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ARTICLE

Habits of cell phone usage and sperm quality – does it warrant attention?

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Abstract Male infertility constitutes 30–40% of all infertility cases. Some studies have shown a continuous decline in semen quality since the beginning of the 20th century. One postulated contributing factor is radio frequency electromagnetic radiation emitted from cell phones. This study investigates an association between characteristics of cell phone usage and semen quality. Questionnaires accessing demographic data and characteristics of cell phone usage were completed by 106 men referred for semen analysis. Results were analysed according to WHO 2010 criteria. Talking for ≥1 h/day and during device charging were associated with higher rates of abnormal semen concentration (60.9% versus 35.7%, $P < 0.04$ and 66.7% versus 35.6%, $P < 0.02$, respectively). Among men who reported holding their phones ≤50 cm from the groin, a non-significantly higher rate of abnormal sperm concentration was found (47.1% versus 11.1%). Multivariate analysis revealed that talking while charging the device and smoking were risk factors for abnormal sperm concentration (OR = 4.13 [95% CI 1.28–13.3], $P < 0.018$ and OR = 3.04 [95% CI 1.14–8.13], $P < 0.027$, respectively). Our findings suggest that certain aspects of cell phone usage may bear adverse effects on sperm concentration. Investigation using large-scale studies is thus needed.

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Introduction

The prevalence of infertility among couples of reproductive age, defined as a failure to conceive for 12 months, is 15% (Chandra et al., 2014). In 34% of the cases, the aetiology is related to male factor (Odisho et al., 2014). Semen quality has been reported to be declining during the last decades by some investigators (Lackner et al., 2005; Rolland et al., 2013), though not by others (Fisch, 2008). Trends observed over time and differences between reports may be due to demographic variations and to both behavioural and environmental factors, such as food composition and quality, smoking, stress, alcohol and drug consumption, global warming, air pollution, chemical toxins and radio frequency electromagnetic radiation (RF-EMR) (Erogul et al., 2006).

The use of cell phones has increased dramatically since their emergence about two decades ago. Throughout the world, they currently serve as an important means of communication, orientation and information source, and contribute to other daily functions. The International Telecommunication Union (ITU) (2013) survey, conducted in February 2013, reported 6.8 billion mobile subscriptions worldwide. Although most scientific and public attention on the safety of RF-EMR has focused on a potentially increased risk for brain tumours, a growing body of research points to another concern – sperm damage (La Vignera et al., 2012).

In the current literature, the effects of RF-EMR on semen parameters are inconclusive. This may be due, at least in part, to differences in study methodologies. While some studies assessed outcomes of in-vitro exposure of semen to radiation, other studies were observational (Agarwal et al., 2008, 2009; Erogul et al., 2006).

Men exposed to higher degrees of RF-EMR during their military service were found to be at higher risk (odds ratio (OR) = 1.86) of being infertile after 1 year (Baste et al., 2008). Another study found a higher rate of reduced semen quality after occupational exposure to electromagnetic fields (OR = 3.22) (Irgens et al., 1999). However, the above-mentioned studies did not sufficiently take into account the many possibly confounding factors such as lifestyle, demographic characteristics, aspects of device usage and occupational and health background.

Thus, the aim in the present study was to investigate possible associations between various aspects of cell phone usage (in addition to demographic and lifestyle parameters) and sperm quality, in light of the extremely high prevalence of cell phone usage in the Western world.

Materials and methods

This prospective study was approved by the local Institutional Review Board on 14 March 2011 (reference code: CMC-10–0087) and informed consent was obtained from all participants upon entering the study.

Study participants consisted of 106 male patients who underwent a first-time semen analysis as a part of infertility workup in the Fertility and IVF division of Carmel Medical Centre during 2011–2012. Each participant completed a detailed questionnaire before performing semen analysis. This included questions regarding their demographic background, i.e. age, place of living, number of children, occupation, ethnicity and educational status. There were also questions on their general medical history and fertility-related conditions (i.e. varicocele, orchitis), as well as lifestyle habits such as smoking and consumption of alcohol. Further questions accessed information about daily habits of cell phone usage such as the number of devices used and the duration of daily use (talking). The latter was classified by four categories: less than 30 min, 30–60 min, 60–120 min and over 120 min. The usual location of the device while talking, carrying and charging was assessed separately. The effect of RF-EMR is inversely proportional to the distance from the origin. As cited from the World Health Organization (WHO) (2015) website regarding electromagnetic fields: 'At a distance of 30 cm the magnetic fields surrounding most household appliances are more than 100 times lower than the given guideline limit of 100 μT at 50 Hz (83 μT at 60 Hz) for the general public'. Therefore, in this study, and in accordance with the work by Fejes *et al.* (Fejes et al., 2005), a conservative approach was adopted and a wider distance of 50 cm was chosen as a cutoff. Distance from the groin was classified by two categories: ≤50 cm or >50 cm.

Data regarding the use of accessories such as hands-free devices and earphones were collected as well. Other variables included the number of years that an individual owned a cell phone, talking while the device is being charged (as a categorical yes/no question) and talking in low reception areas (defined as: elevators and underground floors). Information on cell phone types, models and frequencies was not collected.

Exclusion criteria were: chronic or acute medical conditions that have been associated with a decrease in semen quality (e.g. long-standing diabetes mellitus, hypertension, varicocele, orchitis); smoking more than 10 pack years; and consumption of more than 1 litre of alcoholic beverages per day. After exclusion criteria were applied, smoking status was classified as 'ever smokers' for those who currently smoked or had smoked in the past (in both cases for less than 10 pack years) and 'never smokers' for those who had never smoked.

Semen quality was assessed using four parameters: volume, concentration, motility and morphology, according to the criteria of the World Health Organization, i.e. volume of ≥1.5 ml, concentration $\geq 15 \times 10^6$/ml, progressive motility ≥32% and ≥4% of normal forms. These are accepted normal values (World Health Organization, 2010).

Statistical analysis was performed using PASW statistics 18 (SPSS, Hong Kong). To examine associations between the categorical variables of the semen, a chi-squared test was applied. Correlation between continuous variables and the semen variables was examined with an independent *t*-test. To identify the factors that independently influence semen concentration, the variables that were statistically significant in univariate analysis were included in a multivariate logistic regression analysis. OR were calculated with 95% confidence interval (CI). A value of $P < 0.05$ was considered statistically significant.

Results

One hundred and six men completed the questionnaire. Of them, 26 did not meet study eligibility criteria, and were excluded from the analysis.

Table 1 Descriptive data of the 80 men who were included in the final analysis.

Age	
Range (years)	25–51
Mean (±standard deviation)	34.9 (±5.6)
Residence *n* (%)	
City	49 (61.3)
Rural areas	31 (38.8)
Number of children *n* (%)	
None	54 (67.5)
At least one	26 (32.5)
Cultural background *n* (%)	
Jewish	42 (52.5)
Muslim	25 (31.3)
Druze	6 (7.5)
Christian	2 (2.5)
Other, not known	5 (6.3)
Education *n* (%)	
12 years or less	37 (46.3)
Above 12 years	43 (53.8)
Smoking status *n* (%)	
Never	43 (53.8)
Ever (current/past)[a]	37 (46.3)

[a]Less than 10 pack years.

The mean participants' age was 34.9 ± 5.6 (25–51) years. Demographic data are presented in **Table 1**. Mean duration of possession of cell phones was 12.9 years (±3.8 years). Eighty-six per cent of the men were found to have normal semen volume, 57% normal semen concentration and 71% had normal progressive motility; only one man had abnormal semen morphology. Data regarding semen quality are presented in **Table 2**.

The effects of lifestyle characteristics and habits of cell phone usage characteristics on sperm concentration are presented in **Table 3**. Talking duration of more than one hour per day was associated with a higher rate of abnormal sperm concentration than talking less than one hour per day (60.9% versus 35.7%, $P < 0.04$). Talking on the cell phone while it was being charged was associated with a higher rate of abnormal sperm concentration than not talking on the cell phone while it was being charged (66.7% versus 35.6%, $P < 0.02$). Of the 80 participants whose questionnaires were analysed, 46.3% were 'ever' (past and/or current) smokers: 27.5% current smokers and 18.7% smoked in the past (all of whom had smoked less than 10 pack years). The prevalence of abnormal sperm concentration was higher among ever smokers than among never smokers (56.8% versus 31.0% $P < 0.021$). Regarding the location of the cell device while it was not in use, 87.6% reported that the device was constantly held at a distance of less than 50 cm from the groin (47.5% in trouser pocket, 22.6% in their hands or on their belt, 2.5% in their shirt pocket, and 15% in 'another' place). The rate of abnormal sperm concentration showed a non-significant trend towards a higher value among participants who reported generally keeping their cell phones at a distance ≤50 cm from

Table 2 Semen analysis parameters of the 80 participants.

	Volume (ml)	*Sperm concentration ($\times 10^6$/ml)*	*Progressive motility (%)*	*Abnormal forms (%)*
Mean ± SD	2.93 ± 1.51	26.28 ± 30.88	48.41 ± 24.23	89.50 ± 18.01
(range)	(0.5–9.5)	(0–170)	(0–100)	(0–97)
Normal[a] *n* (%)	69 (86)	45 (57)	57 (71)	79 (99)
Abnormal *n* (%)	11 (14)	34 (43)	23 (29)	1 (1)

[a]According to WHO 2010 laboratory manual for the examination and processing of human semen.

Table 3 Lifestyle and cell phone usage in relation to sperm concentration.

Characteristic	*Categories*	*Sperm concentration*		*P-value*
		Abnormal n = 34	*Normal n = 45*	
		n *(%)*	n *(%)*	
Smoking	Never	13 (31.0)	29 (69.0)	0.021
	Ever (current/past)	21 (56.8)	16 (43.2)	
Total daily talking time	>1 h	14 (60.9)	9 (39.1)	0.040
	≤1 h	20 (35.7)	36 (64.3)	
Talk while charging the device	No	21 (35.6)	38 (64.4)	0.020
	Yes	12 (66.7)	6 (33.3)	
Distance from groin when not in use	≤50 cm	33 (47.1)	37 (52.9)	NS
	>50 cm	1 (11.1)	8 (88.9)	

NS = not statistically significant.

the groin compared with those who kept it at a distance >50 cm from the groin (47.1% versus 11.1%). No association was found between any of the factors investigated and between semen volume and progressive motility (data not shown).

A multivariate logistic regression analysis revealed that two variables, talking while the device is being charged and smoking, were associated with increased risk for abnormal sperm concentration (OR = 4.13 [95% CI 1.28–13.3], $P < 0.018$ and OR = 3.04 [95% CI 1.14–8.13], $P < 0.027$, respectively).

No association was found between other usage-related characteristics (i.e. use of accessories, talking in a low reception area) and between sperm parameters (data not shown). No associations were found between age, residential area, occupation, number of children or years of education and semen parameters. The use of accessories such as hands-free devices, wired and non-wired earphones and duration of charging time were not analysed due to a small sample size. The full list of characteristics investigated, with the categories analysed, are presented in **Table 4**.

Table 4 Demographic and lifestyle characteristics, and aspects of cell phone usage, as assessed in the study questionnaire, together with categories used for analysis.

Characteristic	*Categories*
Age	
Ethnicity	Jews
	Muslims
	Other
Education	12 years or less
	Above 12 years
Type of residence	City
	Rural area
Number of children	None
	At least one
Smoking	Never
	Ever (current/past)
Use of hands-free set	No
	Yes
Total daily talking time	Above 1 h
	1 h or less
Prefer using wire phone at work	No
	Yes
Prefer using wire phone at home	No
	Yes
Talking in places with low telecommunication	No
	Yes
Work in a place with no telecommunication	No
	Yes
Cell phone off while sleeping	No
	Yes
Cell phone at a distance while sleeping	50 cm or less
	More than 50 cm
Cell phone at a distance while charging	50 cm or less
	More than 50 cm
Cell phone charging while staying in the room	No
	Yes
Talking while charging phone	No
	Yes
Cell phone distance from the groin	50 cm or less
	More than 50 cm
Use of wireless earphones	No
	yes

Discussion

In the present study it was found that certain characteristics of cell phone usage are highly associated with low sperm concentration. Several studies have reported observational data on exposure to cell phone radiation and sperm parameters. The main strength of the current study is the detailed information on many characteristics of cell phone usage.

Talking on a cell phone for more than one hour per day was associated with an elevated rate of abnormal sperm concentration. This concurs with the results of Agarwal *et al.*, who reported that talking for a duration of more than 4 h/day on a cell phone was associated with a lower sperm count, as well as a lower number of viable sperm, motility and morphology (Agarwal et al., 2008). Similarly, longer daily transmission time on cell phones was associated with a lower proportion of rapid progressive motile sperm (Fejes et al., 2005).

The lack of association found between cell phone usage and sperm motility, a finding that has been demonstrated in previous studies, may be due to differences in criteria for sperm motility between WHO 1999 and 2010 manuals for reference values for semen parameters.

The reference value for sperm progressive motility in this study was defined by the WHO 2010 manual as ≥32% progressive motility, the numerical sum of grade a (rapid progressive) and b (slow/sluggish progressive) motility. In contrast, most previous studies either used earlier WHO criteria, in which only rapid progressive motility was regarded as a reference value for sperm motility (Agarwal et al., 2008; Fejes et al., 2005) or compared subgroups of sperm motility (Davoudi et al., 2002).

The participants in this study, who reported talking on their phones while the device was being charged, were more likely to have abnormal semen concentration. To our knowledge, this aspect of cell phone use has not been previously addressed. During charging of cell phones, two changes occur: (i) the external power source by itself emits energy; and (ii) due to the continuous supply of energy from the external source, the device transmits at a higher power, without the need for energy saving, in contrast to the usual talking mode.

Participants who constantly carry the device at a distance ≤50 cm from the groin were found to have a higher rate of abnormal sperm concentration. Although the association did not reach statistical significance, it appears that sperm parameters may be affected, even during a stand-by mode (when RF-EMR is emitted from the device for short durations). Similarly, Kilgallon and Simmons reported that men who carried a cell phone in a hip pocket or on their belts had 11% fewer motile sperm than men who kept a phone elsewhere on their body (Kilgallon and Simmons, 2005). Another study showed that men who carried a cell phone on their belt ≥6 h/day for 5 days, had a 19% drop in highly motile sperm from their previous concentrations (Davoudi et al., 2002).

A higher rate of abnormal semen concentration was observed among ever smokers than never smokers. Smoking has been shown to correlate strongly with decreased fertility among both men and women (Jensen et al., 2005; Richthoff et al., 2008; Sepaniak et al., 2006).

A multivariate logistic regression analysis revealed a strong independent effect of two variables on the risk for abnormal sperm concentration: talking while the device is being charged and smoking. It is interesting to note that although heavy smokers were excluded from the study, even lighter past smokers had a three-fold increased risk for abnormal sperm concentration.

A number of mechanisms may explain these findings. For one, emission of RF-EMR has both thermal and non-thermal effects. However; there is no consensus as to which effects predominate (Dasdag et al., 2003; Weisbrot et al., 2003). RF-EMR emitted by cell phones can induce DNA damage to spermatozoa, may affect sperm motility and may correlate with sperm chromatin damage (Davoudi et al., 2002; Giwercman et al., 2003). Studies of military personnel who self-reported exposure to RF-EMR showed an elevated risk for infertility, compared with those who did not (Baste et al., 2008). Similar findings were described recently (Gorpinchenko et al., 2014). This mechanism may be explained in the light of long-term use of cell phones, as an RF-EMR-mediated reduction in spermatogenesis and thus lower sperm concentration. In-vitro studies on mice suggested that Leydig cells are among the most susceptible cells to RF-EMR, a mechanism that may also explain the effect on spermatogenesis (Wang et al., 2003). RF-EMR may cause an increased body temperature, particularly in the groin, and thus cause disruption of spermatogenesis (Jung and Schill, 2000; Kandeel and Swerdloff, 1988). RF-EMR waves emitted from cell phones may lead to oxidative stress in human sperm (Agarwal et al., 2009; Erogul et al., 2006), which causes DNA fragmentation in somatic cells (Sun et al., 1997).The latter may serve as a common postulated pathway to the above-mentioned mechanisms.

According to the WHO 2010 criteria, ≥4% morphologically normal sperm is defined as normal. As only one participant had abnormal sperm morphology in this study, this parameter was not analysed. For most of the existing data on the effect of RF-EMR on sperm morphology, semen analysis was carried out according to the WHO 1999 criteria, in which the lower limit for normal sperm morphology was ≥14%. This may explain the difference in prevalence of abnormal sperm morphology between this study and earlier reports (Agarwal et al., 2009; Gutschi et al., 2011; Wdowiak et al., 2007). While Fejes et al. (2005) found no association with sperm concentration, this study showed an effect on sperm concentration but no effect on sperm progressive motility. The difference between these findings may be due to the change in definition of sperm count in the recent WHO criteria 2010.

Similar to this study, four other reports have used questionnaires to address cell phone usage and possible associations with sperm quality. In their assessment of 304 males, Wdowiak et al. (2007) classified and analysed the study population according to three categories of cell phone usage: non-users, sporadic users for a period of 1–2 years and regular users for >2 years. Analysis of sperm quality was also based solely on users and non-users, although in a much larger population (Gutschi et al., 2011). In the study by Agarwal et al. (2008), participants were classified by users versus non users. The user category was further subdivided according to one aspect of usage: daily talking duration (<2 h/day, 2–4 h/day and >4 h/day). They found that daily use ≥4 h was associated with abnormal sperm count (Agarwal et al., 2008). Fejes et al. (2005) considered three aspects of cell phone usage: duration of possession (in months), daily standby possession (in centimetres) and daily transmission time (in minutes). They reported changes in the characteristics of motile sperm, but no change in the total motility. This study separately addressed 13 distinct aspects of cell phone usage, including duration of possession, number of devices used and duration of daily use, distance held from the groin and talking while charging the device. This wide spectrum of usage aspects is, in our opinion, one of the unique merits of the work.

This study has several limitations. The use of self-reported questionnaires raises the possibility of information bias. In addition, cell phone types/models were not determined, nor was distance from cell phone towers. Different devices may emit different specific RF-EMR, which may result in differences in specific absorption rates (SAR). Body mass index of the study participants was not recorded, though this variable may affect the amount of absorbed radiation. The fact that participants were recruited from a fertility clinic and not from the general population raises the possibility of a selection bias. The limited sample size did not enable analysis of an effect of RF-EMR on sperm morphology, and calls for cautious interpretation of the findings regarding the other parameters.

It was found that talking on a cell phone for more than one hour daily and while it is being charged are associated with low sperm concentration. A possible negative influence from carrying the device near the groin also warrants attention. Talking while charging and smoking may adversely affect sperm concentration.

In conclusion, the findings of this study suggest that a few small changes in cell phone usage, such as avoidance of talking while it is being charged, reducing the total time of conversations and keeping the device away from the groin may be highly beneficial for men seeking fertility. From a practical point of view, men who seek fertility are advised to turn off their devices while charging or, if not possible, to keep the device at least 50 cm from the groin during daily activities and while sleeping. Users are advised to carry the device a distance from the groin, for example in the shirt pocket, and to talk using earphones or to use a speaker whenever possible. A large scale study is needed to a ssess these and other possible effects of cell phone usage on sperm quality.

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