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Research Article

Effects of Radio Waves on the Immune System of an Animal Model

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Abstract

Introduction: Radio waves, such as cordless phones and wireless modems, have increased significantly. This study aimed to measure the effects of the 2.45 GHz wave on a mice's immune system's blood markers.

Method: Seventy-two male mice were used. Mice's were divided into one control group and two radiation-exposed groups (A and B). Then, there were two Wi-Fi modems, one plain and without an antenna, for group a mouse contact. The other was the type with two antennas; the mice in group B were brought into contact. After exposure, blood samples regarding white blood cells, monocytes, lymphocytes, and neutrophils were analyzed.

Results: White blood cells, monocytes, lymphocytes, and neutrophils increased in the control group ($P<0.001$). However, these parameters significantly declined over time in the two intervention groups ($P<0.001$). The blood parameters of the mice in the two intervention groups exposed to various modems were similar ($P>0.05$).

Conclusion: The results indicated the interference of waves of this spectrum, mainly radio frequency, with the immune system of exposed mice. Blood cells are more susceptible to long-term exposure to Wi-Fi waves and have a downward trend in terms of number. Also, no significant difference was observed between the blood parameters of the two groups with different modems.

Keywords: Wi-Fi, Immune System, Electromagnetic Waves.

Introduction

The nature of global pollution and natural hazards has undergone critical changes in the modern and mechanized age. Among these natural toxins is releasing waves of different wavelengths into the environment[1]. These waves form a series of electromagnetic waves used in radio communication systems and have telephones, long-distance and cordless phones, Wi-Fi modems, radars, and other military and civilian media transmission equipment to transmit messages and data[2]. This connectivity strategy is evolving and expanding rapidly, and one of the easiest and fastest strategies to connect to indoor systems or the Internet is a Wi-Fi modem upgrade. The innovation of long-distance Wi-Fi communication uses 2.45 GHz repetition at a wavelength of 12.5 cm of the repetition band between data transmission devices located a few tens of meters away, depending on the gain adjustment and amplification: radio wire and its type. The scope of the balancing technique is also different[3]. Wi-Fi updates transmit waves that do not cause harm but slowly and silently ruin a human life. People spend more time in the virtual world because of the ease of use and accessibility of this innovation[4]. Ask about the various complications associated with these waves. Thus, we cannot present the harmful effects of electromagnetic waves. In this way, they are classified as B-carcinogenic[4]. Of course, this miracle later became known as the "magnetic field effect," which had side

effects that were almost complained about by people working in jobs related to attractive areas. These internal signs, as said, cannot be seen from a distance, but the person complains virtually. Such as brain pain, nausea, blurring, dizziness, etc.; this collection of references, which cannot be cited and taken logically, was seen by individual people. Some analysts call these concerns side effects of "self-reflection." Of course, it cannot be denied that some people have problems due to these functional areas[5-6]. The effects of waves in the 2.45 GHz region are described in detail in various articles, which include Antagonistic effects on gonads and sperm[7], Maturation of the female and its consequences sometime before and after birth[8], Effects on the brain, Brain progression[9], effect on behavior [10], effect on DNA - Tumor location and tumor-promoting potential[11], effect on heart movements[12], activity component - oxidative stress of cells [13 - 14], effect on the cell cycle[15], effect on the thyroid gland [16], effect on quality[17], effect on cell membranes[18], effect on microscopic organisms[19-20], comes to plants[21]. And on the other hand, few consider that no "effect" was found on the impact of these waves[22-28]. Military personnel, especially those working on and from ships, use telecommunications innovations to connect communication devices such as computers, long-distance telephones, and smartphones and to connect to internal systems. These individuals are exposed to different spectrums of electromagnetic waves and constantly suffer from these problems, and from time to time, they almost complain of diseases due to exposure to these waves. On the other hand, these worries cause mental pressure in these people and things comparable to the development of diseases. On the other hand, they compromise their effectiveness when facing the enemy. Since human control is the basic rule of any organization, it is necessary to conduct an extensive investigation to clarify the problems through their accurate detection. In agreement with these cases, we investigate the effects of 2.45 GHz microwaves on blood biomarkers related to the mouse-safe frame.

Methods

This study aims to investigate the effect of Wi-Fi waves (spectrum 2.45 GHz) on blood biomarkers related to the immune system of laboratory mice. This study was conducted in 2022. These markers included white blood cells, monocytes, lymphocytes, and neutrophils. The sampling method was non-probability. The inclusion criteria were a newborn male mouse with regular blood tests without underlying disease, and any disorders in the blood system, and the exclusion criteria were the presence of any conditions in blood markers and the presence of illness and lack of expert approval. The study was approved by the Ethics Committee of the Islamic Azad University, Science and Research Unit (code: IR.IAU.SRB.REC.1398.200). This research used 80 immature male BALB/C mice with an approximate weight of 10 grams and an age range of two weeks. The animal cages were made of polycarbonate with a steel mesh roof, and the dimensions of the cages were 30 x 50 x 30 cm. The bed of the mice was covered with sawdust and wood chips. The floor of the cages was changed once every two days, and the cages were washed once a week with water and soap and disinfected with 70% ethyl alcohol. To prevent the influence of environmental conditions on the experiment, all mice were kept in the animal house during the study period with a fixed day and night cycle (12 hours at night and 12 hours a day) and a temperature of 24 ± 2 centigrade and a humidity of 30%. In this study, according to the veterinarian, the mice's diet was approximately 15 grams per 100 grams of body weight per day with commercial feed (Jawaneh Company) and enough water during the experiment. After the transfer of the mice's, the pet was given two weeks to adapt to the new environment.

First, the initial blood sample was taken from the mice, and according to the inclusion criteria and with the approval of the hematologist, 72 out of 80 mice were included in the study. The mice were divided into two groups; thus, the first group, the control group, had 24 mice, and the second group, the group exposed to the waves, included 48 mice. The second group was divided into 24 (group A and group B). Then two Wi-Fi modems were prepared, one of which was the simplest modem without an antenna with a frequency range of 2.45 GHz, which group A faced, and the second type with two antennas with a frequency range of 2.45 GHz, which group B met Dated with it. The two groups faced different modems.

Before starting the research, the area where the mice were kept was checked with a wave measuring device to ensure that the site was free of 2.45 GHz spectrum waves, and it was found that the waves mentioned above were not located near the place where the mice were

kept. After starting the study, the modems were installed in the animal house and 50 cm from the mouse cage. The mice were exposed for one hour daily for 90 days; in the second trimester, mice were exposed to Wi-Fi waves for eight hours a day, and mice in the control group were not exposed to Wi-Fi waves during these periods. The study was conducted in six months, and blood tests were performed 90 days and 180 days after the start of the study. Also, after the first three months, the study area of groups A and B was again measured with a wave measuring device to ensure that the site was clean of 2.45 GHz spectrum waves.

To analyze descriptive statistics (mean, standard deviation, correlation, frequency, and ratio) and inferential statistics (chi-score test, independent t-test, Mann-Whitney test, dependent t, correlation test, repeated measure design test, McNemar, Friedman test) according to the normality distribution (K-S test). SPSS version 25 software was used, and a significant level of 5% is considered a significant point.

Results

Seventy-two mice were included, and five died during the study (2 mice in the control group, two in group A, and one in group B). According to the chi-square test, the three groups had similar mortality rates (P = 0.807).

Table 1 reports the mean and SD of four biomarkers (WBC, Lymphocyte, Neutrophil, and Monocyte) by time and groups. At the beginning of the study, the three groups were similar regarding four biomarkers (WBC, Lymphocyte, Neutrophil, and Monocyte) (P>0.05). Still, the results showed these variables significantly differed between the three groups on the 90 and 180 days (P<0.001).

Further results also showed that the study variables (WBC, Lymphocyte, Neutrophil, and Monocyte) increased during the study in the control group. Still, these variables decreased significantly in the two intervention groups (Table 1) (Groups A and B) (P<0.001). Also, the results showed no significant difference between the blood parameters of the two groups with different modems (Table 1) (P>0.05).

Table 1: Mean and SD of four biomarkers (WBC, Lymphocyte, Neutrophil, and Monocyte) by times and study group.

Items	**groups**	**Times**						**P-value**	**P-value**
		day-180		**day-90**		**First-day**			
	P-	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**		
Lymphocyte	control	0.42	1.29	0.41	1.28	0.49	1.20	0.157	<0.001
	A	0.46	0.55	0.48	0.84	0.42	1.11	<0.001	
	B	0.32	0.25	0.33	0.69	0.40	1.30	<0.001	
		<0.001	P-value	<0.001	P-value	0.227	P-value		
WBC	control	3.64	7.66	3.53	6.56	3.64	5.91	<0.001	<0.001
	A	2.77	3.44	2.65	4.53	2.60	5.13	<0.001	
	B	1.81	1.71	1.76	3.28	2.01	4.14	<0.001	
		<0.001	P-value	<0.001	P-value	0.05	P-value		
Neutrophil	control	1.05	1.36	1.14	1.73	1.11	1.76	<0.001	<0.001
	A	0.51	0.62	0.84	1.26	1.11	2.21	<0.001	
	B	0.87	0.93	0.93	1.43	0.96	2.19	<0.001	
		0.007	P-value	0.168	P-value	0.104	P-value		
Monocyte	control	0.94	1.28	0.99	1.34	0.97	1.49	0.028	<0.001
	A	0.95	0.89	0.93	1.37	1.05	1.76	<0.001	
	B	0.83	0.51	0.87	1.15	0.94	1.93	<0.001	
		0.001	P-value	0.631	P-value	0.095	P-value		

Discussion

In the control group, the number of white blood cells, lymphocytes, neutrophils, and monocytes increased during the study. However, these variables were significantly reduced in the two intervention groups, which is consistent with some studies2[9-32] and also inconsistent with the results of some other studies[33-34]). Of course, in some studies, their results were consistent with our study for one or more parameters and contrary to our study for other parameters[35-36]. Overall, the results of our study show immune system disorders in mice exposed to waves of this spectrum, mainly radio frequencies. A study on 30 male mice exposed them to 2.45 GHz waves for 8 hours a day for 90 days. The hematological results of this study show that PVC, Hb, and RBC decreased in mice compared to the control group at the end of the study. However, they are still within the normal range, and other blood markers tested in this study are within the normal range. The result of this study is consistent with our study. Of course, the method is similar, but the number of mice, parameters, and exposure time are different in our study, proving our study's innovation and novelty[29]. The study investigated the effects of long exposure time to Wi-Fi waves on various aspects, including the blood parameters of mice. A wide wavelength range from zero Hz to 3 GHz was tested in this study. In the first experiment, groups were formed at the beginning of the study according to the prescribed exposure time and blood analysis (days 60, 120, 180, and 365). Each group included 20 male and 20 female control rats and 20 male and 20 female rats exposed to the wave. The second experiment was performed with 20 female control mice and 20 female mice exposed to the test waves and exposed for 60 days under the conditions described in the first experiment. The results of the above study show a decrease in blood Hgb, HCT, and WBC parameters. In this regard, the above analysis is consistent with our study, but these changes were within the normal range; this may be because long-term spectrum exposure may have different effects, which may manifest differently in different individuals[30]. Another study evaluated three different forms of human blood cells. The first picture is of a person in an environment without electromagnetic waves, the second is the blood of a person who talked on a cordless phone for 10 minutes, and the third is the blood of a person who used a computer and a cable.It runs for 70 minutes. In the two images, the red blood cells clump together more and look like coins. This indicates unhealthy blood; in fact, the function of the blood cells is disturbed, and the number of healthy red blood cells decreases somehow, which is also consistent with our study[31]. In a study with 20 male mice, the mice were divided into four groups and exposed to mobile radio waves at distances of zero, 25, and 50 meters. The study showed differences in blood parameters between exposed and control rats. These observed differences were related to the strength of the electromagnetic fields and the total duration of exposure. A reduction in white blood cells suggests radiofrequency disturbances in the immune system of exposed mice; these results are fully compatible with the current research[32]. Another study investigated the effects of 940 MHz spectral waves on the blood system of mice. Fifty-two immature male BALB/c mice were used in the study. The mice were exposed to the wave for 15 days and 30 minutes daily. Ultimately, they concluded that these waves did not affect the white blood cell count, hemoglobin, mean hematocrit, mean erythrocyte count, or mean red blood cell hemoglobin. Of course, that study's results are inconsistent with the current study; this may be due to the difference in the spectrum of the investigated waves, the exposure time, and the number of mice analyzed. Our study area is 2.45 GHz, our exposure time is twice that of this study in the first stage and 16 times that of this study in the second stage, and the number of mice is 72. It is reasonable that this study is significantly different from our study[33]. In another study, 30 immature Wistar rats were studied, and 30 adult rats were randomly selected and divided into three groups of 10. The control group did not receive radiation. The group is exposed to the wave eight hours a day and five days a week for forty days. This study's data showed that parasite application causes a significant difference in blood factors, including red blood cells, platelets, hemoglobin, and hematocrit, MCV, and RDWCV in adult rats. In immature mice, parasites had no significant effect on hematocrit and hemoglobin. The results of this study are inconsistent with our study. The type of wave spectrum studied, the exposure time, and the number of mice analyzed can lead to different results[35]. Another study investigated the effects of 900 and 1800 MHz waves on blood markers in rats. In this study, researchers divided 48 BALB/c mice into six groups of

eight animals each. Different groups of mice were exposed to the wave for 30 minutes, 60 minutes, 120 minutes, and 240 minutes during a month. Based on the results of this study, MCHC and MCH in the radiation-exposed groups were significantly different from the control group, and they concluded that microwaves significantly affect blood markers in mice. This study's general result is different from ours, and it can be attributed to the different spectrums of the investigated waves, the exposure time, and the number of analyzed mice[36].

Conclusion

The results indicated the interference of waves of this spectrum, mainly radio frequency, with the immune system of exposed mice. Blood cells are more susceptible to long-term exposure to Wi-Fi waves and have a downward trend in terms of number. Also, no significant difference was observed between the blood parameters of the two groups with different modems.

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Conflict of Interest Disclosures

The authors declare that there is no duality of interest associated with this manuscript.

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Authors' Contributions

Hamed Akbari: Conceived and designed the experiments, Performed the experiments, Wrote the paper, Lobat Taghavi: Conceived and designed the experiments, Analyzed and interpreted the data, Seyed Kamal Eshagh Hossaini: Performed the experiments, Analyzed and interpreted the data; Mohammad Gholami-Fesharaki: Contributed analysis tools or data, Wrote the paper, Seyed Alireza Hajiseyed Mirzahosseini: Conceived and designed.

Ethical Statement

The above study has been approved by the Ethics Committee of the Islamic Azad University, Science and Research Branch (Code: IR.IAU.SRB.REC.1398.200).

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