Summaries and assessments of selected studies

In the period from mid of July to mid of October 2020, 108 new publications have been identified, and eight of these were discussed in depth by BERENIS. Based on the selection criteria, three of these publications were selected as the most relevant ones. Their summaries and assessments are provided below.

1) Experimental animal and cell studies

Increased inflammatory response by the combined exposure with a radiofrequency electromagnetic field and particulate matter (Sueiro-Benavides et al. *2020)*

Sueiro-Benavides *et al.* (2020) applied an interesting experimental approach with cultured cells of the immune system, investigating the combined effect of two environmental factors, an RF-EMF and black carbon, a model for particulate matter pollution. The authors exposed a murine macrophage cell line (RAW 264.7) to a 2.45 GHz RF-EMF (SAR 0.4 W/kg) in combination with two different concentrations of black carbon particles for 24 or 72 hours. Cellular responses were compared with single and control treatments. While the higher concentration of black carbon particles led to a decrease in cell viability, a 24-hour RF-EMF exposure alone had no effect but exacerbated the black carbon effect in the combination of both factors. Exposure durations of 72 hours resulted in the same pattern, although the increased combinatory effect was not observed at the lower concentration of black carbon particles, and RF-EMF alone led to a slight reduction in the viability of the cultures. In line with these observations, slight changes in the apoptosis marker caspase 3 were found. Furthermore, the effect of exposure on the inflammatory response was investigated, assessing markers for inflammation such as TNFα (tumour necrosis factor α), IL-1β (interleukin-1β) and nitric oxide (NO). To enforce the immune response, lipopolysaccharides (LPS) from bacterial cell walls were additionally used for NO analysis. Compared to the lower dose of black carbon particles, the 24-hour RF-EMF exposure triggered a more pronounced increase in inflammatory markers, and the combination of both environmental factors led to an increase in NO production, but not to more TNFα and IL-1β. The changes in these immune response parameters were also reflected in the phagocytosis activity of the macrophages. The RF-EMF-exposed cells internalized significantly more black carbon particles than the unexposed control cells.

The observations in this publication are of importance because combinatory effects of environmental factors represent a realistic exposure scenario as numerous environmental factors occur simultaneously in our everyday lives. Their interactions and interplay are relevant for how our organism reacts to or copes with these stress situations. In this regard, the authors speculated that RF-EMF exposure might possibly alter the efficiency of the immune system since it stimulated an inflammatory response by activating signalling pathways and led to prolonged macrophage activities. Yet, some technical and methodological uncertainties still need to be addressed in order to consolidate the conclusions of this study. For example, the figures contain some errors, and the control conditions should be carried out more rigorously in order to exclude potential confounding effects. Nevertheless, this study provides important insight into an influence of RF-EMF on the immune response triggered by other environmental factors.

Plant cryptochrome and radiofrequency electromagnetic fields (Albaqami et al. *2020)*

Although the study by Albaqami *et al.* (2020) is less relevant with regard to human health, it adds to previous studies showing that perception of magnetic fields is mediated by the cryptochrome (CRY) receptor, an evolutionarily conserved flavoprotein that exists not only in mammals and birds, but also in plants in which CRY acts as blue light receptor. Thale cress (Arabidopsis) was exposed to six cycles of blue light for a total of 90 min (5 min blue light, 10 min dark). Exposure for a total of 4 weeks to an EMF with 7 MHz, 2 µT or a weak magnetic field with a field strength of 200 nT for one week reduced the biological response to blue light via CRY1 activity in the seedlings. When the alignment of the artificial magnetic field to the earth's magnetic field was 90°, the observed effect was more pronounced than for 180°.

Blue light causes growth inhibition through increased CRY activity. Exposure to RF-EMF as well as the magnetic field of 200 nT inhibited the phosphorylation and thereby the activation of the CRY1 receptor. Following RF-EMF exposure, thus, the young plants grew faster. The findings were underpinned by increased expression of genes involved in the modulation of CRY1. Based on a theoretical model, the authors attribute these effects to the radical pair mechanism. As already shown in mammals and birds for similar frequencies, the perception of the magnetic field in plants was causally linked to the CRY receptor.

2) Human experimental studies

Little evidence of effects of radiofrequency electromagnetic fields on sleep in healthy younger and older men (Eggert et al. *2020)*

Eggert *et al.* (2020) investigated whether potential RF-EMF effects in men are age-dependent. For this purpose, data from three double-blind and randomised experiments were analysed. Thirty younger (mean age 25.5 years; two groups) and 30 older (mean age 69.1 years) men were exposed to two types of RF-EMF and a control condition without RF-EMF for 30 minutes before sleep and throughout the night. The RF-EMF conditions were GSM900 (Global System for Mobile Communications; carrier frequency 915 MHz, modulation 217 Hz, duty cycle 0.125, SAR 2 W/kg) and TETRA (Terrestrial Trunked Radio; carrier frequency 385 MHz, modulation 17.6 Hz, duty cycle 0.25, SAR 6 W/kg). For each participant, sleep data from nine nights (three sets with three conditions) were registered.

Clear physiological sleep differences between younger and older men were observed in the control condition, as can be expected (such as shorter sleep times, longer latency to fall asleep, more fragmented sleep, lower sleep efficiency, less deep sleep in the older participants). TETRA exposure resulted in a significant reduction of sleep latency (duration to persistent sleep) in both age groups, which can be considered as a sleep-promoting effect. GSM900 exposure had no effect on objective sleep parameters. A weak interaction between age and GSM900 exposure was observed in two of four subjective sleep parameters (sleep duration and number of awakenings).

Overall, the study showed hardly any effects of RF-EMF on sleep. The few significant test results can also be interpreted as chance findings due to the large number of statistical tests performed. The respective effect sizes were small.

References

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

List of abbreviations (pdf)