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Effects of microwave electromagnetic radiations emitted from common Wi-Fi routers on rats' sperm count and motility

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ABSTRACT

Background: Wi-Fi allows electronic devices such as laptops to exchange data or connect to a network resource. The main goal of this study was to assess the bioeffects of short term exposure to 2.4 GHz microwave radiation emitted from a common Wi-Fi router on sperm quality. ***Materials and Methods***: Male Wistar rats were divided into 7 groups; I, sham exposed 4 h/day for 7days at 30 cm from the router. II, exposed for 2 h/day for 7days at 30 cm and sacrificed after 53 days. The exposure protocols for groups III to VII were 2h – 30 cm, 2h – 60 cm, 4 h – 30 cm, 4 h- 60 cm, 4 h – 30 cm (no data exchange) respectively. Rats in all the groups except group II, were sacrificed immediately after exposure and basic parameters of testicles weight, sperm motility, morphology, count, and DNA fragmentation were studied. Non-parametric tests were used to detect statistically significant differences between different groups. ***Results:*** Findings of this study showed statistically significant differences between the relative frequency of progressive and rapid progressive sperms in sham exposed rats compared to those of exposure groups. The testicles weight, DNA fragmentation of sperms and the frequency of sperms with normal morphology were not affected by Wi-Fi radiation. However, statistically significant differences between sperm count of the sham exposed rats compared to those of exposure group were observed. ***Conclusion:*** Exposure to microwave radiation emitted from Wi-Fi routers affects sperm parameters such as count and motility which are among the key parameters determining the chance of conceiving.

Keywords: *Electromagnetic fields, microwave, wi-fi router, sperm count, sperm motility.*

INTRODUCTION

Infertility is a very frequent problem that affects more than 70 million couples of reproductive age worldwide [(1)]. Approximately 15% of couples are infertile (unable to conceive a child in spite of frequent, unprotected sexual intercourse for a year or longer) and in about half of them, male infertility plays a role. It has been reported that over the past decades the

quality of semen in normal men has declined [2-6]. Furthermore, in a meta-analysis of 61 reports published worldwide showed that over the past decades there was a trend toward decreasing sperm count as well as the volume of seminal fluid [6]. Although known factors such as specific diseases, injuries, chronic health problems and life style may lead to male infertility, unknown factors (idiopathic male infertility) play a major role in this worldwide problem. Recent studies indicate that male infertility that is believed to be due to factors such as reduced sperm production and misshapen or immotile sperms may be associated with human exposure to electromagnetic fields (EMFs). Humans now generate, transmit and use electricity in a rapidly increasing manner as an essential component of the modern life. This electricity-linked modern life has caused rapidly increasing exposure to different levels of electromagnetic fields. Numerous studies showed that exposure to common sources of EMF such as mobile phones [5-7], mobile phone jammers [8], laptops [9] or wireless internet-connected laptops [10] or extremely low frequency electromagnetic field (ELFs) [11] decreased human sperm quality.

Over the past several years, our laboratories have expanded their focus on studying the health effects of exposure to some common and/or occupational sources of electromagnetic fields (EMFs) such as cellular phones [12-21], mobile base stations [22], mobile phone jammers [8], laptop computers [23], radars [13], dentistry cavitrons [24] and MRI [25, 26]. Mortazavi *et al*. in 2010 reported that laptop computers may decrease sperm count and motility which adversely affects male reproductive capabilities [9]. Avendano *et al.* in 2012 reported that human sperm samples exposed to Wi-Fi internet-connected laptop for a short period of 4 hours exhibited a statistically significant decrease in progressive sperm motility and also an increase in sperm DNA fragmentation. These authors did not consider the fact that the electromagnetic fields generated by laptop (without any Wi-Fi connection) may also play an important role in inducing adverse effects on the motility of sperm samples. This effect was reported previously [9]. Furthermore, it should be noted that the RF fields in Wi-Fi band varies at different distances from the Wi-Fi client card. Considering the limitations of studies such as that conducted by Avendano *et al*., the main goal of this study was to assess the bioeffects of short term exposure of an animal model to 2.4 GHz microwave radiation emitted from a common Wi -Fi router on sperm quality.

MATERIALS AND METHODS

Animal model

Adult male Wistar rats from an inbred colony weighing 200 -250 g (11–12 weeks old) were kept under a 12 h-12 h light–dark cycle (light on 6.00 a.m. to 6.00 p.m.) at a constant temperature (22 ± 1°C). Animals were kept in standard cages, with free access to water and standard food. Illumination during the 12-h light period was obtained by using 40 W fluorescent bulbs that generated 120 lux at the cage lid. All experimental procedures were conducted in accordance with the guidelines of Shiraz University of Medical Sciences and Yasouj University of Medical Sciences for care and use of animal models.

Experimental design

Wistar rats were randomly divided into 7 groups. Rats in group I served as the control; they were placed in Plexiglas restrainers and sham exposed to Wi-Fi radiation (without energizing the Wi-Fi router) for 4 hours per day in term of 7 days at a distance of 30 cm from the router. Group II rats were exposed to 2.4 GHz microwave radiation for 2 hours per day in term of 7 days at a distance of 30 cm from the router. The rats in this group were allowed to live for 53 days then sacrificed and semen samples analyzed. In this phase of the study, a laptop that was placed in another room was exchanging data via the Wi-Fi router (groups II to VI). Rats in all the groups except group II, were sacrificed immediately after exposure. The exposure protocol for rats in groups III to VI was 2h – 30 cm, 2h – 60 cm, 4 h – 30 cm, 4 h- 60 cm,

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respectively. Rats in group VII treated as group V but the laptop used in the study was not exchanging data via the Wi-Fi router. Irradiation geometry used in these experiments is shown in figure 1.

Wi-Fi router

A D-Link Wi-Fi router (D-Link, D-Link Corporation, Taiwan) was used in this study as the RF exposure source. This modem was exchanging data with a laptop computer that was placed in another room (5 meters away from the Wi-Fi router) during the exposure period. The Wi-Fi router operated on power level of 1W and the Specific Absorption Rate at the distance of 30 cm in animals' head level was 0.091 W/kg.

TB staining

The TB staining was used to assess the chromatin integrity of the sperms. In this method, sperm cell heads with good chromatin integrity are shown in light blue while those of diminished integrity (abnormal sperms) are displayed in deep violet (purple).

Data analysis

Non-parametric Kruskal–*Wallis* and *Mann–Whitney tests were used* to detect significant differences between different groups. All statistical analysis was performed by using SPSS version 18.

Figure 1. Irradiation geometry. Rats were placed in Plexiglas restrainers and exposed/sham exposed to Wi-Fi radiation at a distance of 30 cm or 60 cm from the router.

RESULTS

Findings of this study showed statistically significant differences between the relative frequency of progressive and rapid progressive sperms in sham exposed rats compared to that of group II; exposed for 2 h/day for 7days at 30 cm and sacrificed after 53 days (P=0.025), group VI; 4 h at 60 cm (P=0.010) and group VII; 4 h at 30 cm, no data exchange (P=0.010). The relative frequency of non-motile, sluggish and progressive sperms and the percentages of normal and abnormal sperms in different groups are shown in table 1. The testicles weight, DNA fragmentation of sperms and the frequency of sperms with normal morphology were not affected by Wi-Fi radiation. However, statistically significant differences between sperm count of the sham exposed rats compared to that of group III; 2h – 30 cm (P=0.010), group IV; 2 h at 60 cm (P=0.020) and group VII; 4 h at 30 cm, no data exchange (P=0.026) were observed. The weight of right and left testicles and the sperm count in different groups are summarized in table 2.

DISCUSSION

Results indicate that exposure to microwave radiation emitted from Wi-Fi routers influences sperm parameters such as count and motility which are among the key parameters affecting chance of conceiving. Our findings are generally in line with results obtained in our previous study on mobile jammers [8] as well as the findings reported by other researchers who investigated the effect of exposure of sperms to different sources of electromagnetic fields such as mobile phones [28-30], laptops or wireless internet-connected laptops [27]. Our results are generally in line with several studies suggesting that rats exposed to 900 or 1800 MHz GSM RF radiation (1 h/day for 28 days) showed a statistically significant lower proportion of motile sperms [2] or rabbits exposed to 800 or 900 MHz GSM RF radiation (8 h/day for 12 weeks) in standby mode, revealed a statistically significant

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Table 1. The relative frequency of non-motile, sluggish and progressive sperms and the percentages of normal and abnormal sperms in different groups.

	Sperm Motility			Morphology	
Groups	**Non-motile**	**Sluggish**	**Progressive**	**Normal**	**Abnormal**
I (Sham exposed)	35.3±5.1	61.8±5.4	2.83±2.86	99.2±1.19	0.83±1.19
II (2 h 30 cm) (sacrificed after 53 days)	39.3±7.7	60.5±7.3	0.18±0.60	97.7±1.27	2.27±1.27
III (2h – 30 cm)	43.0±13.0	52.8±13.9	2.50±3.12	98.9±1.04	1.09±1.04
IV (2h – 60 cm)	48.1±18.9	51.0±18.2	0.92±1.56	97.9±2.17	2.09±2.17
V (4 h - 30 cm)	42.3±8.6	56.4±8.3	1.25±2.26	99.1±0.83	0.91±0.83
VI (4 h - 60 cm)	46.0±12.6	54.0±12.6	0.00±0.00	98.0±0.74	2.00±0.74
VII (4 h - 30 cm) (No data exchange)	44.4±14.0	55.6±14.0	0.00±0.00	98.5±1.21	1.55±1.21

Table 2. The weight of right and left testicles and the sperm count in different groups.

Groups	**Weight (g)**		**Sperm Count**
	Right testis	Left testis	
I (Sham exposed)	1.33±0.11	1.34±0.11	27854545±9456888
II (2 h 30 cm) (sacrificed after 53 days)	1.38±0.16	1.38±0.12	32218182±8372791
III (2h – 30 cm)	1.17±0.14	1.24±0.07	15908333±6229615
IV (2h – 60 cm)	1.28±0.22	1.32±0.11	16725000±4714798
V (4 h - 30 cm)	1.30±0.09	1.33±0.08	24450000±9350304
VI (4 h - 60 cm)	1.28±0.15	1.28±0.16	22450000±6030604
VII (4 h - 30 cm) (No data exchange)	1.30±0.13	1.32±0.13	17016667±10004620

decrease in sperm motility [31, 32]. Agarwal *et al.* also evaluated sperm motility and viability, reactive oxygen species (ROS) and DNA damage in fresh semen samples from 23 healthy donors and 7 infertile patients after 1 hour exposure to cell phone radiation in "talk" mode. The differences between exposed and control groups were significant for decreased motility and viability and increased ROS [5]. Erogul *et al*. also exposed fresh human semen to 900 Hz radiofrequency electromagnetic radiation and evaluated the motility of sperms. They reported a significant decrease in percentage of fast and slow progressive sperms and increased percentages of immotile and non-progressive sperms [6]. In this light, as reviewed by La Vignera *et al*., *in vitro* human epidemiologic studies on men exposed to radiofrequency radiation have shown significant decrease in sperm count, motility and increased reactive oxidative stress [33]. However, our findings are in contrast with those reported by Falzone *et al.* who exposed the density-purified human sperm to 900 MHz cell phone radiation. They could not show a significant difference between exposed and control samples regarding sperm kinematic parameters [11].

It is worth mentioning that our study did not have the limitations of the study conducted by Avendano *et al*. in 2012. These authors divided the sperm sample of each individual into two aliquots; the 1st aliquot (exposed) was irradiated with electromagnetic fields generated by a Wi-Fi internet-connected laptop for 4 hours, and the 2nd aliquot (non-exposed) which served as control, incubated under identical conditions with no exposure to the electromagnetic fields of laptop. The authors did not pay attention to the fact that the EMFs generated by laptop (without any Wi-Fi connection) may play a basic role in alterations in sperm motility. In our experiment, animals in the test groups were kept on the marked area on a thermal shield placed on the back of an inverted laptop 7 hours a day for one week. The controls were kept on a switched off laptop for the same period. Our previous study showed a significant decrease in sperm motility in areas with a relatively stronger magnetic field. We could not observe any significant change in sperm count. In conclusion, eexposure to microwave radiation emitted from Wi-Fi routers affects sperm parameters such as count and motility which are among the key parameters determining the chance of conceiving.

Conflicts of interest: *none to declare.*

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