposure to cell phone radiofrequency emissions can up-regulate elements of apoptotic pathways in cells derived from the brain, and that neurons appear to be more sensitive to this effect than astrocytes.**

(45) **Mobile phone radiation inhibits *Vigna radiata* (mung bean) root growth by inducing oxidative stress**

Sci Total Environ. 2009 Oct 15;407(21):5543-7.

<http://www.ncbi.nlm.nih.gov/pubmed/19682728>

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900 MHz PW

0,086 W/m² => 5,7 V/m

Abstract: During the last couple of decades, there has been a tremendous increase in the use of cell phones. It has significantly added to the rapidly increasing EMF smog, an unprecedented type of pollution consisting of radiation in the environment, thereby prompting the scientists to study the effects on humans. However, not many studies have been conducted to explore the effects of cell phone EMFr on growth and biochemical changes in plants. We investigated whether EMFr from cell phones inhibit growth of *Vigna radiata* (mung bean) through induction of conventional stress responses. Effects of cell phone EMFr (power density: 8.55 microW cm⁻²); 900 MHz band width; for 1/2, 1, 2, and 4 h) were determined by measuring the generation of reactive oxygen species (ROS) in terms of malondialdehyde and hydrogen peroxide (H₂O₂) content, root oxidizability and changes in levels of antioxidant enzymes. Our results showed that cell phone EMFr significantly inhibited the germination (at > or =2 h), and radicle and plumule growths (> or =1 h) in mung bean in a time-dependent manner. Further, cell phone EMFr enhanced MDA content (indicating lipid peroxidation), and increased H₂O₂ accumulation and root oxidizability in mung bean roots, thereby inducing oxidative stress and cellular damage. In response to EMFr, there was a significant upregulation in the activities of scavenging enzymes, such as superoxide dismutases, ascorbate peroxidases, guaiacol peroxidases, catalases and glutathione reductases, in mung bean roots. **The study concluded that cell phone EMF inhibit root growth of mung bean by inducing ROS-generated oxidative stress despite increased activities of antioxidant enzymes.**

Cell phone radiations affect early growth of *Vigna radiata* (mung bean) through biochemical alterations.

Z Naturforsch C. 2010 Jan-Feb;65(1-2):66-72.

Sharma VP, Singh HP, Batish DR, Kohli RK.

Department of Environment and Vocational Studies, Panjab University, Chandigarh,
160014, India.

Abstract

The indiscriminate use of wireless technologies, particularly of cell phones, has increased the health risks among living organisms including plants. We investigated the impact of cell phone electromagnetic field (EMF) radiations (power density, 8.55 microW cm⁻²) on

germination, early growth, proteins and carbohydrate contents, and activities of some enzymes in *Vigna radiata*. Cell phone EMF radiations significantly reduced the seedling length and dry weight of *V. radiata* after exposure for 0.5, 1, 2, and 4 h. Furthermore, the contents of proteins and carbohydrates were reduced in EMF-exposed plants. However, the activities of proteases, alpha-amylases, beta-amylases, polyphenol oxidases, and peroxidases were enhanced in EMF-exposed radicles indicating their role in providing protection against EMF-induced stress. The study concludes that cell phone EMFs impair early growth of *V. radiata* seedlings by inducing biochemical changes.

(46) **Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study**

Fertil Steril. 2009 Oct;92(4):1318-25.

<http://www.ncbi.nlm.nih.gov/pubmed/18804757>

Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R.

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Handy

OBJECTIVE: To evaluate effects of cellular phone radiofrequency electromagnetic waves (RF-EMW) during talk mode on unprocessed (neat) ejaculated human semen. **DESIGN:** Prospective pilot study. **SETTING:** Center for reproductive medicine laboratory in tertiary hospital setting. **SAMPLES:** Neat semen samples from normal healthy donors (n = 23) and infertile patients (n = 9). **INTERVENTION(S):** After liquefaction, neat semen samples were divided into two aliquots. One aliquot (experimental) from each patient was exposed to cellular phone radiation (in talk mode) for 1 h, and the second aliquot (unexposed) served as the control sample under identical conditions. **MAIN OUTCOME MEASURE(S):** Evaluation of sperm parameters (motility, viability), reactive oxygen species (ROS), total antioxidant capacity (TAC) of semen, ROS-TAC score, and sperm DNA damage. **RESULT(S):** Samples exposed to RF-EMW showed a significant decrease in sperm motility and viability, increase in ROS level, and decrease in ROS-TAC score. Levels of TAC and DNA damage showed no significant differences from the unexposed group. **CONCLUSION(S):** Radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress in human semen. We speculate that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility.

(47) **Radiofrequency radiation (900 MHz) induces Egr-1 gene expression and affects cell-cycle control in human neuroblastoma cells**

J Cell Physiol. 2007 Dec;213(3):759-67.

<http://www.ncbi.nlm.nih.gov/pubmed/17559061>

Buttiglione M, Roca L, Montemurno E, Vitiello F, Capozzi V, Cibelli G.

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900 MHz PW

23 V/m => 1,403 W/m²

Abstract: Many environmental signals, including ionizing radiation and UV rays, induce activation of Egr-1 gene, thus affecting cell growth and apoptosis. The paucity and the controversial knowledge about the effect of electromagnetic fields (EMF) exposure of nerve cells prompted us to investigate the bioeffects of radiofrequency (RF) radiation on SH-SY5Y neuroblastoma cells. The effect of a modulated RF field of 900 MHz, generated by a wire patch cell (WPC) antenna exposure system on Egr-1 gene expression, was studied as a function of time. Short-term exposures induced a transient increase in Egr-1 mRNA level

paralleled with activation of the MAPK subtypes ERK1/2 and SAPK/JNK. The effects of RF radiations on cell growth rate and apoptosis were also studied. Exposure to RF radiation had an anti-proliferative activity in SH-SY5Y cells with a significant effect observed at 24 h. RF radiation impaired cell cycle progression, reaching a significant G2-M arrest. In addition, the appearance of the sub-G1 peak, a hallmark of apoptosis, was highlighted after a 24-h exposure, together with a significant decrease in mRNA levels of Bcl-2 and survivin genes, both interfering with signaling between G2-M arrest and apoptosis. Our results provide evidence that exposure to a 900 MHz-modulated RF radiation affect both Egr-1 gene expression and cell regulatory functions, involving apoptosis inhibitors like Bcl-2 and survivin, thus providing important insights into a potentially broad mechanism for controlling in vitro cell viability.

(48) **Apoptosis is Induced by Radiofrequency Fields through the Caspase-Independent Mitochondrial Pathway in Cortical Neurons**

Radiat Res. 2008 Jan;169(1):38-45.

<http://www.ncbi.nlm.nih.gov/pubmed/18159956>

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900 MHz CW

2 SAR

Abstract: Apoptosis is Induced by Radiofrequency Fields through the Caspase-Independent Mitochondrial Pathway in Cortical Neurons. Radiat. Res. 169, 38-45 (2008). In the present study, we investigated whether continuous-wave (CW) radiofrequency (RF) fields induce neuron apoptosis in vitro. Rat primary neuronal cultures were exposed to a CW 900 MHz RF field with a specific absorption rate (SAR) of 2 W/kg for 24 h. During exposure, an increase of 2 degrees C was measured in the medium; control experiments with neurons exposed to 39 degrees C were then performed. Apoptosis was assessed by condensation of nuclei with 4',6-diamino-2-phenylindole (DAPI) staining observed with an epifluorescence microscope and fragmentation of DNA with TdT-mediated dUTP nick-end labeling (TUNEL) analyzed by flow cytometry. A statistically significant difference in the rate of apoptosis was found in the RF-field-exposed neurons compared to the sham-, 37 degrees C- and 39 degrees C-exposed neurons either 0 or 24 h after exposure using both methods. To assess whether the observed apoptosis was caspase-dependent or -independent, assays measuring caspase 3 activity and apoptosis-inducing factor (AIF) labeling were performed. No increase in the caspase 3 activity was found, whereas the percentage of AIF-positive nuclei in RF-field-exposed neurons was increased by three- to sevenfold compared to other conditions. Our results show that, under the experimental conditions used, exposure of primary rat neurons to CW RF fields may induce a caspase-independent pathway to apoptosis that involves AIF.

(49) **Mobile phone radiation might alter protein expression in human skin**

BMC Genomics. 2008 Feb 11;9:77.

<http://www.ncbi.nlm.nih.gov/pubmed/18267023>

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1,3 SAR

BACKGROUND: Earlier we have shown that the mobile phone radiation (radiofrequency modulated electromagnetic fields; RF-EMF) alters protein expression in human endothelial cell line. This does not mean that similar response will take place in human body exposed to

this radiation. Therefore, in this pilot human volunteer study, using proteomics approach, we have examined whether a local exposure of human skin to RF-EMF will cause changes in protein expression in living people. **RESULTS:** Small area of forearm's skin in 10 female volunteers was exposed to RF-EMF (specific absorption rate SAR = 1.3 W/kg) and punch biopsies were collected from exposed and non-exposed areas of skin. Proteins extracted from biopsies were separated using 2-DE and protein expression changes were analyzed using PDQuest software. Analysis has identified 8 proteins that were statistically significantly affected (Anova and Wilcoxon tests). Two of the proteins were present in all 10 volunteers. This suggests that protein expression in human skin might be affected by the exposure to RF-EMF. The number of affected proteins was similar to the number of affected proteins observed in our earlier in vitro studies. **CONCLUSION:** This is the first study showing that molecular level changes might take place in human volunteers in response to exposure to RF-EMF. Our study confirms that proteomics screening approach can identify protein targets of RF-EMF in human volunteers.

(50) **Adverse effects of excessive mobile phone use**

Int J Occup Med Environ Health. 2008;21(4):289-93.

<http://www.ncbi.nlm.nih.gov/pubmed/19228576>

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Handy

INTRODUCTION: Research findings indicate that the use of mobile phones may lead to a number of symptoms such as headache, impaired concentration and memory, and also fatigue. **MATERIALS AND METHODS:** The present study was designed to investigate whether the symptoms of ill health reported by young people may be associated with the use of mobile phone (MP) and to analyze its influence on health and development of medical students. The questionnaire was designed specifically for this study and contained items regarding health condition and health complaints as well as the frequency of MP use. The response rate was 86.6% (286 of 330 forms, completed by 73.77% males and 26.22% females). **RESULTS:** Most of the subjects (83.57%) had some knowledge about the adverse effects of MP use. 76.92% of the students carried one mobile, and 23.08% more than one. 55.94%, of the subjects reported the average daily MP use of less than 30 min, 27.97%, of 30-60 min, 11.53%, of 60-90 min and 4.54% of more than 90 min. 16.08% of the subjects complained of headache and 24.48% of fatigue. Impaired concentration was reported by 34.27% of respondents, memory disturbances by 40.56%, sleeplessness by 38.8%, hearing problems by 23.07%, and facial dermatitis by 16.78%. The sensation of warmth within the auricle and behind/around the ear was reported by 28.32%. Out of 286 subjects who participated in this study, 44.4% related their symptoms to mobile phone use. **CONCLUSIONS:** The findings of the present study indicate that mobile phones play a large part in the daily life of medical students. Therefore, its impact on psychology and health should be discussed among the students to prevent the harmful effects of mobile phone use.

(51) **High frequency (900 MHz) low amplitude (5 V m⁻¹) electromagnetic field: a genuine environmental stimulus that affects transcription, translation, calcium and energy charge in tomato**

Springer Berlin / Heidelberg, Volume 227, Number 4 / March 2008, P. 883-891

<http://www.springerlink.com/content/t51217020208288h/>

Roux David , Vian Alain , Girard Sébastien , Bonnet Pierre , Paladian Françoise , Davies Eric and Ledoigt Gérard

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900 MHz

5V/m => 0,066 W/m²

Abstract: Abstract Using an especially-designed facility, the Mode Stirred Reverberation Chamber, we exposed tomato plants (*Lycopersicon esculentum* Mill. VFN8) to low level (900 MHz, 5 V m⁻¹) electromagnetic fields for a short period (10 min) and measured changes in abundance of three specific mRNA soon after exposure. Within minutes of electromagnetic stimulation, stress-related mRNA (calmodulin, calcium-dependent protein kinase and proteinase inhibitor) accumulated in a rapid, large and 3-phase manner typical of an environmental stress response. Accumulation of these transcripts into the polysomal RNA also took place (indicating that the encoded proteins were translated) but was delayed (indicating that newly-synthesized mRNA was not immediately recruited into polysomes). Transcript accumulation was maximal at normal Ca²⁺ levels and was depressed at higher Ca²⁺, especially for those encoding calcium-binding proteins. Removal of Ca²⁺ (by addition of chelating agents or Ca²⁺ channel blocker) led to total suppression of mRNA accumulation. Finally, 30 min after the electromagnetic treatment, ATP concentration and adenylate energy charge were transiently decreased, while transcript accumulation was totally prevented by application of the uncoupling reagent, CCCP. These responses occur very soon after exposure, strongly suggesting that they are the direct consequence of application of radio-frequency fields and their similarities to wound responses strongly suggests that this radiation is perceived by plants as an injurious stimulus.

(52) **Intercellular communication in plants: evidence for two rapidly transmitted systemic signals generated in response to electromagnetic field stimulation in tomato.**

Plant Cell Environ. 2007 Jul;30(7):834-44.

<http://www.ncbi.nlm.nih.gov/pubmed/17547655>

Beaubois E, Girard S, Lallechere S, Davies E, Paladian F, Bonnet P, Ledoigt G, Vian A.
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900MHz

5V/m => 0,066 W/m²

Abstract: Exposing all of a wild-type tomato plant to electromagnetic radiation evoked rapid and substantial accumulation of basic leucine-zipper transcription factor (bZIP) mRNA in the terminal leaf (#4) with kinetics very similar to that seen in response to wounding, while in the abscisic acid (ABA) mutant (Sitiens), the response was more rapid, but transient. Submitting just the oldest leaf (#1) of a wild-type plant to irradiation evoked bZIP mRNA accumulation both locally in the exposed leaf and systemically in the unexposed (distant) leaf #4, although systemic accumulation was delayed somewhat. Accumulation of Pin2 mRNA was less than bZIP in both the exposed and distant leaves in wild type, but there was no delay in the systemic response. In Sitiens, bZIP mRNA accumulation was far less than in wild type in both local and distant leaves, while Pin2 mRNA accumulation was stronger in the exposed leaf, but totally prevented in the systemic leaf. In the jasmonic acid (JA) mutant (JL-5) and in wild-type plants treated with the ABA biosynthesis inhibitor, naproxen, responses were similar to those in the ABA mutant, while treatment of the exposed leaf with calcium antagonists totally abolished both local and systemic increases in bZIP transcript accumulation

- (53) **Effects of mobile phones on oxidant/antioxidant balance in cornea and lens of rats**
Curr Eye Res. 2007 Jan;32(1):21-5.

<http://www.ncbi.nlm.nih.gov/pubmed/17364731>

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900 MHz

1,2 SAR

PURPOSE: To investigate the effects of mobile-phone-emitted radiation on the oxidant/antioxidant balance in corneal and lens tissues and to observe any protective effects of vitamin C in this setting. **METHODS:** Forty female albino Wistar rats were assigned to one of four groups containing 10 rats each. One group received a standardized daily dose of mobile phone radiation for 4 weeks. The second group received this same treatment along with a daily oral dose of vitamin C (250 mg/kg). The third group received this dose of vitamin C alone, while the fourth group received standard laboratory care and served as a control. In corneal and lens tissues, malondialdehyde (MDA) levels and activities of superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), and catalase (CAT) were measured with spectrophotometric methods. **RESULTS:** In corneal tissue, MDA level and CAT activity significantly increased in the mobile phone group compared with the mobile phone plus vitamin C group and the control group ($p < 0.05$), whereas SOD activity was significantly decreased ($p < 0.05$). In the lens tissues, only the MDA level significantly increased in the mobile phone group relative to mobile phone plus vitamin C group and the control groups ($p < 0.05$). In lens tissue, significant differences were not found between the groups in terms of SOD, GSH-Px, or CAT ($p > 0.05$). **CONCLUSIONS:** The results of this study suggest that mobile telephone radiation leads to oxidative stress in corneal and lens tissues and that antioxidants such as vitamin C can help to prevent these effects.

- (54) **Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork (Ciconia ciconia)**

Electromagnetic Biology and Medicine, Volume 24, Issue 2 May 2005, pages 109 – 119

<http://www.informaworld.com/smpp/content~content=a725688480~db=all>

Balmori, Alfonso

Consejería de Medio Ambiente, Junta de Castilla y León, Valladolid, Spain

900 - 1800 MHz PW

2,36 V/m average within range of 200 m => 0,015 W/m²

0,53 V/m average beyond 300 m => 0,001 W/m²

Abstract

Monitoring of a white stork population in Valladolid (Spain) in the vicinity of Cellular Phone Base Stations was carried out, with the objective of detecting possible effects. The total productivity, in the nests located within 200 meters of antennae, was 0.86 ± 0.16 . For those located further than 300 m, the result was practically doubled, with an average of 1.6 ± 0.14 . Very significant differences among the total productivity were found ($U = 240$; $p = 0.001$, Mann-Whitney test). In partial productivity, an average of 1.44 ± 0.16 was obtained for the first group (within 200 m of antennae) and of 1.65 ± 0.13 for the second (further than 300 m of antennae), respectively. The difference between both groups of nests in this case were not statistically significant ($U = 216$; $P = 0.26$, Mann-Whitney Test U). Twelve nests (40%) located within than 200 m of antennae never had chicks, while only one (3.3%) located further than 300 m had no chicks. The electric field intensity was higher on nests within 200 m (2.36 ± 0.82 V/m) than on nests further than 300 m (0.53 ± 0.82 V/m). Interesting behavioral observations of the white stork nesting sites located within 100 m of one or

several cellsite antennae were carried out. These results are compatible with the possibility that microwaves are interfering with the reproduction of white storks and would corroborate the results of laboratory research by other authors.

(55) **A Possible Effect of Electromagnetic Radiation from Mobile Phone Base Stations on the Number of Breeding House Sparrows (*Passer domesticus*)**

Electromagn Biol Med. 2007;26(1):63-72.

<http://www.ncbi.nlm.nih.gov/pubmed/17454083>

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925 - 960 MHz,

Ø for average

0,153 V/m Ø (locality 1), 0,084 V/m Ø (locality 2), 0,245 V/m Ø (locality 3),

0,13 V/m Ø (locality 4), 0,109 V/m Ø (locality 5),

0,043 V/m Ø (locality 6) => 0,0004904 W/m²

1805 - 1880 MHz

0,075 V/m Ø (locality 1), 0,083 V/m Ø (locality 2),

0,056 V/m Ø (locality 4), 0,04 V/m Ø (locality 5), 0,08 V/m Ø (locality 6),

0,017 V/m Ø (locality 3) => 0,0000007 W/m²

Abstract: A possible effect of long-term exposure to low-intensity electromagnetic radiation from mobile phone (GSM) base stations on the number of House Sparrows during the breeding season was studied in six residential districts in Belgium. We sampled 150 point locations within the 6 areas to examine small-scale geographic variation in the number of House Sparrow males and the strength of electromagnetic radiation from base stations. Spatial variation in the number of House Sparrow males was negatively and highly significantly related to the strength of electric fields from both the 900 and 1800 MHz downlink frequency bands and from the sum of these bands (Chi(2)-tests and AIC-criteria, P<0.001). This negative relationship was highly similar within each of the six study areas, despite differences among areas in both the number of birds and radiation levels. Thus, our data show that fewer House Sparrow males were seen at locations with relatively high electric field strength values of GSM base stations and therefore support the notion that long-term exposure to higher levels of radiation negatively affects the abundance or behavior of House Sparrows in the wild.

(56) **Radioprotective effects of honeybee venom (*Apis mellifera*) against 915-MHz microwave radiation-induced DNA damage in wistar rat lymphocytes: in vitro study**

Int J Toxicol. 2009 Mar-Apr;28(2):88-98.

<http://www.ncbi.nlm.nih.gov/pubmed/19482833?dopt=Abstract>

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915 MHz PW

30 V/m => 2,387 W/m²

Abstract: The aim of this study is to investigate the radioprotective effect of bee venom against DNA damage induced by 915-MHz microwave radiation (specific absorption rate of 0.6 W/kg) in Wistar rats. Whole blood lymphocytes of Wistar rats are treated with 1 microg/mL bee venom 4 hours prior to and immediately before irradiation. Standard and formamidopyrimidine-DNA glycosylase (Fpg)-modified comet assays are used to assess basal and oxidative DNA damage produced by reactive oxygen species. Bee venom shows a

decrease in DNA damage compared with irradiated samples. Parameters of Fpg-modified comet assay are statistically different from controls, making this assay more sensitive and suggesting that oxidative stress is a possible mechanism of DNA damage induction. Bee venom is demonstrated to have a radioprotective effect against basal and oxidative DNA damage. Furthermore, bee venom is not genotoxic and does not produce oxidative damage in the low concentrations used in this study.

(57) **The Urban Decline of the House Sparrow (*Passer domesticus*): A Possible Link with Electromagnetic Radiation**

Electromagn Biol Med. 2007;26(2):141-51

<http://www.ncbi.nlm.nih.gov/pubmed/17613041>

Balmori A, Hallberg O.

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Basestation

Abstract: During recent decades, there has been a marked decline of the house sparrow (*Passer domesticus*) population in the United Kingdom and in several western European countries. The aims of this study were to determine whether the population is also declining in Spain and to evaluate the hypothesis that electromagnetic radiation (microwaves) from phone antennae is correlated with the decline in the sparrow population. Between October 2002 and May 2006, point transect sampling was performed at 30 points during 40 visits to Valladolid, Spain. At each point, we carried out counts of sparrows and measured the mean electric field strength (radiofrequencies and microwaves: 1 MHz-3 GHz range). Significant declines ($P = 0.0037$) were observed in the mean bird density over time, and significantly low bird density was observed in areas with high electric field strength. The logarithmic regression of the mean bird density vs. field strength groups (considering field strength in 0.1 V/m increments) was $R = -0.87$ ($P = 0.0001$). The results of this article support the hypothesis that electromagnetic signals are associated with the observed decline in the sparrow population. We conclude that electromagnetic pollution may be responsible, either by itself or in combination with other factors, for the observed decline of the species in European cities during recent years. The apparently strong dependence between bird density and field strength according to this work could be used for a more controlled study to test the hypothesis.

(58) **Cognitive impairment in rats after long-term exposure to GSM-900 mobile phone radiation**

Bioelectromagnetics. 2008 Apr;29(3):219-32.

<http://www.ncbi.nlm.nih.gov/pubmed/18044737>

Nittby H, Grafström G, Tian DP, Malmgren L, Brun A, Persson BR, Salford LG, Eberhardt J. Department of Neurosurgery, Lund University, The Rausing Laboratory and Lund University Hospital, Lund, Sweden. henrietta.nittby@skane.se

GSM 900 MHz

0,0006; 0,060 SAR

Abstract: Considering the frequent use of mobile phones, we have directed attention to possible implications on cognitive functions. In this study we investigated in a rat model the long-term effects of protracted exposure to Global System for Mobile Communication-900 MHz (GSM-900) radiation. Out of a total of 56 rats, 32 were exposed for 2 h each week for 55 weeks to radio-frequency electromagnetic radiation at different SAR levels (0.6 and 60 mW/kg at the initiation of the experimental period) emitted by a (GSM-900) test phone. Sixteen animals were sham exposed and eight animals were cage controls, which never left

the animal house. After this protracted exposure, GSM-900 exposed rats were compared to sham exposed controls. Effects on exploratory behaviour were evaluated in the open-field test, in which no difference was seen. Effects on cognitive functions were evaluated in the episodic-like memory test. In our study, GSM exposed rats had impaired memory for objects and their temporal order of presentation, compared to sham exposed controls (P = 0.02). Detecting the place in which an object was presented was not affected by GSM exposure. Our results suggest significantly reduced memory functions in rats after GSM microwave exposure (P = 0.02).

(59) **Cell death induced by GSM 900-MHz and DCS 1800-MHz mobile telephony radiation**

Mutat Res. 2007 Jan 10;626(1-2):69-78.

<http://www.ncbi.nlm.nih.gov/pubmed/17045516>

<http://www.scribd.com/doc/3983873/Cell-death-induced-by-GSM-900MHz-and-DCS-1800MHz-mobile-telephony-radiation> (full article)

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900 MHz

23,7 V/m => 1,49 W/m²

900 MHz

15,7 V/m => 0,654 W/m²

1800 MHz

15,5 V/m => 0,637 W/m

Abstract: In the present study, the TUNEL (Terminal deoxynucleotide transferase dUTP Nick End Labeling) assay--a well known technique widely used for detecting fragmented DNA in various types of cells--was used to detect cell death (DNA fragmentation) in a biological model, the early and mid stages of oogenesis of the insect *Drosophila melanogaster*. The flies were exposed in vivo to either GSM 900-MHz (Global System for Mobile telecommunications) or DCS 1800-MHz (Digital Cellular System) radiation from a common digital mobile phone, for few minutes per day during the first 6 days of their adult life. The exposure conditions were similar to those to which a mobile phone user is exposed, and were determined according to previous studies of ours [D.J. Panagopoulos, A. Karabarounis, L.H. Margaritis, Effect of GSM 900-MHz mobile phone radiation on the reproductive capacity of *D. melanogaster*, *Electromagn. Biol. Med.* 23 (1) (2004) 29-43; D.J. Panagopoulos, N. Messini, A. Karabarounis, A.L. Philippetis, L.H. Margaritis, Radio frequency electromagnetic radiation within "safety levels" alters the physiological function of insects, in: P. Kostarakis, P. Stavroulakis (Eds.), *Proceedings of the Millennium International Workshop on Biological Effects of Electromagnetic Fields*, Heraklion, Crete, Greece, October 17-20, 2000, pp. 169-175, ISBN: 960-86733-0-5; D.J. Panagopoulos, L.H. Margaritis, Effects of electromagnetic fields on the reproductive capacity of *D. melanogaster*, in: P. Stavroulakis (Ed.), *Biological Effects of Electromagnetic Fields*, Springer, 2003, pp. 545-578], which had shown a large decrease in the oviposition of the same insect caused by GSM radiation. Our present results suggest that the decrease in oviposition previously reported, is due to degeneration of large numbers of egg chambers after DNA fragmentation of their constituent cells, induced by both types of mobile telephony radiation. Induced cell death is recorded for the first time, in all types of cells constituting an egg chamber (follicle cells, nurse cells and the oocyte) and in all stages of the early and mid-oogenesis, from germarium to stage 10, during which programmed cell death does not physiologically occur. Germarium and stages 7-8 were found to be the most sensitive developmental stages also in response to

electromagnetic stress induced by the GSM and DCS fields and, moreover, germarium was found to be even more sensitive than stages 7-8.

(60) **Evaluation of the Maximum Permissible Level of Low-Intensity Electromagnetic Radiation at Mobile Connection Frequency (1 GHz) by Changes in Motor Activity of Spirostomum Ambiguum**

Bull Exp Biol Med. 2009 Apr;147(4):431-3.

<http://www.ncbi.nlm.nih.gov/pubmed/19704941?dopt=Abstract>

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1000 MHz

10 $\mu\text{W}/\text{cm}^2$

Abstract: Electromagnetic radiation at the mobile connection frequency (1 GHz) at maximum energy flow density (10 microW/cm²) permitted in Russia causes serious functional disorders in the studied unicellular hydrobionts infusoria Spirostomum ambiguum: reduction of their spontaneous motor activity. The form of biological reaction is uncommon: the effect is threshold, overall, and does not depend on the duration of microwave exposure.

(61) **Evaluation of the effect of using mobile phones on male fertility**

Ann Agric Environ Med. 2007;14(1):169-72.

<http://www.ncbi.nlm.nih.gov/pubmed/17655195>

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Handy

Abstract: The problem of the lack of offspring is a phenomenon concerning approximately 15% of married couples in Poland. Infertility is defined as inability to conceive after a year of sexual intercourses without the use of contraceptives. In half of the cases the causative factor is the male. Males are exposed to the effect of various environmental factors, which may decrease their reproductive capabilities. A decrease in male fertility is a phenomenon which occurs within years, which may suggest that one of the reasons for the decrease in semen parameters is the effect of the development of techniques in the surrounding environment. A hazardous effect on male fertility may be manifested by a decrease in the amount of sperm cells, disorders in their mobility, as well as structure. The causative agents may be chemical substances, ionizing radiation, stress, as well as electromagnetic waves. The objective of the study was the determination of the effect of the usage of cellular phones on the fertility of males subjected to marital infertility therapy. The following groups were selected from among 304 males covered by the study: Group A: 99 patients who did not use mobile phones, Group B: 157 males who have used GSM equipment sporadically for the period of 1-2 years, and Group C: 48 people who have been regularly using mobile phone for more than 2 years. In the analysis of the effect of GSM equipment on the semen it was noted that an increase in the percentage of sperm cells of abnormal morphology is associated with the duration of exposure to the waves emitted by the GSM phone. It was also confirmed that a decrease in the percentage of sperm cells in vital progressing motility in the semen is correlated with the frequency of using mobile phones.

(62) **Effects of cellular phone emissions on sperm motility in rats**

Fertil Steril. 2007 Oct;88(4):957-64.

<http://www.ncbi.nlm.nih.gov/pubmed/17628553>

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Handy

OBJECTIVE: To evaluate the effects of cellular phone emissions on rat sperm cells. **DESIGN:** Classic experimental. **SETTING:** Animal research laboratory. **SUBJECTS:** Sixteen 3-month-old male Sprague-Dawley rats, weighing 250-300 g. **INTERVENTION(S):** Rats in the experimental group were exposed to two 3-hour periods of daily cellular phone emissions for 18 weeks; sperm samples were then collected for evaluation. **MAIN OUTCOME MEASURE(S):** Evaluation of sperm motility, sperm cell morphology, total sperm cell number, and mRNA levels for two cell surface adhesion proteins. **RESULT(S):** Rats exposed to 6 hours of daily cellular phone emissions for 18 weeks exhibited a significantly higher incidence of sperm cell death than control group rats through chi-squared analysis. In addition, abnormal clumping of sperm cells was present in rats exposed to cellular phone emissions and was not present in control group rats. **CONCLUSION(S):** These results suggest that carrying cell phones near reproductive organs could negatively affect male fertility.

(63) Studies on the Effects of Radio-Frequency Fields on Conifers

22nd BEMS Annual Meeting, Munich, Germany, 2000, 160

Lerchl ,D., Lerchl A., Hantsch P., Bitz A., Streckert J., Hansen V.

Institute of Zoology II, University of Karlsruhe, Germany

Discussions

Observation period: October 1999 – May 2000.

Despite marginally altered growth due to exposure, the physiology of exposed conifers seems to be negatively influenced by exposure to EMF at 383 MHz, causing a decline in the photosynthetic system which may be the first indication of a decline in the plant's overall status.

It is interesting to note that the most prominent effects were seen in *Pinus pumila*. In young plants of this species, needles were more vertically oriented, as compared to the two other species investigated here. It may therefore be possible that the electric component of the EMF is responsible for the observed effects.

(64) Prenatal and Postnatal Exposure to Cell Phone Use and Behavioral Problems in Children

Epidemiology 2008 Jul; 19(4): 523–529

<http://www.ncbi.nlm.nih.gov/pubmed/18467962>

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University of California, Los Angeles, CA; and Institute of Public

Health, Department of General Practice, University of Aarhus, Aarhus, Denmark

Handy

Comment in:

- [Epidemiology. 2008 Jul;19\(4\):530-1.](#)
- [Epidemiology. 2009 Mar;20\(2\):312.](#)
- [Epidemiology. 2008 Jul;19\(4\):534-5.](#)
- [Epidemiology. 2008 Jul;19\(4\):532-3.](#)

BACKGROUND: The World Health Organization has emphasized the need for research into the possible effects of radiofrequency fields in children. We examined the association between prenatal and postnatal exposure to cell phones and behavioral problems in young children. **METHODS:** Mothers were recruited to the Danish National Birth Cohort early in pregnancy. When the children of those pregnancies reached 7 years of age in 2005 and 2006, mothers were asked to complete a questionnaire regarding the current health and behavioral status of children, as well as past exposure to cell phone use. Mothers evaluated the child's behavior problems using the Strength and Difficulties Questionnaire. **RESULTS:** Mothers of 13,159 children completed the follow-up questionnaire reporting their use of cell phones during pregnancy as well as current cell phone use by the child. Greater odds ratios for behavioral problems were observed for children who had possible prenatal or postnatal exposure to cell phone use. After adjustment for potential confounders, the odds ratio for a higher overall behavioral problems score was 1.80 (95% confidence interval = 1.45-2.23) in children with both prenatal and postnatal exposure to cell phones. **CONCLUSIONS:** Exposure to cell phones prenatally-and, to a lesser degree, postnatally-was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry. These associations may be noncausal and may be due to unmeasured confounding. If real, they would be of public health concern given the widespread use of this technology.

(65) **Exposure to 2,45 GHz Microwave Radiation Provokes Cerebral Changes in Induction of HSP-90 α/β Heat Shock Protein in Rat**

Progress In Electromagnetics Research, PIER 100, 351-379, 2010

Jorge-Mora T., Alvarez-Folgueiras M., Leiro J., Jorge-Barreiro F. J., Ares-Pena F. J., Lopez-Martin E.

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2450 MHz CW

0,034; 0,069; 0,27 SAR

Abstract - Physical agents such as non-ionizing continuous-wave 2.45 GHz radiation may cause damage that alters cellular homeostasis and may trigger activation of the genes that encode heat shock proteins (HSP). We used Enzyme-Linked ImmunoSorbent Assay (ELISA) and immunohistochemistry to analyze the changes in levels of HSP-90 and its distribution in the brain of Sprague-Dawley rats, ninety minutes and twenty-four hours after acute (30min) continuous exposure to 2.45 GHz radiation in a Gigahertz Transverse Electromagnetic (GTEM cell). In addition, we studied further indicators of neuronal insult: dark neurons, chromatin condensation and nucleus fragmentation, which were observed under optical conventional or fluorescence microscopy after DAPI staining. The cellular distribution of protein HSP-90 in the brain increased with each corresponding SAR (0.034 ± 3.10^{-3} , 0.069 ± 5.10^{-3} , 0.27 ± 21.10^{-3} W/kg), in hypothalamic nuclei, limbic cortex and somatosensorial cortex after exposure to the radiation. At twenty-four hours post-irradiation, levels of HSP-90 protein remained high in all hypothalamic nuclei for all SARs, and in the parietal cortex, except the limbic system, HSP-90 levels were lower than in non-irradiated rats, almost half the levels in rats exposed to the highest power radiation. Non-apoptotic cellular nuclei and some dark neurons were found ninety minutes and twenty-four hours after maximal SAR exposure. The results suggest that acute exposure to electromagnetic fields triggered an imbalance in anatomical HSP- 90 levels but the anti-apoptotic mechanism is probably sufficient to compensate the non-ionizing stimulus. Further studies are required to

determine the regional effects of chronic electromagnetic pollution on heat shock proteins and their involvement in neurological processes and neuronal damage.

(66) **Qualitative Effect on mRNAs of Injury-Associated Proteins by Cell Phone Like Radiation in Rat Facial Nerves**

Electromagn Biol Med. **2009**; 28(4):383-90.

<http://www.ncbi.nlm.nih.gov/pubmed/20017629?dopt=Abstract>

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800, 1900 MHz

1,8; 0,9; 1,18 SAR

Abstract: Rats were exposed to cell phone radiation for 6 hours per day for 18 weeks. The buccal and mandibular branches of the facial nerve were evaluated for this study. The mRNA levels of four proteins that are usually up regulated when an injury has occurred were investigated; included were Calcium ATP-ase, Endothelin, Neural Cell Adhesion Molecule, and Neural Growth Factor. These isolated mRNAs were subjected to RT-PCR and all four were up regulated. The mandibular nerve showed a higher and broader level of up regulation than the buccal nerve. All four mRNA up regulations for the mandibular nerve and two for the buccal nerve were also statistically significant. These specific injury-related findings were mild. As the use of these cell phones continues, there most likely will be permanent damage to these tissues over the years and the likelihood of tumors, cancers, and system failures will potentially increase.

(67) **Effect of radio-frequency electromagnetic radiations (RF-EMR) on passive avoidance behaviour and hippocampal morphology in Wistar rats**

Ups J Med Sci. **2010** Jan 23

<http://www.ncbi.nlm.nih.gov/pubmed/20095879?dopt=Abstract>

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Handy

Abstract: The interaction of mobile phone radio-frequency electromagnetic radiation (RF-EMR) with the brain is a serious concern of our society. Objective. We evaluated the effect of RF-EMR from mobile phones on passive avoidance behaviour and hippocampal morphology in rats. Materials and methods. Healthy male albino Wistar rats were exposed to RF-EMR by giving 50 missed calls (within 1 hour) per day for 4 weeks, keeping a GSM (0.9 GHz/1.8 GHz) mobile phone in vibratory mode (no ring tone) in the cage. After the experimental period, passive avoidance behaviour and hippocampal morphology were studied. Results. Passive avoidance behaviour was significantly affected in mobile phone RF-EMR-exposed rats demonstrated as shorter entrance latency to the dark compartment when compared to the control rats. Marked morphological changes were also observed in the CA(3) region of the hippocampus of the mobile phone-exposed rats in comparison to the control rats. Conclusion. Mobile phone RF-EMR exposure significantly altered the passive avoidance behaviour and hippocampal morphology in rats.

(68) **Audiologic disturbances in long-term mobile phone users**

J Otolaryngol Head Neck Surg. **2010** Feb 1;39(1):5-11.

<http://www.ncbi.nlm.nih.gov/pubmed/20122338?dopt=Abstract>

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Handy

INTRODUCTION: There is general concern regarding the possible hazardous health effects of exposure to radiofrequency electromagnetic radiation emitted from mobile phones. This study aimed to assess the effects of chronic exposure to electromagnetic waves emitted from Global System for Mobile Communication (GSM) mobile phones on auditory functions.

MATERIAL AND METHODS: A retrospective, cross-sectional, randomized, case control study was carried out in a tertiary care hospital. One hundred twelve subjects who were long-term mobile phone users (more than 1 year) and 50 controls who had never used a mobile phone underwent a battery of audiologic investigations including pure-tone audiometry (both speech and high frequency), tympanometry, distortion product otoacoustic emissions, auditory brain responses, and middle latency responses. Changes in the various parameters were studied in the mobile phone- and non-mobile phone-using ears of subjects and corresponding ears of the controls to ascertain the effects of electromagnetic exposure.

RESULTS: There was no significant difference between users and controls for any of the audiologic parameters. However, trends for audiologic abnormalities were seen within the users. High-frequency loss and absent distortion product otoacoustic emissions were observed with an increase in the duration of mobile phone use, excessive use of mobile phones, and age more than 30 years. Additionally, users with some complaints during mobile phone use demonstrated absent distortion product otoacoustic emissions and abnormalities in auditory brainstem response. **CONCLUSION:** Long-term and intensive mobile phone use may cause inner ear damage. A large sample size would be required to reach definitive conclusions.

(69) **Microwaves from Mobile Phones Inhibit 53BP1 Focus Formation in Human Stem Cells Stronger than in Differentiated Cells: Possible Mechanistic Link to Cancer Risk**

Environ Health Perspect Oct 2009

<http://ehp.niehs.nih.gov/docs/2009/0900781/abstract.pdf>

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Republic

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915; 1947,4 MHz

0,037; 0,039 SAR

Background: It is widely accepted that DNA double-strand breaks (DSB) and their misrepair in stem cells are critical events in the multistage origination of various leukemia and tumors including gliomas.

Objectives: We studied whether microwaves (MW) from mobile phone of Global System for Mobile Communication (GSM) and Universal Global Telecommunications System (UMTS) induce DSB or affect DSB repair in stem cells.

Methods: 53BP1 foci that are typically formed at the sites of DSB location (referred to as DNA repair foci) were analyzed by laser confocal microscopy.

Results: We report for the first time that MW from mobile phones inhibit formation of 53BP1 foci in human primary fibroblasts and mesenchymal stem cells (MSC). These data parallel our previous findings for human lymphocytes. Importantly, the same GSM carrier frequency (915 MHz) and UMTS frequency band (1947.4 MHz) was effective for all cell types. Exposure at 905 MHz did not inhibit 53BP1 foci in differentiated cells, both fibroblasts and

lymphocytes, while some effects at 905 MHz were seen in stem cells. Contrary to fibroblasts, stem cell did not adapt to chronic exposure during two weeks.

Conclusions: Strongest MW effects were always observed in stem cells that may suggest both significant misbalance in DSB repair and severe stress response. Our findings that stem cells are most sensitive to MW exposure and react to more frequencies than differentiated cells may be important for cancer risk assessment and indicate that stem cells are most relevant cellular model for validating the safe mobile communication signals.

(70) **Effect of mobile phone exposure on apoptotic glial cells and status of oxidative stress in rat brain**

Electromagn Biol Med. 2009; 28(4):342-54.

<http://www.ncbi.nlm.nih.gov/pubmed/20017625>

Dasdag S, Akdag MZ, Ulukaya E, Uzunlar AK, Ocak AR.

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dasdag@dicle.edu.tr

900 MHz

16,26 V/m => 0,701 W/m²

29,43 V/m => 2,297 W/m²

Abstract: The aim of this study was to investigate the effects of mobile phone exposure on glial cells in brain. The study carried out on 31 Wistar Albino adult male rats. The rat heads in a carousel exposed to 900 MHz microwave. For the study group (n:14), rats exposed to the radiation 2 h per day (7 days in a week) for 10 months. For the sham group (n:7), rats were placed into the carousel and the same procedure was applied except that the generator was turned off. For the cage control (n:10), nothing applied to rats in this group. In this study, rats were euthanized after 10 months of exposure periods and brains were removed. Brain tissues were immunohistochemically stained for the active (cleaved) caspase-3, which is a well-known apoptosis marker, and p53. The expression of the proteins was evaluated by a semi-quantitative scoring system. However, total antioxidative capacity (TAC), catalase, total oxidant status (TOS), and oxidative stress index were measured in rat brain. Final score for apoptosis in the exposed group was significantly lower than the sham (p < 0.001) and the cage control groups (p < 0.01). p53 was not significantly changed by the exposure (p > 0.05). The total antioxidant capacity and catalase in the experimental group was found higher than that in the sham group (p < 0.001, p < 0.05). In terms of the TOS and oxidative stress index, there was no statistically significant difference between exposure and sham groups (p > 0.05). In conclusion, the final score for apoptosis, total antioxidant capacity and catalase in rat brain might be altered by 900 MHz radiation produced by a generator to represent exposure of global systems for mobile communication (GSM) cellular phones.

(71) **The effect of electromagnetic radiation in the mobile phone range on the behaviour of the rat**

Metab Brain Dis. 2009 Dec;24(4):629-41.

<http://www.ncbi.nlm.nih.gov/pubmed/19823925>

Daniels WM, Pitout IL, Afullo TJ, Mabandla MV.

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840 MHz

60 µW/m² (at 0,93 m from the antenna)

Abstract: Electromagnetic radiation (EMR) is emitted from electromagnetic fields that surround power lines, household appliances and mobile phones. Research has shown that there are connections between EMR exposure and cancer and also that exposure to EMR

may result in structural damage to neurons. In a study by Salford et al. (Environ Health Perspect 111:881-883, 2003) the authors demonstrated the presence of strongly stained areas in the brains of rats that were exposed to mobile phone EMR. These darker neurons were particularly prevalent in the hippocampal area of the brain. The aim of our study was to further investigate the effects of EMR. Since the hippocampus is involved in learning and memory and emotional states, we hypothesised that EMR will have a negative impact on the subject's mood and ability to learn. We subsequently performed behavioural, histological and biochemical tests on exposed and unexposed male and female rats to determine the effects of EMR on learning and memory, emotional states and corticosterone levels. We found no significant differences in the spatial memory test, and morphological assessment of the brain also yielded non-significant differences between the groups. However, in some exposed animals there were decreased locomotor activity, increased grooming and a tendency of increased basal corticosterone levels. These findings suggested that EMR exposure may lead to abnormal brain functioning.

(72) **Increased protein synthesis by cells exposed to a 1,800-MHz radio-frequency mobile phone electromagnetic field, detected by proteome profiling**

Int Arch Occup Environ Health. 2010 Feb 10

<http://www.ncbi.nlm.nih.gov/pubmed/20145945?dopt=Abstract>

Gerner C, Haudek V, Schandl U, Bayer E, Gundacker N, Hutter HP, Mosgoeller W.

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Handy

PURPOSE: To investigate whether or not low intensity radio frequency electromagnetic field exposure (RF-EME) associated with mobile phone use can affect human cells, we used a sensitive proteome analysis method to study changes in protein synthesis in cultured human cells. **METHODS:** Four different cell kinds were exposed to 2 W/kg specific absorption rate in medium containing (35)S-methionine/cysteine, and autoradiography of 2D gel spots was used to measure the increased synthesis of individual proteins.

RESULTS: While short-term RF-EME did not significantly alter the proteome, an 8-h exposure caused a significant increase in protein synthesis in Jurkat T-cells and human fibroblasts, and to a lesser extent in activated primary human mononuclear cells. Quiescent (metabolically inactive) mononuclear cells, did not detectably respond to RF-EME. Since RF exposure induced a temperature increase of less than 0.15 degrees C, we suggest that the observed cellular response is a so called "athermal" effect of RF-EME.

CONCLUSION: Our finding of an association between metabolic activity and the observed cellular reaction to low intensity RF-EME may reconcile conflicting results of previous studies. We further postulate that the observed increased protein synthesis reflects an increased rate of protein turnover stemming from protein folding problems caused by the interference of radio-frequency electromagnetic fields with hydrogen bonds. Our observations do not directly imply a health risk. However, vis-a-vis a synopsis of reports on cells stress and DNA breaks, after short and longer exposure, on active and inactive cells, our findings may contribute to the re-evaluation of previous reports.

(73) **The effect of pulsed 900-MHz GSM mobile phone radiation on the acrosome reaction, head morphometry and zona binding of human spermatozoa**

Int J Androl. 2010 Mar 7

<http://www.ncbi.nlm.nih.gov/pubmed/20236367?dopt=Abstract>

Falzone N, Huyser C, Becker P, Leszczynski D, Franken DR.

Department of Biomedical Sciences, Tshwane University of Technology, Pretoria, South Africa

900-MHz
2 SAR

Abstract: Several recent studies have indicated that radiofrequency electromagnetic fields (RF-EMF) have an adverse effect on human sperm quality, which could translate into an effect on fertilization potential. This study evaluated the effect of RF-EMF on sperm-specific characteristics to assess the fertilizing competence of sperm. Highly motile human spermatozoa were exposed for 1 h to 900-MHz mobile phone radiation at a specific absorption rate of 2.0 W/kg and examined at various times after exposure. The acrosome reaction was evaluated using flow cytometry. The radiation did not affect sperm propensity for the acrosome reaction. Morphometric parameters were assessed using computer-assisted sperm analysis. Significant reduction in sperm head area (9.2 +/- 0.7 μm^2) vs. 18.8 +/- 1.4 μm^2) and acrosome percentage of the head area (21.5 +/- 4% vs. 35.5 +/- 11.4%) was reported among exposed sperm compared with unexposed controls. Sperm-zona binding was assessed directly after exposure using the hemizona assay. The mean number of zona-bound sperm of the test hemizona and controls was 22.8 +/- 12.4 and 31.8 +/- 12.8 ($p < 0.05$), respectively. This study concludes that although RF-EMF exposure did not adversely affect the acrosome reaction, it had a significant effect on sperm morphometry. In addition, a significant decrease in sperm binding to the hemizona was observed. These results could indicate a significant effect of RF-EMF on sperm fertilization potential.

(74) **Electromagnetic pollution from phone masts. Effects on wildlife - Review**

Pathophysiology. 2009 Aug;16(2-3):191-9.
<http://www.ncbi.nlm.nih.gov/pubmed/19264463>
Balmori A.

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Basestation

Abstract

A review on the impact of radiofrequency radiation from wireless telecommunications on wildlife is presented. Electromagnetic radiation is a form of environmental pollution which may hurt wildlife. Phone masts located in their living areas are irradiating continuously some species that could suffer long-term effects, like reduction of their natural defenses, deterioration of their health, problems in reproduction and reduction of their useful territory through habitat deterioration. Electromagnetic radiation can exert an aversive behavioral response in rats, bats and birds such as sparrows. Therefore microwave and radiofrequency pollution constitutes a potential cause for the decline of animal populations and deterioration of health of plants living near phone masts. To measure these effects urgent specific studies are necessary.

Conclusions

This literature review shows that pulsed telephony microwave radiation can produce effects especially on nervous, cardiovascular, immune and reproductive systems:

- Damage to the nervous system by altering electroencephalogram, changes in neural response or changes of the blood-brain barrier.
- Disruption of circadian rhythms (sleep-wake) by interfering with the pineal gland and hormonal imbalances.
- Changes in heart rate and blood pressure.
- Impairment of health and immunity towards pathogens, weakness, exhaustion, deterioration of plumage and growth problems.

- Problems in building the nest or impaired fertility, number of eggs, embryonic development, hatching percentage and survival of chickens.
- Genetic and developmental problems: problems of locomotion, partial albinism and melanism or promotion of tumors.

In the light of current knowledge there is enough evidence of serious effects from this technology to wildlife. For this reason precautionary measures should be developed, alongside environmental impact assessments prior to installation, and a ban on installation of phone masts in protected natural areas and in places where endangered species are present. Surveys should take place to objectively assess the severity of effects.

(75) **Reactive oxygen species levels and DNA fragmentation on astrocytes in primary culture after acute exposure to low intensity microwave electromagnetic field**

Neurosci Lett. **2010** Mar 31;473(1):52-5.

<http://www.ncbi.nlm.nih.gov/pubmed/20156525?dopt=Abstract>

Campisi A, Gulino M, Acquaviva R, Bellia P, Raciti G, Grasso R, Musumeci F, Vanella A, Triglia A.

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900 MHz PW

10 V/m

Abstract

The exposure of primary rat neocortical astroglial cell cultures to acute electromagnetic fields (EMF) in the microwave range was studied. Differentiated astroglial cell cultures at 14 days in vitro were exposed for 5, 10, or 20min to either 900MHz continuous waves or 900MHz waves modulated in amplitude at 50Hz using a sinusoidal waveform and 100% modulation index. The strength of the electric field (rms value) at the sample position was 10V/m. No change in cellular viability evaluated by MTT test and lactate dehydrogenase release was observed. **A significant increase in ROS levels and DNA fragmentation was found only after exposure of the astrocytes to modulated EMF for 20min.** No evident effects were detected when shorter time intervals or continuous waves were used. The irradiation conditions allowed the exclusion of any possible thermal effect. Our data demonstrate, for the first time, that even acute exposure to low intensity EMF induces ROS production and DNA fragmentation in astrocytes in primary cultures, which also represent the principal target of modulated EMF. Our findings also suggest the hypothesis that the effects could be due to hyperstimulation of the glutamate receptors, which play a crucial role in acute and chronic brain damage. Furthermore, the results show the importance of the **amplitude modulation** in the interaction between EMF and neocortical astrocytes.

(76) **Interaction of Microwaves and a Temporally Incoherent Magnetic Field on Single and Double DNA Strand Breaks in Rat Brain Cells**

Electromagnetic Biology and Medicine, Volume 24, Issue 1 January **2005** , pages 23 – 29

<http://www.informaworld.com/smpp/content~db=all~content=a713720240>

Lai H., Singh N. P.

Bioelectromagnetics Research Laboratory, Department of Bioengineering,
University of Washington, Seattle, Washington, USA

2.450 MHz CW

10.000 $\mu\text{W}/\text{m}^2$

Abstract

The effect of a temporally incoherent magnetic field noise on microwave-induced DNA single and double strand breaks in rat brain cells was investigated. Four treatment groups of rats were studied: microwave-exposure (continuous-wave 2450-MHz microwaves, power density 1 mW/cm², average whole-body specific absorption rate of 0.6 W/kg), noise-exposure (45 mG), microwave + noise-exposure, and sham-exposure. Animals were exposed to these conditions for 2h. DNA single- and double-strand breaks in brain cells of these animals were assayed 4h later using a microgel electrophoresis assay. Results show that brain cells of microwave-exposed rats had significantly higher levels of DNA single- and double-strand breaks when compared with sham-exposed animals. Exposure to noise alone did not significantly affect the levels (i.e., they were similar to those of the sham-exposed rats). However, simultaneous noise exposure blocked microwave-induced increases in DNA strand breaks. These data indicate that simultaneous exposure to a temporally incoherent magnetic field could block microwave-induced DNA damage in brain cells of the rat.

(77) Interaction of microwaves and a temporally incoherent magnetic field on spatial learning in the rat

Physiol Behav. 2004 Oct 15;82(5):785-9.

<http://www.ncbi.nlm.nih.gov/pubmed/15451642>

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hlai@u.washington.edu

2.450 MHz CW
20.000 μW/m²

Abstract

The effect of a temporally incoherent magnetic field ('noise') on microwave-induced spatial learning deficit in the rat was investigated. Rats were trained in six sessions to locate a submerged platform in a circular water maze. Four treatment groups of rats were studied: microwave-exposure (2450-MHz continuous-wave microwaves, power density 2 mW/cm², average whole-body specific absorption rate 1.2 W/kg), 'noise' exposure (60 mG), 'microwave+noise' exposure, and sham exposure. Animals were exposed to these conditions for 1 h immediately before each training session. One hour after the last training session, animals were tested in a 2-min probe trial in the maze during which the platform was removed. The time spent during the 2 min in the quadrant of the maze in which the platform had been located was scored. Results show that microwave-exposed rats had significant deficit in learning to locate the submerged platform when compared with the performance of the sham-exposed animals. Exposure to 'noise' alone did not significantly affect the performance of the animals (i.e., it was similar to that of the sham-exposed rats). However, simultaneous exposure to 'noise' significantly attenuated the microwave-induced spatial learning deficit (i.e. 'microwave+noise'-exposed rats learned significantly better than the microwave-exposed rats). During the probe trial, microwave-exposed animals spent significantly less time in the quadrant where the platform was located. However, response of the 'microwave+noise'-exposed animals was similar to that of the sham-exposed animals during the probe trial. Thus, simultaneous exposure to a temporally incoherent magnetic field blocks microwave-induced spatial learning and memory deficits in the rat.

(78) Evaluation of basal DNA damage and oxidative stress in Wistar rat leukocytes after exposure to microwave radiation

Toxicology. 2009 May 17;259(3):107-12.

<http://www.ncbi.nlm.nih.gov/pubmed/19428950>

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915 MHz PW

2,4 W/m²

Abstract

The aim of this study was to assess whether microwave-induced DNA damage is basal or it is also generated through reactive oxygen species (ROS) formation. After having irradiated Wistar rats with 915MHz microwave radiation, we assessed different DNA alterations in peripheral leukocytes using standard and formamidopyrimidine DNA-glycosylase (Fpg)-modified comet assay. The first is a sensitive tool for detecting primary DNA damage, and the second is much more specific for detecting oxidative damage. The animals were irradiated for 1h a day for 2 weeks at a field power density of 2.4W/m², and the whole-body average specific absorption rate (SAR) of 0.6W/kg. **Both the standard and the Fpg-modified comet assay detected increased DNA damage in blood leukocytes of the exposed rats.** The significant increase in Fpg-detected DNA damage in the exposed rats suggests that oxidative stress is likely to be responsible. DNA damage detected by the standard comet assay indicates that some other mechanisms may also be involved. In addition, both methods served proved sensitive enough to measure basal and oxidative DNA damage after long-term exposure to 915MHz microwave radiation in vivo.

(79) **GSM base station electromagnetic radiation and oxidative stress in rats**

Electromagn Biol Med. **2006**;25(3):177-88.

<http://www.ncbi.nlm.nih.gov/pubmed/16954120>

Yurekli AI, Ozkan M, Kalkan T, Saybasili H, Tuncel H, Atukeren P, Gumustas K, Seker S.

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945 MHz PW

3,67 W/m²

Basestation

Abstract

The ever increasing use of cellular phones and the increasing number of associated base stations are becoming a widespread source of nonionizing electromagnetic radiation. Some biological effects are likely to occur even at low-level EM fields. In this study, a gigahertz transverse electromagnetic (GTEM) cell was used as an exposure environment for plane wave conditions of far-field free space EM field propagation at the GSM base transceiver station (BTS) frequency of 945 MHz, and effects on oxidative stress in rats were investigated. **When EM fields at a power density of 3.67 W/m² (specific absorption rate = 11.3 mW/kg), which is well below current exposure limits, were applied, MDA (malondialdehyde) level was found to increase and GSH (reduced glutathione) concentration was found to decrease significantly (p < 0.0001).** Additionally, there was a less significant (p = 0.0190) increase in SOD (superoxide dismutase) activity under EM exposure.

(80) **Mutagenic response of 2.45 GHz radiation exposure on rat brain**

Int J Radiat Biol. **2010** Apr; 86(4):334-43.

<http://www.ncbi.nlm.nih.gov/pubmed/20353343>

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Bioelectromagnetic Laboratory, School of Environmental Sciences, Jawaharlal
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2.450 MHz PW: 50 Hz modulation

3.400.000 $\mu\text{W}/\text{m}^2$

Abstract

PURPOSE: To investigate the effect of 2.45 GHz microwave radiation on rat brain of male wistar strain. **MATERIAL AND METHODS:** Male rats of wistar strain (35 days old with 130 +/- 10 g body weight) were selected for this study. Animals were divided into two groups: Sham exposed and experimental. Animals were exposed for 2 h a day for 35 days to 2.45 GHz frequency at 0.34 mW/cm² power density. The whole body specific absorption rate (SAR) was estimated to be 0.11 W/Kg. Exposure took place in a ventilated Plexiglas cage and kept in anechoic chamber in a far field configuration from the horn antenna. After the completion of exposure period, rats were sacrificed and the whole brain tissue was dissected and used for study of double strand DNA (Deoxyribonucleic acid) breaks by micro gel electrophoresis and the statistical analysis was carried out using comet assay (IV-2 version software). Thereafter, antioxidant enzymes and histone kinase estimation was also performed.

RESULTS: A significant increase was observed in comet head ($P < 0.002$), tail length ($P < 0.0002$) and in tail movement ($P < 0.0001$) in exposed brain cells. An analysis of antioxidant enzymes glutathione peroxidase ($P < 0.005$), and superoxide dismutase ($P < 0.006$) showed a decrease while an increase in catalase ($P < 0.006$) was observed. A significant decrease ($P < 0.023$) in histone kinase was also recorded in the exposed group as compared to the control (sham-exposed) ones. One-way analysis of variance (ANOVA) method was adopted for statistical analysis. **CONCLUSION:** The study concludes that the chronic exposure to these radiations may cause significant damage to brain, which may be an indication of possible tumour promotion (Behari and Paulraj 2007).

(81) Cellular phones, cordless phones, and the risks of glioma and meningioma (Interphone Study Group, Germany).

Am J Epidemiol. 2006 Mar 15;163(6):512-20.

<http://www.ncbi.nlm.nih.gov/pubmed/16443797>

Schüz J, Böhler E, Berg G, Schlehofer B, Hettinger I, Schläefer K, Wahrendorf J, Kunna-Grass K, Blettner M.

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Handy

Abstract

The widespread use of cellular telephones has generated concern about possible adverse health effects, particularly brain tumors. In this population-based case-control study carried out in three regions of Germany, all incident cases of glioma and meningioma among patients aged 30-69 years were ascertained during 2000-2003. Controls matched on age, gender, and region were randomly drawn from population registries. In total, 366 glioma cases, 381 meningioma cases, and 1,494 controls were interviewed. Overall use of a cellular phone was not associated with brain tumor risk; the respective odds ratios were 0.98 (95% confidence interval (CI): 0.74, 1.29) for glioma and 0.84 (95% CI: 0.62, 1.13) for meningioma. Among persons who had used cellular phones for 10 or more years, increased risk was found for glioma (odds ratio = 2.20, 95% CI: 0.94, 5.11) but not for meningioma (odds ratio = 1.09, 95% CI: 0.35, 3.37). No excess of temporal glioma ($p = 0.41$) or meningioma ($p = 0.43$) was observed in cellular phone users as compared with nonusers. Cordless phone use was not related to either glioma risk or meningioma risk. In conclusion, no overall increased risk of

glioma or meningioma was observed among these cellular phone users; however, for long-term cellular phone users, results need to be confirmed before firm conclusions can be drawn.

(82) **The Microwave Syndrome: A preliminary Study in Spain**

Electromagnetic Biology and Medicine, Volume 22, Issue 2, (2003)

http://oikos-associacio.entitats.mataro.cat/files/23-403-document/la_nyora_manuscript.pdf

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Basestation GSM 900/1800

1.100 $\mu\text{W}/\text{m}^2$ < 150 m distance

100 $\mu\text{W}/\text{m}^2$ > 250 m distance

Results

The respondents were male (47%) and female (53%), with a wide age range: 15-25 years (22%), 26-35 years (22%), 36-45 years (19%), 46-55 years (11%), 56-65 years (13%), and more than 65 years (13%).

The exposition time, explained as the time spent in the vicinity of the BS was more than 6 hours per day, 7 days a week, in the 95% of the respondents. The place of permanence was declared the bedroom, the place where the electric field was measured, and included in the survey.

Concerning the attitude of the respondents about the use of cellular phone: 24% of them declared themselves to be active users of mobile GSM-DCS phone for more than 20 minutes per day.

The measurements were very low compared with the European safety guidelines 1999/519/EC DOCE 30/7/99. Actually the levels were lower than 0.2 microwatts/cm², where the Spanish legislation establish a maximum limit of 450 microwatts/cm² at a single frequency (900MHz), the same than European safety guidelines 1999/519/EC DOCE 30/7/99. This is one of the characteristics of the presented work: the low levels of RF exposition.

We divide the surveys in two groups: One group with high exposure, an average exposure of 0.11 microwatts/cm², constituted with 47 respondents. These respondents declared themselves to have living under a distance to the BS lower than 150mts. The second group, has an average exposure of 0.01 microwatts/cm² with distance greater than 250m.

Obviously, both groups have a different distance to the BS, and we have to assume the risk of a distance perception that can influence the survey.

Table 1 shows the averaged declared severity in both groups. A possible relationship between the declared severity of the symptom, and the microwave power density is explored. A mathematical model with logarithmic dependence with the measured electric field (EFM) is analysed. The statistical package SPSS, with their different regression methods has been used for these analysis, whose results for the correlation coefficient and statistical significance is presented in Table 2. Correlation coefficients were grouped in four sections: Astenic, diencefalic, sensorial, and cardiovascular symptoms.

Discussion

It is most interesting the comparison of the severity of the reported symptoms between

both groups of Table 1: more severe symptoms were reported in the first group. The first group (<150 m to BS) was exposed to a mean EMF power density 10 times higher than the second group (>250 m to BS). Asthenic syndrome was a 42% higher in the first group, diencephalic syndrome was a 55% higher in the first group, sensorial alterations were a 25% higher in the first group and cardiovascular alterations a 55% higher as well. However, the use of mobile phone was 30% in the first group and 17% in the second group. Use of the personal computer was a 16% in the first group, and 1% in the second group. Therefore, these differences could bias the health response. The use of the mobile cellular phone implies a considerable higher exposition of the head to microwaves during the phone call, that could arrive roughly to 5mW/cm², 10.000 times higher than the maximum EMF exposition attributed to the BS. Moreover, the symptomatic response could be influenced by personal or human idiosyncrasy. The exposition to radiation from the computer screen is relative to extremely low frequencies and is under 0.3 μT, at normal distance, therefore is not considered significant, and will be the subject of a future work.

Results from Table 2 indicate correlation between severity of the reported symptoms and the logarithm of the measured electric field (EFM) with $p < 0.001$. We find that discomfort (0.544), irritability (0.515), and appetite loss (0.485) are the most relevant symptoms correlated with exposure intensity. Others symptoms: fatigue (0.438), headache (0.413), difficulty in concentrating (0.469) and sleep disturbances (0.413) also show a significant correlation with exposure intensity. However, others such as auditory dysfunction, gait difficulty, and cardiovascular, do have a lower correlation coefficient, but significant $p < 0.01$.

However, the more interesting of our results is the significance of the dependence between both variables: The declared severity of the symptom and the logarithm of the measured electric field. Another interesting observation is that four of the high correlated symptoms (Table 2) such as headache, sleep disturbances, concentration difficulty and irritability also show the most relevant differences between both groups and the highest values in the clinical scale, 2.17, 1.94, 1.56 and 1.56 respectively (Table1).

The presented results demonstrate a significant correlation between several symptoms of the named microwave sickness and the microwave power density associated to the Base Station located in a hill at the edge of a town. The severity of the symptoms weakens for people who live far away, at a distance greater than 250m from the main EMF source and a power density lower than 0.1 μW/cm².

As there is a significant difference between both groups in terms of the irradiated power density, a hypothetical relationship between the DCS emission and the severity of both symptoms could exist.

Further elaboration:

The Microwave syndrome – further aspects of a Spanish Study

G. Oberfeld, A. E. Navarro, M. Portoles, M. Ceferino, C. Gomez-Perretta

http://www.avaate.org/IMG/pdf/Proceedings_Kos_2004.pdf

(83) Mobile phone use and risk of acoustic neuroma: results of the Interphone case-control study in five North European countries

Br J Cancer. 2005 Oct 3;93(7):842-8.

<http://www.ncbi.nlm.nih.gov/pubmed/16136046>

Schoemaker MJ, Swerdlow AJ, Ahlbom A, Auvinen A, Blaasaas KG, Cardis E, Christensen HC, Feychting M, Hepworth SJ, Johansen C, Klaeboe L, Lönn S, McKinney PA, Muir K, Raitanen J, Salminen T, Thomsen J, Tynes T.

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Handy

Abstract

There is public concern that use of mobile phones could increase the risk of brain tumours. If such an effect exists, acoustic neuroma would be of particular concern because of the proximity of the acoustic nerve to the handset. We conducted, to a shared protocol, six population-based case-control studies in four Nordic countries and the UK to assess the risk of acoustic neuroma in relation to mobile phone use. Data were collected by personal interview from 678 cases of acoustic neuroma and 3553 controls. The risk of acoustic neuroma in relation to regular mobile phone use in the pooled data set was not raised (odds ratio (OR) = 0.9, 95% confidence interval (CI): 0.7-1.1). There was no association of risk with duration of use, lifetime cumulative hours of use or number of calls, for phone use overall or for analogue or digital phones separately. Risk of a tumour on the same side of the head as reported phone use was raised for use for 10 years or longer (OR = 1.8, 95% CI: 1.1-3.1). The study suggests that there is no substantial risk of acoustic neuroma in the first decade after starting mobile phone use. However, an increase in risk after longer term use or after a longer lag period could not be ruled out.

(Remark: Few members belong to ICNIRP)

(84) Tumour risk associated with use of cellular telephones or cordless desktop telephones.

World J Surg Oncol. 2006 Oct 11;4:74.

<http://www.ncbi.nlm.nih.gov/pubmed/17034627>

Hardell L, Mild KH, Carlberg M, Söderqvist F.

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Handy

Abstract

BACKGROUND: The use of cellular and cordless telephones has increased dramatically during the last decade. There is concern of health problems such as malignant diseases due to microwave exposure during the use of these devices. The brain is the main target organ. **METHODS:** Since the second part of the 1990's we have performed six case-control studies on this topic encompassing use of both cellular and cordless phones as well as other exposures. Three of the studies concerned brain tumours, one salivary gland tumours, one non-Hodgkin lymphoma (NHL) and one testicular cancer. Exposure was assessed by self-administered questionnaires. **RESULTS:** Regarding acoustic neuroma analogue cellular phones yielded odds ratio (OR) = 2.9, 95 % confidence interval (CI) = 2.0-4.3, digital cellular phones OR = 1.5, 95 % CI = 1.1-2.1 and cordless phones OR = 1.5, 95 % CI = 1.04-2.0. The corresponding results were for astrocytoma grade III-IV OR = 1.7, 95 % CI = 1.3-2.3; OR = 1.5, 95 % CI = 1.2-1.9 and OR = 1.5, 95 % CI = 1.1-1.9, respectively. The ORs increased with latency period with highest estimates using > 10 years time period from first use of these phone types. Lower ORs were calculated for astrocytoma grade I-II. No association was found with salivary gland tumours, NHL or testicular cancer although an association with NHL of T-cell type could not be ruled out. **CONCLUSION:** We found for all studied phone types an increased risk for brain tumours, mainly acoustic neuroma and malignant brain tumours. OR increased with latency period, especially for astrocytoma grade III-IV. No consistent pattern of an increased risk was found for salivary gland tumours, NHL, or testicular cancer.

Comment

This publication had been excluded in the Interphone report 2010 with reference to the review of Ahlbom et al 2009, although this review did not find any fault in Hardell's research.

Ahlbom A, Feychting M, Green A et al. Epidemiologic evidence on mobile phones and tumor risk: a review. *Epidemiology* 2009;20:639–52

The comment by one of the leading Epidemiologists, Kenneth Rothman, in 2009 to this publication is: "Ahlbom et al identified no single methodologic problem that could explain the difference between the studies by Hardell and the results from the other studies. In their words, ". . . the series of decisions in methods, analysis, and presentation provide the most plausible explanation for the deviation of the findings of the Hardell studies from those of other investigators." "

Found in <http://journals.lww.com/epidem/toc/2009/09000>

(85) Case-control study of the association between the use of cellular and cordless telephones and malignant brain tumors diagnosed during 2000-2003

Environ Res. 2006 Feb;100(2):232-41.

<http://www.ncbi.nlm.nih.gov/pubmed/16023098>

Hardell L, Carlberg M, Mild KH.

Department of Oncology, University Hospital, SE-701 85 Orebro, Sweden.

Handy**Abstract**

We performed a case-control study on the use of cellular and cordless telephones and the risk for brain tumors diagnosed during 2000-2003. We report the results for malignant brain tumors with data from 317 cases (88%) and 692 controls (84%). The use of analog cellular phones yielded odds ratio (OR) of 2.6 and a 95% confidence interval (CI) of 1.5-4.3, increasing to OR=3.5 and 95% CI=2.0-6.4 with a >10-year latency period. Regarding digital cellular telephones, the corresponding results were OR=1.9, 95% CI=1.3-2.7 and OR=3.6, 95% CI=1.7-7.5, respectively. Cordless telephones yielded OR=2.1, 95% CI=1.4-3.0, and with a >10-year latency period, OR=2.9, 95% CI=1.6-5.2. The OR increased with the cumulative number of hours of use and was highest for high-grade astrocytoma. A somewhat increased risk was also found for low-grade astrocytoma and other types of malignant brain tumors, although not significantly so. In multivariate analysis, all three phone types studied showed an increased risk.

Comment

Interesting and amusing is the reply of L. Hardell and K.H. Mild to the publication "Mobile phone use and risk of acoustic neuroma: results of the interphone case-control study in five North European countries" given in 2006:

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2361400/#bib9>

"We are surprised that the authors (inserted: [Schoemaker et al, 2005](#)) claim that our first study ([Hardell et al, 2002](#), [2003a](#), [2003b](#)) has been 'heavily criticised for methodological limitations'. They give reference to five short comments or reports, two published in 2000 and 2001 ([Rothman, 2000](#), [2001](#)), thus even before our publication! The report by [Boice and McLaughlin \(2002\)](#) has never been published in a prereview journal and they are employed at an institute that has been linked to Motorola ([Hardell, 2004](#)). The other two references include authors of the Interphone study, thus merely themselves. No information is given in the paper ([Schoemaker et al, 2005](#)) regarding our 'methodological limitations', so we

compare standard epidemiological methods in the Interphone study and our studies (same methods were used in our two studies)."

[Authors of [Schoemaker et al, 2005](#) belong to the private club ICNIRP – which is close to industry]

(86) Bioeffects of mobile telephony radiation in relation to its intensity or distance from the antenna

Int J Radiat Biol. 2010 May; 86(5):345-57.

<http://www.ncbi.nlm.nih.gov/pubmed/20397839>

Panagopoulos DJ, Chavdoula ED, Margaritis LH.

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900 MHz PW, 1800 MHz PW

100.000 $\mu\text{W}/\text{m}^2$

effect less for **10.000 $\mu\text{W}/\text{m}^2$**

Abstract

PURPOSE: To examine the bioactivity of GSM 900 and 1800 (Global System for Mobile Telecommunications) radiations, in relation to the distance from the antenna or to the radiation-field intensities. **MATERIALS AND METHODS:** Drosophila melanogaster adult insects were exposed to the radiation of a GSM 900/1800 mobile phone antenna at different distances ranging from 0 to 100 cm, and the effect on their reproductive capacity and cell death induction in the gonads by the use of TUNEL (Terminal deoxynucleotide transferase dUTP Nick End Labeling) assay, was studied. **RESULTS:** These radiations/fields decreased the reproductive capacity by cell death induction, at all the different distances tested. The effect diminished with the distance/decreasing intensities. An increased bioactivity 'window' was revealed at distances of 20-30 cm from the mobile phone antenna, (radiation intensity around 10 microW/cm(2)) where the effect became highest, in relation to smaller or longer distances. The effect diminished considerably for distances longer than 40-50 cm and became not evident for distances longer than 1 m or radiation intensities smaller than 1 microW/cm(2). **CONCLUSIONS:** GSM bioactivity is highest for intensities down to less than 10 microW/cm(2) and still evident until 1 microW/cm(2) exhibiting 'window' effects.

Int J Radiat Biol. 2010 May;86(5):358-66.

The identification of an intensity 'window' on the bioeffects of mobile telephony radiation.

CONCLUSIONS: The bioactivity window seems to be due to the intensity of radiation-field (10 microW/cm(2), 0.6-0.7 V/m) at 30 or 20 cm from the GSM 900 or 1800 mobile phone antenna, respectively.

(87) Exposure to radio-frequency electromagnetic fields and behavioural problems in Bavarian children and adolescents

Eur J Epidemiol. 2010 Feb;25(2):135-41.

<http://www.ncbi.nlm.nih.gov/pubmed/19960235>

Thomas S, Heinrich S, von Kries R, Radon K.

Unit for Occupational and Environmental Epidemiology & NetTeaching, Institute and Outpatient Clinic for Occupational, Social and Environmental Medicine, Hospital of the Ludwig-Maximilians-University, Ziemssenstrasse 1, Munich, Germany. silke.thomas@med.lmu.de

Different Expositions: GMS, UMTS,WLAN,DECT

Abstract

Only few studies have so far investigated possible health effects of radio-frequency electromagnetic fields (RF EMF) in children and adolescents, although experts discuss a potential higher vulnerability to such fields. We aimed to investigate a possible association between measured exposure to RF EMF fields and behavioural problems in children and adolescents. 1,498 children and 1,524 adolescents were randomly selected from the population registries of four Bavarian (South of Germany) cities. During an Interview data on participants' mental health, socio-demographic characteristics and potential confounders were collected. Mental health behaviour was assessed using the German version of the Strengths and Difficulties Questionnaire (SDQ). Using a personal dosimeter, we obtained radio-frequency EMF exposure profiles over 24 h. Exposure levels over waking hours were expressed as mean percentage of the reference level. Overall, exposure to radiofrequency electromagnetic fields was far below the reference level. **Seven percent of the children and 5% of the adolescents showed an abnormal mental behaviour.** In the multiple logistic regression analyses measured exposure to RF fields in the highest quartile was associated to overall behavioural problems for adolescents (OR 2.2; 95% CI 1.1-4.5) but not for children (1.3; 0.7-2.6). These results are mainly driven by one subscale, as the results showed an **association between exposure and conduct problems** for **adolescents (3.7; 1.6-8.4)** and **children (2.9; 1.4-5.9)**. As this is one of the first studies that investigated an association between exposure to mobile telecommunication networks and mental health behaviour more studies using personal dosimetry are warranted to confirm these findings.

(88) Whole body exposure with GSM 900MHz affects spatial memory in mice

Pathophysiology. 2010 Jun;17(3):179-187.

<http://www.ncbi.nlm.nih.gov/pubmed/19954937>

Fragopoulou AF, Miltiados P, Stamatakis A, Stylianopoulou F, Koussoulakos SL, Margaritis LH.

Department of Cell Biology and Biophysics, Faculty of Biology, N. & K. University of Athens, Panepistimiopolis, Zographou 15784, Athens, Greece.

900 MHz PW

500.000 – 2.000.000 $\mu\text{W}/\text{m}^2$

Abstract

Extended work has been performed worldwide on the effects of mobile phone radiation upon rats' cognitive functions, however there is great controversy to the existence or not of deficits. The present work has been designed in order to test the effects of mobile phone radiation on spatial learning and memory in mice *Mus musculus* Balb/c using the Morris water maze (a hippocampal-dependent spatial memory task), since there is just one other study on mice with very low SAR level (0.05W/kg) showing no effects. We have applied a 2h daily dose of pulsed GSM 900MHz radiation from commercially available mobile phone for 4 days at SAR values ranging from 0.41 to 0.98W/kg. Statistical analysis revealed that during learning, exposed animals showed a deficit in transferring the acquired spatial information across training days (increased escape latency and distance swam, compared to the sham-exposed animals, on the first trial of training days 2-4). Moreover, during the memory probe-
trial sham-exposed animals showed the expected preference for the target quadrant, while the exposed animals showed no preference, indicating that **the exposed mice had deficits in consolidation and/or retrieval of the learned spatial information.** Our results provide a basis for more thorough investigations considering reports on non-thermal effects of electromagnetic fields (EMFs).

(89) Mobile phone emission modulates interhemispheric functional coupling of EEG alpha rhythms

Eur J Neurosci. 2007 Mar;25(6):1908-13.

<http://www.ncbi.nlm.nih.gov/pubmed/17432975>

Vecchio F, Babiloni C, Ferreri F, Curcio G, Fini R, Del Percio C, Rossini PM.

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902,4 MHz PW

0,5 SAR Gehirn

Abstract

We tested the working hypothesis that electromagnetic fields from mobile phones (EMFs) affect interhemispheric synchronization of cerebral rhythms, an important physiological feature of information transfer into the brain. Ten subjects underwent two electroencephalographic (EEG) recordings, separated by 1 week, following a crossover double-blind paradigm in which they were exposed to a mobile phone signal (global system for mobile communications; GSM). The mobile phone was held on the left side of the subject head by a modified helmet, and orientated in the normal position for use over the ear. The microphone was orientated towards the corner of the mouth, and the antenna was near the head in the parietotemporal area. In addition, we positioned another similar phone (but without battery) on the right side of the helmet, to balance the weight and to prevent the subject localizing the side of GSM stimulation (and consequently lateralizing attention). In one session the exposure was real (GSM) while in the other it was Sham; both sessions lasted 45 min. Functional interhemispheric connectivity was modelled using the analysis of EEG spectral coherence between frontal, central and parietal electrode pairs. Individual EEG rhythms of interest were delta (about 2-4 Hz), theta (about 4-6 Hz), alpha 1 (about 6-8 Hz), alpha 2 (about 8-10 Hz) and alpha 3 (about 10-12 Hz). Results showed that, compared to Sham stimulation, GSM stimulation modulated the interhemispheric frontal and temporal coherence at alpha 2 and alpha 3 bands. The present results suggest that prolonged mobile phone emission affects not only the cortical activity but also the spread of neural synchronization conveyed by interhemispherical functional coupling of EEG rhythms.

(90) Effects of exposure to 1.8 GHz radiofrequency field on the expression of Hsps and phosphorylation of MAPKs in human lens epithelial cells

Cell Research (2008) 18:1233-1235

<http://www.nature.com/cr/journal/v18/n12/full/cr2008306a.html>

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1800 MHz

2 SAR

Abstract

There is evidence that induction of the MAPK pathway plays significant roles in the activation of specific Hsps. We thus examined the activation of MAPKs after exposure to RF at SARs of 2, 3, and 4 W/kg for 0, 5, 15, 30, 60, and 120 min. The results showed that ERK1/2 was markedly activated as early as 5 min after RF exposure; the activation peaked at 30 min and lasted up to 2 h after exposure. Phosphorylation of JNK1/2 was

detected at 2 h after exposure, while p38 activation was not detected. Recently, it was reported that ERK was activated within 5 min of the radiation, with the peak activity occurring within 10-15 min, whereas no phosphorylation of JNKs or p38 was detected within a short time of exposure. Our results with human LECs are consistent with that study. These results indicate that mobile phone radiation can induce an immediate effect in the cytoplasm that activates ERK signaling so as to further induce transcription of a variety of genes, and that long exposure can activate JNK. However, we did not find the activation of p38 after RF exposure. **The appearance of p-ERK1/2 and p-JNK1/2, together with Hsp up-regulation, suggests that non-thermal RF exposure can induce the stress response in human LECs.**

Our results suggest that exposure to RF of wireless communications can induce expression of Hsp27 and Hsp70 and the activation of ERK1/2 and JNK1/2 in human LECs. The induction of Hsp27 and Hsp70, by a non-thermal stress, together with the activation of signal transduction pathways, provides reliable and sensitive biomarkers that could serve as the basis for improved mobile phone safety guidelines.

(91) **Studying gene expression profile of rat neuron exposed to 1800MHz radiofrequency electromagnetic fields with cDNA microassay**

Toxicology. **2007** Jun 25;235(3):167-75.

<http://www.ncbi.nlm.nih.gov/pubmed/17449163>

Zhao R, Zhang S, Xu Z, Ju L, Lu D, Yao G.

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1800 PW 217 Hz

2 SAR

Abstract

A widespread use of mobile phone (MP) evokes a growing concern for their possible adverse effects on human, especially the brain. Gene expression is a unique way of characterizing how cells and organism adapt to changes in the external environment, so the aim of this investigation was to determine whether 1800 MHz radiofrequency electromagnetic fields (RF EMF) can influence the gene expression of neuron. Affymetrix Rat Neurobiology U34 array was applied to investigate the changes of gene expression in rat neuron after exposed to the pulsed RF EMF at a frequency of 1800 MHz modulated by 217 Hz which is commonly used in MP. Among 1200 candidate genes, 24 up-regulated genes and 10 down-regulated genes were identified after 24-h intermittent exposure at an average special absorption rate (SAR) of 2 W/kg, which are associated with multiple cellular functions (cytoskeleton, signal transduction pathway, metabolism, etc.) after functional classification. The results were further confirmed by quantitative real-time polymerase chain reaction (RT PCR). **The present results indicated that the gene expression of rat neuron could be altered by exposure to RF EMF under our experimental conditions.**

(92) **Mobile phone 'talk-mode' signal delays EEG-determined sleep onset**

Neurosci Lett. **2007** Jun 21;421(1):82-6.

<http://www.ncbi.nlm.nih.gov/pubmed/17548154>

Hung CS, Anderson C, Horne JA, McEvoy P.

Sleep Research Centre, Loughborough University, UK

Handy 900 MHz PW

0,133; 0,015; 0,001 SAR

Abstract

Mobile phones signals are pulse-modulated microwaves, and EEG studies suggest that the extremely low-frequency (ELF) pulse modulation has sleep effects. However, 'talk', 'listen' and 'standby' modes differ in the ELF (2, 8, and 217Hz) spectral components and specific absorption rates, but no sleep study has differentiated these modes. We used a GSM900 mobile phone controlled by a base-station simulator and a test SIM card to simulate these three specific modes, transmitted at 12.5% (23dBm) of maximum power. At weekly intervals, 10 healthy young adults, sleep restricted to 6h, were randomly and single-blind exposed to one of: talk, listen, standby and sham (nil signal) modes, for 30 min, at 13:30 h, whilst lying in a sound-proof, lit bedroom, with a thermally insulated silent phone beside the right ear. Bipolar EEGs were recorded continuously, and subjective ratings of sleepiness obtained every 3 min (before, during and after exposure). After exposure the phone and base-station were switched off, the bedroom darkened, and a 90 min sleep opportunity followed. We report on sleep onset using: (i) visually scored latency to onset of stage 2 sleep, (ii) EEG power spectral analysis. There was no condition effect for subjective sleepiness. Post-exposure, sleep latency after talk mode was markedly and significantly delayed beyond listen and sham modes. This condition effect over time was also quite evident in 1-4Hz EEG frontal power, which is a frequency range particularly sensitive to sleep onset. **It is possible that 2, 8, 217Hz modulation may differentially affect sleep onset.**

(93) Effects of 900-MHz electromagnetic field emitted from cellular phone on brain oxidative stress and some vitamin levels of guinea pigs

Brain Res. 2007 Sep 12;1169:120-4.

<http://www.ncbi.nlm.nih.gov/pubmed/17674954>

Meral I, Mert H, Mert N, Deger Y, Yoruk I, Yetkin A, Keskin S.

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890 - 915 MHz PW

0,95 SAR max

Abstract

This study was designed to demonstrate the effects of 900-MHz electromagnetic field (EMF) emitted from cellular phone on brain tissue and also blood malondialdehyde (MDA), glutathione (GSH), retinol (vitamin A), vitamin D(3) and tocopherol (vitamin E) levels, and catalase (CAT) enzyme activity of guinea pigs. Fourteen male guinea pigs, weighing 500-800 g were randomly divided into one of two experimental groups: control and treatment (EMF-exposed), each containing seven animals. Animals in treatment group were exposed to 890- to 915-MHz EMF (217-Hz pulse rate, 2-W maximum peak power, SAR 0.95 w/kg) of a cellular phone for 12 h/day (11-h 45-min stand-by and 15-min spiking mode) for 30 days. Control guinea pigs were housed in a separate room without exposing EMF of a cellular phone. Blood samples were collected through a cardiac puncture and brains were removed after decapitation for the biochemical analysis at the end of the 30 days of experimental period. It was found that the MDA level increased ($P<0.05$), GSH level and CAT enzyme activity decreased ($P<0.05$), and vitamins A, E and D(3) levels did not change ($P>0.05$) in the brain tissues of EMF-exposed guinea pigs. In addition, MDA, vitamins A, D(3) and E levels, and CAT enzyme activity increased ($P<0.05$), and GSH level decreased ($P<0.05$) in the blood of EMF-exposed guinea pigs. **It was concluded that electromagnetic field emitted from cellular phone might produce oxidative stress in brain tissue of guinea pigs.** However, more studies are needed to demonstrate whether these effects are harmful or/and affect the neural functions.

(94) Pulsed radio frequency radiation affects cognitive performance and the waking electroencephalogram.

Neuroreport. 2007 May 28;18(8):803-7.

<http://www.ncbi.nlm.nih.gov/pubmed/17471070>

Regel SJ, Gottselig JM, Schuderer J, Tinguely G, Rétey JV, Kuster N, Landolt HP, Achermann P.

University of Zürich, Institute of Pharmacology and Toxicology, Zürich, Switzerland.

900 GSM

1 SAR**Abstract**

We investigated the effects of radio frequency electromagnetic fields on brain physiology. Twenty-four healthy young men were exposed for 30 min to pulse-modulated or continuous-wave radio frequency electromagnetic fields (900 MHz; peak specific absorption rate 1 W/kg), or sham exposed. During exposure, participants performed cognitive tasks. Waking electroencephalogram was recorded during baseline, immediately after, and 30 and 60 min after exposure. **Pulse-modulated radio frequency electromagnetic field exposure reduced reaction speed and increased accuracy in a working-memory task.** It also increased spectral power in the waking electroencephalogram in the 10.5-11 Hz range 30 min after exposure. No effects were observed for continuous-wave radio frequency electromagnetic fields. These findings provide further evidence for a nonthermal biological effect of pulsed radio frequency electromagnetic fields.

(95) Fetal and neonatal responses following maternal exposure to mobile phones

Saudi Med J. 2008 Feb;29(2):218-23.

<http://www.ncbi.nlm.nih.gov/pubmed/18246230>

Rezk AY, Abdulqawi K, Mustafa RM, Abo El-Azm TM, Al-Inany H.

Department of Obstetrics and Gynecology, Benha Faculty of Medicine, Zagazig University, Cairo, Egypt.

Handy**Abstract**

OBJECTIVE: To study fetal and neonatal heart rate (HR) and cardiac output (COP), following acute maternal exposure to electromagnetic fields (EMF) emitted by mobile phones.

METHODS: The present study was carried out at Benha University Hospital and El-Shorouq Hospital, Cairo, Egypt, from October 2003 to March 2004. Ninety women with uncomplicated pregnancies aged 18-33 years, and 30 full term healthy newborn infants were included. The pregnant mothers were exposed to EMF emitted by mobile telephones while on telephone-dialing mode for 10 minutes during pregnancy and after birth. The main outcome were measurements of fetal and neonatal HR and COP. **RESULTS:** A statistical significant increase in fetal and neonatal HR, and statistical significant decrease in stroke volume and COP before and after use of mobile phone were noted. All these changes are attenuated with increase in gestational age. **CONCLUSION:** **Exposure of pregnant women to mobile phone significantly increase fetal and neonatal HR, and significantly decreased the COP.**

(96) Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG

J Sleep Res. 2002 Dec;11(4):289-95.

<http://www.ncbi.nlm.nih.gov/pubmed/12464096>

Huber R, Treyer V, Borbély AA, Schuderer J, Gottselig JM, Landolt HP, Werth E, Berthold T, Kuster N, Buck A, Achermann P.

Institute of Pharmacology and Toxicology, University of Zurich, Zurich,
Switzerland.

900 MHz PW

1 SAR max

Abstract

Usage of mobile phones is rapidly increasing, but there is limited data on the possible effects of electromagnetic field (EMF) exposure on brain physiology. We investigated the effect of EMF vs. sham control exposure on waking regional cerebral blood flow (rCBF) and on waking and sleep electroencephalogram (EEG) in humans. In Experiment 1, positron emission tomography (PET) scans were taken after unilateral head exposure to 30-min pulse-modulated 900 MHz electromagnetic field (pm-EMF). In Experiment 2, night-time sleep was polysomnographically recorded after EMF exposure. Pulse-modulated EMF exposure increased relative rCBF in the dorsolateral prefrontal cortex ipsilateral to exposure. Also, pm-EMF exposure enhanced EEG power in the alpha frequency range prior to sleep onset and in the spindle frequency range during stage 2 sleep. Exposure to EMF without pulse modulation did not enhance power in the waking or sleep EEG. We previously observed EMF effects on the sleep EEG (A. A. Borbély, R. Huber, T. Graf, B. Fuchs, E. Gallmann and P. Achermann. *Neurosci. Lett.*, 1999, 275: 207-210; R. Huber, T. Graf, K. A. Cote, L. Wittmann, E. Gallmann, D. Matter, J. Schuderer, N. Kuster, A. A. Borbély, and P. Achermann. *Neuroreport*, 2000, 11: 3321-3325), but the basis for these effects was unknown. **The present results show for the first time that (1) pm-EMF alters waking rCBF and (2) pulse modulation of EMF is necessary to induce waking and sleep EEG changes.** Pulse-modulated EMF exposure may provide a new, non-invasive method for modifying brain function for experimental, diagnostic and therapeutic purposes.

(97) **Effect of high-frequency electromagnetic fields on trophoblastic connexins**

Reprod Toxicol. **2009** Jul; 28(1):59-65.

<http://www.ncbi.nlm.nih.gov/pubmed/19490996>

Cervellati F, Franceschetti G, Lunghi L, Franzellitti S, Valbonesi P, Fabbri E, Biondi C, Vesce F.

Department of Biology and Evolution, Section of General Physiology, University of Ferrara, via L. Borsari 46, 44100 Ferrara, Italy.

1817 MHz PW

2 SAR average

Abstract

Connexins (Cx) are membrane proteins able to influence trophoblast functions. Here we investigated the effect of high-frequency electromagnetic fields (HF-EMF) on Cx expression and localization in extravillous trophoblast cell line HTR-8/SVneo. We also analysed cell ultrastructural changes induced by HF-EMF exposure. Samples were exposed to pulse-modulated 1817 MHz sinusoidal waves (GSM-217 Hz; 1h: SAR of 2 W/kg). Cx mRNA expression was assessed through semi-quantitative RT-PCR, protein expression by Western blotting, protein localization by indirect immunofluorescence, cell ultrastructure using electron microscopy. HF-EMF exposure significantly and selectively increased Cx40 and Cx43, without altering protein expression. Nevertheless, Cx40 and Cx43 lost their punctuate fluorescence within the cell membrane, becoming diffuse after HF-EMF exposure. Electron microscopy evidenced a sharp decrease in intercellular gap junction-like structures. **This study is the first to indicate that exposure of extravillous trophoblast to GSM-217 Hz signals can modify Cx gene expression, Cx protein localization and cellular ultrastructure.**

(98) Mobile phone affects cerebral blood flow in humans

J Cereb Blood Flow Metab. **2006** Jul; 26(7):885-90.

<http://www.ncbi.nlm.nih.gov/pubmed/16495939>

Aalto S, Haarala C, Brück A, Sipilä H, Hämäläinen H, Rinne JO

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Handy

0,743 SAR average (10g)

1,51 SAR peak value

Abstract

Mobile phones create a radio-frequency electromagnetic field (EMF) around them when in use, the effects of which on brain physiology in humans are not well known. We studied the effects of a commercial mobile phone on regional cerebral blood flow (rCBF) in healthy humans using positron emission tomography (PET) imaging. Positron emission tomography data was acquired using a double-blind, counterbalanced study design with 12 male subjects performing a computer-controlled verbal working memory task (letter 1-back). Explorative and objective voxel-based statistical analysis revealed that a mobile phone in operation induces a local decrease in rCBF beneath the antenna in the inferior temporal cortex and an increase more distantly in the prefrontal cortex. **Our results provide the first evidence, suggesting that the EMF emitted by a commercial mobile phone affects rCBF in humans.** These results are consistent with the postulation that EMF induces changes in neuronal activity.

(99) Ultra high frequency-electromagnetic field irradiation during pregnancy leads to an increase in erythrocytes micronuclei incidence in rat offspring.

Life Sci. **2006** Dec 3;80(1):43-50.

<http://www.ncbi.nlm.nih.gov/pubmed/16978664>

Ferreira AR, Knakievicz T, Pasquali MA, Gelain DP, Dal-Pizzol F, Fernández CE, de Salles AA, Ferreira HB, Moreira JC

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834 GSM

26,8 - 40 V/m => 1,905 W/m²

Abstract

Mobile telephones and their base stations are an important ultra high frequency-electromagnetic field (UHF-EMF) source and their utilization is increasing all over the world. Epidemiological studies suggested that low energy UHF-EMF emitted from a cellular telephone may cause biological effects, such as DNA damage and changes on oxidative metabolism. An in vivo mammalian cytogenetic test, the micronucleus (MN) assay, was used to investigate the occurrence of chromosomal damage in erythrocytes from rat offspring exposed to a non-thermal UHF-EMF from a cellular phone during their embryogenesis; the irradiated group showed a significant increase in MN occurrence. In order to investigate if UHF-EMF could also alter oxidative parameters in the peripheral blood and in the liver - an important hematopoietic tissue in rat embryos and newborns - we also measured the activity of antioxidant enzymes, quantified total sulfhydryl content, protein carbonyl groups, thiobarbituric acid-reactive species and total non-enzymatic antioxidant defense. No significant differences were found in any oxidative parameter of offspring blood and liver. The average number of pups in each litter has also not been significantly altered. **Our results suggest that, under our experimental conditions, UHF-EMF is able to induce a genotoxic**

response in hematopoietic tissue during the embryogenesis through an unknown mechanism.

(100) **Is there a relationship between cell phone use and semen quality**

Arch Androl. **2005** Sep-Oct;51(5):385-93.

<http://www.ncbi.nlm.nih.gov/pubmed/16087567>

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Handy

Abstract

This study was conducted to determine a possible relationship between regular cell phone use and different human semen attributes. The history-taking of men in our university clinic was supplemented with questions concerning cell phone use habits, including possession, daily standby position and daily transmission times. Semen analyses were performed by conventional methods. Statistics were calculated with SPSS statistical software. A total of 371 were included in the study. The duration of possession and the daily transmission time correlated negatively with the proportion of rapid progressive motile sperm ($r = -0.12$ and $r = -0.19$, respectively), and positively with the proportion of slow progressive motile sperm ($r = 0.12$ and $r = 0.28$, respectively). The low and high transmitter groups also differed in the proportion of rapid progressive motile sperm (48.7% vs. 40.6%). **The prolonged use of cell phones may have negative effects on the sperm motility characteristics.**

(101) **Effects of intensive and moderate cellular phone use on hearing function**

Electromagn Biol Med. **2006**; 25(1):13-21

<http://www.ncbi.nlm.nih.gov/pubmed/16595330>

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Handy

Abstract

The purpose of this study is to investigate the effects of radiation emitted by mobile phones on the hearing of users. The study was carried out on three groups: 1) 20 men who have used a cellular phone frequently and spoken approximately 2 h per day for four years; 2) 20 men who have used a cellular phone for 10-20 min per day for four years; and 3) 20 healthy men who have never used a cellular phone (the control group). Brainstem evoked response audiometric (BERA) and pure tone audiometric (PTA) methods were used to measure the effects of exposure on hearing function of the subjects. In BERA measurements, I-III, III-V, and I-V interpeak latencies were evaluated. Interpeak latency of subjects in two experimental groups was compared to that of subjects in the control group. The BERA results showed no differences among the groups ($p > 0.05$). In PTA measurements, detection thresholds at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz frequencies were measured in all three groups. No differences were observed between moderate mobile phone users (10-20 min. per day) and control subjects. However, detection thresholds in those who talked approximately 2 h per day were found to be higher than those in either moderate users or control subjects. Differences at 4000 Hz for both bone and air conduction for right ears, and 500 Hz, and 4000 Hz bone and air conduction for left ears were significant for mean hearing threshold. **This study shows that a higher degree of hearing loss is**

associated with long-term exposure to electromagnetic (EM) field generated by cellular phones.

(102) **Influence of 400, 900, and 1900 MHz electromagnetic fields on Lemna minor growth and peroxidase activity**

Bioelectromagnetics. **2005** Apr;26(3):185-93.

<http://www.ncbi.nlm.nih.gov/pubmed/15768427>

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900 MHz

23V/m => 1,403 W/m²

Abstract

Increased use of radio and microwave frequencies requires investigations of their effects on living organisms. Duckweed (*Lemna minor* L.) has been commonly used as a model plant for environmental monitoring. In the present study, duckweed growth and peroxidase activity was evaluated after exposure in a Gigahertz Transversal Electromagnetic (GTEM) cell to electric fields of frequencies 400, 900, and 1900 MHz. The growth of plants exposed for 2 h to the 23 V/m electric field of 900 MHz significantly decreased in comparison with the control, while an electric field of the same strength but at 400 MHz did not have such effect. A modulated field at 900 MHz strongly inhibited the growth, while at 400 MHz modulation did not influence the growth significantly. At both frequencies a longer exposure mostly decreased the growth and the highest electric field (390 V/m) strongly inhibited the growth. Exposure of plants to lower field strength (10 V/m) for 14 h caused significant decrease at 400 and 1900 MHz while 900 MHz did not influence the growth. Peroxidase activity in exposed plants varied, depending on the exposure characteristics. Observed changes were mostly small, except in plants exposed for 2 h to 41 V/m at 900 MHz where a significant increase (41%) was found. Our results suggest that investigated electromagnetic fields (EMFs) might influence plant growth and, to some extent, peroxidase activity. However, the effects of EMFs strongly depended on the characteristics of the field exposure.

(103) **Erythropoietic changes in rats after 2.45 GHz nonthermal irradiation.**

Int J Hyg Environ Health. **2004** Dec;207(6):549-54.

<http://www.ncbi.nlm.nih.gov/pubmed/15729835>

Busljeta I, Trosic I, Milkovic-Kraus S.

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2,45 GHz CW

50 W/m²

Abstract

The purpose of this study was to observe the erythropoietic changes in rats subchronically exposed to radiofrequency microwave (RF/MW) irradiation at nonthermal level. Adult male Wistar rats (N=40) were exposed to 2.45 GHz continuous RF/MW fields for 2 hours daily, 7 days a week, at 5-10 mW/cm². Exposed animals were divided into four subgroups (n=10 animals in each subgroup) in order to be irradiated for 2, 8, 15 and 30 days. Animals were sacrificed on the final irradiation day of each treated subgroup. Unexposed rats were used as control (N=24). Six animals were included into the each control subgroup. Bone marrow smears were examined to determine absolute counts of anuclear cells and erythropoietic precursor cells. The absolute erythrocyte count, haemoglobin and haematocrit values were observed in the peripheral blood by an automatic cell counter. The bone marrow cytogenetic

analysis was accomplished by micronucleus (MN) tests. In the exposed animals erythrocyte count, haemoglobin and haematocrit were increased in peripheral blood on irradiation days 8 and 15. Concurrently, anuclear cells and erythropoietic precursor cells were significantly decreased ($p < 0.05$) in the bone marrow on day 15, but micronucleated cells' frequency was increased. In the applied experimental condition, RF/MW radiation might cause disturbance in red cell maturation and proliferation, and induce micronucleus formation in erythropoietic cells.

(104) **Impact of 1.8-GHz radiofrequency radiation (RFR) on DNA damage and repair induced by doxorubicin in human B-cell lymphoblastoid cells**

Mutat Res. **2010** Jan;695(1-2):16-21.

<http://www.ncbi.nlm.nih.gov/pubmed/19833226>

Zhijian C, Xiaoxue L, Yezhen L, Shijie C, Lifen J, Jianlin L, Deqiang L, Jiliang H.

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1.800 MHz PW

2 SAR

Abstract

In the present in vitro study, a comet assay was used to determine whether 1.8-GHz radiofrequency radiation (RFR, SAR of 2W/kg) can influence DNA repair in human B-cell lymphoblastoid cells exposed to doxorubicin (DOX) at the doses of 0microg/ml, 0.05microg/ml, 0.075microg/ml, 0.10microg/ml, 0.15microg/ml and 0.20microg/ml. The combinative exposures to RFR with DOX were divided into five categories. DNA damage was detected at 0h, 6h, 12h, 18h and 24h after exposure to DOX via the comet assay, and the percent of DNA in the tail (% tail DNA) served as the indicator of DNA damage. The results demonstrated that (1) RFR could not directly induce DNA damage of human B-cell lymphoblastoid cells; (2) DOX could significantly induce DNA damage of human B-cell lymphoblastoid cells with the dose-effect relationship, and there were special repair characteristics of DNA damage induced by DOX; (3) E-E-E type (exposure to RFR for 2h, then simultaneous exposure to RFR and DOX, and exposure to RFR for 6h, 12h, 18h and 24h after exposure to DOX) combinative exposure could obviously influence DNA repair at 6h and 12h after exposure to DOX for four DOX doses (0.075microg/ml, 0.10microg/ml, 0.15microg/ml and 0.20microg/ml) in human B-cell lymphoblastoid cells.

(105) **The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns**

Gen Physiol Biophys. **2010** Mar; 29(1):59-66

<http://www.ncbi.nlm.nih.gov/pubmed/20371881>

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1.800 GMS

14 V/m => 0,52 W/m²

Abstract

The concerns of people on possible adverse health effects of radiofrequency radiation (RFR) generated from mobile phones as well as their supporting transmitters (base stations) have increased markedly. RFR effect on oversensitive people, such as pregnant women and their developing fetuses, and older people is another source of concern that should be considered. In this study, oxidative DNA damage and lipid peroxidation levels in the brain tissue of

pregnant and non-pregnant New Zealand White rabbits and their newborns exposed to RFR were investigated. Thirteen-month-old rabbits were studied in four groups as non-pregnant-control, non-pregnant-RFR exposed, pregnant-control and pregnant-RFR exposed. They were exposed to RFR (1800 MHz GSM; 14 V/m as reference level) for 15 min/day during 7 days. Malondialdehyde (MDA) and 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels were analyzed. **MDA and 8-OHdG levels of non-pregnant and pregnant-RFR exposed animals significantly increased with respect to controls** ($p < 0.001$, Mann-Whitney test). No difference was found in the newborns ($p > 0.05$, Mann-Whitney). There exist very few experimental studies on the effects of RFR during pregnancy. It would be beneficial to increase the number of these studies in order to establish international standards for the protection of pregnant women from RFR.

(106) **Ginkgo biloba prevents mobile phone-induced oxidative**

Clin Chim Acta. 2004 Feb;340(1-2):153-62.

<http://www.ncbi.nlm.nih.gov/pubmed/14734207>

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900 MHz CW

0,25 SAR, 2 SAR max

Abstract

BACKGROUND: The widespread use of mobile phones (MP) in recent years has raised the research activities in many countries to determine the consequences of exposure to the low-intensity electromagnetic radiation (EMR) of mobile phones. Since several experimental studies suggest a role of reactive oxygen species (ROS) in EMR-induced oxidative damage in tissues, in this study, we investigated the effect of Ginkgo biloba (Gb) on MP-induced oxidative damage in brain tissue of rats. **METHODS:** Rats (EMR+) were exposed to 900 MHz EMR from MP for 7 days (1 h/day). In the EMR+Gb groups, rats were exposed to EMR and pretreated with Gb. Control and Gb-administrated groups were produced by turning off the mobile phone while the animals were in the same exposure conditions. Subsequently, oxidative stress markers and pathological changes in brain tissue were examined for each groups. **RESULTS:** Oxidative damage was evident by the: (i) increase in malondialdehyde (MDA) and nitric oxide (NO) levels in brain tissue, (ii) decrease in brain superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) activities and (iii) increase in brain xanthine oxidase (XO) and adenosine deaminase (ADA) activities. These alterations were prevented by Gb treatment. Furthermore, Gb prevented the MP-induced cellular injury in brain tissue histopathologically. **CONCLUSION:** Reactive oxygen species may play a role in the mechanism that has been proposed to explain the biological side effects of MP, and Gb prevents the MP-induced oxidative stress to preserve antioxidant enzymes activity in brain tissue.

(107) **Individual responsiveness to induction of micronuclei in human lymphocytes after exposure in vitro to 1800-MHz microwave radiation**

Mutation Research/Genetic Toxicology and Environmental Mutagenesis

Volume 582, Issues 1-2, 4 April 2005, Pages 42-52

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T2D-4FJV21Y-2&_user=10&_coverDate=04%2F04%2F2005&_rdoc=1&_fmt=high&_orig=search&_sort=d&_docanchor=&view=c&_searchStrId=1365682377&_rerunOrigin=google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=7cae8c142c4aecc4a8118d73aefa16c6

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1800 MHz CW

5mW/cm² => 50.000.000 µW/ m²

Abstract

The widespread application of microwaves is of great concern in view of possible consequences for human health. Many in vitro studies have been carried out to detect possible effects on DNA and chromatin structure following exposure to microwave radiation. The aim of this study is to assess the capability of microwaves, at different power densities and exposure times, to induce genotoxic effects as evaluated by the in vitro micronucleus (MN) assay on peripheral blood lymphocytes from nine different healthy donors, and to investigate also the possible inter-individual response variability. Whole blood samples were exposed for 60, 120 and 180 min to continuous microwave radiation with a frequency of 1800 MHz and power densities of 5, 10 and 20 mW/cm². Reproducibility was tested by repeating the experiment 3 months later. Multivariate analysis showed that lymphocyte proliferation indices were significantly different among donors ($p < 0.004$) and between experiments ($p < 0.01$), whereas the applied power density and the exposure time did not have any effect on them. Both spontaneous and induced MN frequencies varied in a highly significant way among donors ($p < 0.009$) and between experiments ($p < 0.002$), and a statistically significant increase of MN, although rather low, was observed dependent on exposure time ($p = 0.0004$) and applied power density ($p = 0.0166$). A considerable decrease in spontaneous and induced MN frequencies was measured in the second experiment. The results show that microwaves are able to induce MN in short-time exposures to medium power density fields. Our data analysis highlights a wide inter-individual variability in the response, which was confirmed to be a characteristic reproducible trait by means of the second experiment.

(108) Study on potential effects of "902-MHz GSM-type Wireless Communication Signals" on DMBA-induced mammary tumours in Sprague-Dawley rats.

Mutat Res. 2008 Jan 8;649(1-2):34-44. Epub 2007 Sep 19

<http://www.ncbi.nlm.nih.gov/pubmed/17981079>

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GSM

Handy

Abstract

The aim of the study was to detect whether long-term exposure to "902-MHz GSM-type Wireless Communication Signals" ("radio-frequency (RF)-exposure") would affect 7,12-dimethylbenz(a)anthracene (DMBA)-induced mammary tumours in female Sprague-Dawley rats. Five hundred female rats were each given a single oral dose of 17 mg DMBA per kg body weight (bw) at an age of 46-48 days. Three groups of 100 animals each were RF-exposed (902 MHz; crest factor 8; pulse width=0.57 ms) from the next day onwards to normal whole-body averaged doses (expressed as specific absorption rate, SAR) of 0.4, 1.3 or 4.0 W/kg bw (low/mid/high-dose group) for 4h/d, 5d/week, during 6 months. A sham-exposed and a cage-control group remained without RF-exposure ($<<0.01$ mW/kg). Animals were weekly weighed and palpated for mammary tumours; all mammary glands were examined histopathologically. There were several statistically significant differences

between RF-exposed groups and the sham-exposed group, as follows: All RF-exposed groups had, at different times, significantly more palpable tissue masses. There were fewer animals with benign neoplasms, but more with malignant tumours in the high-dose group. In addition, there were more adenocarcinomas in the low-dose group, more malignant neoplasms in the low- and high-dose groups, more animals with adenocarcinomas in the high-dose group, and fewer animals with fibroadenomas in the low- and mid-dose groups. The cage-control group had, when compared with the sham-exposed group, statistically significantly more palpable tissue masses, more benign and also more malignant neoplasms. The cage-control group had in most aspects the highest incidence and malignancy of neoplasms among all groups. None of the above findings in RF-exposed animals produced a clear dose-response relation and the responses of the cage-control group were either similar to or stronger than those of any of the RF-exposed group. The significant differences between the sham-exposed animals and one or more RF-exposed groups may be interpreted as evidence of an effect of RF-exposure. In the context of the results of the cage-control group, in the light of controversial results reported in the literature, and given the fact that the DMBA-mammary tumour model is known to be prone to high variations in the results, it is the authors' opinion that the differences between the groups are rather incidental ones.

(to understand authors' opinion: see the sponsors!)

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(109) Ø