Bundesamt
für Strahlenschutz

Spotlight on EMF Research

Spotlight on "Assessment of electrical brain activity of healthy volunteers exposed to 3.5 GHz of 5G signals within environmental levels: A controlled-randomised study" by Jamal et al. in International Journal of Environmental Research and Public Health (2023)

Category [radiofrequency, human study]

Spotlight - Mai/2024 no.5 (Eng)

Competence Centre Electromagnetic Fields (KEMF)

1 Putting the paper into context by the BfS

The effects of radiofrequency electromagnetic fields (RF-EMF) from older generations of mobile communications up to the maximum exposure levels permitted for mobile devices on the electroencephalogram (EEG) have been comprehensively investigated, but with often conflicting results [2]. The frequency band in the 3.5 GHz range has been previously used for mobile communications such as WiMax (Worldwide Interoperability for Microwave Access). However, the technology has not become established, and thus the frequency range has rarely been investigated from a radiation protection perspective. The 3.5 GHz frequency band is currently being used for 5G mobile communications.

2 Results and conclusions from the authors' perspective

The authors of the present study investigated the effects of 3.5 GHz RF-EMF far-field exposure on the waking EEG of young, healthy volunteers. Each of the 34 participants (17 male and 17 female) underwent two experimental sessions at a maximum interval of one week, with exposure taking place in one of the sessions and sham exposure in the other. The far-field exposure was applied using a pulse-modulated signal (pulse length: 577 µs, pulse repetition time: 4.6 ms, effective value of the electric field strength: approx. 2 V/m in the head area). The specific absorption rate (SAR) determined by numerical simulation and averaged over the head and brain tissue was 0.037 mW/kg and 0.008 mW/kg, respectively. The EEG was recorded with 64 electrodes before, during and after exposure with eyes open and closed in the EEG frequency bands beta (12-35 Hz), alpha (8-12 Hz), theta (4-8 Hz), and delta (1-4 Hz). The power spectral density of the EEG was analysed. The data were evaluated in three steps:

- Three-way repeated measures ANOVA with the factors exposure (sham and real), time period (baseline, during and after exposure/sham exposure), eye condition (open or closed) and their interactions
- One-way repeated measures ANOVA: baseline-corrected exposure and post-exposure data were analysed separately for open and closed eyes conditions.
- Permutation tests corrected for multiple testing.

There were statistically significant effects of exposure on the spectral power of the EEG in all frequency bands only at individual electrodes.

Beta band: The three-way ANOVA showed statistically significant changes in the spectral power of the EEG only at two of 64 electrodes during exposure and at one electrode after exposure. These results were not confirmed in the one-way ANOVA and the permutation test. Time had also no influence. Opening and closing the eyes caused statistically significant differences at 40 electrodes during and 39 electrodes after exposure.

Alpha-Band The three-way ANOVA showed a statistically significant difference of the spectral power only at one electrode after exposure. The one-way ANOVA with eyes closed showed a lower spectral power at two electrodes during and at one electrode after exposure. These effects disappeared after the permutation test. The factor time showed statistically significant effects at 51 electrodes during and at 52 electrodes after exposure/sham exposure; the factor open or closed eyes showed statistically significant differences at all 64 electrodes.

Theta band: The three-way ANOVA showed no effect of exposure. The one-way ANOVA showed a statistically significant increase in spectral power at one electrode during and at five electrodes after exposure. These effects disappeared after the permutation test. The factor time showed a statistically significant effect at one electrode during and at 10 electrodes after exposure/sham exposure; the difference between open and closed eyes was statistically significant at 57 electrodes.

Delta band: The three-way ANOVA showed no statistically significant effects of exposure. The one-way ANOVA showed a statistically significant increase of power at two electrodes during exposure with eyes closed. Similar results were obtained at three electrodes after exposure with eyes open. These effects disappeared after the permutation test. The factor time showed statistically significant effects at 58 electrodes only after exposure/sham exposure. A statistically significant difference between open and closed eyes was found at about half of the electrodes.

The authors present a detailed discussion of their results in the context of previous studies, some of which have identified effects. The discrepancies are primarily attributable to different study protocols. For 2G, effects were observed at higher exposures from mobile phones (approximately 0.5 - 1 W/kg) [3]. Furthermore, the 2G frequency of 900 MHz has a greater penetration depth than 3.5 GHz (5G).

According to the authors, the differences observed as a result of the time course and especially with open and closed eyes are consistent with the findings in scientific literature.

The applied exposure levels are below the recommended limits, and the authors conclude that such RF-EMF exposure in the 3.5 GHz frequency band has no effect on the waking EEG of humans.

3 Comments by the BfS

The study adheres to high methodological standards. Volunteers were selected according to strict inclusion criteria pertaining to sleep patterns, health, and the intake of medication and stimulants. For women, the menstrual cycle was considered in the initial session used for inclusion into the study. However, it is unclear whether this was also the case in the subsequent test sessions during the study. The statistical power was calculated in advance and was set to 80% for the purpose of demonstrating a medium effect size.

On a positive note, the study was counterbalanced, randomized and triple-blinded: neither the volunteers nor the staff knew when an exposure occurred during the tests. Neither did the researchers who analysed the results. Randomized allocation of the exposure condition and blinding were carried out by different persons, but the measures applied are not described, which slightly limits comprehensibility. The tests were performed at the same time of day for each subject in a shielded room, which greatly reduces the possibility of bias due to time-of-day effects.

Exposure and room temperature were continuously monitored. The SAR averaged over the head (0.037 ± 0.11 mW/kg) and brain (0.008 ± 0.019 mW/kg) was calculated using numerical simulations. However, specific procedures were not explained in detail. The SAR distribution in the brain regions and the results of an uncertainty analysis were not reported, but spatially resolved exposure data would be of great importance for a detailed understanding of any occurring or absent effects on the brain.

EEG registration was performed using 64 electrodes. Artefacts due to eye blinks and cardiac artefacts were detected using additional electrodes and corrected, so it is unlikely that such artefacts biased the results.

Results from men and women were combined for analyses. Therefore, possible sex differences in the baseline or in the effect of RF-EMF could not be detected [4].

Due to its high methodological quality, the study considerably contributes to radiation protection at the 3.5 GHz frequency used for 5G, which has been little studied. No relevant effects on the human EEG were found at the low exposure levels that can be expected in the vicinity of base stations.

References

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urn:nbn:de:0221-2024053044079

Spotlight - Mai/2024 no.5 (Eng)