**Research article**

# Smart phones and the sperm: Do smartphones have an effect on semen parameters-An analytical cross-sectional study in an Indian tertiary care center

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## ABSTRACT

**Introduction and Aim:** Cell phones are an essential part of our daily life. The effect of the electromagnetic radiation emitted by smart phones on male infertility is unclear and subject to debate. The objective of this study was to determine the effect of smartphone devices on semen parameters.

**Materials and Methods**: This was a cross-sectional prospective, analytical study conducted on 145 infertile men attending the Out-patient department of Father Muller Medical College Hospital. The participants were recruited through a questionnaire-based approach following an abstinence of minimum 3 days. A minimum of 1 ml of semen sample was collected by masturbation in a sterile container. The participants were divided into 2 groups (< 2 hours and >2 hours) based on the hours of mobile usage. The main outcome measures analyzed were volume, liquefaction time, pH, viscosity, sperm concentration, motility, viability, and sperm morphology.

**Results**: The mean age of the study participants was 35.31±5.70 years, with primary male infertility being the chief complaint in 96.6% (140 cases). Our study showed a statistically insignificant inverse correlation between the time spent on the phone in hours with sperm concentration and motility. A weak negative correlation was also seen with usage of phone over 5 years and normal morphology. All other parameters did not show any significant difference.

**Conclusion:** Our study failed to show any significant association between semen parameters and smartphone usage. However, a slight reduction in concentration, motility and normal morphology was observed which opens up avenues for future research.

**Keywords:** Semen parameters; male infertility; smartphones.

## INTRODUCTION

Approximately 10 to 15% couples of reproductive age in the world are affected by infertility, out of which 30 to 40% is due to "male factor" infertility (1). Infertility is inability to conceive after 1 or 2 years of regular unprotected intercourse. The causes for male infertility may be due to suboptimal production, abnormal morphology or transport abnormalities. Many factors are responsible for male infertility like alcohol (2), smoking (3), infections, heat and chemical agents (4).

Mobile phones have become an integral part of our daily life in the past few decades. It is low power, single channel, two-way radio and emits signals in the form of electromagnetic radiation (EMR). Mobile phones have an EMR at a frequency between 400-2700 MHz. Specific Absorption Rate (SAR) is a measure of the rate at which energy is absorbed per unit mass by a human body when exposed to a radio frequency (RF) electromagnetic field. Most mobile phones are nowadays in the range of 0.5-0.6W/kg, the limit of SAR being 1.6W/kg averaged over 1 gram of human tissue (5). In spite of the low absorption rate potential adverse effects on human beings have been documented both through thermal as well as non-thermal affects.

Studies done on humans and animal models have reported potential damaging effect on male reproductive system (6,7). Literature study reveals adverse effects of radiofrequency electromagnetic waves on endocrine system, heart and brain. EMR can alter brain electroencephalographic activity and cause sleep disturbances (8), fatigue and headache (9). It has been postulated that the human exposure to EMR can have adverse effects like increased resting blood pressure and reduced production of melatonin (10,11). Previous studies have shown a link between cell phone use and infertility (12-14). Significant effects on seminal parameters like sperm concentration, motility and morphology have been well documented. In spite of innumerable studies done previously by many scientists, the effect of mobile phone on semen parameters have been unclear. Also, most of the studies have been done on feature phones (basic/non-smart phones). However, we have made an attempt to analyse the effect on semen parameters due to the usage of modern smartphones.

## METHODOLOGY

This is a cross sectional prospective analytical study done on patients attending infertility clinic of a tertiary care hospital. The study was conducted after Institutional board review and ethical committee approval. Informed consent was obtained from all the participants. A questionnaire was given to the male patients with questions based on personal history including mobile phone usage, past medical history, treatment history and occupation history.

### Inclusion criteria

Married male patients with failure to conceive for 12 months with regular unprotected intercourse were included in the study.

### Exclusion criteria

1) Male patients with inflammation /infection of the urogenital system, diabetes, hypertension, personal history of smoking and alcohol consumption and history of urogenital surgery.
2) Those using non-smart phones.
3) Patients with known female factor infertility were also excluded from the study.

### Sample collection and procedure for analysis

Participants who enrolled in the study followed a minimum of 3 days and a maximum of 7 days of sexual abstinence.1 ml of sample was collected in a sterile wide mouthed container after masturbation in a private room near the sample collection centre. All samples were processed within 60 - 90 minutes of collection. The semen analysis was done following liquefaction at room temperature as per the World Health Organization guidelines 2010. The following parameters were analysed: volume, liquefaction time, pH, viscosity, sperm motility, sperm concentration, viability and sperm morphology. For semen pH, litmus paper was used. Sperm motility was assessed as soon as possible after liquefaction of the sample, preferably at 30 minutes and analysed by clinical pathologist.

Wet mount preparation was done by placing a standard volume of semen, 10 microliter, onto a clean glass slide and covered with a coverslip. The slide was examined under microscope, lowering the condenser and the light. Approximately 200 spermatozoa were assessed for the percentage of different motile categories. The motility of each spermatozoon were graded as progressive (PR), nonprogressive (NP) and immotile (IM).

For sperm concentration, In general, 1 + 19 (1:20) dilution was used, and sperms were counted in the 4 large WBC squares of the improved Neubauer haemocytometer chamber. The 1:20 dilution was achieved by mixing 1 drop of the liquefied semen with 19 drops of the diluting fluid. The improved Neubauer haemocytometer chamber was loaded and spermatozoa were allowed to settle. The samples were assessed within 10-15 mins. under microscope and the concentration of spermatozoa per ml were calculated as per the following.

Sperm concentration per ml= Number of sperms counted x 50,000.

Viability was done using Eosin- Nigrosin staining and reported as percentage. The sample size was calculated based on the prevalence of infertility which affects 8-12% of married couples (15). The sample size was calculated using the equation $n = z^2 pq /d^2$ . Where 'n' stands for sample size, 'z' is the value of the 95% confidence level=1.96, 'p' is the estimated prevalence of infertility=10.5%, q=1-p and 'd' is the margin of error=5%. Thus, the sample size required was: $n=(1.96)^2 (0.105) (0.895)/(0.05)^2 = 145$.

Semen was analysed for sperm concentration, motility, viability, and percentage normal morphology (16). The clinical pathologist analysing the semen samples were blinded to the use of cell phones by the subjects.

### Statistical analysis

Descriptive statistics was calculated as mean, standard deviation for age, time spent on phone per day and duration of use. Median and interquartile range was calculated for data which did not follow normal distribution. Spearman's rank correlation and Mann Whitney test was used to test for statistical significance. Statistical analysis was done using the software IBM SPSS, Version 22.0 (Armonk, NY: IBM Corp). $P< 0.05$ was considered to be significant.

## RESULTS

A total of 145 participants were taken in this study, the mean age of the study population being 35.31 ± 5.70 yrs. Primary infertility was the chief complaint in 96.6% (140 cases) and 3.4% (5 cases) complained of secondary infertility. Mean of the time spent on cell phone was 2.1± 1.10 hrs. and duration of use was 5.14 ± 2.29 yrs.

The respondents who used cell phone for < 2 hrs were 44% (64 cases) and those who used the cell phone > 2 hrs were 56% (81 cases). Mobile data was used by 80% (116 cases) of the participants.15% (22 cases) of the participants admitted to using cell phone while charging the battery. Telecommunication tower was within 1 km proximity of their domicile in 11% (16 cases). Mobile phone was kept in the trouser pocket in 75% (109 cases) and in the shirt pocket in 25% (36 cases).

The mean values and frequencies of the study participant's semen quality are presented in Tables 1 and 2. The median [interquartile range] sperm

concentration is 15.25 [2.5, 60], motility is 60 [ 30, 78.75] (Table 1). Majority of the participants showed normal viscosity, liquefaction time and morphology (Table 2). There was a weak positive correlation between age and neck defect, tail defect, however this was not statistically significant (Table 3)**.** Our study showed a weak negative or inverse correlation between time spent on phone per day in hours and sperm concentration and motility (Table 3) but it was not statistically significant. Median [IQR] of normal morphology is 60 [50, 70.5] in more than 2 hours' group spent on mobile phone per day compared to 70 [50,80] in less than 2 hours' group and it is statistically significant. Other parameters did not differ significantly (Table 4).

There was a weak negative correlation between time spent and normal morphology with usage of smartphones over 5 years (correlation coefficient= -0.211, P=0.011; Table 3). Median value of sperm concentration and live sperms reduced in more than 5 years of mobile use. It did not differ significantly between less than 5 years and more than 5 years of mobile use (P>0.05; Table 5).

**Table 1:** Mean (SD) and Median (IQR) of the study participants' semen parameters

| **Variable** | **Mean ±SD** | **Minimum, Maximum** |
|---|---|---|
| **Sperm concentration (million/ml)** | 31.72 ±33.75 | 0.00, 130.00 |
| **Volume (ml)** | 1.58 ± 0.61 | 1.00, 3.00 |
| **pH** | 8.00 ±7.30 | 7.20, 8.10 |
| **Sperm motility** | | |
| Progressively motile (PR)% | 38.12 ±27.4 | 0.00, 90.00 |
| Non-progressively motile (NPR)% | 13.46 ±9.90 | 0.00, 75.00 |
| Immotile% | 38.48 ±27.2 | 0.00,100.00 |
| | **Median** | **IQR** |
| **Sperm Concentration** | 15.25 | 2.50, 60.00 |
| **Motility** | 60.00 | 30.00, 78.75 |
| **Normal morphology** | 70.00 | 50.00, 79.00 |
| **Neck defects** | 8.00 | 5.00, 10.00 |
| **Head defects** | 10.00 | 5.25, 17.75 |
| **Tail defects** | 5.00 | 3.00, 10.00 |
| **Live sperms** | 60.00 | 40.00, 79.00 |
| **Dead sperms** | 30.00 | 15.00, 50.00 |

**Table 2:** Frequency (%) of the study participants' semen parameters

| **Viscosity** | **N** | **%** |
|---|---|---|
| Normal | 113 | 77.9 |
| Abnormal | 32 | 22.1 |
| **Liquefaction time** | | |
| Complete within 20 minutes | 120 | 82.8 |
| Incomplete within 20 minutes | 25 | 17.2 |
| **Sperm** concentration **(million)** | | |
| < 15 | 98 | 67.6 |
| >15 | 57 | 39.4 |
| **Morphology** | | |
| Normal | 133 | 91.7 |
| Abnormal | 12 | 8.3 |

**Table 3:** Correlation of age, time spent, duration of use of mobile with semen parameters

| | | Concentration | Motility | Normal morphology | Neck defect | Head defect | Tail defect | Live sperm | Dead sperm |
|---|---|---|---|---|---|---|---|---|---|
| Age | Correlation Coefficient | -0.110 | -0.099 | -0.122 | -0.054 | -0.068 | -0.073 | -0.107 | -0.050 |
| | P | 0.188 | 0.237 | 0.146 | 0.522 | 0.418 | 0.384 | 0.204 | 0.554 |
| Time spent on phone per day | Correlation Coefficient | -0.072 | -0.121 | -0.211* | -0.075 | 0.025 | -0.033 | 0.004 | -0.143 |
| | P | 0.390 | 0.148 | 0.011 | 0.375 | 0.769 | 0.691 | 0.961 | 0.087 |
| Duration of use (yrs) | Correlation Coefficient | -0.043 | 0.008 | 0.082 | -0.086 | -0.117 | 0.120 | -0.073 | 0.047 |
| | P | 0.607 | 0.924 | 0.328 | 0.306 | 0.164 | 0.153 | 0.383 | 0.580 |

**Table 4:** Semen quality parameters based on time spent on the mobile phones per day

| | Time spent per day | Median | IQR | P |
|---|---|---|---|---|
| Sperm concentration | <=2hrs | 17.00 | 4.00, 65.00 | 0.255 |
| | >2hrs | 15.00 | 1.50, 52.50 | |
| Motility | <=2hrs | 60.00 | 30.00, 80.00 | 0.084 |
| | >2hrs | 60.00 | 10.00,72.50 | |
| Normal morphology | <=2hrs | 70.00 | 50.00,80.00 | 0.005 |
| | >2hrs | 60.00 | 50.00,70.50 | |
| Neck defect | <=2hrs | 8.00 | 5.00,10.00 | 0.798 |
| | >2hrs | 9.00 | 3.50,10.00 | |
| Head defect | <=2hrs | 10.00 | 5.00,17.00 | 0.726 |
| | >2hrs | 10.00 | 7.00,20.00 | |
| Tail defect | <=2hrs | 5.00 | 3.00,10.00 | 0.503 |
| | >2hrs | 5.00 | 3.00,11.00 | |
| Live sperms | <=2hrs | 60.00 | 40.00,80.00 | 0.546 |
| | >2hrs | 60.00 | 25.00,78.50 | |
| Dead sperms | <=2hrs | 25.00 | 15.00,50.00 | 0.341 |
| | >2hrs | 32.00 | 10.00,45.00 | |

**Table 5:** Duration of phone use in years

| Parameters | Duration | Median | IQR | P |
|---|---|---|---|---|
| Sperm concentration | <=5yrs | 23.00 | 2.25,65.00 | 0.411 |
| | >5yrs | 12.00 | 3.00,50.00 | |
| Motility | <=5yrs | 60.00 | 26.00,77.50 | 0.994 |
| | >5yrs | 60.00 | 30.00,80.00 | |
| Normal | <=5yrs | 67.00 | 40.00,76.50 | 0.294 |
| | >5yrs | 70.00 | 50.00,80.00 | |
| Neck | <=5yrs | 8.00 | 5.00,10.00 | 0.271 |
| | >5yrs | 6.00 | 4.00,10.00 | |
| Head | <=5yrs | 10.00 | 7.00,20.00 | 0.166 |
| | >5yrs | 10.00 | 5.00,15.00 | |
| Tail | <=5yrs | 5.00 | 3.00,10.00 | 0.308 |
| | >5yrs | 8.00 | 3.00,10.00 | |
| Live | <=5yrs | 64.00 | 40.00,80.00 | 0.307 |
| | >5yrs | 60.00 | 40.00,75.00 | |
| Dead | <=5yrs | 30.00 | 15.00,42.50 | 0.614 |
| | >5yrs | 31.00 | 12.00,50.00 | |

## DISCUSSION

By 2020, there were over 3.5 billion smart phone users i.e., 44.69% of the world population owned a smart phone. Radiations are not good for human body. Hence smartphones with low SAR values are always safer. Most countries have their limitations for the SAR value. Most smartphones have an SAR value between 0.25W/kg to 1.19W/kg. In India the SAR limit is fixed at 1.6w/kg (5).

Although many researchers have investigated the effect of mobile phone usage, the results have been inconsistent. Also most of these studies were done on non-smartphones. In our study we aimed to study the effect of smartphones on semen parameters based on hours and duration of usage. We found a reduction in sperm concentration and motility as the duration of phone usage increased in hours. However, this finding was not statistically significant. Also there was a slight reduction in normal morphology over 5 year's duration but it was not significant. There was no difference observed in other parameters.

According to El Helaly *et al.,* cell phone use of more than one hour lowered the semen volume, vitality and morphological index (17). A cross sectional study done by Al Bayyari on 159 men attending fertility

clinic in Jordan revealed differences in sperm concentration, volume, viscosity, motility and abnormal morphology (18). These findings too were not statistically significant. Both the studies do not reveal the type of phones included in their study design. Similar findings have also been reported by Gutschi *et al.,* Rago *et al.,* and Feijo *et al.,(*19-21).

However, a few other researchers derived at results discordant to this study. Agarwal *et al.,* divided 361 male patients undergoing infertility evaluation into 4 groups according to their active phone usage from no use to more than 4 hours of usage. They reported a significant reduction in sperm concentration, viability, motility and normal morphology with an increase in daily use of cell phone (12). Fejes *et al.*, reported a significant negative correlation with cell phone usage and proportion of rapid progressive motile sperms and positive correlation with proportion of slow progressive motile sperms (13). Al-Chalabi and Al - Wattar concluded that a decrease in concentration, motility and normal morphology is correlated with duration of mobile phone use (22).

Spermatogenesis takes place in the testis at a temperature 3°degree lower than the body temperature. Any increase in testicular temperature due to cryptorchidism and varicocoele can affect spermatogenesis. Mobile phones kept in the trouser pocket may affect spermatogenesis by increasing the local body temperature. According to a study done on effect of mobile phone over various body parts, those who kept their cell phone in their trouser pockets had lower sperm motility compared to those who kept their cell phone in their waist pouch, shirt pocket or in hands (17). Al-Chalabi and Al- Wattar, Agarwal *et al.*, and Kilgallon *et al.,* concluded that keeping cell phones in the trouser pocket negatively affect spermatozoa (22-24). In our study we did not attempt to study the effect of mobile phone use in relation to various body parts.

Electromagnetic exposure can reduce serum testosterone levels by affecting Leydig cell function, shrink the seminiferous tubules and reduce sperm motility and concentration (24). Mobile phone radiation increases hydroxyl free radical formation in the testicular cells via Fenton reaction and causes cellular damage in the testis. Kesari *et al.,* suggested a possible correlation between mobile phone exposure, reactive oxygen species formation and tumour progression (24).

The results of this study should be interpreted with caution due to the limitation which include recall bias on the part of respondents, small sample size and considering SAR of individual mobile phone models, occupation and environmental factors were not taken into consideration.

## CONCLUSION

In conclusion, our study failed to show any significant difference in semen parameters in association with smartphone usage. However due to slight reduction in sperm concentration, motility and normal morphology though not significant should be investigated further over a larger sample size using longitudinal study design and also in correlation with male fertility hormones like testosterone, luteinizing hormone and follicle stimulating hormone. Hence our study opens up avenues for future studies on the same subject.

## CONFLICT OF INTEREST

No conflict of interest.

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