Summaries and assessments of selected studies

In the period from mid of May to end of July 2017, 62 new publications have been identified, and seven of these were discussed in depth by BERENIS. Based on the selection criteria, four of these publications were selected as the most relevant ones. Their summaries and assessments are provided below.

1) Experimental animal and cell studies

Radiofrequency electromagnetic fields and adaptive cell response (He et al. *2017)*

In this *in vitro* study, He *et al.* (2017) have made interesting observations regarding the modification of the effects of genotoxic radioactive irradiation by prior exposure to radiofrequency electromagnetic fields (RF EMF). This phenomenon is referred to as adaptive cell response, where previous exposure with environmental factor "A" modifies or conditions the cells in such a way that the consequences/effects of environmental factor "B" are attenuated. The authors isolated a relatively heterogeneous population of mouse bone marrow stromal cells, and subjected them to the following conditions: controls, sham exposure or exposure to a weak continuous RF EMF (900 MHz, 0.41 mW/kg 120 µW/cm^2) during five days for 3 h per day. In some of the samples, the genome of the cells was damaged by exposing them to an acute dose of 1.5 Gy gamma radiation. In a next step, the authors analysed the expression and transcription of PARP1 (a key sensor of DNA damage and regulator of repair mechanisms) and the amount of DNA damage over the course of two hours (0, 30, 60, 90, 120 minutes). After five days of RF EMF exposure – without subsequent exposure to gamma radiation – the amount of transcript and protein of PARP1 was found to be increased by a factor of 9 and 5, respectively, compared to control and sham exposed cells. This effect was suppressed when the cells were treated with a specific inhibitor for the proteins PARP1 and PARP2. It can thus be concluded that the RF EMF exposure has a direct influence on this protein. The comet assay was used to analyse genome damage; RF EMF pre-treatment resulted in a 50% decrease of DNA fragmentation caused by gamma radiation, which in turn could be partly suppressed by blocking PARP1/2. However, treating the cells either with the RF EMF or with the PARP1/2 inhibitor alone did not cause a significant increase of DNA damage. It could thus be shown that the induction of PARP1 by the RF EMF plays a role in the triggered adaptive response with regard to dealing with DNA damage. Nevertheless, it remains unclear whether this protective effect of the RF EMF on the integrity of the genetic material (DNA) was caused by accelerated DNA repair or by other activated cellular protective mechanisms. It would be interesting to elicit how long the pre-treatment/exposure needs to be, whether this protection persists, and whether there is a dose-response relationship. The observed adaptive cell response following RF EMF exposure is remarkable, and corresponds well with the fact that in experiments with cell cultures, effects of the exposure are modified by a combination with other stress factors. Therefore, these observations suggest that RF EMF exposure puts the cell on alert.

Radiofrequency electromagnetic fields, neuronal inflammation and cell response in the rat brain (Lameth et al. *2017)*

In this *in vivo* study, Lameth *et al.* (2017) studied the effect of a RF EMF (GSM, 1800 MHz, 2.9 W/kg) on induced inflammation in the brain (particularly the cerebral cortex). For this purpose, the heads of anesthetised two week old as well as adult rats were exposed to the RF EMF once for two hours. Corresponding positive controls were available. Neuroinflammation was induced by lipopolysaccharides (LPS). LPS induction is often used to study the response of microglia under a variety of pathological conditions, and LPS is also used to model depression. Subsequently, cytokines and other inflammatory parameters (IL1β, NOX2 NADPH oxidase) were measured. Significant differences were found between young and adult rats: In young rats, the inflammatory markers in the cerebral cortex were significantly reduced 24 hours after exposure, whereas in the adult animals only IL1β was reduced. Significant growth of microglia was observed in adult RF EMF exposed animals. Since neuronal inflammation is usually accompanied by altered arousal potential and its transmission, expression and phosphorylation of the excitatory AMPA receptor were also analysed. RF EMF exposure caused a decreased phosphorylation of certain amino acids of this receptor, which affects the activity of the receptor. Such changes in post-translational modifications have been reported to occur in acute stress.

The observed effects were transient and undetectable 72 hours after the single 2-hour exposure. The data are interesting because they show that with pre-existing damage by inflammation, RF EMF modulates inflammation markers on the one hand and neuronal excitation on the other hand. Activation of the microglia can be expected in neuronal inflammatory processes, as they occur, for example, in infections. The tasks of the microglia are versatile, the cells perceive chemical or physical substrates, phagocytise substrates/pathogens to protect the cells, but they also interact with neighbouring cells (neurons, astrocytes, etc.). The experiment indicates that RF EMF effects occur in pre-damaged tissue.

Magnetic fields and memory performance of mice (Zhang et al. *2017)*

In the study by Zhang et al. (2017), mice were exposed to a static magnetic field, a 50 Hz magnetic field (1 mT, 2 h/day for 7 days) or a control condition without exposure. The mice completed a memory test (decision at fork in the path) and electrophysiological measurements were performed in the hippocampus. Control mice and mice exposed to the static magnetic field showed an approximately constant correct decision frequency and a reduction in the decision time over the 7 days. In mice exposed to a 50 Hz magnetic field, both parameters deteriorated with increasing exposure time. The electrophysiological measurements showed a similar picture. These findings are quite interesting, but there are some limitations. The exposure is not exactly reproducible, and for the electrophysiological measurements, electrodes were implanted in the brain of the mice. Therefore, it cannot be ruled out that the 50 Hz magnetic field has led to direct stimulation of the brain via these electrodes. In this case, the effect would be due to stimulation and not the exposure *per se*. The study lacks a control experiment, namely mice without implanted electrodes to show that the memory deterioration is due to the 50 Hz exposure.

2) Epidemiological studies

Extremely low frequency magnetic field exposure by high voltage power lines and amyotrophic lateral sclerosis in Italy (Vinceti et al. *2017)*

Amyotrophic lateral sclerosis (ALS) is a rare, mostly fatal neurodegenerative disease. The causes of ALS are largely unknown. Epidemiological studies found partially elevated risks for ALS in occupational groups with high exposure to ELF MF, yet the results are contradictory. It has also been considered that electric shocks, rather than chronic ELF MF exposure, could be a cause of ALS. Vinceti *et al.* (2017) have now investigated the ALS risk in Italy in relation to ELF MF exposure of high voltage power lines with a voltage of 132 kV or higher. They identified all cases diagnosed between 1998 and 2011 in Northern Italy (Emilia Romagna) and Sicily (Catania) as well as comparable healthy controls. The mean ELF MF exposure for 2001 of all study participants was modelled. A total of 703 patients and 2,737 control subjects were included in the study. Only six patients and 35 controls had an ELF MF of 0.1 µT or higher at their place of residence. There was thus no increased risk (relative risk: 0.65 with a confidence interval of 0.27-1.55). Limitations of the study are that the selection of the controls is not described, ELF-MF exposure at the workplace was not taken into account and the number of exposed persons is very small. On the other hand, this is the first study on ALS and ELF MF exposure at the place of residence carrying out exposure modelling. The previous four studies from Switzerland, Denmark, the Netherlands and Brazil only considered distance to power lines as a measure of exposure. None of these five studies found any indication that ELF MF from power lines might cause ALS. This suggests that ELF MF of high voltage power lines is rather not a risk factor for ALS. It remains unclear whether stronger ELF MFs or electric shocks, as they may occur in certain workplaces, may pose a risk.

References

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Contact

Dr Stefan Dongus
BERENIS Secretariat
Swiss Tropical and Public Health Institute
Department of Epidemiology and Public Health
Environmental Exposures and Health Unit
Socinstr. 57, P.O. Box, CH-4002 Basel, Switzerland
Tel: +41 61 284 8111
Email: stefan.dongus@swisstph.ch

Additional information:

BERENIS - Swiss expert group on electromagnetic fields and non-ionising radiation

List of abbreviations (pdf)