Male reproductive health under threat: Short term exposure to radiofrequency radiations emitted by common mobile jammers

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ABSTRACT

BACKGROUND: Modern life prompted man to increasingly generate, transmit and use electricity that leads to exposure to different levels of electromagnetic fields (EMFs). Substantial evidence indicates that exposure to common sources of EMF such as mobile phones, laptops or wireless internet-connected laptops decreases human semen quality. In some countries, mobile jammers are occasionally used in offices, shrines, conference rooms and cinemas to block the signal. **AIMS:** To the best of our knowledge, this is the first study to investigate the effect of short term exposure of human sperm samples to radiofrequency (RF) radiations emitted by common mobile jammers. **SUBJECTS AND METHODS:** Fresh semen samples were collected by masturbation from 30 healthy donors who had referred to Infertility Treatment Center at the Mother and Child Hospital with their wives. Female problem was diagnosed as the reason for infertility in these couples. **STATISTICAL ANALYSIS:** *T*-test and analysis of variance were used to show statistical significance. **RESULTS:** The motility of sperm samples exposed to jammer RF radiation for 2 or 4 h were significantly lower than those of sham-exposed samples. These findings lead us to the conclusion that mobile jammers may significantly decrease sperm motility and the couples' chances of conception. **CONCLUSION:** Based on these results, it can be suggested that in countries that have not banned mobile jammer use, legislations should be urgently passed to restrict the use of these signal blocking devices in public or private places.

KEY WORDS: Electromagnetic fields, male reproductive health, microwave, mobile jammers, radiofrequency, sperm motility

INTRODUCTION

Male infertility is a very common problem caused by factors such as low sperm generation, low sperm motility or obstructions, which prevent sperm delivery.[1] Over the past decades, it was widely believed that male infertility can be caused by known factors such as some diseases, injuries, chronic health problems, life-style choices and unknown factors (idiopathic male infertility). Modern life prompted man to increasingly generate, transmit and use electricity that leads to exposure to different levels of electromagnetic fields (EMFs).

Substantial evidence indicate that exposure to common sources of EMF such as mobile phones,[2-4] laptops or wireless internet-connected laptops[5] decreases human semen quality. It is worth mentioning that in 2010, Mortazavi *et al*. for the first time reported that laptop computers might decrease sperm count and sperm motility and ultimately affect male reproductive capabilities.[6] Currently, mobile phones are essential tools for effective communication in our daily life. Mobile jammers are radiofrequency (RF) transmitters that deliberately block mobile communications. As jammers also block critical and emergency communications, in many countries there are strict rules that inhibit marketing, selling, or using these devices. US Federal Communications Commission has declared that "a single violation of the jamming prohibition can result in tens of thousands of dollars in monetary penalties, seizure of the illegal device, and imprisonment."[7] Theater and restaurant owners in some countries use a

cell phone jamming devices to limit the disruption caused by inappropriate mobile phone use. In countries that using mobile jammers is not prohibited by law, these devices are occasionally used for blocking mobile phone calls, text messages and Wi-Fi internet communications. In some countries, mobile jammers can be bought in electronic markets without any license; mobile phone jammers are occasionally used in universities to prevent students from cheating (receiving calls or text messages from other students who are taking part in the exam or other persons outside the university). Over the past several years, our laboratory has focused on investigation of the bioeffects of exposure to common sources of EMFs such as mobile phones,[8-13] cavitrons,[14,15] magnetic resonance imaging[16] and laptops[6] as well as non-biological effects.[17] This study is an attempt to investigate the effect of short-term exposure of human sperm samples to RF radiations emitted by common mobile jammers on their motility character. To the best of our knowledge, this is the first study to assess the effects of short term irradiation of human sperm with mobile jammer RF radiation.

MATERIALS AND METHODS

Mobile jammer

The mobile jammer used in this study (MB06-Mobile Blocker) was designed to work in four different frequency range (global system for mobile communications [GSM], digital cellular service, code division multiple access, third-generation). Shielding radius for this jammer was announced to be 10-40 m.

Semen samples

Fresh semen samples were collected by masturbation from 30 healthy donors who had referred to Infertility Treatment Center at the Mother and Child Hospital, with their wives. Female problem was diagnosed as the reason for infertility in these couples. All participants in this study signed the informed consent form that was prepared according to the ethical codes. WHO criteria[18] were used for defining normal semen analysis (lower reference limit: Sperm concentration 15×10^6/ml, total sperm count 39×10^6, progressive motility 32%). Standard swim-up technique for collection of motile and active sperms was used. The semen samples diluted and centrifuged at 2000 revolutions per minute (RPM) for 3-5 min and the pellet loosened and overlaid with pre-warmed 1 ml of Ham's F-10 culture medium supplemented with 5% human serum albumin for 30 min. Motile sperm samples were divided into six aliquots of nearly 5×10^6 sperms.

Sperm motility scoring

Sperm motility was determined by study of at least five microscopic fields to categorize minimum 200 sperms (×400 magnifications). The motility was graded into four levels; i.e. rapid progressive, progressive, non-progressive and immotile. Approximately 200 sperms were assessed and categorized based on their motility (defined as a percentage). For the first time, to better evaluate the effect of mobile jammer radiations on motility of human sperms we defined a new parameter as the total motility score (TMS). The TMS of each sample was calculated as follows:

$$TMS = (\text{Rapid progressive } (\%) \times 3) + (\text{Progressive } (\%) \times 2) + (\text{Non-progressive } (\%) \times 1) \quad (1)$$

We used standard swim-up technique for collection of motile and active sperms. The supernatant was discarded and the pellet was suspended in pre-warmed 1 ml of Ham's F-10 culture medium supplemented with 5% human serum albumin. In this technique, sperm samples were centrifuged at 2000 RPM for 3-5 min.

Semen samples of each participant were divided into six aliquots. Two aliquots from each participant were exposed to mobile jammer RF radiation at a distance of 50 cm from its antenna. The exposure time for one aliquot was 2 h while the 2nd aliquot was exposed for 4 h. Two other aliquots from each participant were exposed at a distance of 100 cm. The exposure time for one aliquot from each of the above interventions was 2 h while the other aliquot was exposed for 4 h. Sperm motility scores were assigned by a qualified scoring expert.

Data analysis

Data were analyzed by using appropriate statistical tests such as *t*-test and analysis of variance.

RESULTS

The mean power density at distances of 50 and 100 cm from jammer were 10.4 ± 5.2 and 2.3 ± 0.9 μW/m^2, respectively. In sperm samples sham-exposed to jammer RF radiation for 2 h, the mean (±SD) percentages of sperm graded as rapid progressive, progressive, non-progressive and immotile were 25.53 ± 18.92, 48.97 ± 18.64, 17.40 ± 8.19 and 8.13 ± 5.04, respectively. On the other hand, in sperm samples exposed to jammer RF radiation at a distance of 50 cm from the jammer antenna for the same duration (2 h), the percentages of sperm graded as rapid progressive, progressive, non-progressive and immotile were 13.83 ± 11.79, 40.20 ± 12.31, 38.30 ± 12.00 and 7.73 ± 5.66, respectively. Furthermore, in sperm samples exposed at a distance of 100 cm for the same duration (2 h), the percentages of sperm graded as rapid progressive, progressive, non-progressive and immotile were 16.60 ± 15.07, 42.27 ± 14.16, 32.60 ± 10.40 and 9.17 ± 5.58, respectively.

On the other hand, in sperm samples sham-exposed to jammer RF radiation for 4 h, the mean percentages of sperm graded as rapid progressive, progressive, non-progressive and immotile were 19.77 ± 16.01, 48.77 ± 17.11, 23.43 ± 9.32

and 8.47 ± 5.44, respectively. Moreover, in sperm samples exposed to jammer RF radiation at a distance of 50 cm from the jammer antenna for the same duration (4 h), the percentages of sperm graded as rapid progressive, progressive, non-progressive and immotile were 9.40 ± 8.58, 38.43 ± 11.38, 43.87 ± 13.43, and 8.373 ± 5.50, respectively. In addition, in sperm samples exposed at a distance of 100 cm for the same duration (4 h), the percentages of sperm graded as rapid progressive, progressive, non-progressive and immotile were 12.53 ± 12.33, 40.10 ± 11.51, 38.57 ± 13.36, and 8.83 ± 6.71, respectively.

The TMS for the sperms sham-exposed for 2 h, exposed at 50 cm and exposed at 100 cm for the same duration (2 h) were 31.99 ± 4.19, 26.70 ± 3.73, and 27.82 ± 4.33, respectively. In addition, the TMS for the sperms sham-exposed for 4 h, exposed at 50 cm and exposed at 100 cm for the same duration (4 h) were 30.04 ± 3.65, 24.82 ± 3.04, and 26.07 ± 3.46, respectively. Figure 1 shows the percentages of rapid progressive (Panel a), progressive (Panel b), non-progressive (Panel c), and immotile sperms (Panel d) in samples sham-exposed for 2 h, exposed at a distance of 50 cm from the mobile jammer antenna for 2 h and exposed at a distance of 100 cm for the same duration. Figure 2 shows these percentages in samples exposed for 4 h. The TMSs in sperms sham-exposed or exposed to jammer RF radiations at a distance of 50 or 100 cm from the mobile jammer antenna for 2 or 4 h are indicated in Table 1.

DISCUSSION

Results obtained in this study clearly showed that the motility of sperm samples exposed to jammer RF radiation for 2 or 4 h were significantly lower than those of sham-exposed samples. Although the percentages of rapid progressive, progressive, non-progressive and immotile sperms in samples sham-exposed or exposed at a distance of 50 or 100 cm from the jammer for 2 or 4 h show some unexpected variations (partly due to statistical fluctuations), the differences in TMSs can be easily interpreted. In this light, regardless of the exposure time (2 or 4 h), the lowest and highest TMSs were observed in samples exposed at a distance of 50 cm and those sham exposed, respectively. The TMS of the samples exposed at a distance of 100 cm was between the scores of the sham-exposed samples and those exposed at a distance of 50 cm from the jammer.

These results are generally in line with findings reported by investigators who assessed the effect of sperm exposure to EMF sources such as mobile phones,[2-4,19,20] laptops or wireless internet-connected laptops.[5] Our results are especially in line with observations reported by Mailankot *et al*. who showed that rats exposed to 900 or 1800 MHz GSM RF radiation (1 h/day for 28 days) exhibited a significantly significant reduced percentage of motile sperm.[21] Our findings can also be supported by reports of Salama *et al*. who indicated that exposure to 800 or 900 MHz GSM RF radiation (8 h/day for 12 weeks) in standby mode caused a significantly significant decrease in sperm motility.[22,23]

On the other hand, Avendano *et al*. in 2012 also reported that sperm samples from each patient exposed to an internet-connected laptop by Wi-Fi for 4 h showed a

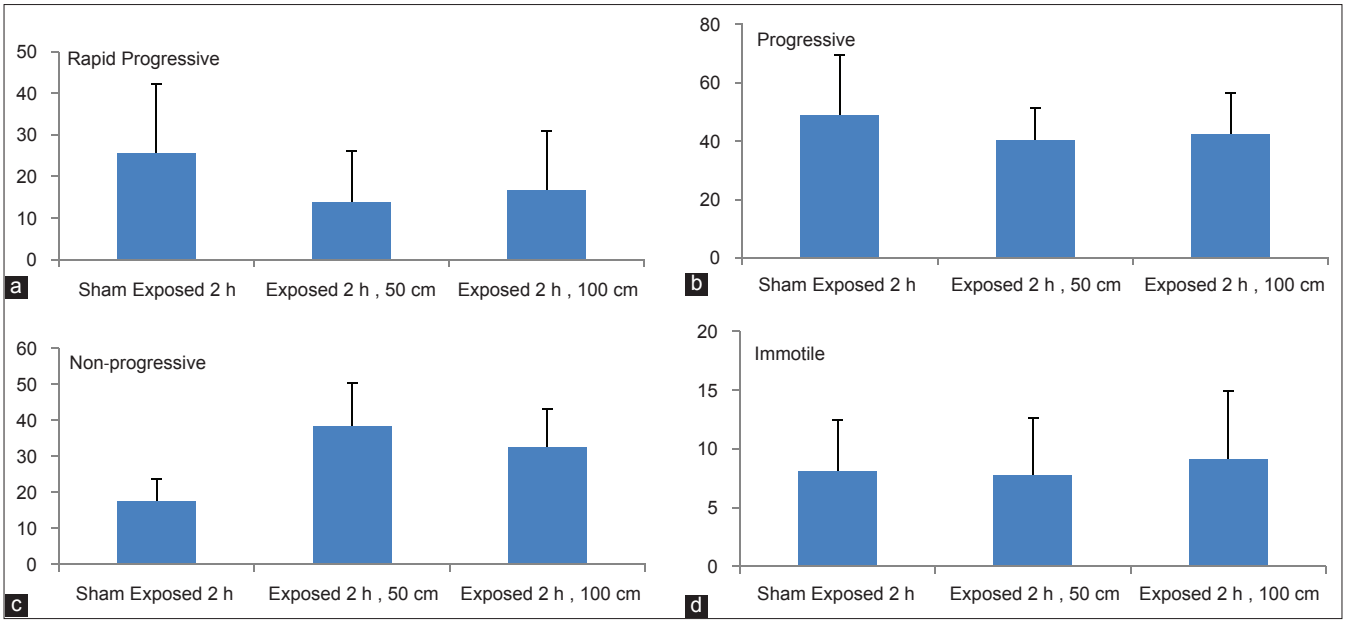

Figure 1: The percentages of rapid progressive (Panel a), progressive (Panel b), non-progressive (Panel c), and immotile sperms (Panel d) in samples sham-exposed for 2 h, exposed at a distance of 50 cm from the mobile jammer antenna for 2 h and exposed at a distance of 100 cm for the same duration

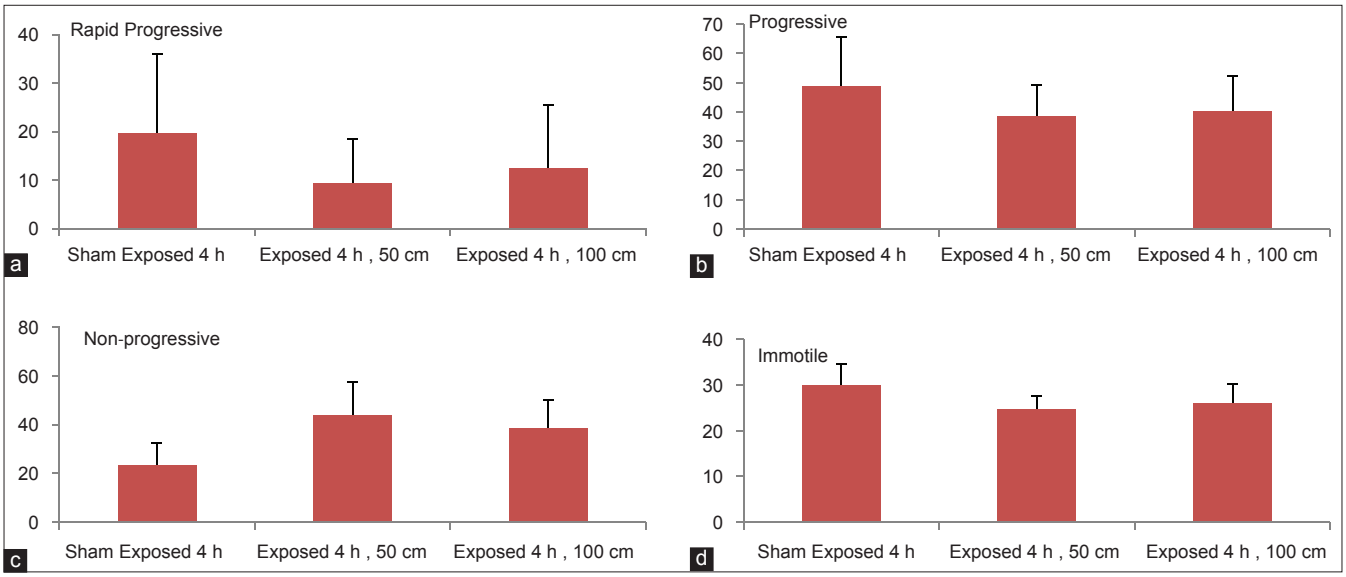

Figure 2: The percentages of rapid progressive (Panel a), progressive (Panel b), non-progressive (Panel c), and immotile sperms (Panel d) in samples sham-exposed for 4 h, exposed at a distance of 50 cm from the mobile jammer antenna for 4 h and exposed at a distance of 100 cm for the same duration

Table 1: The total motility score in sperms sham-exposed or exposed to jammer radiations at a distance of 50 or 100 cm from the mobile jammer antenna for 2 or 4 h

Duration of exposure	No. of samples	Sham exposure	Exposure, 50 cm (10.4±5.2 μW/m^2)	Exposure, 100 cm (2.3±0.9 μW/m^2)	Significance (*P* value)
2 h	30	31.99±4.19	26.70±3.73	27.82±4.33	<0.001
4 h	30	30.04±3.65	24.82±3.04	26.06±3.46	<0.001
Significance (*P* value)	-	NS	*P*<0.05	NS	-

NS=Not significant

significant decrease in progressive sperm motility and an increase in sperm deoxyribonucleic acid (DNA) fragmentation. Avendano's paper had some severe methodological flaws. Authors had divided each sperm suspension into two aliquots; one sperm aliquot (experimental) from each patient was exposed to an internet-connected laptop by Wi-Fi for 4 h and the second aliquot (unexposed) which was used as control, incubated under identical conditions without being exposed to the laptop. The authors were not aware of the fact that the EMFs generated by laptop (without any Wi-Fi connection) may play a basic role in alterations in sperm motility. This is exactly what we have reported earlier. Based on the results reported in our paper published in July 2010 in the Journal of Reproduction and Infertility,[6] a significant decrease in sperm motility was showed for animals kept in areas over a laptop with a relatively stronger magnetic field. On the other hand, Avendano *et al*.[5] were possibly unaware of the fact that RF fields in Wi-Fi band varies at different distances from the Wi-Fi client card in a laptop during uploading and downloading.[24] In this regard, the RF level in any point they placed the sperm samples must be reported. Shortcomings of Avendano's report prompted us to take these confounding factors into account in all of our studies on Wi-Fi and jammer bands.

International commission on non-ionizing radiation protection has established limits to protect the public from exposure to RF radiation[25] (specific absorption rates (SAR) of 1.6 and 2.0 W/kg as the limits of radiation exposure from a mobile phone in the US and Europe, respectively.[25,26] Substantial evidence indicate that RF radiation from cell phones at these SAR levels do not cause thermal effects. However, non-thermal effects such as alterations in cell plasma membrane,[27-30] increase in annexin V (a marker of apoptosis) staining,[30] and increased production of mitochondrial reactive oxygen species by human spermatozoa,[31] have been widely reported after exposure to RF radiation. It seems that potential mechanisms such as vulnerability of human sperms to oxidative stress due to abundant availability of substrates for invasion by free radicals and lack of cytoplasmic space to accumulate antioxidant enzymes that have been proposed by researchers who studied the bioeffects of mobile phone radiations,[31] play a similar critical role in detrimental effects of exposure of sperms to radiations of mobile phone jammers. In this light, mobile jammers possibly induce oxidative stress in sperms that leads to decreased fertilization capacity and sperm DNA damage.

CONCLUSION

This is the first study to investigate the effect of short term exposure of human sperm to RF radiations emitted by common mobile jammers. Altogether, findings of this study indicate that the semen samples exposed to radiations emitted by a common mobile jammer showed significantly lower sperm motility. In this light, it can be concluded that in countries that have not banned mobile jammer use, legislations should be urgently passed to restrict the use of these signal blocking devices in public or private places.

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