Effect of Microwave Wi-Fi Radiation at Frequency of 2.4 GHz on Epileptic Behavior of Rats

Mahmoudi A.[1], Shojaeifard M. B.[2,3]*, Nematollahii S.[4], Mortazavi S. M. J.[3], Mehdizadeh A. R.[3]

[1]Medical Student, Shiraz University of Medical Sciences, Shiraz, Iran
[2]Physiology Department, Fasa University of Medical Sciences, Fasa, Iran
[3]Ionizing and Non-ionizing Radiation Protection Research Center (INIRPRC), Shiraz University of Medical Sciences, Shiraz, Iran
[4]Biostatistic Department, Medical sciences Shiraz University of Medical Sciences, Shiraz, Iran

ABSTRACT

Background: Electromagnetic fields (EMF) with different intensities are widely used at home, offices and public places.Today, there is a growing global concern about the effects of human exposure to EMFs. Epilepsy is one of the most common chronic neurological diseases, affecting 50 million people of all ages worldwide. We aimed to investigate the effect of exposure to Wi-Fi radiation on epileptic behavior of rats.

Materials and Methods: 147 male rats, weighing 200-250 g, were divided into seven groups; negative control (no intervention), sham 1(distilled water), positive control (Pentylentetrazol [PTZ]), intervention group 1 (PTZ + Wi-Fi "off"), sham 2 (distilled water + Wi-Fi "off"), sham 3 (distilled water + Wi-Fi "on"), and intervention group 2 (PTZ + Wi-Fi "on"). The rats were exposed to Wi-Fi for 2h at a distance of 30cm from a commercial Wi-Fi router. Convulsive behaviors of rats were monitored and scored based on the intensity and type by measuring latency/threshold time, number of convulsions, sum of scores and durations of seizure, and duration of score 6 seizure. Kruskal-Wallis and Mann-Whitney U-tests were used to analyze the data.

Results: Convulsion was observed in interventions Group 4 and Group 7, and positive control. The mean number of events, and sum of scores were significantly different in intervention 2 than other two groups. However, the differences in mean threshold, mean sum of durations and " time to show convulsion with score 6 " were not statistically significant (P>0.05).

Conclusion: Due to limitations of our study including the sample size, these findings should be interpreted with caution. In this study, exposure to 2.4 GHz Wi-Fi radiation showed significant beneficial effects on the epileptic behaviour of rats. More experiments are needed to verify if these exposures can be used as a therapeutic approach for amelioration of seizures in epilepsy.

Keywords

Electromagnetic Fields (EMF), Epilepsy, Seizure, Wi-Fi

Introduction

Wide range use of electromagnetic fields (EMF) in everyday human life has raised concerns about their side effects on different structures of human body. Studies have investigated the biological effects of different wavelengths that humans are commonly exposed to. One of the greatest fears is related to the use of cellular phones, microwaves and wireless fidelity (Wi-Fi). However whether

*Corresponding author:
M. B. Shojaeifard
Department of Physiology, Fasa University of Medical Sciences, Fasa, Iran
E-mail: Shojaeim@sums.ac.ir

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these radiations have positive, negative or no effects on human health is not clear [1].

Some studies have reported several adverse effects on humans, including oxidative stress on human semen and unfavorable effects on sperm quality and motility [2, 3], and review studies raised scientific uncertainty of the risk of radiofrequency (RF) transmissions (including phones, radio and TV) to human health, and suggested taking precautions, especially in children [4, 5]. In addition, microwave radiations are investigated at different wavelengths, and exposure to 6000 MHz radiation at high power density level is postulated to induce minor long-term neurophysiologic alterations, while without hyperthermic state, microwave frequencies seem to have no consistent increase in reproductive risk [6]. In addition to temperature, pulsed electric fields are posited to have higher biological actions, such as brain tumors, physiological stress and various neuropsychiatric disorders, including sleep disturbance, headache, depression, fatigue, irritability, etc. [7-9].

In contrast, some other studies suggest no increased risk of brain tumors for long-term cell phone use [10, 11]. Several animal studies suggest that gestational exposure to mobile telecommunication EMF and Wi-Fi has no significant detrimental effect on reproductive and embryonic parameters [12-14].

Other studies have even reported some beneficiary effects of microwave irradiation [15]; It has been postulated that 4.5-hour exposure to 2.4 GHz Wi-Fi radiation increases the sensitivity of bacteria to antibiotics [16]. Some have announced beneficial cognitive effects of RF radiation in Alzheimer's disease [17-19]. Similarly, other researchers introduced the protective effects of 4 hertz(Hz) EMF on epilepsy [20], and others have explained the possible underlying mechanism [21]. Considering the increasing rate of epilepsy as a major health issue [22] with an incidence of about 5–10/1000 cases worldwide, along with the unclear etiology and related morbidity and mortality, the effect of EMF on epilepsy is worth studying. Therefore, we aimed to investigate the microwave Wi-Fi radiation at frequency of 2.4 GHz on threshold or latency (the duration after the injection of PTZ till the start of the 1st seizure) and intensity (scores in each attack), number of convulsions in 1.5 hours, that is called events, the sum of duration of convulsions in 1.5 hours. All these factors are considered epileptic behavior.

Materials and Methods

One hundred forty-seven mature male Wistar rats, weighing 200-250 g, 3 months old were purchased from the animal lab of Shiraz University of Medical Sciences. All experiences and handling the rats were according to the guidelines provided by the Ethics Committee of SUMS.

All animals were housed individually and fed by standard food throughout the experiment. The animals freely lived in cages (one animal per cage) with unlimited access to water and standard rodent chow and under controlled standard laboratory conditions (24°C, relative humidity and 12/12 hour light/dark cycle). They were monitored and acclimated to the new environment for one week. The animals were initially evaluated for illness by physical examination and laboratory screening.

Experimental Design

To induce acute epilepsy, we injected a single dose of 60 mg/kg Pentylentetrazol (PTZ,Sigma Aldrich) intraperitoneally (IP). PTZ was dissolved in saline solution. A chronometer was used for determining the duration of the beginning and the first seizure after injection [23]. The animals were divided into seven groups using the randomized block design method:

1. Control group with no intervention
2. Sham 1 received distilled water

3. Sham 2 received distilled water half an hour before they were exposed to turn off Wi-Fi for 2 h.

4. Sham 3 receiving distilled water half an hour before they are exposed to turn on Wi-Fi for 2 h.

5. Positive control received PTZ without any exposure [23].

6. Intervention 1 received PTZ half an hour prior they were exposed to turn off Wi-Fi condition for 2 h.

7. Intervention 2 received PTZ half an hour before they were exposed to turn on Wi-Fi for 2 h.

Wi-Fi device was (802-16e 2005 WiMAX Indoor CPE antenna, model number: WIXFMM-130, China) with a frequency of 2.45 GHz. Duration of radiation was 2 hours per day in a 30-cm distance from antenna to the cages [24, 25].

The intensity of seizures was scored according to the Racine's scoring system [26]. Score 1 indicated only one tick, score 2, the extension of hands or tail, score 3 frequent limb movement with head extension, score 4 standing on two legs and falling, score 5 frequent standing and falling, and score 6 indicated severe tonic-colonic attacks [23-26]. The components measured and compared between the groups included threshold (latency), number of convulsions (during one hour), intensity (total scores in each attack during 1.5 hours), the duration of convulsions (sum of durations), and the time to show the convulsion with score 6.

All ethical considerations were met in this study, and the study was approved by the Institutional Review Board and the Ethics Committee of Shiraz University of Medical Sciences. Studied animals were handled in conformity with guidelines for the care and handling of laboratory animals provided by Shiraz Laboratory Animals Center in accordance with global standards for laboratory biosafety guidelines.

The results were presented as mean and standard error (SE) and analyzed using Mann-Whitney U and Kruskal-Wallis tests. For statistical analyses, SPSS software, version 18.0 for Windows (SPSS Inc, Chicago, IL) was used. P values of 0.05 or less were considered statistically significant.

Results

Kruskal-Wallis test exhibited a significant difference in the mean values of the threshold among all groups (P=0.001, Table 1). Mann-Whitney test revealed a significant difference just between the shams and control with those showing the epileptic seizures.

All animals received PTZ showing epileptic seizures. The mean value of the threshold was the same statistically in the intervention groups 1 and 2, and positive control. Although it is not significant, the occurrence of the first seizure was postponed in the intervention 2 groups compared with two other aforementioned groups (P>0.05, Table 2).

The number of seizure attacks occurred during the course of an hour and a half is called an even. Mean number of events was statistically significant among seven groups (P=0.001, Table 1) and was also significantly less in the intervention group 2 than other two groups (P=0.021, Table 2).

Mean sum of scores means: What is the severity of each seizure attack and how much does the total intensity or score of seizure attacks occur during the course of an hour and a half?

Mean sum of scores was statistically significant among these seven groups (P=0.001, Table 1) and was also significantly less in the intervention group 2 than other two groups (P=0.022, Table 2).

The mean sum of durations means: How long does it take for each seizure attack and how long is the total duration of seizure attacks occurring during an hour and a half? The mean sum of durations was statistically significant among the seven groups (P=0.001, Table 1), but was not significantly different among

Table 1: Mean and standard error of the measured variables in the seven study groups.

Considering factors	Group 1, negative-control (Mean± SE)	Group 2, sham 1 (IP distilled water) (Mean± SE)	Group 3, posi-potive control (IP PTZ) (Mean± SE)	Group 4, Intervention 1 (IP PTZ+Off Wi-Fi)(Mean± SE)	Group 5, Sham 2 (IP distilled water+Off Wi-Fi) (Mean± SE)	Group 6, sham 3 (IP distilled water+On Wi-Fi) (Mean± SE)	Group 7, Intervention 2(IP PTZ+On Wi-Fi)(Mean± SE)	P-Value
Threshold/delay (seconds)	0	0	522.857 ± 71.010	500 ± 56.213	0	0	780.476 ± 147.387	0.001
Number of events	0	0	25.809± 5.728	23.428±3.787	0	0	12.190 ± 2.485	0.001
Sum of scores	0	0	67.571 ± 15.963	62.857 ± 9.636	0	0	34.666 ± 8.918	0.001
Sum of Duration, (seconds)	0	0	102.809 ± 20.423	102.809 ± 20.423	0	0	63.523 ± 11.947	0.001
Time of Score 6 convulsion, (seconds)	0	0	605.142 ± 160.155	666.857 ± 80.917	0	0	843.333 ± 215.372	0.001

the three groups with convulsion (P=0.146, Table 2).

The time to show convulsion with score 6 was statistically significant among seven groups (P=0.001, Table 1), but was not significantly different among three groups with convulsion (P=0.438, Table 2).

Paired comparison by Mann-Whitney U-test revealed a statistically significant difference between number of events and sum of scores between intervention group 2 and positive control (P=0.022 and 0.038, respectively) or between the intervention groups 2 and 1 (P=0.013 and 0.010, respectively); hence, there was no statistically significant difference between intervention group 1 and positive control (P=0.831 and 0.521, respectively).

Discussion

The present study indicated significantly fewer number of events and less sum of scores in the intervention group 2 than other two groups with seizure (both P=0.02), while the difference in the mean threshold in the intervention group 2 was statistically similar. Like our findings, other studies found that EMF did not change statistically on the duration of the 1st seizures in mice [27].

Furthermore, lower frequency exposure demonstrated no difference in seizure latency [28, 29]. Ossenkopp and Cain reported that EMF exposure at 60Hz reduced the seizure duration and lethality in rats [30], which are consistent with the results of the current study. It has been shown that EMF exposure to 4 Hz was as effective as anti-oxidative agents on seizure [20].

Human studies have also supported this finding. Schüz and colleagues suggested decreased rate of hospitalization among mobile phone users with dementia, Parkinson and epilepsy in men; nonetheless, there was no such a correlation in women. Papageorgiou and colleagues reported the 60-min exposure to Wi-Fi altered the working memory and electroencephalogram (EEG) in women [31]. In addition, it was found that Wi-Fi at 2.4GHz did not have any detrimental influence on DNA

Table 2: Mean and standard error of the measured variables in three groups with convulsion.

Group	Control group (IP PTZ)(Mean± SE)	Intervention group 1 (IP PTZ+Off Wi-Fi) (Mean± SE)	Intervention group 2 (IP PTZ+On Wi-Fi) (Mean± SE)	P-Value
Threshold/ delay(seconds)	522.857 ± 71.010	500 ± 56.213	780.476 ± 147.387	0.339
Number of events	205.809± 5.728	23.428±3.787	12.190 ± 2.485	0.021
Sum of scores	67.571 ± 15.963	62.857 ± 9.636	34.666 ± 8.918	0.022
Sum of Duration, (seconds)	102.809 ± 20.423	102.809 ± 20.423	63.523 ± 11.947	0.146
Time of Score 6 convulsion,(seconds)	605.142 ± 160.155	666.857 ± 80.917	843.333 ± 215.372	0.438

[32]. The results of the present study indicate a significant reduction in seizure frequency and scores in epileptic animal model. It can guide the researchers to find therapeutic approaches by EMFs on epilepsy treatment. Although the exact mechanism of the beneficial impact of WiFi exposure on epilepsy remained to be clear, some possible suggestive mechanisms may include the EMF exposure on ionic currents, pumps, neurotransmitters [33, 34] through reaction with PTZ-mediated chemical binds. Besides, oxidative stress in the brain is commonly the reason of seizures [35]. Despite WiFi exposure has been shown to induce oxidative stress, our data demonstrated the amelioration of epilepsy in PTZ-treated animals. Our data was in line with the finding of Snezˇ and Raus that showed WiFi ameliorated cerebral Ischemia [36].

The present study had some limitations, including assessing one single wavelength for a short exposure duration and lack of long term follow-up. Further studies need to compare the effect of different wavelengths, with several exposure durations. Long-term follow-up of the animals is also recommended.

Conclusion

Despite adverse effects of WiFi in other reports, the data from the current study revealed that WiFi exposure ameliorated the number and intensity of the epileptic seizures in animal model. More experiments are needed to verify if these exposures can be used as a therapeutic approach for amelioration of seizures in epilepsy.

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Conflict of Interest

None Declared.

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