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The effect of cell phone usage on semen quality and fertility among Jordanian males



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ABSTRACT

Background and objective: Cell phones emit radiofrequency electromagnetic radiation are prejudicial to human fertility. The objective was to study the effect of cell phone usage on semen quality and men's fertility.

Materials and methods: A cross-sectional observational study conducted on 159 men attending infertility clinics at North, Middle and South Governorates in Jordan and undergoing infertility evaluation were divided into two groups according to their active cell phone use: group A: ≤ 1 h/day and group B: > 1 h/day. No interventions were given to patients and semen samples were collected by masturbation in a sterile container after an abstinence period of 5 days. The main outcome measures were sperm volume, liquefaction time, pH, viscosity, count, motility and morphology.

Results: There were no statistical significance differences ($p > 0.05$) between both groups regarding sperm quality parameters according to cell phone use, but there were statistical differences in the frequencies of sperm concentration, volume, viscosity, liquefaction time and means of immotile sperms and abnormal morphology. In addition, time spend on watching television and using wireless phones were significantly ($p \leq 0.05$) associated with decreasing mean percentages of normal morphology. The distance from telecommunication tower was significantly ($p \leq 0.05$) associated with decreasing sperms volume. Meanwhile, the time spend on sending or receiving messages was significantly ($p \leq 0.05$) associated with decreasing sperms count and carrying mobile phone in trouser pocket was significantly associated with increasing means of immotile sperms.

Conclusion: Cell phone use might have a negative effect on semen quality parameters and further research is needed.

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1. Introduction

Cell phones are widely spread among all age groups especially adults and it has been noticed that people spend long hours using cell phones for different purposes. These phones emit radiofrequency electromagnetic waves (EMW), a low-level radiofrequency (RF), at a frequency of between 800 and 2200 MHz [1], that can be absorbed by the human body and have potential adverse effect on brain, heart, endocrine system, and DNA of humans and animals. They affect the brain electroencephalographic activity and cause disturbance in sleep [2]; difficulty in concentration, fatigue, and headache [3]; and increase reaction time in a time-dependent manner [4]. Additionally, they increase the resting blood pressure [5] and reduce the production of melatonin [6]. They are also implicated in DNA strand breaks [7], induce chromosomal

instability and lead to increased cancer risk [4,7,8]. In addition, La Vignera [9] and his colleagues in 2012 suggested that mobile phones, and other electromagnetic devices that emit RF-EMR radiation, are prejudicial to human fertility.

Infertility defined as inability to conceive after a year of sexual intercourse without the use of contraceptives. It affects approximately 15% of couples of reproductive ages, and approximately 50% of these cases resulting from male factor infertility [8,10]. Men usually carry mobile phones in their pockets or in holders close to their reproductive organs. Thus, it is important to evaluate the effects of mobile phone use on male fertility. Although, many recent epidemiological studies have suggested that mobile phone use may play a role in male infertility [10–14], but the mode of action on the male reproductive system remains unclear. Mobile phones might influence the reproductive system via EMW thermal and non-thermal effects and they may interfere with normal spermatogenesis and result in a significant decrease in sperm quality [15–17]. However, the adverse impacts on semen quality that

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might cause due to cell phone usage have not been extensively addressed all over the world as well as in Jordan. Therefore, the objective of this study was to study the effect of cell phone usage on the semen quality and male fertility in Jordan.

2. Materials and methods

2.1. Study population and design

The study was approved by the Institutional Review Board committee at the three sites of data collection, and from each patient participating in the study an informed consent was obtained. The study design was a cross sectional observational study conducted on 159 men attending the infertility clinics in the North, Middle and South Governorates of Jordan between November 2015 and October 2016. The mean and the standard deviation (SD) age of the study participants was 33.26 (5.97) years. Participants had a history of smoking, alcohol consumption, orchitis, varicocele, diabetes mellitus, hypertension, cardiac, neural, or nephrotic disease, viral or bacterial infection in the past 4 weeks, or had a family history of genetic disease were excluded from the study.

2.2. Sample size determination

The sample size was determined depending on the prevalence of infertility worldwide which was estimated to affect 8–12% of reproductive aged couples [18]. The sample size was calculated using the infinite population equation $n = z^2pq/d^2$ [19]. Where n stands for sample size, z is the value of the 95% confidence level, P is the estimated average prevalence of infertility, q is $1 - p$ and d is the accepted error which is the precision around the population mean. Thus, the sample size required was: $n = (1.96)^2(0.1)(0.90)/(0.05)^2 = 138.3$. To guarantee the collection of the calculated sample size and to increase the power of the analysis, 20 more participants were collected.

2.3. Questionnaire

A structured, valid and reliable questionnaire was completed through a personal interview from each subject at the beginning of the study. All questions of the questionnaire were formed based on previous literature. To test whether the questionnaire is measuring what it intended to measure (validity), the questionnaire was reviewed by two specialists in obstetrics and gynecology. For testing whether the questionnaire consistently measures whatever it supposed to measure (reliability or repeatability) a pilot study was carried out on 10–15 non-participants' men before applying the questionnaire on the study population and was tested after completion using reliability coefficient (alpha) test and was revised accordingly. Also, to ensure the reliability, the questionnaire was completed for a second time after the completion of semen analysis in the participant next visit and Kappa coefficient statistic test was used to measure the agreement of answers of each question. Answers with Kappa coefficient <0.7 was excluded from the analysis. To ensure consistency, the questionnaire was completed only by the main researcher through personal interview with participants using a constant standardized procedure.

2.4. Semen collection and patients grouping

A sterile wide-opening calibrated container was utilized to collect the semen samples after an abstinence period of 5 days by masturbation. Moreover, the World Health Organization (WHO) guidelines were used to evaluate sperm parameters including volume, liquefaction time, pH, viscosity, sperm concentration, motility and morphology [20]. All semen samples were analyzed by

the same research certified laboratory technician who was blinded to the study participants cell phone usage. Time of talking by cell phone was recorded and the subjects were divided into 2 groups; group A ≤ 1 h/day ($n = 104$); group B > 1 h/day ($n = 52$) and participants who did not use cell phone ($n = 3$) were excluded from the statistical analysis regarding studying the effect of time spent in calling or receiving calls.

2.5. Statistical analysis

Collected data was entered twice in data sheets, checked and analyzed using SPSS statistical package (IBM, SPSS version 22, 2013). Descriptive statistics were performed using frequency as well as means and standard error of the means (SEM) to describe the categorical and numeric data, respectively. The nonparametric Kolmogorov-Smirnov test was used to examine all numeric variables for normal distribution. Student t -test for independent variables was used to compare means of the normally distributed numeric variables. Numeric variables were converted to categorical variables according to international and/or the laboratory cut-off points. The Pearson's Chi-square (χ^2) and Fisher's exact tests were applied to assess the associations among dichotomous and categorical variables and P -value ≤ 0.05 was considered significant.

3. Results

The study participants were ($n = 159$), their mean age was 33.26 ± 0.47 years, 98.1% using cell phone, and 32.7% of them calling or receiving calls per day for more than one hour. The frequency distributions of the socio-demographic and lifestyle characteristics of the study participants showed that, 69.2% had children, 44.6% living in villages, 90.6% using television remote controls, 72.3% were not using computers, 34.6% were using wireless (cordless) phones, 63.5% were carrying their mobiles in the pocket of the trouser, 77.4% sending messages by mobile, 38.4% using blue tooth technique, 37.1% working or living near telecommunications tower and 78.6% did not reported a family history of infertility. The descriptive statistics of the study participants regarding anthropometry and lifestyle characteristics are shown in Table 1. The mean values and frequencies of the study participants semen quality are presented in Table 2 which showed higher means of immotile sperms (55.00 ± 2.05) comparing to straight forward motile sperms (2.39 ± 0.45), a lower means of normal oval morphology (7.15 ± 0.75) comparing to abnormal morphology (66.0 ± 2.35) and the semen concentration mean was (31.04 ± 2.90) million/ml. In addition, 75.5% had abnormal viscosity and 95% their liquefaction time completed within 20 min.

Table 3 showed that there was no statistically significant difference ($P > 0.05$) between the study participant groups regarding time spend in calling or receiving calls by cell phones and the semen quality parameters. Nevertheless, there were statistical differences regarding sperm count >20 million/ml (63.2% vs 36.8%), volume >3 ml (62.7% vs 37.3%), normal viscosity (71.8% vs 28.2%), complete liquefaction within 20 min (66.9% vs 33.1%), mean of the percent immotile sperms (52.64 ± 2.58 vs 59.87 ± 3.48) and the mean of the percent abnormal sperm morphology (63.07 ± 2.95 vs 70.32 ± 4.01) respectively.

Furthermore, there were a few statically significant associations ($P \leq 0.05$) between some of the semen quality parameters and some of the study variables (Table 4). The mean percentage of the morphology normal was significantly ($P = 0.024$) higher for the participants watching television ≤ 3 h/day compared with participants watching television >3 h/day. The mean percentage of morphology abnormal was significantly ($P = 0.047$) higher for the

Table 1

Descriptive statistics of the study participants (n = 159).

Variable	n	Mean $\pm$ SEM	Minimum	Maximum
<i>Anthropometric characteristics</i>				
Age (years)	159	33.26 $\pm$ 0.47	20.0	61.0
Body weight (kg)	159	79.83 $\pm$ 1.20	52.0	150.0
Height (cm)	159	173.77 $\pm$ 0.61	155.0	200.0
Body mass index (kg/m ²)	159	26.43 $\pm$ 0.39	17.0	55.1
<i>Lifestyle characteristics</i>				
Driving hours/day	41	2.85 $\pm$ 0.36	0.15	10.0
Television watching hours	159	3.20 $\pm$ 0.16	0.00	12.00
Wireless phone time (h)	55	4.02 $\pm$ 0.57	0.25	17.00
Hours spending on computer	44	3.30 $\pm$ 0.42	1.00	12.00
Bluetooth time (min)	61	13.61 $\pm$ 1.80	0.00	60.00
Messages time (min)	124	11.72 $\pm$ 1.21	2.00	60.00
Distance between home or work and the telecommunications tower (km)	60	1.19 $\pm$ 0.35	0.00	20.00

Table 2

Descriptive statistics of the study participants semen quality parameters (n = 159).

Variable	Mean $\pm$ SEM	Minimum	Maximum
Sperm concentration (million/ml)	31.04 $\pm$ 2.90	0.00	182.0
Volume (ml)	3.18 $\pm$ 0.13	0.50	10.0
PH	8.00 $\pm$ 0.00	7.3	8.1
<i>Sperm motility (%)</i>			
Type 1: Straight forward motile sperm	2.39 $\pm$ 0.45	0.00	36.0
Type 2: Fast circular moving sperm	9.03 $\pm$ 0.85	0.00	45.0
Type 3: Locally shaking sperm	26.15 $\pm$ 1.40	0.00	70.0
Type 4: Immotile sperm	55.00 $\pm$ 2.05	0.00	100.0
<i>Sperm morphology (%)</i>			
Normal oval	7.15 $\pm$ 0.75	0.00	60.00
Slightly abnormal	16.13 $\pm$ 1.16	0.00	90.00
Abnormal	66.0 $\pm$ 2.35	0.00	100.0
	n	%	
<i>Viscosity</i>			
Normal	39	24.50	
Abnormal	120	75.50	
<i>Liquefaction time</i>			
Complete within 20 min	151	95.00	
Uncomplete within 20 min	8	5.00	
<i>Sperm count (million)</i>			
≤ 20	88	55.30	
> 20	71	44.70	

Values are presented as means $\pm$ SEM, minimum and maximum and as frequency (n) and percentages (%).

participants spending > 2 h/day using wireless phones compared with those spending ≤ 2 h/day. Participants who lived or worked on a distance > 1 km of the telecommunication tower had significantly ($P = 0.036$) larger mean values of sperms volume compared with those lived or worked on a distance ≤ 1 km. The mean values of sperms count were significantly ($P = 0.013$) higher for the participants spending ≤ 20 min/day in sending messages compared with those spending > 20 min/day. In addition, the mean percentage of immotile sperms were significantly ($P = 0.045$) higher for the participants carrying their mobile phones in trouser pocket compared with belt.

4. Discussion

Discussing the results of this study should done in caution, due to the differences in studies type (in vivo versus in vitro) and the variations between the participants such as age, race, occupation, location of living and health status. The types and models of mobile phones, time spending in using mobile phones, way of carrying

mobile phones and other medical and environmental variables that may affect the parameters of semen quality.

The sperm quality parameters of 159 males attending an infertility clinics were studied after segregating them into two groups depending on time spending on using mobile phones. I found that the comparisons of the seventh sperm parameters: sperm concentration, volume, pH, motility, morphology, liquefaction time and viscosity were not significantly different. Nevertheless, there were statistical differences among both groups regarding the percentages of sperm concentration > 20 million/ml, volume > 3 ml, normal viscosity and liquefaction time completed within 20 min which were statistically higher among mobile phone users for less than one hour, but the means of immotile sperms and abnormal morphology were statistically higher among mobile phone users for more than one hour. This led to thinking of the adverse effects of using mobile phones on the semen quality parameters by decreasing the sperm counts, motility, morphology and viability, which might cause male infertility.

In a recent study conducted by El-Helaly and Mansour [21], on 262 males attending an andrology clinic for infertility evaluation, they reported that all semen quality parameters did not differ significantly between cell phone users according to daily use in minutes. However, the difference is not significant their study showed that those used cell phone for more than 60 min daily have lower semen volume, vitality and morphological index compared to those used cell phone for less than 60 min daily. Gutschi et al. [22], reported that the use of cell phones has no effect on total sperm count. In a cross sectional study conducted by Rago et al. [23], on 63 healthy and fertile men referred to andrology center, results showed that none of the conventional sperm parameters were significantly altered among the 3 study groups according to daily cell phone use in hours. Furthermore, Feijo et al. [24], found that sperm parameters were not significantly different in non-users and users with increased cell phone use and this study results are in accordance with these authors.

On the contrary, Fejes et al. [14], studied the sperm concentration and motility for 371 men suffer from infertility problems and found that the duration of possession and the daily transmission time were correlated negatively with the proportion of rapid progressive motile spermatozoa, and positively with the proportion of slow progressive motile spermatozoa. Also, a significant increase in the percentage of sperm cells of abnormal morphology and a decrease in the percentage of spermatozoa with progressive motility was associated with the duration of exposure to GSM phone and with the frequency of mobile phone usage [25]. Similarly, Agarwal et al. [26], reported significantly lower sperm count, motility, and viability and normal morphology in 3 groups of men using cellular phones for different periods of time (< 2 h/d, $2-4$ h/d, and > 4 h/d), compared with men who did not use cell

Table 3

Frequencies and means of semen quality parameters according to time spending in calling or receiving calls per day.

	Total (N = 156)	≤1 h/day (n = 104)	>1 h/day (n = 52)	P-value
Variable	N (%)	n (%)	n (%)	(χ^2)
<i>Sperm concentration (million/ml)</i>				
≤20	88 (56.4)	61 (69.3)	27 (30.7)	0.494
>20	68 (43.6)	43 (63.2)	25 (36.8)	
<i>Volume (ml)</i>				
≤3	89 (57.0)	62 (69.7)	27 (30.3)	0.457
>3	67 (43.0)	42 (62.7)	25 (37.3)	
<i>Viscosity</i>				
Normal	39 (25.0)	28 (71.8)	11 (28.2)	0.556
Abnormal	117 (75.0)	76 (65.0)	41 (35.0)	
<i>Liquefaction time</i>				
Complete within 20 min	148 (94.9)	99 (66.9)	49 (33.1)	0.534
Uncomplete within 20 min	8 (5.1)	5 (62.5)	3 (37.5)	
Variable	Mean ± SEM		Mean ± SEM	P-value
<i>Sperm motility (%)</i>				
Type 1: Straight forward motile sperm	2.30 ± 0.50		2.54 ± 0.98	0.806
Type 2: Fast circular moving sperm	9.03 ± 1.07		8.50 ± 1.38	0.752
Type 3: Locally shaking sperm	27.50 ± 1.79		23.37 ± 2.31	0.173
Type 4: Immotile sperm	52.64 ± 2.58		59.87 ± 3.48	0.103
PH	7.99 ± 0.007		8.00 ± 0.003	0.273
<i>Sperm morphology (%)</i>				
Normal oval	7.77 ± 0.95		6.09 ± 1.30	0.305
Slightly abnormal	17.38 ± 1.52		14.00 ± 1.78	0.177
Abnormal	63.07 ± 2.95		70.32 ± 4.01	0.162

Values of categorical variables are presented as frequency (n) and percentages (%). Values of continuous variables are presented as means ± SEM. P-value ≤0.05 is statistically significant for Chi-square and student t-test.

Table 4

Sperm quality parameters significantly associated with study variables using independent t-test.

Variable	Mean ± SEM	Mean ± SEM	P-value
<i>Television watching hours/day</i>			
≤3 h (n = 101)		> 3 h (n = 58)	0.024
Morphology normal (%)	8.44 ± 1.07	4.91 ± 0.84	
<i>Wireless phone time day</i>			
≤2 h (n = 32)		>2 h (n = 23)	0.047
Morphology abnormal (%)	58.88 ± 5.60	74.70 ± 4.80	
<i>Telecommunication tower distance</i>			
≤1 km (n = 45)		>1 km (n = 15)	0.036
Volume (ml)	2.99 ± 0.214	3.95 ± 0.434	
<i>Messages sending time/day</i>			
≤20 min (n = 109)		>20 min (n = 15)	0.013
Sperms count (million/ml)	31.66 ± 3.66	17.54 ± 4.04	
<i>Way of carrying mobile</i>			
On belt n = 46		Trouser pocket n = 101	0.045
Immotile sperms (%)	52.84 ± 2.53	61.91 ± 3.64	

Values are presented as means ± SEM. P-value ≤0.05 is statistically significant for student t-test.

phones. Furthermore, Boulos and Hassan [27], concluded that cell phone use in men is associated with decreased semen quality in the form of decreased sperm count, motility, viability and normal morphology, which depend on the duration of cell phone exposure time. As noticed these results are in contrast with this study results.

In an unprecedented step in this research I tried to study the effect of some behavioral and environmental factors on semen parameters. The results were within my expectations where watching television for more than 3 h/day lead to decrease the

mean values of the normal morphology and using wireless phones (cordless) for more than 2 h/day increased the mean percentage of the abnormal morphology significantly. This means that watching televisions and using wireless phones for prolonged time is associated with negative effects of RF-EMR from televisions and wireless phones on sperms morphology. Furthermore, the sperms volume was significantly lower for those live or work on a distance less or equal to one kilometer from the telecommunication towers and the sperms count was significantly lower among those sending messages for more than 20 min/day. Moreover, the mean percentage of the immotile sperms was significantly higher among those carrying their mobile phones on trouser pocket.

Television (TV) watching and semen quality has not been studied previously except by Gaskins et al. [28], who found that lower TV watching hours were associated with higher sperm concentration and total sperm count but unrelated to sperm morphology, motility or sample volume. This comes in conflict with this study result which might be a chance finding, therefore further research is needed to confirm this study result with TV watching hours and explore the possible mechanisms of action. Unfortunately, the effect of using wireless (cordless) phones on semen parameters has not been studied directly. Although, the effect was studied on other health problems as testicular cancer [29].

The effect of RF-EMR exposure from text messaging on body organs remains understudied [30] as well as on semen quality. Bhat et al. [31], study the effect of mobile phone towers radiation on human body and found that electromagnetic radiation emitted by mobile phone and mobile phone towers are harmful for the people who are living nearby the transmission towers and people should keep away from the transmission towers but they did not study the effect on semen quality or male fertility. Dahat [32], in 2013 reported that people living 50 to 300-meter radius is in high danger and negative impact is promoted in case of direct contact and at the same height of the tower especially to those who live in tall buildings near the transmitting towers. These findings

confirm the negative effect of telecommunication towers on human body but they did not study its effect on semen quality.

The effects of RF-EMR on the quality of the sperm parameters according to the way of carrying mobile phones was studied by Kilgallon and Simmons [33], on a sample of 52 men aged 18–35 years. The study results showed that men who carried a mobile phone in their hip pockets or on their belts had a lower sperm concentration than men either who did not carry a mobile phone or who carried it elsewhere. Also, in a hospital based study conducted by El-Helaly and Mansour [21], they reported that men who kept their cell phone in their trouser pockets had lower sperm motility percentage compared to keeping cell phones in waist pouch, shirt pocket or in hands, but the difference was statistically insignificant. These results agree with this study result as well as with Agarwal et al. [34], who concluded that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility.

Although, the mechanisms of the effect of cell phone use on male fertility are not yet clear, but it has been hypothesized that the electromagnetic waves might affect male reproduction through three mechanisms: (a) an EMW-specific effect; (b) a thermal molecular effect; or (c) a combination of these two factors [15]. These might affect spermatogenesis via causing injury in the Leydig cells [35]. Also, the EMW might cause reversible disruption of spermatogenesis by increasing the tissue or body temperature [36,37] or through decreasing melatonin and increasing the production of the reactive oxygen species (ROS) which negatively correlated with sperm motility and sperm chromatin damage [1].

This study has some limitations which might explain the statistical insignificant differences in the results. One of these limitations is the small number of cell phone users for more than one hour/day ($n = 52$) compared with cell phone users for less or equal than one hour/day ($n = 104$) due to small sample size. All the study participants attending infertility clinics and it could be better to compare with healthy individuals. I relied only on self-perceived history of the participants without validating their cell phone use. I did not consider the effect of the specific absorption rate of each cell phone model and the effects of cell phone possession in standby mode. Therefore, a follow-up studies with large sample sizes are needed to validate the cell phone research results.

In conclusion, the study failed to find any significant decrease in semen quality but there were statistical differences in some semen parameters according to cell phone use which might support the suggestion of the negative effect of prolonged cell phone use on male fertility. Nevertheless, the study revealed significant findings in this area which open a way for future research.

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