

ElectrosmogReport

Expert information on the significance of electromagnetic fields for the environment and human health



Effects of radio-frequency radiation from base stations

Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radio-frequency field representative of a 1.8 GHz GSM base station environmental emission. By: Falcioni L, Bua L, Tibaldi E, Lauriola M, De Angelis L, Gnudi F, Mandrioli D, Manservigi M, Manservigi F, Manzoli I, Menghetti I, Montella R, Panzacchi S, Sgargi D, Strollo V, Vornoli A, Belpoggi F. Published in: Environmental Research. 2018; (October 2017): 1.

In 2005, the Ramazzini Institute performed a lifespan study on Sprague-Dawley rats to evaluate the carcinogenic effects of radio-frequency radiation. This study has now been concluded and the findings suggest that the classification of radio-frequency radiation as possibly carcinogenic to humans (Group 2B) should be reevaluated. Already in the early 2000s, published studies showed that those who use cell phones have a significantly higher risk of developing brain tumors and schwannomas (benign tumors of the peripheral nervous system). Modern case-control studies also confirm this increased risk. Experimental studies, however, were for the most part insufficient because of too short exposure durations, too few study animals or incorrect exposure conditions. The study by the Ramazzini Institute, however, used a total of 2448 animals.

Study design and procedure:

A total of 2448 study animals were analyzed. The animals were exposed for 19 hours per day from day 12 of gestation until their natural death. A 1.8 GHz GSM antenna (2G) served as the radio-frequency radiation source. The study animals were divided into 4 groups. Group I was the control group and the animals were not exposed. Group II was exposed, resulting in a SAR value of 0.001 W/kg. Group III and Group IV were also exposed, resulting in a SAR value of 0.03 W/Kg and 0.1 W/Kg.

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CONTENTS

PAGE 01 > SCIENCE Effects of radio-frequency radiation exposure from a base station: report of final results regarding brain and heart tumors in Sprague-Dawley rats...

02 > Effects of microwaves on the brain: acute neuro-inflammation promotes cell responses to 1800 MHz GSM electromagnetic fields in the rat cerebral cortex

03 > Effects of microwaves on the brain: age-dependent acute interference with stem and progenitor cell proliferation in the hippocampus after exposure to 1800 MHz electromagnetic radiation

04 > Effects of 5G terahertz frequencies: the human skin as a sub-THz receiver – does 5G pose a danger to it or not?

To rule out any external exposure, the animals were housed in shielded rooms. The clinical status of the study animals was unremarkable for the entire duration of the experiment. There were also no differences among the groups with regard to such biological parameters as water and food intake as well as survival index throughout the entire experiment. The scientists used histopathological methods to assess the brains and hearts of the study animals.

Findings:

The research group found that the male rats of Group IV had developed statistically significantly more heart schwannomas than those in the control group (0% vs. 1.4%). In contrast to humans, schwannomas in rats are classified as malignant tumors. Furthermore, the male animals of this group also showed an increased incidence of hyperplasia (excessive increase in the number of cells produced) in the Schwann cells of the heart; this increase, however, was not statistically significant (0.7% vs. 2.4%). This increased incidence of hyperplasia in the Schwann cells of the heart was also observed in the female animals of Group IV. In the latter group, statistical significance was not reached either (0.5% vs. 1.0%). Likewise, the analysis of the brains of the rats did not produce any statistically significant data. In female animals, however, a trend could be observed that was dependent on the exposure level: 0.5% of Group I, 0.7% of Group II, 1.0% of Group III and 1.5% of Group IV developed malignant gliomas (tumors of glial cells in the central nervous system). It is remarkable that the US National Toxicology Program (NTP) carried out a study that is simi-

lar to the one by the Ramazzini Institute (Wyde et al. 2018). In the NTP study, rats were exposed to radio-frequency radiation as follows: 18 h/day, 10 min on / 10 min off, 7 day/week, 104 weeks. The animals were also divided into four groups with SAR values ranging from 0, 1.5, 3 to 6 W/kg. In contrast to the study by the Ramazzini Institute, the animals in the NTP study were not exposed for quite as long (18 h instead of 19 h), not continuously (10 min on / 10 min off) and for a shorter duration (104 weeks instead of whole lifespan), but at much higher exposure levels. The observations of both research groups are in agreement with regard to the histopathological analysis of the hearts and brains.

Conclusions:

Due to the authors, the Ramazzini study is significant for three reasons:

- > Even the small increase in tumor incidence observed in the study can have a great impact on public health.
- > The two independent studies by the Ramazzini Institute and the US National Toxicology Program show data that is in agreement.
- > The observed tumors originate from the same types of cells that have been found in the mentioned epidemiological case studies of cell phone users. Based on these experimental studies, the scientists demand that the cancer classification of radio-frequency electromagnetic fields by the International Agency for Research on Cancer (IARC) shall be reevaluated. (IW)



Effects of microwaves on the brain

Acute neuroinflammation promotes cell responses to 1800 MHz GSM electromagnetic fields in the rat cerebral cortex. By: Lameth J, Gervais A, Colin C, Lévêque P, Jay TM, Edeline JM, Mallat M. Published in: *Neurotoxicity Research*. 2017; 32(3): 444–459; Erratum: *Neurotoxicity Research*. DOI 10.1007/s12640-017-9774-1

The authors of this paper claim that the effects of microwaves on health and well-being are not clear. This study aimed to investigate specifically how the brain reacts to microwave exposure with regard to memory, blood-brain barrier, oxidative stress, survival of nerve cells and salutatory conduction. The researchers induced an inflammatory reaction in the nervous tissue of young rats (2 weeks old) and adult rats (2 months old) by injecting lipopolysaccharides (LPS, cell wall components of gram-negative bacteria). After injection, the question was studied as to whether a 2-hour microwave exposure of the head would have positive or negative effects on this inflammatory response. The focus of the investigation was on the cerebral cortex. Since the inflammation of nervous tissue is frequently associated with a change in the level of excitatory transmissions, AMPA receptors (α -amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid receptors) were studied, among others. These receptors are common cation channels for neurotransmitters in the nervous system.

Study design and procedure:

Two main groups were investigated: young developing rats (14 days old) and adult male rats (2 months old). At first, the effect of LPS by itself on pro-inflammatory gene expression was analyzed in both groups (6 animals each per group). The LPS was injected into the abdomen of the study animals. Twenty-four hours after injection, the inflammation markers in the cortex were analyzed. The two main groups were then further divided into 6 subgroups with young animals (5–7 animals each) and 10 subgroups with adult animals (6 animals each). These groups were given a single exposure of 1800 MHz (2.9 W/kg) to the head or a combination of microwave exposure and LPS injection. In the groups with the combined treatment (microwave exposure + LPS injection), the microwave exposure occurred 24 hours after injection. Half of the groups were sham-exposed. The brains were removed either 24 or 72 hours after the microwave exposure. In the tissue of the cerebral cor-

tex, the gene expression of different inflammation markers (TNF- α , IL-1 β , IL-6, CCL2, NOX2, NOS2) was determined and the morphology of microglia cells assessed.

Findings:

In adult rats, a significant increase in the gene expression of inflammation markers was observed 24 hours after the LPS injection. The transcripts of NOX2 and IL-1 β , in particular, had increased 4-fold or 12-fold, respectively. The young rats had a similar response. The administration of LPS, however, resulted in a decrease in NOS2 and IL-6 gene expression in young rats, while the TNF- α transcription level did not differ significantly from the controls. In adult rats, this was not observed.

In both young and adult rats, the described microwave exposure led to a downregulation of the LPS-induced IL-1 β expression. The NOX2 transcript was only significantly reduced by microwave exposure in young rats. These effects were only seen 24 hours after exposure, but not after 72 hours.

To investigate an association between neuroinflammation and changes in excitatory neurotransmission, the scientists analyzed changes in the expression and phosphorylation of AMPA receptors. The microwave exposure at 1800 MHz caused a decrease in phosphorylation at two residues on the subunit GluA1 AMPAR (serine 831 and 845). Seventy-two hours after the LPS injection, the microwave exposure-induced changes in gene expression and GluA1 phosphorylation were not seen anymore, and the changes were not seen at all in those animals who had not been pretreated with LPS.

Conclusions:

The data show that a single short exposure of 1800 MHz GSM radiation at 2.9 W/kg to the head of rats is sufficient in temporarily changing pro-inflammatory gene expression and activating microglia cells, which results in changes to functional markers of excitatory neurotransmission. The data also show that inflamed cells in the cerebral cortex respond to microwave exposure and that their inflammatory response is reduced by microwave exposure. These responses do not occur when healthy brains are exposed to microwave radiation at 1800 MHz. The exposure levels resulting in 2.9 W/kg used here were above the currently permissible exposure limit for humans (2 W/kg). Further research is called for in this area to understand the possible advantageous or damaging effects of microwave exposure, depending on the neuropathological state of a given brain. (IW)



Effects of microwaves on the brain

Age-dependent acute interference with stem and progenitor cell proliferation in the hippocampus after exposure to 1800 MHz electromagnetic radiation.

By: Xu F, Bai Q, Zhou K, Ma L, Duan J, Zhuang F, Xie C, Li W, Zou P, Zhu C.

Published in: *Electromagnetic Biology and Medicine*. 2017; 36(2): 158–166.

In comparison to adults, developing organisms are more vulnerable to electromagnetic radiation. Also, certain organs are more vulnerable than others. The brain, in particular, is affected, and the region of the hippocampus is the most vulnerable. In case of interference with the hippocampus, neurological dysfunction can occur, such as movement and learning difficulties. Radiation exposure can cause cell death (apoptosis) in or damage to the cell growth or cell differentiation of stem cells in the hippocampus. Apoptosis is an important process for maintaining homeostasis, but especially during early brain development. Neurogenesis (formation of new nerve cells) still occurs after birth in certain areas of the brain. In the hippocampus, neurogenesis is associated with the formation of memories and it is affected by diverse physiological and pathological stimuli. Radiation exposure or a lack of oxygen during circulatory problems are two such examples.

Study design and procedure:

In this study, newborn mice (P7) and juvenile mice (P21) were investigated. There were three study groups (control, sham-exposed and exposed group) with 6 female and 6 male animals each. The animals were exposed to 1800 MHz radiation for 8 hours per day for 3 days, which is similar to the radiation exposure in close proximity to a cell phone. The electric field of 28 V/m resulted in a SAR value of 1.16 W/kg in the brain. Twenty-four hours after the exposure had ceased, the brains were removed and analyzed for cell growth, number of cells, apoptosis and DNA synthesis. The following markers were used:

Protease caspase-3 induces apoptosis, which means that active caspase-3 functions as a signal for programmed cell death. BrdU (bromodeoxyuridine) is embedded in newly formed DNA and thus serves as a signal for DNA synthesis. Phosphorylase PHH3 (phospho-histone-H3) serves as a signal for cell division. Furthermore, BLBP (brain-specific lipid-binding protein) was assessed. BLBP characterizes the stem cell population of neuronal progenitor cells from which functional neurons (nerve cells) develop through differentiation.

Findings:

The analysis of the brain did not show any significant effect of the exposure on the apoptosis in the hippocampus, cortex, striatum and thalamus.

The cell growth in the hippocampus was increased in the P7 animals compared to the P21 animals. The exposure increased DNA synthesis in the stem and progenitor cells of the P7 animals, but decreased cell division and the total number of stem cells in the hippocampus compared to the controls. In contrast, the P21 animals did not show any significant changes in cell growth after exposure. There were also no differences between the male and female animals of both age groups. In the P7 animals, however, the stem cell population was changed due to exposure. The number of BLBP-positive stem cells decreased significantly after exposure. In the P21 animals, however, no BLBP markers were statistically significantly different after exposure.

Conclusions:

The findings of this short-term study suggest that very young, still developing organisms are more vulnerable in their response than older ones. The scientists cannot establish an association between the radiation exposure at 1800 MHz and cell death; however, further research is needed to rule out a dose-dependent connection between exposure and apoptosis of nerve cells. The methods used in this study analyze the effects of 1800 MHz radiation on three different cell processes in the hippocampus. BrdU is embedded in the S phase of the cell cycle in newly synthesized DNA. PHH3 is particularly active during the M phase (cell division) of the cell cycle. BLBP characterizes the stem cells from which functional neurons develop through differentiation. The short-term exposure led to an increased DNA synthesis (BrdU) in newborn mice, but not in juvenile ones. At the same time, cell division was lowered in newborn mice. The juvenile animals showed no change in cell division. Furthermore, the stem cell population in the brains of newborns was lower, probably due to the impaired cell division.

In summary, this shows that the vulnerability to radiation exposure at 1800 MHz during early development must be considered when protective measures against electromagnetic fields are evaluated. With regard to long-term effects of this radiation on neurological functions, further research is needed. (IW)



Effects of 5G terahertz frequencies

The human skin as a sub-THz receiver – does 5G pose a danger to it or not? By: Betzalel N, Paul Ben Ishai PB, Feldman Y. Published in: Environmental Research. 2018; 163 (January): 208–216.

Humanity faces a new era of telecommunication technology. The “Internet of Things” (IoT) refers to a global connectivity platform of devices and sensors, which are meant to make our everyday lives easier. To make this happen, a new standard for wireless communication networks has to be created because ever-increasing amounts of data have to be transmitted. In the near future, this change will be facilitated by the deployment of the 5G standard. The currently existing frequency ranges used for wireless connectivity are not suitable for the envisioned data expansion. Therefore, the 5G standard also includes frequencies at 28 GHz and could reach into the sub-THz range later. The price for the exorbitant bandwidth (up to 10,000 mbit/s) needed for this level of connectivity is the increasing exposure to electromagnetic fields. The cell phone industry denies any health risks of 5G. Over the last years, however, numerous studies have been published that even question the safety of the currently deployed 4G technology (LTE).

The authors of this paper propose a thesis as to why 5G might be not as safe for humans as has been previously assumed. The helical structure of the sweat ducts in our skin form the basis of their thesis. Human skin consists essentially of three components (from the outer to the inner layer): epidermis (upper skin), dermis (corium) and subcutis (lower skin). The epidermis is less transparent to electric fields than the dermis. Due to this difference in electromagnetic properties of the dermis and epidermis as well as the helical structure of the sweat ducts, the scientists conceived the idea that sweat ducts could act as small, imperfect helical antennas. The scientists predicted that sweat ducts may receive signals in the sub-THz range. Previously, they could show an association between the activities of sweat glands (induced by physical activity or mental stress) and a change in the reflection pattern of electromagnetic waves in the W band (75–110 GHz).

The polarization of the reflected electromagnetic fields was another indicator that sweat ducts are involved. Similar to lac-

tic acid, the helical (coiled) structure of the ducts has chirality, which means that the incident radiation is reflected back either in a clockwise (right-handed) or counterclockwise (left-handed) direction. Indeed, the large majority of sweat ducts in our skin are right-handed and thus also cause a right-handed circular polarization in the radiation.

Study design and procedure:

The study authors created a simulation model of the human skin to calculate SAR values. In their model, they considered the various skin layers, the specified water content in each segment and the helical structure of sweat ducts. They ran a thin skin simulation and a thick skin simulation with electrical conductivities of 2000, 5000 and 10,000 S/m. For the simulation, a perpendicular plane wave was chosen as the radiation source.

Findings:

The thin skin model, with an electrical conductivity of 10,000 S/m, suggests that, at a frequency of 440 GHz, the energy is mainly absorbed in the sweat ducts. The same was also found in the thick skin model at 450 GHz. The thin skin model shows that the maximum absorption of electromagnetic waves in the sub-THz range in our skin occurs at 440 and 580 GHz. In the thick skin model, the maximum absorption occurs at 410 and 500 GHz. Furthermore, the simulation model shows that even at a low electrical conductivity of the skin at 2000 S/m, a much higher SAR value is reached when the helical structure of sweat ducts are considered.

Conclusions:

With their simulation model, the authors of this study show that the helical sweat ducts of our sweat glands represent an important mechanism for the absorption of electromagnetic fields in the sub-THz range. The high band of 5G technology starts at 28 GHz, but could also reach into the sub-THz range. The methods currently used by the industry to evaluate SAR values do not consider the antenna character of sweat ducts at sub-THz frequencies. As a result, lower SAR values are calculated than they could occur in reality. Lastly, the authors call for a deeper investigation into possible health effects caused by the use of 5G technology. According to their opinion, there is sufficient evidence for nonthermal effects. (RH)