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Research Report

Deleterious impacts of a 900-MHz electromagnetic field on hippocampal pyramidal neurons of 8-week-old Sprague Dawley male rats

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ABSTRACT

Children are at potential risk due to their intense use of mobile phones. We examined 8-week-old rats because this age of the rats is comparable with the preadolescent period in humans. The number of pyramidal neurons in the cornu ammonis of the Sprague Dawley male rat (8-weeks old, weighing 180–250 g) hippocampus following exposure to a 900 MHz (MHz) electromagnetic field (EMF) were examined. The study consisted of control (CN-G), sham exposed (SHM-EG) and EMF exposed (EMF-EG) groups with 6 rats in each. The EMF-EG rats were exposed to 900 MHz EMF (1 h/day for 30 days) in an EMF jar. The SHM-EG rats were placed in the EMF jar but not exposed to the EMF (1 h/day for 30 days). The CN-G rats were not placed into the exposure jar and were not exposed to the EMF during the study period. All animals were sacrificed at the end of the experiment, and their brains were removed for histopathological and stereological analysis. The number of pyramidal neurons in the cornu ammonis of the hippocampus was estimated on Cresyl violet stained sections of the brain using the optical dissector counting technique. Histopathological evaluations were also performed on these sections. Histopathological observation showed abundant cells with abnormal, black or dark blue cytoplasm and shrunken morphology among the normal pyramidal neurons. The largest lateral ventricles were observed in the EMF-EG sections compared to those from the other groups. Stereological analyses showed that the total number of pyramidal neurons in the cornu ammonis of the EMF-EG rats was significantly lower than those in the CN-G ($p<0.05$) and the SHM-EG ($p<0.05$). In conclusion, our results suggest that pyramidal neuron loss and histopathological changes in the cornu ammonis of 8-week-old male rats may be due to the 900-MHz EMF exposure.

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1. Introduction

Several studies have reported that the electromagnetic field (EMF) emitted from natural or non-natural sources has severe effects on human health and that these can give rise to significant pathologies in various tissues and organs (Davis et al., 2013; Gultekin and Moeller, 2013). The most popular communication device today is the mobile phone, an important source of EMF. The effects of EMF on human health established by mobile phones is therefore the subject of significant research and debate among scientists (Hancı et al., 2013, 2015; ikinci et al., 2013; Türedi et al., 2014; Topal et al., 2015). Mobile phones are the source of EMF used in the greatest proximity to the human body, and the field established by them includes organs and tissues with vital functions such as the brain, cerebellum, eye and hearing organs. Some scientists maintain that these effects can have serious pathological outcomes affecting human health (Davis et al., 2013), while others maintain the opposite (Inskip et al., 2010).

Gultekin and Moeller (2013) recently showed that currently used cell phones can produce hotspots in living brain tissue or brain-related tissue/organs. In another study, Volkow et al. (2011) reported that 50 min of mobile phone use produces a significant change in glucose metabolism in the area of the human brain that absorbs most of the radiation. Although the cause of the marked increase in pathological conditions in humans such as brain tumors or skin cancer incidence is unknown (Corle et al., 2012; Inskip et al., 2010; Poulsen et al., 2013), there is nevertheless concern that cell phones can trigger biological effects and that several decades of cell phone use in an individual is a probable carcinogen (Davis et al., 2013).

Children's brains are more affected by EMF than the adult brains when speaking on mobile phones. This is because the brain membrane, skull bones and components associated with those bones that protect central nervous system (CNS) structures inside the skull against external agents have not yet achieved the thickness and morphological characteristics of those in adulthood. In the light of studies reporting that exposure, even in adulthood, can cause significant pathological changes in CNS structures (Bas et al., 2009a, 2009b; Odaci et al., 2008; Sonmez et al., 2010), exposure to EMF in childhood may well affect the child brain and related structures and the development thereof.

The CNS of rodents (i.e. rats) tested must be comparable to that in the same stage of development in humans, regardless of whether it is tested during the fetal, prenatal or postnatal periods (Dobbing, 1970; Dobbing and Sands, 1973; Jacobson, 1991; Rodier, 1980). We examined the brains of 8-week-old rats after exposure to 900-MHz megahertz (MHz) EMF because that age is comparable with the human preadolescent period (Baş et al., 2009b; Odaci et al., 2004, 2008). In addition to histopathological examination, we also used the stereological optical dissector method for neuron number estimation because it represents an unbiased means of estimating the total neuron numbers.

2. Results

2.1. Physical examination and weights

Physical examination revealed no skeletal anomaly or pathological findings in the CN-G, SHM-EG or EMF-EG rats. No significant difference was determined among the groups in terms of rats' body or brain weights at the end of the experiment ($p>0.05$), (Table 1).

2.2. Pyramidal neuron numbers

The total number of pyramidal neurons in the cornu ammonis of the hippocampus was significantly lower in the EMF-EG rats compared to the CN-G and the SHM-EG ($p<0.05$). There was no significant difference in total pyramidal neuron

Table 1 – Mean values for total pyramidal neuron numbers, body and brain weights, CV and CE of stereological analysis, optical dissector analysis data for estimation of total pyramidal neuron numbers in the Ca for CN-G, SHM-EG and EMF-EG rats.

Parameters	CN-G ($n=6$)	SHM-EG ($n=6$)	EMF-EG ($n=6$)
Total pyramidal neuron number (Mean ± SD)	607332 ± 23828	621455 ± 25644	549238 ± 11477[a]
Body weight (g) (end of the experiment) (Mean ± SD)	317.326 ± 16.473	332.262 ± 57.69	257.465 ± 10.911
Brain weight (g) (Mean ± SD)	1.5 ± 1.90	1.4 ± 1.55	1.4 ± 0.89
Dissector particle number (mean)	438.1	449.5	396.4
Number of sampled sections (mean)	15.3	15.8	15.6
Section thickness (mean) (μm)	21.5	21.7	21.1
Number of steps for counting (mean)	178.2	189.4	173.3
Section-sampling fraction (coronal)	1/7	1/7	1/7
Counting frame size (μm^2)	580	580	580
Area sampling fraction ($\mu m^2/\mu m^2$)	580/40000	580/40000	580/40000
Thickness sampling fraction (μm/μm)	10/21.5	10/21.7	10/21.1
CE (mean)	0.07	0.07	0.08
CV	0.04	0.04	0.05

SD, standard deviation; EMF, electromagnetic field; CE, coefficient of error; CV, coefficient of variation; CN-G, control group; SHM-EG, sham exposed group; EMF-EG, EMF exposed group; Ca, cornu ammonis.

[a] The total number of pyramidal neurons in the cornu ammonis of the hippocampus was significantly lower in the EMF-EG rats compared to those in the CN-G and SHM-EG rats ($p<0.05$).