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Original Research Article

Thermal and Biochemical Effects of Low Level Electromagnetic Radiation on Rat Brains and Bodies

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Abstract

Aim: The detrimental effects of low level electromagnetic radiations to brain are known. However, scientific proof has not yet been fully carried out. Therefore, we have initiated a study which shows the effect of 900 MHz cell phone on rats brains, where thermographic images, serotonin and glutamate levels were examined for low level electromagnetic radiation treated rats. **Method:** The study was performed at Bezmialem Vakif University, Faculty of Medicine, for 10 rats in 2012. Blood samples and thermal camera images of rats were taken pre- and post- low level electromagnetic radiations eposure. The control group consists of rats whose blood samples and thermal images were taken before the application. Low level electromagnetic radiation (900M Hz) was applied to rat heads for 45 minutes. One and one-half hours later, blood tests and thermographic images were taken again and the thermal images, glutamate and serotonin (5-HT) results were statistically analyzed. **Results:** Wilcoxon analysis results showed statistically significant differences for head and brain region of rat temperatures between pre and post-application values (p=0.004). In Biochemical analysis a significant elevation was seen for 5-HT (p=0.043). **Conclusion:** We tried to show effects only within a 45 minute period of time and significant thermal effects was obtained on the head and brains localization of rat scalp. An increase was seen in serotonin values as a result of short term low level electromagnetic radiation application in rats.

Introduction

Low level electromagnetic radiation (LLER) of cell phones can cause unwanted effects for the body and brain. The objective of our study is to examine the thermal camera images and the two important biochemical parameters: glutamate and serotonin (5-HT). While other studies investigated the long term effects of cell phone usage. In our study a single 45-minute application was investigated.

Some studies also revealed that different types of radiations causes harmful effects to the brain.[1, 2, 3] High laser energy may cause cortical tissue heating and exacerbate stroke injury.[1] Repeated MRI applications

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also may cause brain injury deep in the white matter. Because it was ascertained that the tip of the transducer had been melted and scorched,[2] the animal displayed no reaction other than that due to the hearing effect until the peak absorbed energy density in the brain exceeded 28 kJ/kg, or an absorbed energy in the head of 680 J. Previous studies have indicated that auditory responses could be evoked in the head of animals that are exposed to small absorbed energies (5–180 mJ/kg).[3]

Different methods have been developed to show the temperature changes in the brain: Infrared thermography was used to monitor the skin temperature.[4] A thermoviewer, was utilized for finding the effect of microwave heat energy absorption in rats and mice brains following microwave irradiation (MWR). Thermal image with its temperature information was stored.[5]

Sympathetic vasoconstriction and antidromic vasodilation was investigated by using laser Doppler (LD) flowmetry and an infrared thermometer.[6] Measuring of infrared radiation was performed by functionally mapping the cerebral cortex using a computerized infrared imaging system.[7] We used the thermographic imaging method to measure the skin temperature to show the increase in body temperature caused by the cell phones.

Normal human body temperature is known as normothermia. Different parts of the body may have different temperatures. The measurements taken directly inside the body cavity, such as rectal and vaginal measurements, are typically slightly higher than the skin temperature. The commonly accepted average core body temperature which taken internally is 37.0 °C (98.6 °F) for the healthy people.[8] The body temperature of a healthy person varies during the day by about 0.5 °C (0.9 °F). The humans would have lower temperatures in the morning and higher temperatures in the late afternoon and evening. Normal body temperature may also differ as much as 0.5 °C (0.9 °F) from one day to the next and often stated as 36.5–37.5 °C (97.7–99.5 °F).[9] Tympanic measurements was higher than rectal and core body measurements.[10] The skin was used as a tool to increase or decrease core temperature by body.[10] Neurologic exciting and exercise raise body temperatures.

Cell phones are known to also seriously affect the human hormones and chemicals.[11] LLER has various affects on the nervous system, it decreases sperm count, increases DNA fragmentation and brain tumors.[12, 13, 14] Most of these effects depend on the change of hormonal profiles. This study reviewed two separate parameters: serotonin (5-HT) and glutamate.

In humans, serotonin levels can be affected by diet. An increase in the ratio of tryptophan can increase serotonin levels. A diet rich in carbohydrates and low in protein will increase serotonin by secreting insulin.[15] Muscles use many of the amino acids and tryptophan which allow to produce more serotonin.[16]

Serotonin is necessary for intestinal movement, sleep, appetite, conscious functions and learning abilities.[18] When serotonin is at a normal level, people feel better and happier. Deficiency of serotonin may cause depression, nausea, vomiting, and diarrhea. Serotonin is released from the ventromedial nuclei and enterochromaffin cells in the bowels. Serotonin receptors are located in the hippocampus region in the brain.[19]

The glutamate can easily pass the blood-brain barrier; therefore, it is one of the most important sources of energy. It is also regulates the cerebral and muscular functions by elevating the level of gamma amino butyric acid (GABA). Glutamine is used in the treatment of schizophrenia and senility, loss of muscular strength, and to increase intelligence as a supportive treatment, but excess amounts are harmful.[20]

Experimental

The study was performed in Bezmialem Vakif University, Faculty of Medicine, Department of Scientific research Center for 10 rats in 2012. This is an animal study for exploratory experimentation. In this study we used 10 male Wistar albino rats of 4 months old, their weights ranged from 250 to 300 g. Before the application, the rats were grouped as three and four and were intraperitoneally anesthesized by cetamine (35mg/kg) and xyilazine (5mg/kg) (Figure 1). Anesthetic time was 120 minutes.

Figure 1. Rats during LLER application.

Blood samples and thermal camera images of rats were taken before and after LLR. Control group consist of blood samples and thermal images which were taken before the application. After the procedure of bloodletting was completed, the rats were placed onto their special places on a plexiglass flat ground prepared previously.

Processing the thermal images: A Fluke Ti32 thermographic camera was used for processing thermal scalp images of the rats. Thermal images were taken

before the procedure and then every 5 minutes during the application for a 45 minute period. The rat scalps were evaluated at three regions, after processing the rat scalp thermographic images (Figure 2, 3).

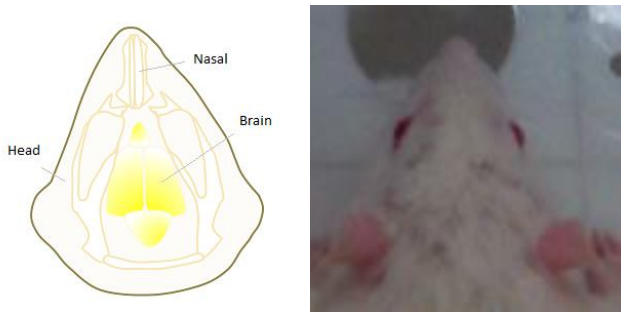

Figure 2. Head of rat, schaematic illustration

Blood (0.5 ml) was taken from their tail veins, put into lithium tubes, and stored at -80 degrees until biochemical analysis was made.

Assay of 5-HT Levels: Plasma 5-HT levels were measured by enzyme immunoassay (EIA) using a 5-HT kit (Cusabio Biotech Co., Ltd., China). The coefficients of intra- and inter-assay variations were < 10 %.

Assay of Glutamate Levels: Plasma glutamate levels were measured by enzyme immunoassay (EIA) using a glutamate kit (Cusabio Biotech Co, Ltd., China). The coefficients of intra- and interassay variations were < 10 %.

Because the frequency emitted by the cell phones is not stable, a fixed equivalent frequency emitter device was used.

Signal Generator: R&S SMBV100A

Transmitting antenna: Agilent 11965A

Field Measurement: Spectran HF-6080

A sign to be an electromagnetic field 15.14 V/m (608mW/m2) in strength in the head region with 100kHz FM modulation at 900MHz was applied to the animals.

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 10 rats were grouped side by side in groups of three and four (Figure 1). 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, blood was again drawn from their tail veins. This amount of time was needed for peak values of 5-HT and glutamate to be realized. A longer wait would have required the administration of repetitive anesthetic agent, which would have negatively affected the biochemical data.

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

The study was approved by the Animal Ethics Committee of the Bezmialem Vakif University Medical Faculty.

Results and Discussion

When the thermal image results reviewed, the hottest region of the scalp skin was at nasal localization and the measurement median was 93 ^{0}F before the application (Table 1, Figure 3 A). Conversely, coolest region of the scalp skin was at brain localization (Table 1) and the measurement median was 88 ^{0}F at this time (Figure 3 A). Brain temperature median was 85 ^{0}F at 20 min and 93 ^{0}F at 45 min (Table 1) (Figure 3 B,C,D, Figure 4). Scalp and nasal region temperatures were 94 ^{0}F and 93 ^{0}F respectively at 45 min post-application period. Rat brains, scalps and nasal skin regions heat increase and decrease curves are shown in Figures 4, 5 and 6. Examination of the results showed that the temperature was increased by median 5, 4 and 0 ^{0}F after processing according to pre-processing level for brain, head and nasal regions of rats, respectively. For the 10 rats, Wilcoxon analysis results were found have statistically significant difference for brain localization of the rat temperatures between pre and after application values (p=0.004). Wilcoxon analysis results were found to have statistically significant difference for the rat head temperatures between before and after application values (p=0.004). In the 10 rats, Wilcoxon analysis results found no statistically significant differences for either 5-HT (p=0.3) and glutamate (p=0.7).

Table 1: Heat measurements for rat brain, head and nasal localizations.

Gruplar	**Heat measurements Median (^{0}F)**		
	Rat brain localizations	**Rat scalp localizations**	**Rat nasal localizations**
Pre-application	88 (87-89)	90 (81-96)	93 (93-94)
Post-application (Min)			
5	88 (87-89)	90(87-95)	94 (94-95)
20	85 (85-86)	91(85-92)	93 (92-93)
45	93 (91-94)	94(93-95)	93 (93-94)

When the data were reviewed, for the values of 91 and below for 5-HT, an elevation was seen in the values after the procedure in 5 rats. For the values of 91 and above, a decrease was seen in the values after the procedure for 5 rats. Because of these differences, re-analysis was made by dividing the blood samples analysis into two separate groups (Table 2). In 5 rats of which the onset of serotonin values in blood samples

were received before the procedure were 91 or below, a significant elevation was seen in the values after the procedure (p=0.043).

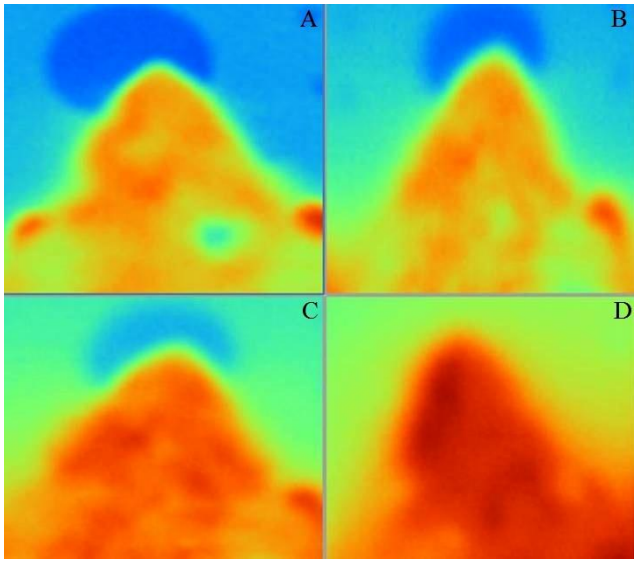

Figure 3. Thermographic images for head of rats; A:0 min, B: 20 min, C: 40 min, D: 45 min.

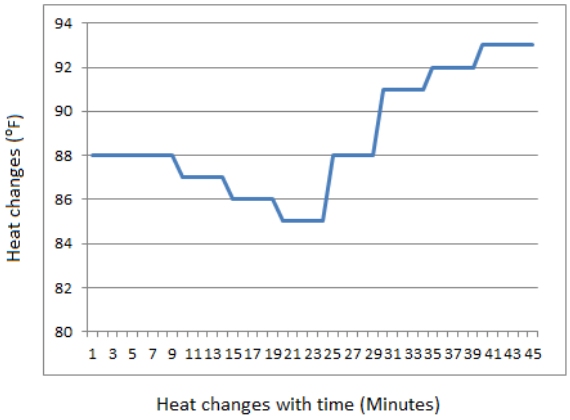

Figure 4. Heat thermal changes for brain localizations of rats.

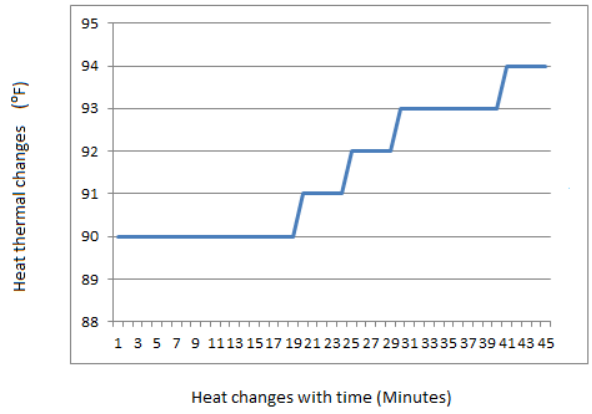

Figure 5. Heat thermal changes for head localizations of rats.

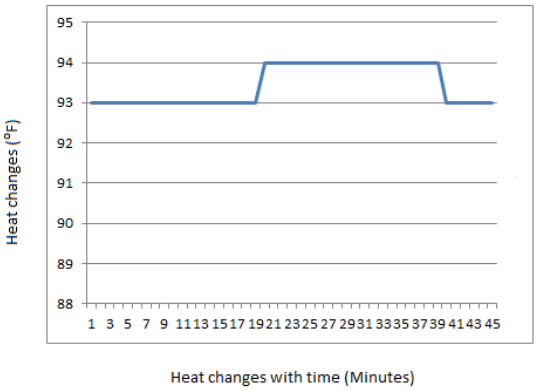

Figure 6. Heat thermal changes for nasal localizations of rats.

Table 2. Wilcoxon analysis results for 5-HT in 5 rats of which 5-HT value before the procedure is ≤91 p=0.03 and found significant.

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

Discussion

When the thermal image results reviewed, the results showed that the most fixed heat region was nasal region. Conversely, most variable region of the scalp is the brain localization. The results showed that the temperature was increased 5 ^{0}F after processing according to pre-processing level for brain regions of rats. In the 10 rats, Wilcoxon analysis results were found to have statistically significant differences for the rat's brain and head temperatures between pre and after application values.

Widespread concern continues about the deleterious effects of radiofrequency radiations on human tissues and potential carcinogenesis.[21] A significant positive association for harmful effect was observed in various studies.[22, 23] A single 915 MHz pulsed magnetic field with sufficient intensity produce a specific absorption rate level as high as 4 × 105 W/kg. Maximum temperature rise of 8 °C or final maximum brain temperature of 46–46.5 °C can cause reactions in animals. The reaction consisted of petit or grand mal seizures, decrease in the heartbeat rate for the exposed un-anesthetized animals. The animals began moving when the brain temperature returned to within 1 °C of their normal values. Histological examinations of some animal brains showed some demyelization of neurons 1 day after exposure and some microfocal glial nodules in the brain 1 month after exposure.[3]

In other studies in the literature, data had been obtained mostly with cerebral tissue. If we had made an examination of the cerebral tissue, the rats would have

died and we would have been unable to take a usable thermal images and blood sample 1.5 hours later. We thought to obtain short-term effects best with this method.

In other similar studies in the literature[23, 24], LLER waves were applied to rats for a much longer period, e.g., between 45 days and 6 months, after which samples were taken from cerebral tissues and examined.[23, 24] We tried to show effects only within a 45 min period of time and only for over thermal images, 5-HT and glutamate. Our aim was to show change in temperature, biochemical data resulting from a single, long-term talk. The base values in blood samples received before the procedure formed the control group. An increase was seen in serotonin values as a result of short-term LLER application in rats where the onset serotonin values were below 91. In this group, only serotonin was found to be statistically significant. When the literature was reviewed, no significant results were able to be obtained with short-term LLER application.[21, 25, 26]

In our study, a significant value for increasing thermal skin heat on brain, head localizations and serotonin values are important. Thermal heat changes observed were significant. The ups and downs of serotonin may have negative effects on the brain and body. But we obtained maximum 5 ^{0}F heat increase on the rat scalp skin for only single 45 minutes LLR. We cannot yet fully understand how these skin heat difference effects on body health. But we believe that these heat effects may cause some hearing and brain exciting complaints and may cause brain tumors. These findings should be supported with other chemical and thermal studies for brain and we should also evaluate hearing and ear effects in different studies.

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