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Biophysical Effect of EMR Emitted from 2.45 GHz Router on the Reproductive System of Male White Rats

Qusay Kh. AL-Dulamey
Department of Medical physics
College of Science, University of Mosul
Mosul, Iraq
qusaykhatab@uomosul.edu.iq

Afrah Hassoon Oraibi
Department of Electrical Engineering
College of Engineering, University of Kufa
Najaf, Iraq
afrah.aljuburi@uokufa.edu.iq

Abdalrahman Al-Salihi
Department of Basic Sciences
College of Dentistry, University of Basrah
Basrah, Iraq
abdalrahman.hassan@uobasrah.edu.iq

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Abstract – **This study aims to determine the impact of exposure to microwave radiation on the male reproductive system of white rats at different power densities. The experiment involved twenty blub/c white rats of 2-3 months old in good health, weighing between 23 and 30 grams. After dividing the rats randomly into 4 groups of 5 rats each, the rats were exposed to 300, 400, and 700 microwatts/cm^2 (µW/cm^2) for 7 hours a day, over a period of 80 days. Following exposure, testicles were collected from each male group, and an investigation was conducted on the sperm. The parameters used in this study are the number of sperm cells in epididymis, the percentage of living and dead sperm cells, and the percentage of normal and abnormal sperm cells, which were all recorded for the control group (without exposure) and the test groups that were subjected to different power densities, being 300, 400, and 700 µW/cm^2, respectively. Based on the obtained results, the conclusion is drawn that long-term exposure to radiation via Wi-Fi-compatible communications or any other internet connection should be avoided, because it harms the reproductive system physiologically. As the use of the router is very similar to the intensity of the waves emitted by the power device on the Internet and has a biological effect on infecting the reproductive systems of rats, the advantages of this study demonstrate the impact of microwaves at low intensities, which are comparable to the measured intensities in tablets and mobile communication devices.**

Keywords: Power density, reproductive system, radiation, rats, sperm, router.

I. INTRODUCTION

In the case of low radiation energy, the constant human exposure to radiation at frequencies of (50 - 60) Hz can lead to risks on the reproduction system [1]. There are no severe symptoms mentioned to be experienced at extremely low frequencies (ELF) and which influence mammal reproduction. The radiation effect that can be noticed is due to the heat created as a consequence of exposure to the ELF [2]. A large number of published papers that deal with experimental animals have shown that its effect is similar to being exposed to an ELF field under a certain level of heat. Because the testis is sensitive to heat, concerns have been focused on ELF effects on the gonadal function. In 413 days, 40 percent of the exposed animals (8% of the control animals) showed testicular degeneration. Recently published studies are mostly related to the impact of exposure to electromagnetic ELF radiation upon the sperm count and nature. As a significant decrease in mouse sperm count was reported, the epididymis was correlated with a major increase in sperm percent. Abnormal sperm were observed in animals while being subjected for a long time to the frequency of 9.45 x 10^9 Hz with 1.2 Watt / kg [3]. In rat experiments subjected to (890 x10^9 - 915 x10^9) Hz for 30 days, there was a decline in sperm tubule diameters [4, 5]. The total weight of the testis of the exposed rats at the same frequency for four weeks was also decreased. In the case of the ELF influence on the fertility and reproduction of humans exposed to this area, the analysis in [6] found that of the 21 males exposed to (3.6 x10^9 -10 x10^9) Hz, about 74 percent of them suggested improvements in sperm production, as well as natural sperm. However, they did not report any difference in the levels of 17-ketosteroids, as compared to the control levels. In males exposed for 14 years, they found Azoospermia. One of the reviews stated that the mean sperm density was not high, as compared to the regulation, which was confirmed by previous publications [7]. The current experiment intends to explore the effect of ELF radiation at 300, 400 and 700 microwatt/cm^2 exposures on rats, subjected to 2.45 x10^9 Hz for 7 hours a day over a period of 80 days.

Since the researchers in [8] observed a decrease in malondialdehyde of elongated spermatids of rats subjected to 50 Hz of ELF for 28 days, it is stated that low frequencies (50-60 Hz) have various effects on male multiplication. It has been noted that adult male rats exposed to 50 Hz for 90 days had an impact on female rats' fertility [9]. This was demonstrated by [10], who observed that rats exposed to 50 Hz for two weeks had less sperm and were less mobile.

The average testis weight of the rats treated to the same frequency over a four-week period decreased likewise. The research conducted by [11] revealed that the exposure of 21 males to microwave radiation at 3.6 – 10.0 GHz throughout their employment for 1–17 years had a negative impact on the fertility and reproduction in the event of ELF exposure of males. The production of sperm had changed in around 74% of them, including the number of motile and natural sperm as well as a decline in both. They did not, however, mention any

variation in the amount of 17-ketosteroids as compared to the control group.

Men who had been exposed for 14 years showed signs of azoospermia. In a survey of Danish troops serving in mobile ground-air projectile units equipped with radar systems, it was discovered that the average sperm density was much lower than that of the control group, which was corroborated by earlier research [12]. This was further supported by the experiment of [7], which found that rats exposed to 2.9 GHz with a power density of 10 m W/cm 2 for six weeks did not significantly differ in the weight of their testicles, prostate, adrenal glands, pituitary glands, or thyroid glands. Therefore, the purpose of their study was to investigate the effects of ELF radiation at doses of 300, 400, and 700 microwatt/cm^2 on mice's testes after 60 days of daily exposure to 2.45 GHz for six hours.
The strengths in their study show the effect of microwaves with low intensities, which are close to the measured intensities in mobile communication devices and tablets, as the use of the router is very close to the intensity of the waves emitted by the power device of the Internet, and has a biological effect of infecting the reproductive system of rats.

According to the mentioned measurements, there are significant physiological changes that affect the effectiveness of fertility due to the generation of free radicals when radiation interacts with the living cell, or a change in the electrical properties of the cell membrane of the affected organs, which causes a change in its functional activities and inhibits it. This is important when applied to humans exposed to the same physical effect, which is waves. The minute waves with high frequency, intensity, and low frequency travel at different distances between the organism and the source of the wave.

II. SUBJECTS AND METHODS

The experiment of this study involves white blub/c Wister rats of 2 to 3 months old, weighing between 150-200g. The healthy rats were collected from the University of Mosul/ Veterinary College and put in covered cages (40x60x20) cm^3. Procedures to certify proper hygiene have been introduced. Throughout the experiment, the ambient temperature and humidity of the control group were held at 26 C^0 ± 2 and 35 percent ± 5 percent, respectively, and the sawdust was adjusted each week. The experiment animals were provided with water and a food mix consisting of milk powder (1%), protein (10%), soy (20%), corn (34%) and wheat (35%) [13].

A. Experiment System

The work set up consists of a TP-link router source generating electromagnetic waves that target rats with 2.45 x10^9 Hz, having different power density in units of microwatt/cm^2. With seven hours of exposure a day, the instrument was connected to the internet. It is normal to obtain the power density of the router from a shift in software, as seen in Fig. 1. Using the microwave radiation power density calculation, the meter of power was applied to define the density of power. The instrument was used for the calculation of electromagnetic wave power density in units of W/m^2. The instrument showed the radiation exposure rate within the frequencies of microwave applied in telecommunications.
It was also necessary for this instrument to determine the amplitude of high frequency sound waves in positive or negative decibel units [7]. Another feature of this instrument is to calculate electric field intensity in volt per meter units. The instrument was positioned near to radiation source. As a kind of radiation contamination, the detector has other uses, such as detecting the intensity density of the microwave dose emitted from the other setting, as well as the radiation escape from microwave ovens.

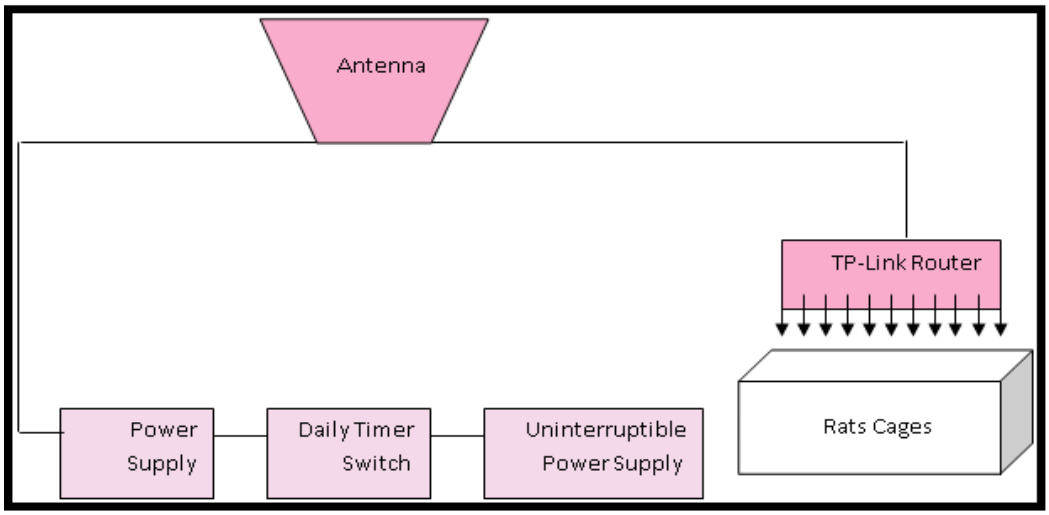

Fig.1: Work set up

Collecting of Semen

The animals have been weighed and fully anaesthetized with ether at (100mg/kg body weight), which results in an effect on respiration and terminate life. Semen samples were taken from the tail of the epididymis. Using an optical microscope, as defined by Zemjanis [14], the sperm percentage was detected in a progressive unidirectional motion over a field on a slide. Briefly, a small drop of sperm, combined with a hot sodium citrate drop and protected with a glass slip, was placed on a heated slide. Sperms moving in circles, backwards, or exhibiting a pendulum motion were omitted, however, sperms moving in a simple unidirectional motion were counted.

Live-Dead Ratio or Percentage Live ability (%)

As introduced by Wells and Awa, a drop of semen was combined on a hot slide with a drop of eosin-nigrosine stain [15]. A thin smear of the mixture of semen and stain was then made. The smear was air-dried, and under the microscope, a total of four hundred sperm were detected. The living and dead sperm cells were counted separately and live to dead sperm ratios calculated according to the method of Zemjanis [14].

Sperm Morphological Defects

Morphological defects have been determined in a total of 400 sperm using the Wells and Awa process [15]. Concisely, on a warm slide, a drop of semen and Wells and Awa stain were put, mixed and a smear was created. Under a light microscope, the stained smear was then air dried and visualized. Defects, as identified by Bloom [16] and Parkinson [17], have been classified.

B. Design of Experiments

Twenty rats were included in the experiment; the doses selected were categorized and irradiated as follows:

1- The control group, comprised of five rats, is not subjected to the field of electromagnetic radiation.
2- The first group consists of five white male rats which are subjected to 300 $\mu W/cm^2$.
3- The second group consists of five white male rats which are subjected to 400 $\mu W/cm^2$.
4- The third group consists of five white male rats which are subjected to 700 $\mu W/cm^2$.

The work system was arranged at a frequency of 2.45 GHz, as shown in Fig. 1, with various exposures of power density (300, 400 and 700 $\mu W/cm^2$) on the rats for 80 days at a rate of 7 hours per day.

C. Study of Statistics

This study adopted the one direction analysis of (ANOVA) after variance. The differences have been computed by Duncan. The significant degree of inclusion was calculated at $p \leq 0.05$.

III. RESULTS

The table I, presents the obtained results of experiment.

Table I: Results of the impact of microwave radiation from a router on rat sperm

Percent of sperm cells with abnormalities	Percentage of healthy (normal) sperm cells	Percentage of sperm cells that have died	Percent of sperm cells that are still alive	Sperm cells in the epididymis, number	Distance in (cm) between router and rats in cage	Measurements / Groups
14.45d±0.82	85.55a±0.82	13.31d±0.80	86.69a±0.81	36.8a±1.10	……	Control
56.12c±0.62	43.88b±0.52	54.91c±0.61	45.09b±0.51	19.74b±0.64	25	300 μ W/cm^2
66.30b±0.54	33.7c±0.47	36.81b±0.46	63.19c±0.54	14.32c±0.56	35	400 μ W/cm^2
77.61a± 0.51	22.39d±0.46	25.60a±0.45	74.4d±0.52	6.11d±0.44	45	700 μ W/cm^2

Mean± S.D. p-0.05 n=5 T=20
*Mean and standard deviations are reported in Table I.
** Level of Significance ($p \leq 0.05$). as a, b, c, d between groups;
***Number of animals per groups,
****Total number of animals used

IV. DISCUSSION

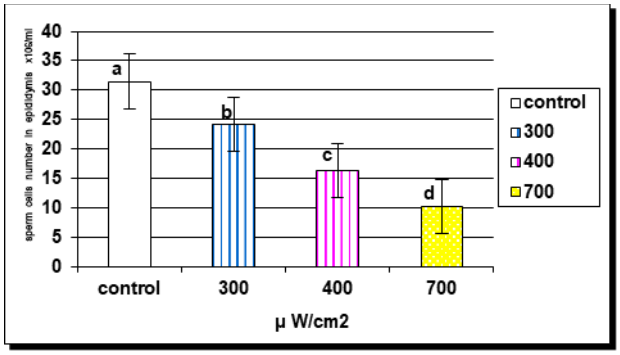

Fig. 2: Impact of radiation at 300, 400, and 700 µW/cm^2 on rat sperm cells in epididymis with a mean standard error.

Figure (2) shows a substantial decline ($p< 0.05$) in the amount of epididymis sperm in rats irradiated with 2.45 x 10^9 Hz for 7 h/day for 80 days, while the dosage of 300, 400 and 700 microwatts/cm^2 was used in accordance with the control procedure. This is in line with [18], who investigated the impacts of 50 GHz on epididymis sperm count, testis weight and other sensual organs in mice. Important decreases in sperm count in the epididymis, as well as in the sperm count of the semen tubules, were reported in rats irradiated for 1h or 2h. A reported study showed that a substantial rise is observed in sex hormone serum by quantitative examination of ledig cells in the testis (testosterone) [19]. The number of sperm cells in the sperm tubules of the irradiated rats was also greatly decreased as compared to the control group. The study [20] found that sensitivity of rabbits to EMR varied at low intensity frequencies. The study [21] shows that sustained exposure to the radiation resulted in the automatic killing of sperm in Blab/c strain rats. These results address the probability of engineered spermatogenetic cell killing in mice [22]. The World Health Organization (WHO) [23] warns against over-irradiated to radiation that would contribute to sperm death. Compared to those with mild exposure, this would result in a sharp decline in the sperm speed of these individuals. The disparity in the consistency of the semen of people that are over-irradiated to electric fields is the result of doses that induce serious nucleic acid damage, which in turn affect the testis cells that contain the testosterone hormone or the semen-producing tubes. The researchers in [24] determined that cell phones at 9x108 Hz induce a decline in their productiveness. A study [25] showed that the radiation emitted from the mobile caused a substantial reduction in the amount of sperm in rats.

Figures (3-5) demonstrate a substantial decline ($p< 0.05$) in the proportion of living and normal sperm exposed to radiation at 2.45 GHz for 7 hours during 80-day period, exposed to 300, 400 and 700 µW/cm2, respectively. On the other hand, the proportion of non-live and dysfunctional sperm seen in Fig. (4-6) show an improvement ($p< 0.05$) when they were previously subjected to the same therapy.

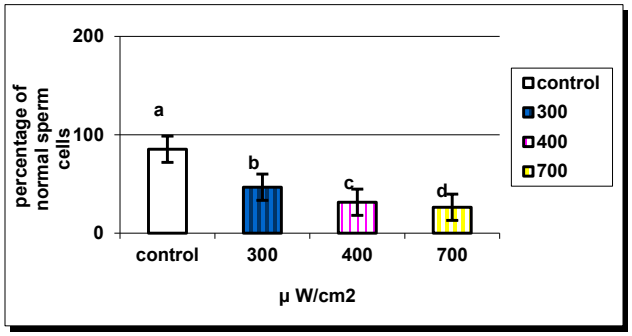

Fig. 3: Impact of radiation at 300, 400, and 700 µW/cm^2 on living rat sperm cells.

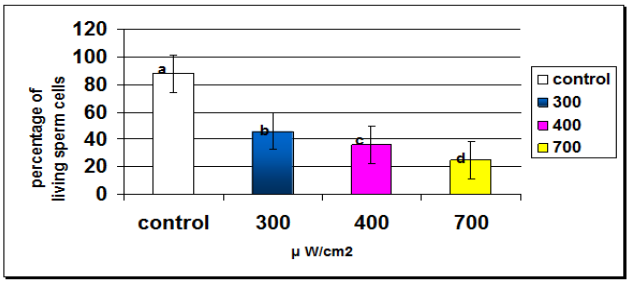

Fig. 4: Impact of radiation at 300, 400, and 700 µW/cm^2 on dead rat sperm cells.

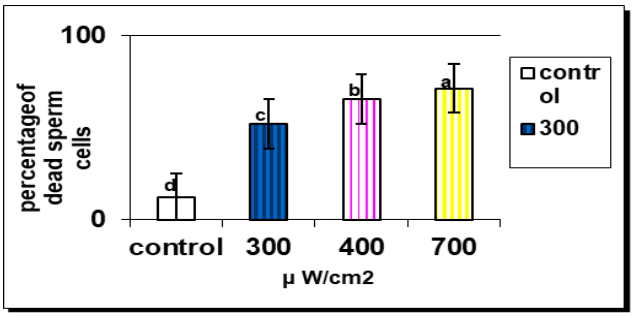

Fig. 5: Impact of radiation at 300, 400, and 700 µW/cm^2 on normal rat sperm cells.

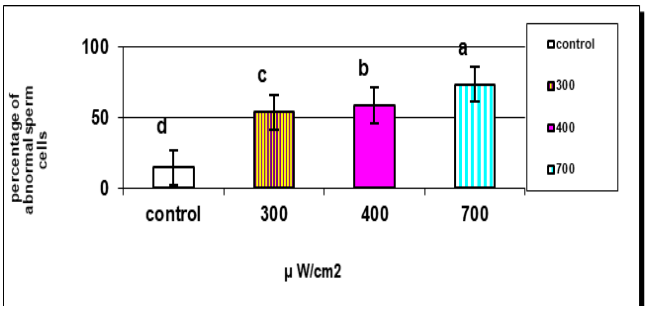

Fig. 6: Impact of radiation at 300, 400, and 700 μW/cm^2 on abnormal rat sperm cells.

Table (I) and Fig. (2-6) explain the following details: (a) values represented by mean ± experimental error, (b) separate letters on each rectangle indicate substantial variations at a stage of lower than 0.05%, (c) each group consists of 5 experiment animals. As the use of the router is very close to the intensity of the waves emitted by the power device of the Internet and has a biological effect on infecting the reproductive system of rats, the study's strengths demonstrate the effect of microwaves with low intensities that are close to the measured intensities in mobile communication devices and tablets.

A change in the electrical properties of the cell membrane of the affected organs, which results in a change in its functional activities, is important when applied to humans exposed to the same physical effect. According to the measurements, there are significant physiological changes that affect the effectiveness of fertility due to the generation of free radicals when radiation interacts with the living cell. High frequency, low intensity waves that travel varied lengths from the organism to the wave source. This is in agreement with the findings of Al-Dulamry et al. [13] who obtained similar measurements on the Bohr device emitting microwaves at the frequency of 5GHz and at low intensities in units of microwatts per cm^2, close to the intensities in this study. The weakness or negative side of this study lies in covering wide values of low intensities in units of microwatts, as well as changing the frequency for each measurement in units of GHz.

The findings are also being consistent with [26], the work consequences found that the short-wave radio electromagnetic field at 1.6x 10^6 Hz, 2.4 x 10^6 Hz and 3.2 x 10^6 Hz with a power density of 16 mill watts/cm^2 has a harmful impact on the production of semen and the operation of the testis. There was a decline in the amount of sperm at epididymis head and a rise in the proportion of dead and irregular sperm at epididymis tail, opposed to a reduction in live sperm percentage. These outcomes were compatible with those of [27], where rats exposed to the 9.45 GHz resulted in a decrease in the amount of sperm in the epididymis and a rise in the proportion of dead sperm. In subjects exposed for 14 years, there were also no sperm cells produced. A study [28] shows that average sperm density found in militaries irradiated to radar pulses was substantially decreased. This was in accordance with [29], who observed that cell phone waves were placed on rats 70 days earlier when used 2 hours a day for 45 days. Front, neck and tail sperm anomalies, rather than lack of testis weight and number of living sperm reproduction hormones, ultimately affect the overall reproductive rate in men [30]. The experiment in [31] found that exposure to varying frequencies resulted in thermal or heat susceptibility of the testis in animals. In 1980, Cairnie and Leach conducted a report on the impact of temperature on testis by heating mice to 32^{0}C -43 ^{0}C water baths. After that, they showed damage to the testis tissue for 4 hours, which caused a decline in the amount of sperm in the epididymis after 30 minutes of heating. The consequences caused by radiation were close to those caused by heat in the testis [32]. The accumulation of radiation by the organs and tissues led to a rise in the temperature of the testis and a decline in the production of sperm in animals when subjected to temperatures significantly greater than the average body temperature. The heat produced by electromagnetic field exposure induces certain results similar to those effects arising from elevated temperature in testis functions. The rats subjected to 2.45x 10^9 Hz demonstrated a rise in temperature resulting in primary spermatocyte exhaustion [33], with an increase in sperm abnormality percentages. Lipid sperm is vulnerable to oxidation [34] [35]. Free radicals play a detrimental role in the production of malondialdehyde [36] in the phosphorus-lipids present in the cell membrane. Lipid peroxidation can be predicted by malondialdehyde measurements [37]. As a result of sperm lack and a rapid energy loss within the cell, the sperm action is destroyed or reduced [38]. This transition may be due to the association of active oxygen variations produced as an outcome of electromagnetic field experience with sperm energy production and metabolism, leading to lower sperm ATP concentrations and ultimately sperm loss and death [39]. A science paper [40] stated that exposure to electromagnetic fields caused the sources of energy to decrease. Sperm forming requires a high degree of energy, mobility and fertilization power. By glucose and fructose metabolism, the power houses physiologically offer the sperm with energy because fructose is presented [41]. Changes in activated energy are toxic to cells and tissues because they are responsible for histological pathogenic variations in body and tissue cells [42] [43].

V. CONCLUSION

The reproductive system is negatively impacted by extended exposure to router radiation from communications that use the same frequency as Wi-Fi or any other internet connection. It is therefore recommended that exposure to such condition should be avoided at all costs.

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