

## EXPERIMENTAL STUDY

# Effect of Short-term 900 MHz low level electromagnetic radiation exposure on blood serotonin and glutamate levels

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**Abstract:** *Background:* Long term exposure to low level electromagnetic radiation (LLER) by using cellular phones causes serious health problems.

*Methods:* Ten male Wistar Albino rats were anesthetized 30 min before the LLER exposure, 0.5 ml blood was taken from the tail vein of rats in order to determine control values. Rats were grouped by three and placed on a plexi-glass flat. A fixed equivalent frequency emitter device was used. A sign to be an electromagnetic field 15.14 V/m (608 mW/m<sup>2</sup>) in strength in the head region with 100 kHz FM modulation at 900 MHz was applied to the animals. After calculating the ideal position for the device, electromagnetic LLER energy was applied for 45 minutes from a distance to be equal with energy transmitted by a mobile phone from a 0.5–1 cm distance to their head regions. After 1.5 hours and before the rats awoke, 0.5 ml of blood was taken from the tail veins in order to determine the treatment values.

*Results:* Plasma 5-HT and glutamate levels were measured by enzyme immunoassay (EIA) using commercial kits. It was found that a single 45 min of LLER exposure increased the blood 5-HT level significantly, but did not change the glutamate level of rats.

*Conclusion:* It was concluded that even a single 45 min of LLER exposure may produce an increase in 5-HT level without changing the blood glutamate level. Increased 5-HT level may lead to a retarded learning and a deficit in spatial memory (Tab. 2, Fig. 2, Ref. 24). Text in PDF [www.elis.sk](http://www.elis.sk).

Key words: low level electromagnetic radiation, serotonin, glutamate, rat.

## Introduction

The use of cellular phones has been increased rapidly worldwide during the last 20 years. It is now estimated that there is more than 1.5 billion cellular phones in use. Such rapid growth of mobile phone telecommunications has increased the scientific interest on biological effects of electromagnetic field emitted from cellular phones and their consequences on human health. Mobile phones have been reported to seriously affect the hormonal systems and chemical structure of humans (1–3). Long term exposure to low level electromagnetic radiation (LLER) by using cellular phones causes serious health problems (4). LLER variously affects the nervous system (5), increases the rate of cerebral tumor develop-

ment (6, 7), decreases sperm count, increases DNA fragmentation (8) and increases the risk of multiple sclerosis (9).

Serotonin (5-hydroxytryptamine, 5-HT) and glutamate are thought to particularly affect cerebral function. Serotonin, a monoamine neurotransmitter consisting of tryptophan amino acid, is most commonly found in the gastrointestinal tract, thrombocytes, and nervous system of the body. It is necessary for intestinal movement, sleep, appetite, conscious functions, and learning (10, 11). When it is at a normal level, people feel better, and happier. Deficiency of serotonin may cause depression, nausea, vomiting, and diarrhea. It is released from the ventromedial nuclei and enterochromaffin cells in the bowels. Its receptors are in the hippocampus region in the brain. In humans, deficiency of serotonin has been found in sudden infant death syndrome (SIDS) (12). A different but equally fatal serotonin syndrome occurs with high doses of serotonin (13).

Glutamine, glucose-like chemical is used for energy when glucose is not available (14, 15). It can easily pass the blood-brain barrier; therefore, it is one of the most important sources of energy. It also regulates cerebral and muscular functions by elevating the level of gamma amino butyric acid (GABA), enabling ammonium to be cleaned from the brain, thus delaying cerebral ageing (16). Glutamine and glutamic acid are used in the treatment of schizophrenia and senility, loss of muscular strength, and to increase intelligence as a supportive treatment, but excess of them is harmful (17).

Early studies have reported changes in various neurotransmitters (catecholamines, serotonin and acetylcholine) in the brain of animals exposed only to high intensities of radiofrequency (18, 19). However, there are more recent studies that show changes in

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neurotransmitter functions after exposure to low intensities of radiofrequency. This study was designed to demonstrate the effects of 900-MHz LLER exposure on blood glutamate and 5-HT levels of rats. This study differs from previous studies by exposing animals to only a single dose of LLER for 45 min.

## Materials and methods

### Treatment of rats

Ten male Wistar Albino rats, aged 4 months and weighing 250–300 g were used. The study was approved by the Animal Ethics Committee of the Bezmialem Vakif University. The rats were anesthetized by intraperitoneal injections of cetamine (35 mg/kg) and xylazine (5 mg/kg). Anesthesia lasted for 120 min. Before the LLER exposure, 0.5 ml blood was taken from the tail vein of rats in order to determine base values, and stored at -80 degrees until the biochemical analysis. These base values were served as control values. One of the rats died during the anesthesia, and was excluded from the experiment. Rats were grouped by three and placed on a plexi-glass flat plate prepared previously. Because the frequency emitted by cell phones is not stable, a fixed equivalent frequency emitter device (Sign Generator: R&S SMBV100A, Transmitting antenna: Agilent 11965A, Field measurement: Spectran HF-6080, Munich, Germany) was used. A sign to be an electromagnetic field 15.14 V/m (608 mW/m<sup>2</sup>) in strength in the head region with 100 kHz FM modulation at 900 MHz was applied to the animals (Fig. 1). Frequency measurements with the device were done with the rats positioned side by side. LLER doses received by the brain were calculated to be equivalent by putting rats in groups of one or four. The 9 rats were grouped side by side in groups of three (Fig. 2). After calculating the ideal position for the device, electromagnetic LLER energy was applied for 45 minutes from a distance to be equal with energy transmitted by a mobile phone from a 0.5–1 cm distance to their head regions. After 1.5 hours and before the rats awoke, 0.5 ml of blood was taken from the tail veins in order to determine the treatment values, and stored at -80 degrees until the biochemical analysis.

### Biochemical analysis

Plasma 5-HT and glutamate levels were measured by enzyme immunoassay (EIA) using commercial kits (Cusabio Biotech Co.,



Fig. 1. Frequency meter device.

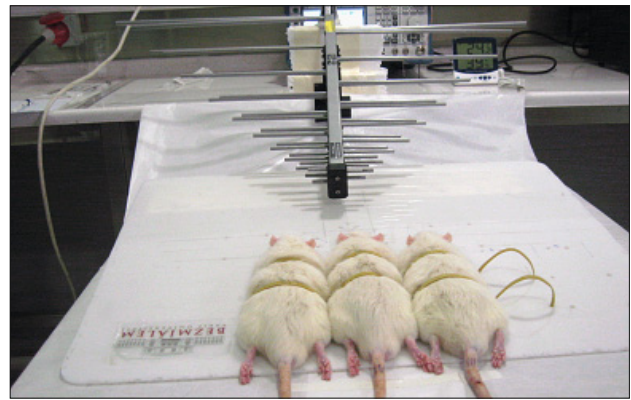


Fig. 2. Rats during LLER application.

Ltd., China). The coefficients of intra- and inter-assay variations were <10 %.

### Data analysis

Numerical variables are presented as means (with standard deviations) and nominal variables (in ratios). Rats were evaluated before and after application in groups. Ordinal paired variables were compared using the Wilcoxon test for 5-HT and glutamate levels, and the before application and after application groups. A *p* value of  $\leq 0.05$  was considered to be statistically significant.

## Results

A single 45 min of LLER exposure increased the blood 5-HT level significantly ( $p < 0.05$ ), but did not change ( $p > 0.05$ ) the glutamate level of rats (Tabs 1 and 2).

## Discussion

An electromagnetic field influences the biological functions of nerve cells and induces changes in neurotransmitter contents. Electromagnetic field emitted by mobile phones may induce an alteration in both excitatory and inhibitory neurotransmitters due to changed amino acid concentration (19). Due to the close proximity of the cellular phone to the head, human brain is exposed to relatively high electromagnetic radiation compared to the rest of the body. Therefore, electromagnetic LLER energy was applied to be equal with energy transmitted by a mobile phone from a 0.5–1 cm distance to the head regions of animals in this study.

It was found that a single 45 min of LLER exposure increased the blood 5-HT level of rats. Our result is consistent with the results of Aboul Ezz et al (20) who investigated the effect of pulsed electromagnetic radiation from mobile phone on the levels of monoamine neurotransmitters in four different areas of rat brain, and found a significant increase in 5-HT level in adult rat brain, 1 and 2 months after the daily exposure of electromagnetic radiation. Our study has indicated that even a single 45 min of LLER exposure increases blood 5-HT levels of rats. Previous studies suggested that 5-HT has an inhibitory effect on learning and memory, and also on some of hippocampal pathways involved in spatial information process-

**Tab. 1. Blood 5-HT levels of rats before and after a single 45 min of LLER exposure (n = 9).**

5-HT	Mean±SD (nmol/ml)	p
Before application	77.4±13	0.043
After application	195.5±116.9	

Values are expressed as mean ± standard deviation.

**Tab. 2. Blood glutamate levels of rats before and after a single 45 min of LLER exposure (n = 9).**

Glutamate	Mean±SD (nmol/ml)	p
Before application	181.8±16.3	0.07
After application	204.04±12.7	

Values are expressed as mean ± standard deviation.

ing (21). Therefore, increased 5-HT level after 45 min of LLER exposure may affect the memory and learning ability. In support of this idea, it has been reported that rats exposed to pulsed EMR showed retarded learning and a deficit in spatial memory (22).

It was also found that a single 45 min of LLER exposure did not change the blood glutamate level of rats. In a previous study, it was found that cerebellar glutamate level increased after one hour of EMF exposure. However, this increase was reversed into significant decrease after one month and four months of exposure (19). It has been suggested that electromagnetic field may increase the influx of glucose (main source of glutamate) to the brain (23). It has been also suggested that increased glutamate level was due to the conversion of glutamine (stored in glia cells and taken up by neurons) to glutamate via the phosphate-dependent glutaminase pathway (24). Excessive glutamate release from presynaptic neurons or reduced clearance of glutamate from the synaptic cleft leads to an increase in glutamate level. In our study, glutamate level tended to increase but the increase was not significant after the 45 min of LLER exposure.

It was concluded that even a single 45 min of LLER exposure may produce an increase in 5-HT level without changing the blood glutamate level. Increased 5-HT level may lead to a retarded learning and a deficit in spatial memory.

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