Effects of exposure to pulsed 900 MHz electromagnetic fields on sleep and the sleep electroencephalogram

P. Achermann*, T. Graf *, R. Huber*, N. Kuster**, A.A. Borbély*
*Institute of Pharmacology and Toxicology, University of Zürich, CH-8057 Zürich, Switzerland
**Foundation for Research on Information Technologies in Society (IT'IS), CH-8045 Zürich, Switzerland

(Principal contact: acherman@pharma.unizh.ch)

Abstract: Results of two recent studies of the effects of electromagnetic fields (EMF) similar to mobile phones on sleep and the sleep electroencephalogram (EEG) are summarized and further research directions are outlined.

1. Introduction

The extensive use of mobile phones has given rise to public debate about possible adverse effects on human health. There are increasing numbers of studies investigating biological effects of exposure to radio frequency EMF of the type GSM (Global System for Mobile communications) on cell cultures, animals and humans.

2. Effects of EMF on sleep and sleep EEG

Pulsed high-frequency EMF corresponding to those emitted by radiotelephones of type GSM were applied to healthy young males to investigate possible effects on sleep. In a first experiment [1], subjects were exposed during an entire nighttime sleep episode to an intermittent radiation schedule (900 MHz; maximum specific absorption rate 1 W/kg) consisting of alternating 15-min on – 15-min off intervals. In a second experiment [2], subjects were unihemispherically exposed for 30 min prior to a 3-h daytime sleep episode. Compared to the control condition with sham exposure, spectral power in the 9-14 Hz range of the EEG in non-rapid-eye-movement sleep (nonREM) was increased in both experiments [1, 2]. The maximum rises occurred during the initial parts of sleep and then subsided. Unilateral exposure in the second experiment induced no hemispheric asymmetry of EEG power [2]. A reduction in waking after sleep onset was observed in the first experiment during sleep with EMF exposure [1]. However, the presence of a mild sleep disturbance may have been a prerequisite for the manifestation of this effect. REM sleep and the REM sleep EEG was not affected in the two studies.

The change in EEG power was similar for both hemispheres and no asymmetry was detected after unilateral exposure in the second experiment [2]. Two explanations may be considered: 1) The SAR ratio of about 5:1 between the exposed and non-exposed hemisphere may have been too low to induce a differential effect or a ceiling effect may have been present (i.e. the lower field strength at the non-exposed hemisphere may have been sufficient for a maximal effect). 2) Subcortical regions may contain the most sensitive structures to EMF and their bilateral cortical projection may explain the absence of a hemispheric asymmetry. The latter interpretation is supported by preliminary results of computer simulations of the distribution of the specific absorption rate (SAR) of the EMF within the brain. An additional maximum in the distribution of the SAR was found in subcortical structures for both experiments.

The changes in EEG power are manifested rapidly when exposure occurs during sleep [1]. They outlast exposure by 20-50 min when EMF is applied during waking prior to sleep [2]. These studies demonstrated that exposure to EMF emitted by mobile phones has an effect on brain physiology. Conclusions about possible adverse effects on human health are premature because the underlying mechanisms are unknown.

3. Perspectives

Positron emission tomography (PET) could be used to assess changes in regional cerebral blood flow caused by unihemispheric EMF exposure. Such a PET study may indicate the brain structures affected by the EMF.

Further studies are needed to specify field strength – response relations, and to define the critical field parameters (e.g. modulation, frequency).

4. Acknowledgements

The studies were supported by Swiss National Science Foundation, grant 3100-053005.97, the Human Frontiers Science Program grant RG-81/96, Swisscom [1] and the Swiss Federal Office of Public Health [2].

5. References

[1] Borbély A.A., Huber R., Graf T., Fuchs B., Gallmann E., Achermann P. Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram. Neurosci. Letters 275: 207-210

[2] Huber R., Graf T., Cote K.A., Wittmann L., Gallmann E., Matter D., Schuderer J., Kuster N., Borbély A.A., Achermann P. (2000) Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG. NeuroReport 11: 3321-3325