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Low-power density of 950 MHz radiation does not affect long-term potentiation in rat dentate gyrus

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Introduction: Over the last decade, exposure to non-ionizing electromagnetic waves due to base station antenna has increased. This *in vivo* study was planned for evaluating the effects of whole-body exposure to 950 MHz field of GSM mobile phone system on rat dentate gyrus long-term potentiation. ***Materials and Methods:*** 24 naive male Wistar rats (3 month old, 225±25 g) were randomly divided in the three groups (sham-exposed, GSM and continuous field exposed). The exposure program was planned for 10 sessions at 3 days. Animals were exposed to electromagnetic field for 45 minutes in a circular plastic chamber (mean power density=0.835 mW/cm^2). Immediately after end exposure, anesthesia was induced for long term potentiation (LTP) induction. Field potentials were recorded and analyzed using the population spike amplitude and EPSP slope for 60-min. ***Results:*** There were no significant differences in population spike amplitude, EPSP slope and EPSP slope maintenance among the three groups. ***Conclusion:*** This study provides no evidence indicating that long-term potentiation can be affected by the whole-body exposure to low-power density of 950 MHz field of GSM mobile phone system. **Iran. J. Radiat. Res., 2007; 5 (3): 119-124**

Keywords: *Electromagnetic field, base station, long-term potentiation, dentate gyrus, rat.*

INTRODUCTION

Nowadays, with growth in mobile communications, exposure to non-ionizing electromagnetic field (EMF) has increased due to mobile handset and base station antenna. The GSM mobile phone system that is used in most countries has a frequency of either 900 or 1800 MHz (pulsed at 217 Hz, Band width of 200 KHz). The spectrum of 900 MHz has two band areas: 890-915 MHz that is specific for handset and 935-960 MHz that is specific for base station antenna.

During the last decade, many researches have studied the effects of the exposure to mobile phone electromagnetic fields (EMFs) on different nervous system functions such as memory in human and animals. Some of these studies have revealed deficits on memory due to EMF exposure (1-16), whereas others studies have not (17-21).

A number of studies have suggested that low frequency EMF may interact with learning and memory processes (12, 22). Nevertheless, other studies have suggested that much higher frequency fields may also affect spatial memory (10, 12, 23). Wang and Lai (12, 23) reported deficits in two spatial learning tasks (Morris water maze and radial maze) after 45 minutes exposure to continuous or pulsed 2450 MHz EMF.

Since the spatial memory was accepted to have a substantial hippocampal involvement, these studies suggested that EMF may affect hippocampal function. This is supported by a report that exposure to 700 MHz continuous field can change electrical activity in the hippocampus of rats (24).

The hippocampal formation, in particular the dentate gyrus (DG), is associated with spatial learning and memory (25). Long-term potentiation (LTP) is a long-lasting increase in synaptic efficacy resulting from the high-frequency stimulation of afferent fibers (26). LTP is an attractive hypothesis to explain the cellular mechanisms of relational learning.

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Hippocampal LTP may allow formation of specific associations between multiple stimuli, which may be the basis of learning relationships between environmental (e.g. spatial) cues [27].

To get insights into the cellular effects that 950 MHz radiation (as a frequency in middle of base station band) could induce on hippocampus, it was decided to conduct a general study to investigate the consequences of exposure to continuous and pulsed (GSM) waves of 950 MHz EMF. Thus, the aim of this study was to examine the effects of exposure to 950 MHz radiation on rat dentate gyrus long-term potentiation.

MATERIALS AND METHODS

Electromagnetic field exposure

For whole body exposure to EMF, a GSM simulator (made by Khaje-Nasir Toosi University, Tehran, Iran) was used to produce 950 MHz fields, in continuous (without any modulation) or GSM (217 Hz modulated and band width of 200 KHz) waveform. It was connected to a 15 cm rod antenna fixed at the center of a circular plastic chamber (diameter=30 cm). The animal could freely move inside the chamber. To prevent unknown exposure to reactive area of EMF, some of the near field restricted by a plastic mesh (radius=5 cm). The power density inside the chamber was measured with RF meter (Narda 8716, USA) in different distances with 5 cm height from the base of antenna. With these records, the average value for power density was 0.835 mW/cm^2. The exposure room was adjacent to the experimental room.

The exposure program was consisted of ten×45 minutes irradiation, delivered at 3 days. In the first and second days, each animal was exposed or sham-exposed to 4 sessions of 45 minutes irradiation, with 1 hour interval. Subsequently, animals had two irradiation sessions in the third day. Immediately after the last exposure, anesthesia was delivered for LTP induction.

Animals

24 naive male Wistar rats (3 month old, 225±25 g) were randomly divided in three groups: sham-exposed (n=8), GSM (n=8) and continuous field exposed (n=8). Rats were maintained on a 12-h light-dark cycle and with an ambient temperature of 21°C. They were housed in a maximum of 8 rats per breeding cage and allowed access to food and water *ad libitum*. All experiments were performed between 9:00 a.m and 13:00 p.m during the light cycle.

Surgical method

Animals were food and water deprived for 1 hour prior to surgery. For electrophysiological recording, the rats were anesthetized with Urethane (1.5 g/Kg, i.p., with supplemental injections as required) and stereotaxically implanted with a bipolar Teflon-coated silver electrode (125 µm diameter) in the perforant pathway (coordinates: AP -6.8 mm, L -4.1 mm, DV -3 mm, from skull surface), and a recording electrode (glass micropipette, 1- 3 MΩ, filled with physiological saline) in the dentate gyrus granule cell layer (coordinates: AP -2.8 mm, L -1.8 mm, DV-3 mm, from skull surface).

Electrophysiological recordings

The stimulating and recording electrodes were adjusted to produce maximum field potentials by applying a single pulse stimulus (0.1 Hz, 200µs pulse width) and recording field potentials in the DG granule cell layer.

Test stimulus intensity, was selected which was sufficient to produce population spike (PS) with approximately 50% of maximum amplitude. After the 15 minute base line recording, for LTP induction, two high frequency stimulus (250 Hz, 1s, 30s interval) were delivered to the perforant pathway with test stimulus intensity. The field potentials were recorded at 10, 20, 30, 40, 50 and 60-min after the tetanic stimulations, with 0.1 Hz pulse stimulus. The evoked responses were amplified, filtered (band-pass: 5 Hz - 3 KHz), sampled at a rate of 20 KHz and stored.

Evaluation indexes were PS amplitude, excitatory postsynaptic potentiation (EPSP) slope and EPSP maintenance. The LTP signal parameters were extracted as shown in figure 1. For EPSP maintenance, the percent of changes in each recording time were calculated as: (Last record value - first record value / first record value) × 100.

Data were statistically analyzed by one-way analysis of variance (ANOVA) with groups as a repeated measure. Values of $P<0.05$ were considered to be significant.

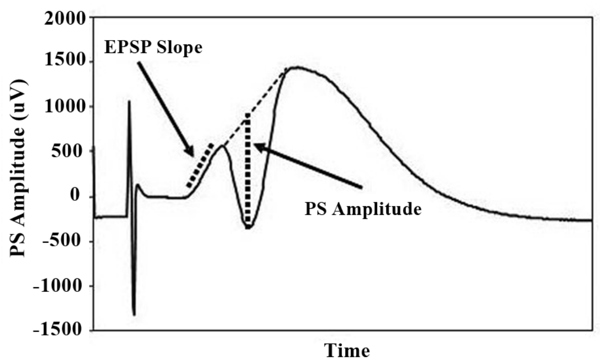

Figure 1. EPSP slope and PS amplitude that extracted from LTP signal.

RESULTS

The results of EPSP slope of three groups, during the base line and 60-min recording are shown in figure 2. One-way ANOVA showed no significant differences among the groups.

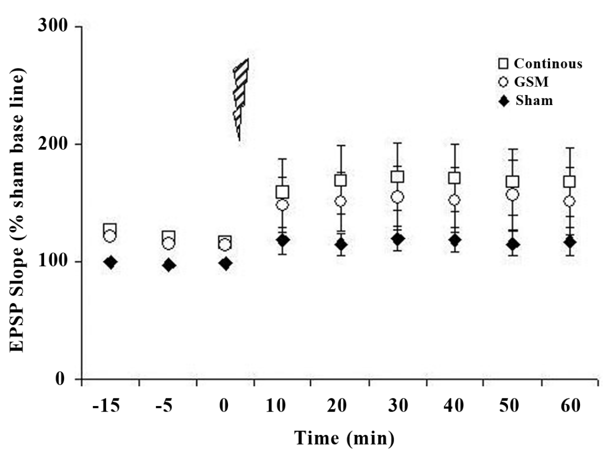

Figure 2. EPSP slope of three experimental groups (Mean± SEM). Analysis of the data showed no significant differences between sham, continuous and GSM exposed groups.

Figure 3, illustrates the EPSP slope maintenance during the recording time. One-way ANOVA indicated no significant differences among the groups.

Results of the population spike amplitude are presented in figure 4. There were no significant differences between amplitudes of three groups during the base line recording and after LTP induction.

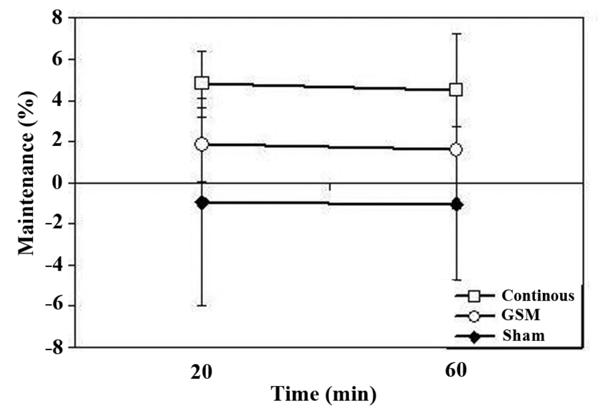

Figure 3. EPSP slope maintenance among the groups (Mean±SEM). There was no significant difference between maintenance phase of the stimulated and sham exposed groups.

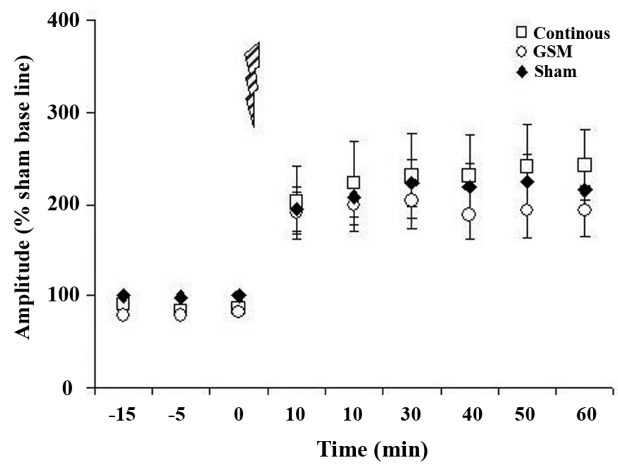

Figure 4. Population spike amplitude (Mean±SEM). There were no significant differences between LTP induction and PS amplitude in the sham, continuous and GSM exposed groups.

DISCUSSION

The mobile phones and their base station non-ionizing electromagnetic fields have low specific absorption rate which induce very low rise in brain temperature. Thus, the possible biological effects of mobile phone systems on brain would be expected to be the non-thermal effects [7]. The results showed that exposure to continuous GSM waves of 950 MHz EMF did not affect the LTP parameters. This has been agreement with recent studies showing that 900MHz EMF, in head-only exposure conditions, can not alter performances of rats in spatial memory and non-spatial memory tasks [2, 20]. Another study has shown that 900MHz GSM EMF dose not alter mice performance in an 8-arm radial-maze experiment [21].

On the other hand, Tattersall [24] indicated that exposure to 700 MHz continuous EMF for 5 to 15 minutes could have reduced spontaneous epileptiform activity of rat hippocampus. Moreover, the results of Ogiue-Ikeda [28, 29] experiments signified the effect of low frequency magnetic field on EPSP slope of LTP.

Lai and Carino [12] found that low level microwave irradiations can alter the cholinergic functions in the rat hippocampus and cortex. Such decrease in cholinergic activity in the brain can impair the rat; spatial memory [12]. Wang and Lai [12, 23] showed that 45 minutes exposure to 2.45 GHz microwaves can alter spatial memory. However, Cassel [17] could not access the same results with their testing protocol was as similar as possible to that of the Lai and Carino [12] study.

The memory impairment reported by Wang and Lai [12, 23] can be related to a hyperthermia, because hyperthermia can produce amnesic effects [2].

Results of epidemiologic studies, performed on the effects of EMF for those lining in areas near the base station antennas, showed that people's complaints (sleep disorders, headaches, concentration difficulties and fatigue) have been due to EMF [30, 31]. These signs appeared after exposure, and decreased slowly. Santini [32] has suggested that the signs differ with the increase of distance from antenna. In addition to distance, it seems that the antenna characteristics are also among the important factors.

Bornkessel and Stocker-Meier [33] studies on 24 antennas showed that although electrical fields' intensities of these antennas have been in the standard limit, the results were time dependent and could differ with different antenna traffic along a day. Although some of these studies suggest that exposure level is less than the allowed level by ICNIRP in areas near the base station antenna, the probability of long term exposure dangers of these waves for those living in such areas are not rejected. In agreement with this point, Lai and Carino [11] showed that the intensity and duration of exposure have interactions in the effectiveness of the field on memory so that high-intensity/short-duration exposure and lower-intensity/longer-duration exposure could have similar effects on frontal cortex and hippocampus cholinergic activity and memory. In addition, it has been shown that chronic exposure to EMF can increase plasma corticosterone level [15]. This elevated level of corticosterone can induce time-dependent neuronal damage in hippocampus and impair cognitive function [34].

In the present research, the effect of exposure to 950 MHz non-ionizing radiation emitted by base station antenna on electrical activity of hippocampus was investigated via the long-term potentiation. Although this set of experiment provides no evidence indicating that LTP signal can be affected by the continuous or GSM waveform of 950 MHz EMF, further studies are needed to test other durations and intensities on brain activity. In addition, with rapid increase in number of mobile phone users in the world, and base station antenna in urban area, it seems that the knowledge about the effects of EMF on human body, especially human brain, is a necessity.

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