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Exposure to radiofrequency radiation emitted from mobile phone jammers adversely affects the quality of human sperm

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ABSTRACT

Background: The health effect of rapidly increasing everyday exposure of humans to radiofrequency radiation is a major global concern. Mobile phone jammers prevent the mobile phones from receiving signals from base stations by interfering with authorized mobile carriers' services. In spite of the fact that mobile jammer use is illegal, they are occasionally used in offices, shrines, conference rooms and cinemas. *The purpose of this study was to investigate the biological effects of short term exposure of human sperm to* radiofrequency radiation emitted from a commercial mobile phone jammer. ***Materials and Methods***: Fresh semen samples were obtained by masturbation from 50 healthy donors who had referred with their wives to Infertility Treatment Center at the Mother and Child Hospital, Shiraz University of Medical Sciences. Female problem was diagnosed as the reason for infertility in these couples. The semen sample of each participant was divided into 4 aliquots. The first aliquot was subjected to *swim-up* and exposed to jammer radiation. The second aliquot was not subjected to *swim-up* but was exposed to jammer radiation. The third and fourth aliquots were not exposed to jammer radiation but only the 3rd aliquot was subjected to *swim-up*. ***Results:*** Semen samples exposed to radiofrequency radiation showed a significant decrease in sperm motility and increase in DNA fragmentation. ***Conclusion:*** Electromagnetic radiation in radiofrequency range emitted from mobile phone jammers may lead to decreased motility and increased DNA fragmentation in human semen. It can be concluded that mobile phone jamming might exert adverse reproductive health effects.

Keywords: *Mobile phone jammers, sperm motility, DNA fragmentation, EMFs, microwave, RF, reproductive health.*

INTRODUCTION

Infertility is a relatively common disorder [(1)] affecting 10-15% of American couples and 20% of couples at reproductive age worldwide. Modern life has prompted humans to generate, transmit and use more electricity and now electricity is an essential component of the life in

developed and developing countries. The strong link between electricity and modern life has led to exponentially increasing exposure to different sources of EMFs. New findings show that male infertility that is associated with factors such as reduced sperm production and misshapen or immotile sperms may be linked with human exposure to different electromagnetic fields (EMFs). Substantial evidence now indicates that exposure to different sources of EMFs such as mobile phones [1-5], mobile phone jammers [6], laptops [7] or wireless internet-connected laptops [8] or extremely low frequency electromagnetic field (ELFs) [9] may decrease the quality of human sperm.

In 2009, Mailankot and colleagues reported the result of their study on sperm function in a rat model. Their study revealed that exposure to radiofrequency radiation at 0.9/1.8GHz results in decreased motility and induction of oxidative stress in exposed sperms [10]. Agarwal et al reported a human study on unprocessed ejaculated semen after exposure to cell phone electromagnetic radiation. They compared sperm motility, reactive oxidative stress (ROS), and DNA damage in specimen exposed to mobile radiations in talk mode and intact specimen. The results showed significant decrease in motility and viability, and increased ROS and DNA damage in the group of specimens exposed to mobile electromagnetic radiations [11].

Mobile phone jammers are electronic devices that emit radiofrequency radiation with similar frequencies to that of mobile phones to block the access of the cell phone to the mobile base stations. These devices are used in places that mobile phone utilization is prohibited such as examination halls, and places where mobile phone ringing causes disturbance such as libraries. Most of mobile jammers propagate radiofrequency radiation at 800-1900MHz within a 10 meter diameter. Over the past years, our laboratories at INIRPRC have focused on studying the health effects of exposure of laboratory animals and humans to some common and/or occupational sources of electromagnetic fields such as mobile phones [12-20] and their base stations [21], mobile phone jammers [22], laptop computers [23], radars [24], dentistry cavitrons [25] and MRI [26, 27]. To the best of our knowledge there is limited number of investigations dealing with the bioeffects of exposure to microwave radiation emited by mobile phone jammers on DNA fragmentation. The aim of present study was to investigate possible effects of radiofrequency radiation from mobile jammer devices on sperm motility and DNA fragmentation.

MATERIALS AND METHODS

Study population

Semen samples were obtained by masturbation from 50 healthy volunteers who had referred to Mother and Child hospital for evaluation of their infertility and female factor infertility was confirmed by the tests. All participants had no history of any medical disorder which could affect semen quality. Systemic autoimmune disorders, history of or evident cryptorchidism, UTI symptoms or history of urogenital infections, high radiofrequency occupational exposure or residential area, smoking, cystic fibrosis, history of vasectomy, history of major testicular trauma or operation, varicocele, hydrocele, testicular hypertrophy or atrophy in physical examination were exclusion criteria for sample collection.

All participants voluntarily participated in this study and informed consent was obtained from each individual. The project was approved by the ethics committee of the institutional review board for human medical research of Shiraz University of Medical Sciences.

Experimental protocol

Semen samples were collected according to standard protocols for semen analysis after a period of sexual abstinence (2-7 days). A total number of 50 semen samples were selected after initial evaluation according to WHO guidelines [28] for semen analysis with specific attention to sperm motility and sperm count. Collected semen specimens were protected from extremes of temperature and delivered to the laboratory within 1-2 hours of collection. To avoid the problems caused by the time interval between

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semen specimen collection and its delivery to the laboratory, control specimens were treated in a similar manner.

After liquefaction, semen samples from each donor were coded and divided into 2 aliquots labeled as A, B. In group A samples, swim-up technique was performed for elimination of seminal fluid and selecting the most active and motile sperms. B-labeled samples were used fresh. The swim-up technique uses sperm self-migration to obtain a sperm sample with a motility of at least 90%. In this technique, a layer of fresh media is added to the semen sample and the majority of the motile sperms will swim out of the sample and upward into the added media.

Exposure system

A mobile jammer device (MB06-Mobile Blocker) which operates in four distinct frequency ranges including global system for mobile communications (GSM, 850 MHz, 900 MHz, 1800 MHz, 1900 MHz), digital cellular service (DCS), code division multiple access (CDMA), and the third-generation (3G) was used in this study. The maximum effective radius for operation of this device was reported by the manufacturer to range 10 to 40 meters. Group A and B samples from each donor were divided in 4 aliquots. Group 1, 2, and 3 were placed at distances of 1, 3, and 5 meters from the jammer device and the forth group placed at a point at least 500 meters away from the jammer device. After 2 hours, a sample from each specimen was evaluated for motility and DNA fragmentation. Re-sampling performed after another 2 hours in all groups for same the mentioned characteristics.

Sperm quality assessment

Motility of sperms was measured according to the well-defined four categories of motility:

1. Fast progressive motility: characterized by active movement, either linearly or in a large circle with a speed higher than 25 µm/sec
2. Slow progressive motility: characterized by active movement, either linearly or in a large circle with a speed less than 25 µm/sec
3. Non-progressive motility: regarding any type of motility without effective progression such as swimming in small circles, the flagellar force hardly displacing the head, or when only a flagellar beat can be observed.
4. Immotility: when no movement is seen by the sperms

   Percentage of each type of mentioned categories were measured in each sampling and compared with other groups.

For measurement of DNA fragmentation, ultrathin smears of semen specimen were prepared and fixed using 30 minutes in the 1:1 solution of acetone-ethanol. After fixation, and drying in room temperature, staining with toluidine blue 0.05% in phosphate citrate buffer for 10 minute was performed. In toluidine blue staining, those nuclei with fragmented DNA and damaged nucleic content are stained dark blue or violet and those with intact DNA materials stained light blue color. By counting sperms with each nucleus color in multiple high power fields and reporting the percentage of each type, measurement of DNA fragmentation was performed.

Inspection and evaluation of semen specimen for motility and DNA fragmentation was performed at 100X magnification by, Leica DM2700 light microscope (Leica Microsstems, Wetzlar, Germany).

Statistical analysis method

Data regarding motility and DNA fragmentation were recorded. Comparison of variables among studied groups at different distances (1, 3 and 5 meters) as well as different exposure times (2 and 4 hours) were performed using repeated measure analysis of variance. SPSS 18 software (IBM corporations, Armonk, New York, U.S) was used for data analysis. P-value < 0.05 was considered as significant.

RESULTS

Demographic data of the men participated in this study are summarized in table 1. The mean (±SD) age of the participants was 35.49 ± 7.00

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years (ranged 24-50 years). Effect of distance from jammer device on sperm motility and DNA fragmentation in washed specimen after 2 hours is summarized in table 2. In the exposed sperm samples, 2 hours of exposure to electromagnetic fields at a distance of 1 meter from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms *(p<0.001).* Furthermore, exposure to the Wi-Fi electromagnetic fields produced a significant increase in DNA fragmentation (p<0.01).

On the other hand, sperm samples exposed for 2 hours at a distance of 3 meters from the Wi -Fi router produced a significant decrease in the proportion of fast progressive sperms (p < 0.001). However, exposure to the Wi-Fi electromagnetic fields could not produce a significant increase in DNA fragmentation (p =1). Furthermore, sperm samples exposed for 2 hours at a distance of 5 meters from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms (p < 0.001). However, exposure to the Wi-Fi electromagnetic fields could not produce a significant increase in DNA fragmentation (p =0.29).

Table 3 summarizes the effect of distance from jammer device on sperm motility and DNA fragmentation in washed specimen after 4 hours. In the exposed sperm samples, 4 hours of exposure to electromagnetic fields at a distance of 1 meter from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms (p<0.001). Furthermore, exposure to the Wi-Fi electromagnetic fields produced a significant increase in DNA fragmentation (p<0.001). On the other hand, sperm samples exposed for 4 hours at a distance of 3 meters from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms (p<0.001). However, exposure to the Wi-Fi electromagnetic fields could not produce a significant increase in DNA fragmentation (p=0.095). Furthermore, sperm samples exposed for 4 hours at a distance of 5 meters from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms (p<0.001). However, exposure to the Wi-Fi electromagnetic fields produced a significant increase in DNA fragmentation (p=0.04).

Table 1. Characteristics of the men participated in this study.

Characters	Frequency (Percentage)
Age at the Time of Exam	
Mean± SD (Range)	**35.49 ± 7.00 (24 - 50)**
Distribution	
24–30 years	**33 (33.0%)**
31-35 years	**23 (23.0%)**
36-40 years	**22 (22.0%)**
41-45 years	**11 (11.0%)**
≥46 years	**11 (11.0%)**
Education	
High School Diploma or Less	**42 (42.0%)**
College Degree	**14 (14.0%)**
B.Sc or Master	**43 (43.0%)**
G.P (Medical Doctor)	**1 (1.0%)**
Job	
Jobless	**3 (3.0%)**
Private Business	**43 (43.0%)**
Teacher	**17 (17.0%)**
Worker	**6 (6.0%)**
Government Employee	**26 (26.0%)**
University Lecturer	**3 (3.0%)**
Other Jobs	**2 (2.0%)**

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Table 2. Effect of distance from jammer device on sperm motility and DNA fragmentation in washed specimen after 2 hours.

Group A	*Fast progressive % (Mean± SD)*	*Slow progressive % (Mean± SD)*	*Non-progressive % (Mean± SD)*	*Immotile % (Mean± SD)*	*DNA fragmentation % (Mean± SD)*
Washed sample control	24.2± 13.4	40.1±10.2	12.9±6.4	22.6±9.9	14.3±8.1
1 meter distance	13.0± 10.7	36.3±9.6	25.2±8.9	25.2±10.0	15.7±8.5
3 meters distance	14.6±10.9	36.0±11.2	24.3±7.8	25.0±8.5	14.5±9.3
5 meters distance	15.0± 10.2	38.0±9.7	22.6±6.7	24.1±9.5	14.9±8.1
P-value	0.0001	0.008	0.0001	0.0001	0.1

Table 3. Effect of distance from jammer device on sperm motility and DNA fragmentation in washed specimen after 4 hours.

Group A	*Fast progressive % (Mean± SD)*	*Slow progressive % (Mean± SD)*	*Non-progressive % (Mean± SD)*	*Immotile % (Mean± SD)*	*DNA fragmentation % (Mean± SD)*
Washed sample control	22.5±11.8	41.0±8.9	14.0±6.6	22.8±11.1	15.0±7.2
1 meter distance	12.2±9.2	35.5±9.8	27.7±8.3	24.8±10.5	15.9±7.9
3 meters distance	14.0±9.7	35.4±9.1	25.7±8.0	25.2±10.7	14.5±6.3
5 meters distance	14.7±9.7	36.5±9.9	23.4±6.7	24.4±11.1	14.6±8.1
P-value	<0.0001	<0.0001	<0.0001	0.002	0.15

Table 4 summarizes the effect of distance from jammer device on sperm motility and DNA fragmentation in fresh specimen after 2 hours. In the exposed sperm samples, 2 hours of exposure to electromagnetic fields at a distance of 1 meter from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms ($p < 0.001$). Furthermore, exposure to the Wi-Fi electromagnetic fields produced a significant increase in DNA fragmentation ($p < 0.001$). On the other hand, sperm samples exposed for 2 hours at a distance of 3 meters from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms ($p < 0.001$). However, exposure to the Wi-Fi electromagnetic fields could not produce a significant increase in DNA fragmentation ($p =0.095$). Furthermore, sperm samples exposed for 2 hours at a distance of 5 meters from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms ($p < 0.001$). However, exposure to the Wi-Fi electromagnetic fields produced a significant increase in DNA fragmentation ($p =0.04$).

Table 4. Effect of distance from jammer device of sperm motility and DNA fragmentation in fresh specimen after 2 hours.

Group B	*Fast progressive % (Mean± SD)*	*Slow progressive % (Mean± SD)*	*Non-progressive % (Mean± SD)*	*Immotile % (Mean± SD)*	*DNA fragmentation % (Mean± SD)*
Fresh sample control	51.1±18.5	34.4±13.8	10.6±6.5	4.0±4.4	13.2±9.3
1 meter distance	28.3±14.6	44.5±12.6	22.5±8.3	4.7±4.2	12.7±9.1
3 meters distance	31.6±15.1	40.6±12.4	22.3±9.5	5.4±4.5	13.2±9.9
5 meters distance	31.5±15.4	43.9±13.4	19.0±7.8	6.1±6.2	13.8±8.7
P-value	<0.0001	<0.0001	<0.0001	0.022	0.2

Table 5 summarizes the effect of distance from jammer device on sperm motility and DNA fragmentation in fresh specimen after 4 hours. In the exposed sperm samples, 4 hours of exposure to electromagnetic fields at a distance of 1 meter from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms ($p<0.001$). Furthermore, exposure to the Wi-Fi electromagnetic fields produced a significant increase in DNA fragmentation ($p<0.001$). On the other hand, sperm samples exposed for 4 hours at a distance

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of 3 meters from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms (p<0.001). However, exposure to the Wi-Fi electromagnetic fields could not produce a significant increase in DNA fragmentation (p=0.095). Furthermore, sperm samples exposed for 4 hours at a distance of 5 meters from the Wi-Fi router produced a significant decrease in the proportion of fast progressive sperms (p<0.001). However, exposure to the Wi-Fi electromagnetic fields produced a significant increase in DNA fragmentation (p=0.04).

Table 5. Effect of distance from jammer device of sperm motility and DNA fragmentation in fresh specimen after 4 hours.

Group B	*Fast progressive % (Mean± SD)*	*Slow progressive % (Mean± SD)*	*Non-progressive % (Mean± SD)*	*Immotile % (Mean± SD)*	*DNA fragmentation % (Mean± SD)*
Fresh sample control	46.7±18.9	38.3±15.5	11.6±6.3	3.6±2.7	12.4±8.1
1 meter distance	28.9±14.5	40.6±13.0	24.4±8.5	5.2±3.7	12.7±8.2
3 meters distance	29.0±14.6	43.5±12.0	22.6±9.7	5.2±6.3	12.6±8.6
5 meters distance	31.1±16.0	42.9±12.3	20.8±8.8	5.7±7.4	12.4±7.5
P-value	<0.0001	0.01	<0.0001	0.051	0.92

DISCUSSION

In the present study, we aimed to investigate the effects of radiofrequency electromagnetic waves propagated from a mobile jammer device at frequency of 800-1900 Hz on 2 major characteristics of human semen; motility and DNA fragmentation. The results altogether strongly suggest a significant distance dependent influence of mobile jammer radiations on sperm motility. The highest influence was observed at a radius of 3 meters from the device. Regarding DNA fragmentation, significant difference was observed between exposed and sham-exposed specimens. Washed semen samples exposed to Wi-Fi radiation had significantly higher percentages of sperms with DNA damage. In fresh semen samples, DNA fragmentation was significantly higher in samples exposed for 4 hours compared to those of the controls. However, there was no difference between 2 hour exposed groups and the controls.

Generally speaking our results are in line with our previous findings. Mortazavi *et al.* for the first time reported that the exposure of rats to electromagnetic fields caused by laptop computers can decrease sperm count and motility which adversely affects male reproductive capabilities [7]. Avendano *et al.* 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 [8].

Numerous animal and human model studies have shown decreased sperm motility after exposure to radiofrequency radiation emitted from cell phones operating at 0.9/1.8GHz frequency. In a pilot human study performed in 2009, Agarwal *et al.* evaluated sperm motility and viability, 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. Based on these observations, the authors linked impaired sperm characteristic to reactive oxygen stress caused by non-thermal damage due to radiofrequency electromagnetic radiation. On the other hand, for the DNA damage, there was no significant difference between radiation-exposed samples and controls, similar to the findings of this study [3]. Same findings were reported by Erogul *et al.* who exposed fresh human semen to 900 Hz radiofrequency electromagnetic radiation and evaluated the motility of sperms. The results showed a significant decrease in percentage of fast and slow progressive sperms and increased

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percentages of immotile and non-progressive sperms [4]. Later in 2008, in a similar study by Falzone *et al.,* density-purified human sperm were exposed to 900 MHz cell phone radiation. The authors found no significant variation between exposed and control samples regarding sperm kinematic parameters. Also evaluation of mitochondrial membrane potential was performed and revealed no difference between exposed and control semen samples [9]. *In vitro* human epidemiologic studies on male individuals exposed to radiofrequency electromagnetic radiation have shown significant decrease in sperm count, motility and increased reactive oxidative stress [29].

In the present study, results obtained by assessment of sperm motility and DNA fragmentation revealed significant decrease in sperm motility. Unfortunately due to limitations in funding, we were unable to perform reactive oxidative stress tests to investigate possible links between sperm motility impairments and ROS alterations. The main advantage in the protocol used in this study was performing the experiment using both fresh sperms and swim-up washed specimen. In this light, we were able to evaluate the radiofrequency effect on both fresh samples and motility gated sperms which revealed decreased motility in both samples.

For further investigations on this topic, we suggest performing this study with evaluation of ROS and total antioxidant capacity (TAC) in samples to shed light on cellular mechanisms which caused electromagnetic radiation induced decreased sperm motility in human sperms.

CONCLUSION

Based on the findings of this study, exposure of human sperms to radiofrequency radiation emitted by a mobile phone jammer adversely affects the sperm quality. Semen samples exposed to jammer radiation showed a significant decrease in their motility and an increase in DNA fragmentation. The proportion of rapid progressive sperms in samples exposed to jammer radiofrequency radiation at different distances was significantly lower than those of the sham-exposed samples. On the other hand, a significant increase was observed in DNA fragmentation in sperms exposed to jammer radiofrequency radiation compared to those of sham-exposed samples.

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***Conflict of interest*:** *Declared none.*

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