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Research Article

Effect of Electromagnetic Radiation on Semen Parameters Among Males Seeking Infertility Treatment: A Cross-Sectional Observational Study

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Abstract:

Aim:

To evaluate the effect of electromagnetic radiation on semen parameters among males seeking infertility treatment

Materials and Methods: A cross-sectional study conducted at tertiary centre from May2024 to April2025 after ethical approval (AIIMSA1273/03.05.2024). Males between 21-42years who consulted for infertility were included. Males who were having systemic diseases, history of chemo/radiotherapy/malignancy, not willing to participate, or not able to give sample were excluded. All recruited participants were asked to fill questionnaire and followed by semen-analysis. Outcomes were effect of duration of mobile phones usage/day, effect of frequency of mobile phone use/day, position of mobile phone, internet usage/day and total duration of mobile phone use and residence proximity to telecommunication tower on semen quality. Statistical analyses were performed using Stata-16 (TX,USA).

Results:

All semen analyses were carried out according to WHO guidelines(6thEdition). Mean age of participants was 33.04 ±4.93years. According to analysis, there were significant differences among different groups of daily mobile phone use time in terms of total sperm count, total motility, progressive motility, abnormal morphology and vitality with overall p=<0.001. Bonferroni pairwise comparison showed significant differences in abnormal morphology Pa=1.00, Pb=1.00, Pc=0.001 and Pd=0.001 for <10times/day vs ≥10 to ≤20times/day, <10times vs >20 to ≤40 times/day, <10 times vs ≥40 to ≤ 60 times/day respectively. By keeping smart phones in trouser pocket, there was significant decline in morphology(p=0.001) and vitality(p= 0.004). Residence within 1Kilometer of telecommunication tower led to significant differences in abnormal morphology(p=0.005). Bonferroni pairwise comparison showed significant differences in the abnormal morphology Pa= 0.002, Pb=0.001, Pc=0.001 and Pd=0.001 for <30minutes/day vs ≥30mitutes to <1hour/day, <30minutes vs ≥1 to ≤3hours/day, <30minutes vs >3 to ≤ 6hours/day, <30minutes vs >6hours/day respectively. There were significant differences in the progressive motility(p= 0.03), head defect (p= 0.001), and vitality(p= 0.007) among four different groups of total duration of mobile phone usage in whole life.

Conclusion: We suggest that average daily cell phone use duration may affect sperm parameters. Therefore, we recommend that men should avoid prolonged usage of mobile phones for calls, message or internet, keep the device away from the groin and stay 1kilometer away from telecommunication tower to preserve their fertility.

Keywords: mobile phone, radiofrequency-electromagnetic waves, semen parameters, infertility, telecommunication towers

Introduction

According to International Committee for Monitoring Assisted Reproductive Technology (ICMART) and World Health Organization (WHO), infertility is disease characterized by inability in achieving a pregnancy after 12months of timed unprotected sexual intercourse [1]. More than 186million people worldwide suffer from infertility. Between 8-12% of couples of childbearing age are affected by infertility [1]. In 2019, global prevalence of male infertility was estimated to be 56million reflecting a substantial 76.9% increase since 1990. Regions with highest male infertility in 2019 were

Western Sub-Saharan Africa, Eastern-Europe, and East-Asia. Prevalence and male infertility peaked in 30–34year age-group worldwide [2].

The rapid decline in global fertility rates in recent decades has occurred alongside decreasing sperm count and quality suggesting that decline in fertility may be due to decreasing sperm quality [3]. A systematic review examining time frame of nearly 40years, showed significant decrease in sperm concentration (113million/ml to 66million/ml) and semen volume (3.40ml to 2.75ml) over evaluated timespan [1]. Based on study in 2017; identified a significant decrease between 1980 and 2015, declining from 91.65million/ml to 39.34million/ml (r=−.313,p-0.0002). This reflected an approximate 57% abatement in sperm count worldwide since 1980 [4]. Studies have also suggested that prolonged use of mobile phones and wearing of tight underwear also impact negatively on semen parameters and DNA integrity [5].

Mechanism by which lifestyle and environmental factors reduce quality of sperms is not fully understood; however, there are studies that suggest disruption of endocrine function, aberrant DNA methylation in sperm, abnormal seminal plasma zinc levels, and morphological damage to sperms [6-8]. Recent publication has shown several genes linked to fertility, and mutations to these single genes lead to low sperm quality [9]. Phones are emitting RF-EMWs (Radiofrequency-Electromagnetic Waves) which are having thermal and non-thermal effect on spermatogenesis. Some studies have suggested that EMWs can affect membrane fluidity and ability of sperm to interact with oocyte, thereby diminishing probability of fertilisation. In addition to oxidative damage, other hypotheses include alteration of cellular metabolism and possible epigenetic modifications of spermatozoa. EMFs could affect gene expression and DNA methylation, leading to changes in sperm function [6]. However, these mechanisms require further investigation to be fully understood.

There has been significant increase in amount of time spent using different devices emitting RF-EMWs. It was interesting to note that many subfertile males were using these devices so often. Therefore, we wanted to find if there is a causal association between use of RF-EMWs devices and changes in semen parameters.

2.Material and Methods

2.1 Study Design:

It was cross-sectional study conducted at tertiary centre from May 2024 till April 2025 after approval from Institutional Ethics Committee(IEC) with reference number AIIMSA1273/03.05.2024 and informed consent from participants. This study was conducted as per Helsinki Declaration. Male partners between 21-42years who consulted for infertility and planned for semen analysis were included. Males who were having systemic diseases, history of chemo/radiotherapy/malignancy, not willing to participate, or not able to give sample were excluded. All recruited participants were asked to fill questionnaire and followed by semen analysis. Subjects were enrolled after inclusion and exclusion criteria during span of 1year attending infertility clinic in tertiary center.

2.2 Semen collection and analysis:

As per table-1; semen quality was assessed using four parameters: concentration, motility and morphology, and vitality according to WHO Criteria (6th edition,2021) i.e., concentration ≥15×106/ml, total sperm count 39×106/ejaculate, total motility 42%, progressive motility ≥30%, vitality ≥54% and ≥4% of normal forms. These were accepted as normal values.

- Sample was collected after 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 following parameters were analysed: Sperm motility, sperm concentration, viability and sperm morphology
- Sperm motility assessed as soon as possible after liquefaction of the sample, preferably at 30 minutes.
- Wet mount preparation was formed by placing a standard volume of semen, 10 microliter, onto a clean glass slide and covered with a coverslip and will examine under microscope.
- Approximately 200 spermatozoa will be 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, 1 + 19 (1:20) dilution will be used, and sperms will be counted in the 4 large WBC squares of the improved Neubauer haemocytometer chamber. The 1:20 dilution will be achieved by mixing 1 drop of the liquefied semen with 19 drops of the diluting fluid.
- Sperm concentration per ml= Number of sperms counted x 50,000.
- Viability will be checked by using Eosin-Nigrosine staining and reported as percentage.

Table 1: Sample collection and analysis protocol

2.3 Questionnaire:

A self-designed questionnaire was used in study as per table-2. Questionnaire was completed before semen extraction, and answers were collected and reviewed by same researcher.

- Questionnaire consisted of two parts: basic demographic information and habits of mobile phone usage.
- Subjects were divided into different groups according to habits of mobile phone usage, such as duration of mobile phone use per day (<1hour/day, ≥1 to ≤3hours/day, >3 to ≤6hours/day, ≥6hours/day).
- Frequency of mobile phone use per day (<10times/day, ≥10 to ≤20times/day, >20 to ≤40times/day, >40 to ≤ 60times/day and >60times/day).
- Position where mobile phone was carried (trouser pocket, shirt pocket or not in touch with body).
- Residence proximity to telecommunication tower (<1kilometre or ≥1kilometre).
- Internet usage per day (<30minutes/day, <30minutes/day to ≥1hour/day, ≥1 to ≤3hours/day, >3 to ≤6hours/day, ≥6hours/day).
- Total duration of mobile phone use in life (<10years, ≥10 to <20years, ≥20 to <30years, ≥30years).

Table 2: Questionnaire for study population

2.4 Outcomes:

Primary outcome was to assess effect of duration of mobile phones usage per day on semen parameters. Secondary outcomes were to assess effect of frequency of mobile phone usage per day, mobile phone position, internet usage per day; and total duration of mobile phone usage and residence proximity to telecommunication tower on semen quality.

3.Statistical analysis:

Statistical analyses were performed using Stata16 (Stata Corp LLC, College Station, TX, USA). Categorical variables were compared using Chi-square test or Fisher's exact test, as appropriate. Continuous variables were analyzed using one-way ANOVA for normally distributed data or Kruskal-Wallis test for non-normally distributed data, followed by post-hoc comparisons with Bonferroni test or Wilcoxon rank-sum test. P-value less than 0.05 was considered statistically significant. All tests were two-tailed.

4.Results

All semen analyses were carried out according to WHO guidelines applicable at time of publication (WHO;2021). Figure-1 is showing flow diagram for study.

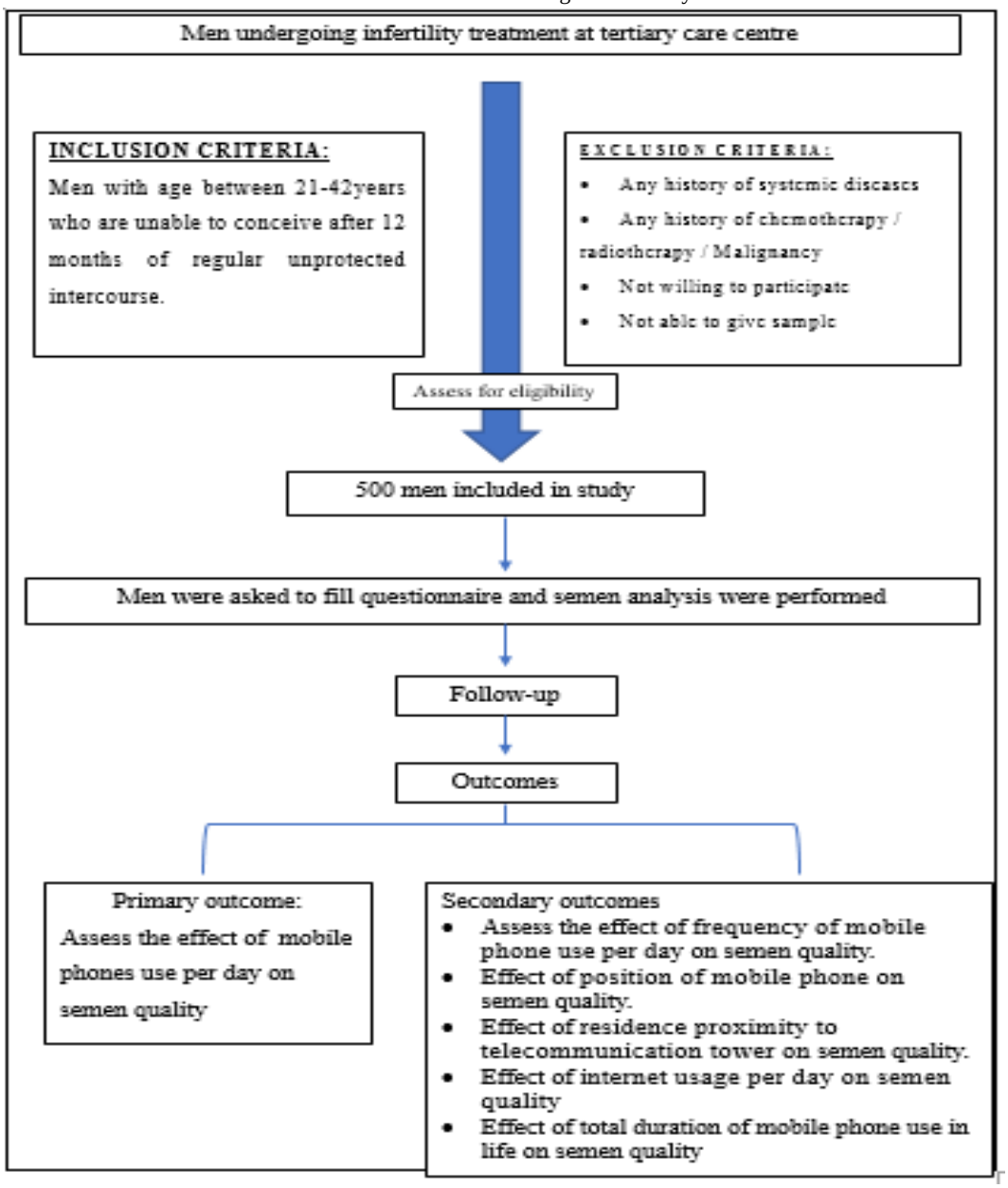

Figure 1: Flow diagram for study

4.1 Demography of Study Participants:

Total 500 men between ages of 21-42years were recruited into study. Mean age of participants was 33.04±4.93years. As shown in table-3, largest age group was 31-35years comprising 46.20%, whereas least age group represented was 21-25 years of age 0.80%.

Age Groups (in years)	Frequency (Number)	Percentage (%)
21-25	4	0.80
26-30	121	24.20
31-35	231	46.20
36-40	112	22.40
41-42	32	6.40
Total	500	100

Table 3: Age distribution of participants

4.2 Effect of daily mobile phone usage time on semen parameters:

According to analysis, there were significant differences among different groups of daily mobile phone use time in terms of total sperm count, total motility, progressive motility, abnormal morphology and vitality with overall p-value <0.001. Bonferroni pairwise comparison showed that with increase in mobile phone usage led to progressively compromised semen quality which is shown in table-4 and figure-2.

Parameter	Group-1 Duration <1hour (N=71)	Group-2 Duration ≥1 To ≤3hours (N=116)	Group-3 Duration >3 To ≤ 6hours (N=64)	Group-4 Duration >6 Hours (N=249)	Overall-p-Value	Bonferroni Group-wise comparisons		
						Pa	Pb	Pc
Total Sperm Count (TSC, X10⁶)	244.5 ± 155.0	154.2 ± 75.1	150.6 ± 73.0	117.7 ± 107.5	0.001	0.990	0.05	0.001
Concentration (X10⁶/ml)	96.2 ± 65.5	56.6 ± 31.2	58.1 ± 41.7	47.8 ± 41.2	0.001	0.001	0.001	0.001
Total Motility (%)	60.3 ± 13.8	60.3 ± 13.0	52.6 ± 20.7	51.4 ± 17.9	0.001	1.00	0.05	0.001
Progressive Motility (%)	48.5 ± 15.5	48.4 ± 14.4	46.9 ± 18.9	34.1 ± 18.9	0.001	1.00	1.00	0.001
Abnormal Morphology (%)	83.9 ± 10.7	85.4 ± 15.7	96.5 ± 4.5	98.0 ± 2.2	0.001	1.00	0.001	0.001
Head Defect (%)	72.9 ± 25.4	76.0 ± 25.6	86.8 ± 26.8	94.5 ± 6.9	0.001	1.00	0.001	0.001
Midpiece Defect (%)	18.7 ± 18.8	12.1 ± 13.8	6.4 ± 9.0	20.9 ± 19.6	0.001	0.001	0.001	0.17
Excess Cytoplasm Defect (%)	2.1 ± 2.4	2.4 ± 3.1	1.3 ± 2.0	2.7 ± 2.9	0.001	0.37	0.009	0.09
Tail Defect (%)	10.3 ± 6.1	7.7 ± 6.6	8.8 ± 7.8	9.1 ± 7.7	0.008	0.001	0.01	0.03
Vitality (%)	73.7 ± 12.1	61.0 ± 15.3	46.3 ± 22.3	45.4 ± 17.4	0.001	0.001	0.001	0.001

Table 4: Duration of mobile phone usage per day on semen parameters

Notes:

- Values Are Presented As Mean ± SD
- One way **ANOVA:** p-value =Significant group effect on outcome ($p < 0.05$)
- **Bonferroni groupwise comparisons:** Pa = p-value for Group 1 vs Group 2; Pb= p-value for Group 1 vs Group 3; Pc= p-value for Group 1 vs Group 4

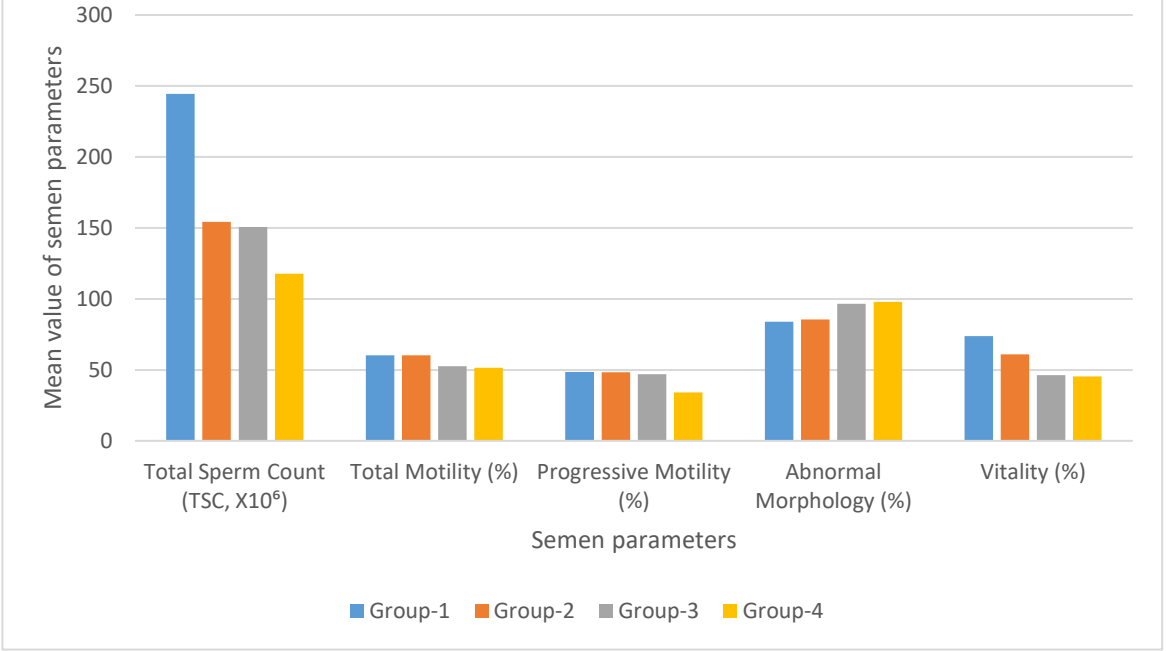

Figure 2.1: Effect of duration of mobile phone use per day on TSC, total motility, progressive motility, abnormal morphology, and vitality

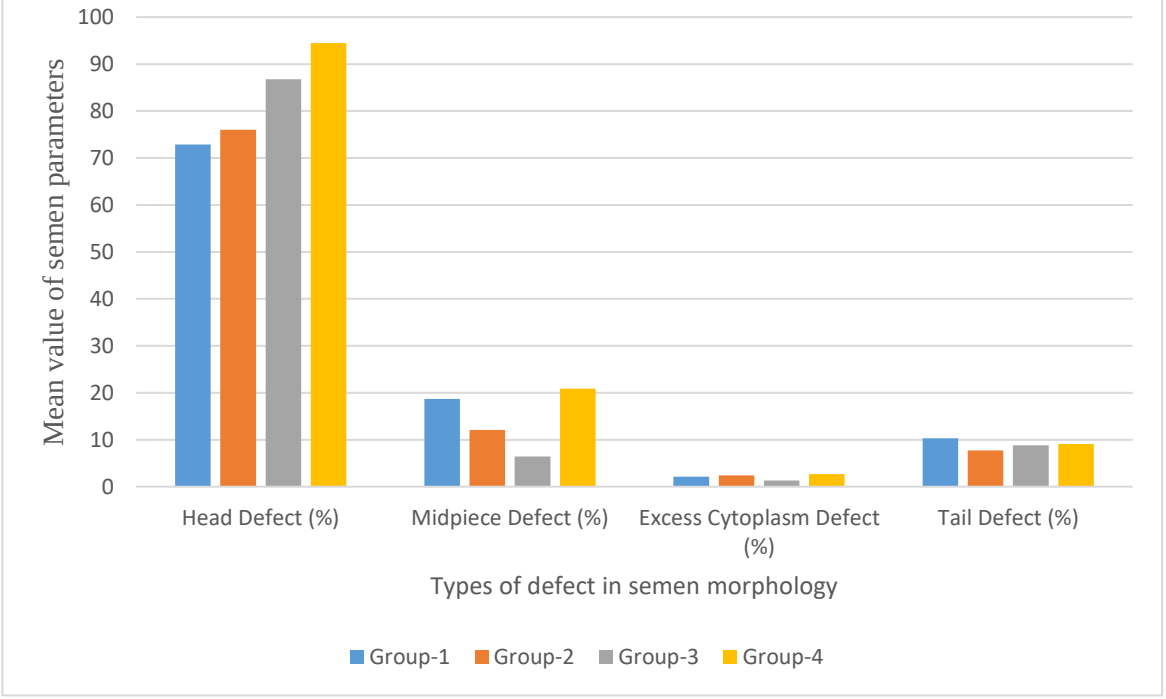

Figure 2.2: Effect of duration of mobile phone use per day on semen morphology

Figure 2: Effect of duration of mobile phone use per day on semen parameters

Note: Usage of mobile phone per day (Group 1= <1 hour per day, group 2= ≥1 to ≤3 hours per day, group 3= >3 to ≤6 hours per day, group=4 ≥6 hours per day)

4.3 Effect of frequency of mobile phone use per day on semen parameters:

Table-5 and figure-3 shows that there were significant differences in semen parameters among five groups of different frequency of mobile phone use per day including total sperm count (p-value 0.001), total motility (p-value 0.001), progressive motility (p-value 0.001), abnormal morphology (p-value 0.001), and vitality (p-value 0.001). Bonferroni pairwise comparison showed significant differences in the abnormal morphology (Pa=1.00, Pb=1.00, Pc=0.001 and Pd=0.001 for <10 times per day vs ≥10 to ≤20 times per day, <10times vs >20 to ≤40 times per day, <10 times vs ≥40 to ≤ 60 times per day respectively.

Parameter	Group-1 <10times/day (N=15)	Group-2 ≥10 to ≤20 times/day (N=72)	Group-3 >20 to ≤40 times/day (N=81)	Group-4 ≥40 to ≤ 60 times/day (N=52)	Group-5 ≥60 times/day (N=280)	overall P-Value	Bonferroni groupwise comparisons			
							Pa	Pb	Pc	Pd
Total Sperm Count (X10⁶)	332.80 ± 107.53	195.02 ± 120.97	155.85 ± 99.45	100.22 ± 65.34	133.30± 109.76	0.001	0.001	0.001	0.001	0.001
Concentration (X10⁶/ML)	109.00 ± 62.47	80.39 ± 54.79	55.02 ± 36.22	49.38 ± 43.00	52.06± 42.98	0.001	0.001	0.001	0.001	0.001
Total Motility (%)	64.00 ± 19.97	59.57 ± 13.42	60.90 ± 11.95	51.71 ± 16.38	52.03± 18.60	0.001	1.00	1.00	0.13	0.07
Progressive Motility (%)	56.80 ± 17.18	46.19 ± 15.83	46.54 ± 16.35	43.15 ± 18.68	36.99± 19.13	0.001	0.41	0.45	0.10	0.001
Abnormal Morphology (%)	85.6±9.56	82.43 ± 12.14	85.58 ± 17.30	95.81 ± 4.82	97.56±2.68	0.001	1.00	1.00	0.001	0.001
Head Defect (%)	71.20 ± 32.91	69.21 ± 26.12	78.68 ± 25.24	87.25 ± 22.28	93.26±11.45	0.001	1.00	1.00	0.03	0.001
Midpiece Defect (%)	14.00 ± 17.12	12.36 ± 14.04	19.79 ± 18.71	13.25 ± 18.83	17.70±18.30	0.04	0.65	0.056	0.789	0.234
Excess Cytoplasm Defect (%)	0.80 ± 1.21	1.74 ± 2.14	3.21 ± 2.97	3.02 ± 4.00	2.29±2.67	0.001	0.23	0.01	0.01	0.04
Tail Defect (%)	13.60 ± 7.31	9.40 ± 6.79	8.16 ± 5.50	8.87 ± 6.83	8.77±7.86	0.11	0.09	0.05	0.10	0.09
Vitality (%)	77.20 ± 11.59	71.96 ± 15.43	57.30 ± 14.45	44.90 ± 22.23	47.36±17.92	0.001	1.00	0.001	0.001	0.001

Notes:

- Values Are Presented As Mean ± SD, Rounded To Two Decimal Places.
- One way **ANOVA:** p-value =Significant group effect on outcome ($p < 0.05$)
- **Bonferroni groupwise comparisons:** Pa = p-value for Group 1 vs Group 2; Pb= p-value for Group 1 vs Group 3; Pc= p-value for Group 1 vs Group 4, Pd= p-value for Group 1 vs Group 5

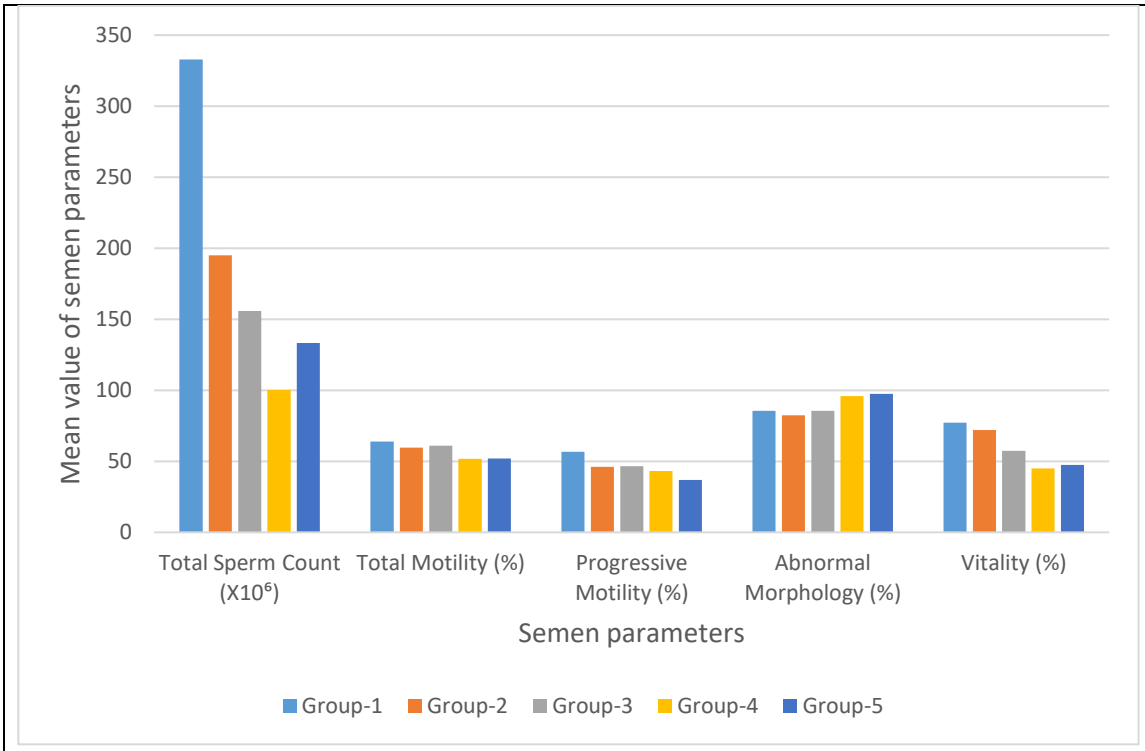

Figure 3.1: Effect of frequency of mobile phone usage per day on TSC, total motility, progressive motility, abnormal morphology, and vitality

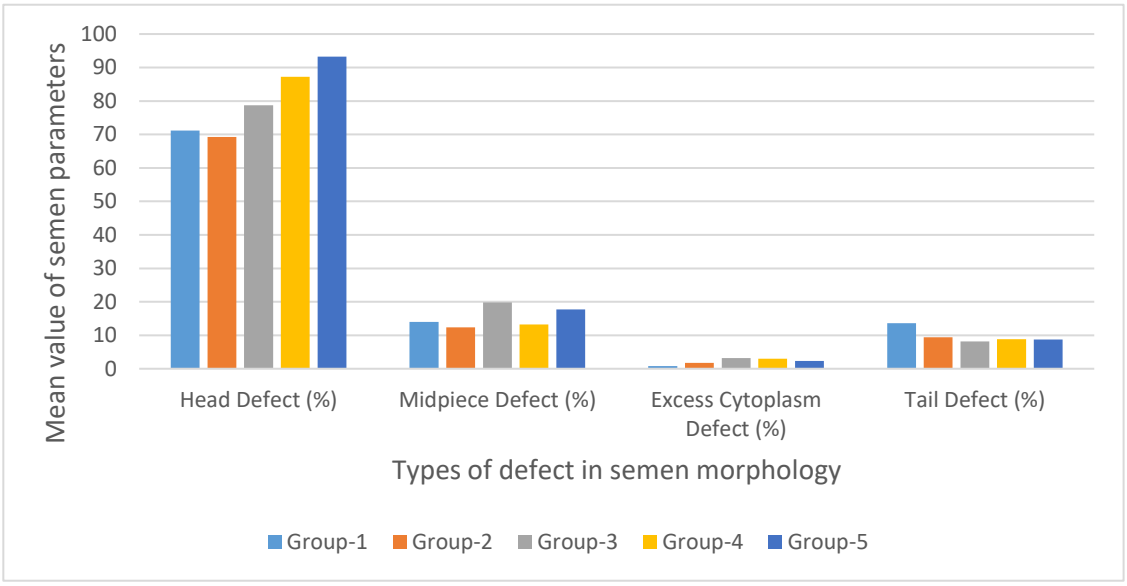

Figure 3.2: Effect of frequency of mobile phone usage per day on semen morphology

Figure 3: Effect of frequency of mobile phone use per day on semen parameters

Note: Frequency of mobile phone use per day; group 1= <10 times per day, group 2= ≥10 to ≤20 times per day, group 3= >20 to ≤40 times per day, group =4 >40 to ≤ 60 times per day, group 5= >60 times per day

4.4 Effect of mobile phone position on semen parameters:

As shown in table-6 and figure-4, there were significant differences in abnormal morphology (p-value 0.001) and vitality (p-value 0.004) when phones were kept in trouser pocket.

Parameters	Group-1 Trouser Pocket N=412	Group-2 Shirt Pocket N=10	Group-3 Not In Touch with Body N=78	p-value	Bonferroni groupwise comparisons	
					Pa	Pb
Total Sperm Count ($X10^6$)	144.96 ± 111.48	225.38 ± 180.86	156.63 ± 111.38	0.25	0.07	0.18
Concentration ($X10^6$/ml)	56.37 ± 43.12	85.40 ± 73.49	63.42 ± 56.77	0.50	0.12	0.42
Total Motility (%)	55.83 ± 17.10	61.80 ± 17.33	48.92 ± 16.94	0.002	0.82	0.003
Progressive Motility (%)	40.94 ± 18.89	51.60 ± 15.15	40.59 ± 18.48	0.68	0.22	1.00
Abnormal Morphology (%)	93.94 ± 9.80	82.00 ± 11.37	88.78 ± 13.89	0.001	0.001	0.001
Head Defect (%)	87.04 ± 20.27	79.60 ± 8.96	82.27 ± 24.91	0.001	0.80	0.20
Midpiece Defect (%)	17.58 ± 18.63	15.20 ± 16.32	12.23 ± 13.40	0.03	0.32	0.004
Excess Cytoplasm Defect (%)	2.28 ± 2.71	4.40 ± 2.95	2.71 ± 3.35	0.02	0.004	0.18
Tail Defect (%)	9.29 ± 7.57	8.60 ± 2.46	6.96 ± 5.71	0.01	0.33	0.001
Vitality (%)	52.69 ± 19.00	71.40 ± 13.13	53.23 ± 24.28	0.004	0.01	1.00

Table 6: Effect of position of mobile phone on semen parameters

- Values Are Presented As Mean ± SD, Rounded To Two Decimal Places.
- One way **ANOVA:** p-value =Significant group effect on outcome ($p < 0.05$)
- **Bonferroni groupwise comparisons:** Pa = p-value for Group 1 vs Group 2; Pb= p-value for Group 1 vs Group 3;

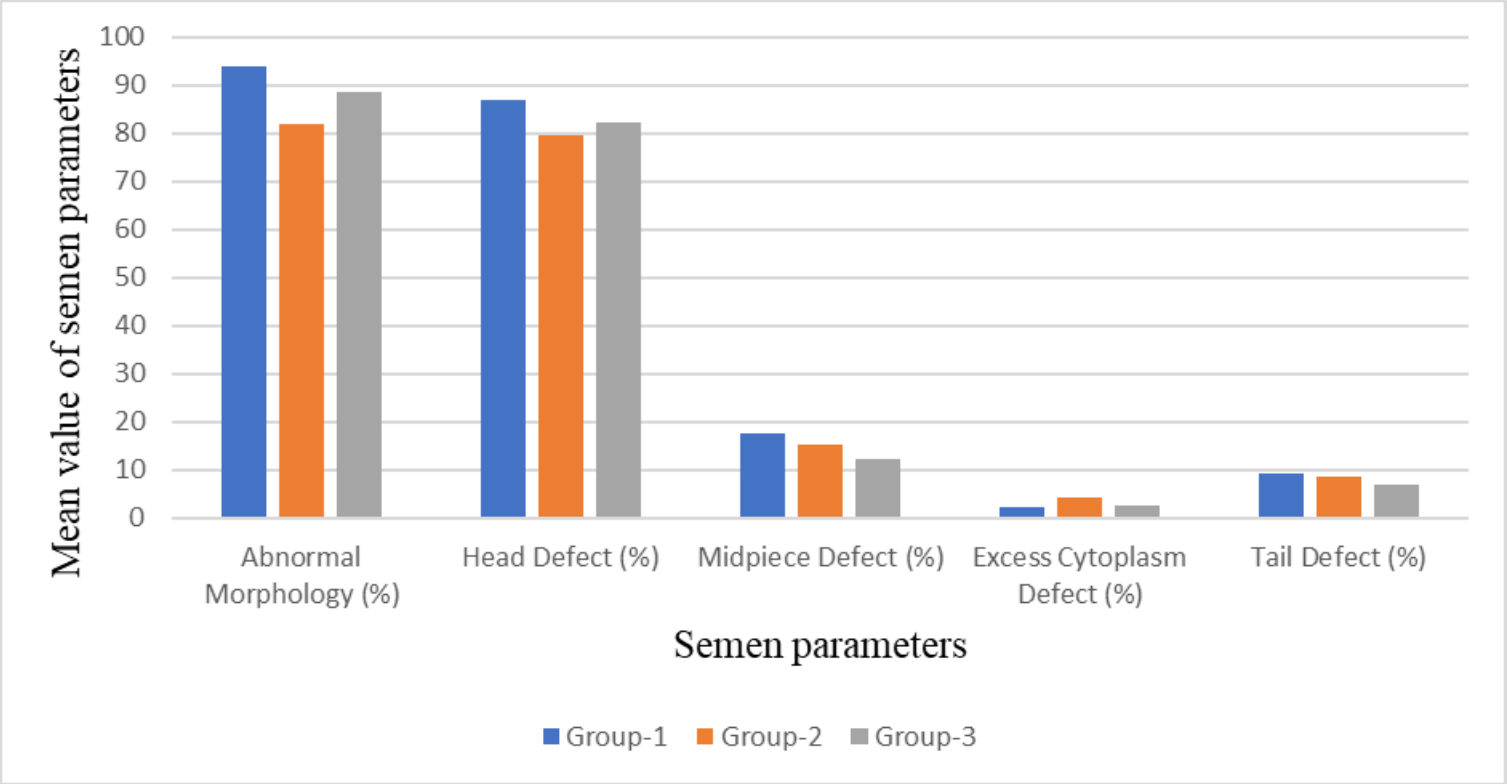

Figure 4: Effect Of Position of Mobile Phone on Semen Parameters

Note: Position Of Mobile Phone (Group 1= Trouser pocket, group 2= shirt pocket, group 3= not in touch with body)

4.5 Effect of proximity to telecommunication tower on semen parameters:

As shown in table-7, there were no differences among groups in the sperm concentration, total sperm number, total motility, progressive sperm motility, or vitality (p-value >0.05). However, there were significant differences in abnormal morphology (p-value 0.005) when residences were within 1kilometer to telecommunication tower.

Parameter	Group-1 <1 kilometer N=78	Group-2 ≥1 kilometer N=422	P-Value
Total Sperm Count ($X10^6$)	126.76 ±84.05	152.38 ±117.77	0.37
Concentration ($X10^6$/ml)	54.78 ±33.13	58.65 ±48.41	0.55
Total Motility (%)	54.28 ±18.64	54.99 ±17.01	0.74
Progressive Motility (%)	38.92 ±18.78	41.50 ±18.78	0.26
Abnormal Morphology (%)	96.78 ±4.34	92.18 ±11.49	0.005
Head Defect (%)	87.18 ±23.87	85.96 ±20.40	0.63
Midpiece Defect (%)	20.09 ±22.20	16.07 ±17.00	0.16
Excess Cytoplasm Defect (%)	2.31 ±2.66	2.41 ±2.87	0.89
Tail Defect (%)	7.99 ±5.83	9.09 ±7.51	0.26
Vitality (%)	53.37 ±20.16	53.11 ±19.94	0.91

Table 7: Effect of proximity to telecommunication tower on semen parameters

Notes: Values are presented as Mean ± SD, rounded to two decimal places

4.6 Effect of internet usage on semen parameters:

Table-8 and figure-5 shows that there were significant differences in semen parameters among groups of different internet use/day including total sperm count (p-value 0.001), total motility (p-value 0.001), progressive motility (p-value 0.001), abnormal morphology (p-value 0.001), and vitality (p-value 0.001). Bonferroni pairwise comparison showed significant differences in the abnormal morphology Pa= 0.002, Pb=0.001, Pc=0.001 and Pd=0.001 for <30minutes/day vs ≥30mitutes to <1hour/day, <30minutes vs ≥1 to ≤3hours/day, <30minutes vs >3 to ≤ 6hours/day, <30minutes vs >6hours/day respectively.

Parameters	Group-1 <30minutes (N=40)	Group-2 ≥30min To <1hour (N=128)	Group-3 ≥1 To ≤3hours (N=63)	Group-4 >3 To ≤ 6hours (N=62)	Group-5 >6 Hours (N=207)	Overall P-Value	Bonferroni Groupwise Comparisons			
							Pa	Pb	Pc	Pd
Total Sperm Count (X10^6)	243.05 ± 126.89	170.94 ± 116.64	158.08 ± 73.07	129.29 ± 114.36	118.92 ± 105.90	0.001	0.001	0.005	0.001	0.001
Concentration (X10^6/Ml)	85.05 ± 59.80	70.40 ± 50.92	54.13 ± 32.54	48.31 ± 40.46	49.30 ± 42.17	0.001	0.086	0.005	0.001	0.001
Total Motility (%)	55.40 ± 17.92	60.35 ± 12.36	53.29 ± 21.77	57.60 ± 17.83	51.06 ± 17.12	0.001	1.00	1.00	1.00	1.00
Progressive Motility (%)	44.98 ± 22.20	49.28 ± 11.59	43.29 ± 20.57	47.32 ± 19.57	32.75 ± 17.62	0.001	1.00	1.00	1.00	0.001
Non-Progressive Motility (%)	10.88 ± 11.59	11.09 ± 10.75	9.33 ± 10.82	8.56 ± 8.55	18.33 ± 15.74	0.001	0.17	0.33	0.37	0.003
Abnormal Morphology (%)	81.85 ± 11.52	88.20 ± 10.48	89.24 ± 18.87	97.53 ± 4.33	97.66 ± 2.72	0.001	0.002	0.001	0.001	0.001
Head Defect (%)	66.20 ± 31.40	82.03 ± 19.06	80.43 ± 27.84	92.03 ± 20.28	92.53 ± 12.23	0.001	0.001	0.003	0.001	0.001
Midpiece Defect (%)	10.58 ± 12.05	17.37 ± 17.52	5.24 ± 7.35	13.06 ± 13.44	22.03 ± 20.33	0.001	0.10	0.004	0.14	0.001
Excess Cytoplasm Defect (%)	0.80 ± 1.84	2.74 ± 3.08	1.67 ± 2.12	2.94 ± 3.38	2.54 ± 2.71	0.001	0.001	0.007	0.001	0.001
Tail Defect (%)	8.98 ± 6.24	8.41 ± 5.98	7.83 ± 8.20	9.85 ± 6.72	9.27 ± 8.03	0.89	0.31	0.034	0.28	0.47
Vitality (%)	74.88 ± 18.06	62.16 ± 16.73	48.63 ± 19.93	44.13 ± 17.90	47.46 ± 17.63	0.001	0.001	0.001	0.001	0.001

Table 8: Effect of internet usage on semen parameters

- Values Are Presented As Mean ± SD, Rounded To Two Decimal Places.
- One way **ANOVA:** p-value =Significant group effect on outcome ($p < 0.05$)
- **Bonferroni groupwise comparisons:** Pa = p-value for Group 1 vs Group 2; Pb= p-value for Group 1 vs Group 3; Pc= p-value for Group 1 vs Group 4, Pd= p-value for Group 1 vs Group 5

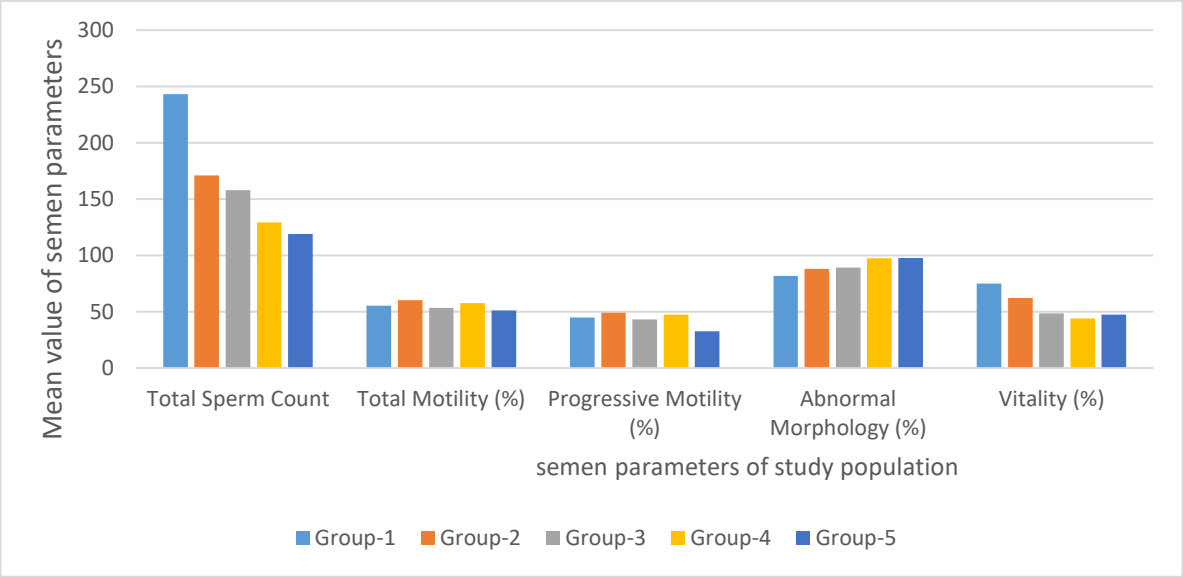

Figure 5.1: Effect of internet usage per day on TSC, total motility, progressive motility, abnormal morphology, and vitality

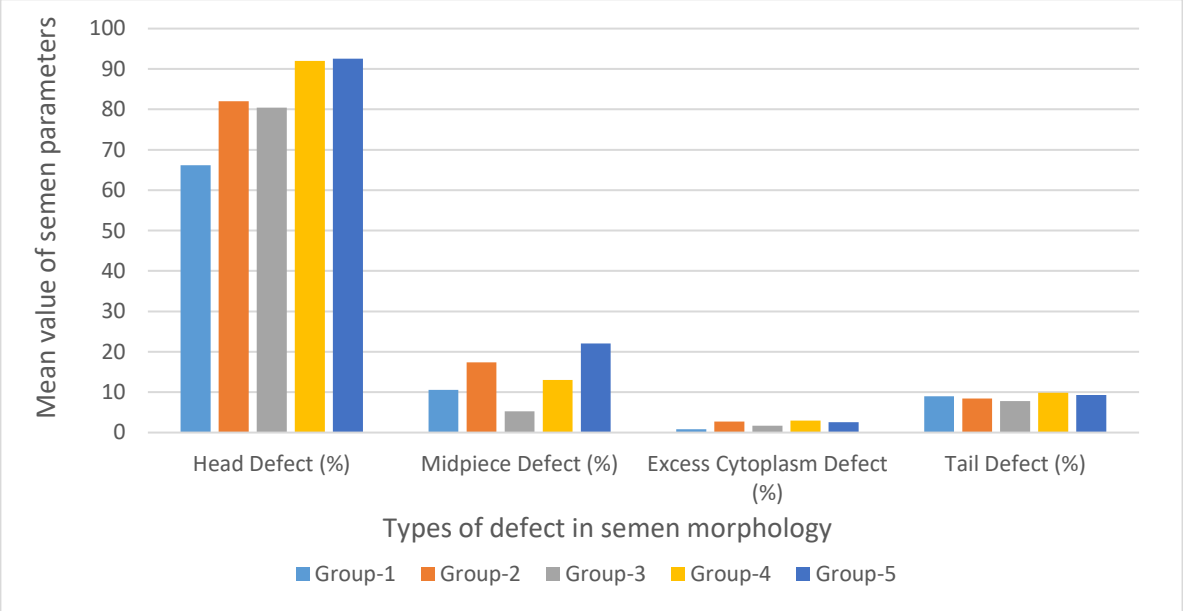

Figure 5.2: Effect of internet usage per day on semen morphology

Figure 5: Effect of internet usage per day on semen quality

Note: Internet usage per day (group 1= <30 minutes per day, group =2 <30 minutes per day to ≥1 hour per day, group 3= ≥1 to ≤3 hours per day, group 4= >3 to ≤6 hours per day, group5= ≥6 hours per day)

4.7 Effect of total duration of mobile phone usage on semen parameters:

Table-9 shows that there were significant differences in semen parameters among groups of different total duration of mobile phone usage in life in terms of progressive motility (p-value 0.03), head defect (p-value 0.001), and vitality (p-value 0.007).

Parameters	Group 1 <10years (N=43)	Group 2 ≥10years to <20years (N=409)	Group 3 ≥20years to <30years (N=21)	Group 4 ≥30years (N=27)	overall p-Value	Bonferroni groupwise comparisons		
						Pa	Pb	Pc
Total Sperm Count (X10^6)	156.07 ± 113.47	147.43 ± 115.51	149.50 ± 83.14	149.78± 107.56	0.08	0.23	0.30	0.40
Concentration (X10^6/ml)	52.30 ± 39.97	59.05 ± 48.02	64.48 ± 38.03	47.00 ± 33.53	0.93	0.17	0.06	0.44
Total Motility (%)	50.14 ± 24.14	55.26 ± 15.99	59.14 ± 19.19	53.33 ± 20.48	0.18	0.38	0.30	1.00
Progressive Motility (%)	33.53 ± 22.39	42.03 ± 17.66	43.19 ± 22.09	37.33 ± 23.87	0.03	0.03	0.31	1.00
Abnormal Morphology (%)	90.09 ± 9.51	93.10 ± 11.14	93.05 ± 8.50	94.22 ± 9.04	0.33	0.50	1.00	0.72
Head Defect (%)	76.42 ± 29.67	87.65 ± 18.35	70.95 ± 39.70	90.67 ± 10.70	0.001	0.004	1.00	0.03
Midpiece Defect (%)	19.47 ± 13.15	16.26 ± 18.63	19.00 ± 15.62	17.11 ± 15.71	0.65	0.01	0.37	0.24
Excess Cytoplasm Defect (%)	2.40 ± 2.99	2.40 ± 2.80	1.81 ± 2.11	2.67 ± 3.53	0.76	0.31	0.32	0.47
Tail Defect (%)	9.81 ± 5.50	8.70 ± 7.54	10.52 ± 5.50	9.44 ± 7.00	0.54	0.03	0.33	0.25
Vitality (%)	61.02 ± 25.68	52.14 ± 18.51	61.10 ± 24.76	49.78 ± 23.45	0.007	0.03	1.00	0.13

Table 9: Effect of total duration of mobile phone use on semen parameters

- Values Are Presented As Mean ± SD, Rounded To Two Decimal Places.
- One way **ANOVA:** p-value =Significant group effect on outcome ($p < 0.05$)
- **Bonferroni groupwise comparisons:** Pa = p-value for Group 1 vs Group 2; Pb= p-value for Group 1 vs Group 3; Pc= p-value for Group 1 vs Group 4,

5.Discussion

Recently, an increasing number of mobile phone users as mobile phones have become an important part of everyday life. Although many researchers have investigated the effect of mobile phone usage, results have been inconsistent. RF-EMWs which are emitted from mobile phones have mainly two types of mechanisms to affects sperm quality. First, thermal effect; which could increase intensity of heat near testis and outer gonadal organs, thereby damaging sperm production [7]. Second, non-thermal radiation effect which affect sperm quality by producing reactive oxygen species (ROS). ROS attack nuclear DNA of spermatozoa, causing impaired mitochondrial electron transport chain and isocitrate dehydrogenase activity [8]. Alternatively, RF-EMWs could act indirectly on semen quality by altering endocrine status of men like disrupting hypothalamic-pituitary-gonadal axis. Hence EMWs are not good for human spermatogenesis. For assessing exposure from transmitters located near body, most useful quantity is specific absorption rate (SAR). In India SAR limit is fixed at 1.6w/kg [10].

5.1 Effect of daily mobile phone usage time on semen parameters:

We found that most of comparisons of four sperm parameters: sperm count, motility, viability, and abnormal morphology between all cell phone user groups were significantly different. Out of 500 participants, 49.8% participant used mobile phone >6hours/day. This led us to suggest that use of phones may adversely affect quality of semen by decreasing sperm counts, motility, viability, and morphology which contribute to infertility. During detailed analysis, we found that with increasing duration of mobile usage from 1hour to >6hours/day, there is significant decline in quality with overall p-value <0.001. Similar results were found in few previous studies [3,11-13]. Similar results were found by Agarwal et.al. in 2008 [11]. Another study by Zilberlicht et.al. found that talking for ≥1hours/day and during device charging were associated with abnormal semen concentration (p-value< 0.04 and p-value< 0.02, respectively) [14].

Zhang et. al. in 2022 conducted similar study on daily mobile phone usage (<2hours/day, 2–4hours/day, 4–6hours/day and >6hours/day); found that significant associations among different groups of daily mobile phone use time and calls in terms of progressively motility and total motility [13]. Present study results are in accordance with these authors, although we found that not only motility but also sperm count, viability, and morphology are negatively affected by phones usage. Till now there are two meta-analysis on effect of mobile phone usage on semen parameters, earliest conducted in 2014 by Adams el.at. on 1492 men and concluded that exposure to mobile phones was associated with reduced sperm motility (mean difference−8.1%(95%CI−13.1,−3.2) and viability (mean difference−9.1%(95%CI−18.4,0.2), with equivocal effects on concentration [15]. Consistent with results of previous meta-analysis, another meta-analysis came in 2021 by Kim et.al.; included 4280 men and found that overall decline in semen quality with use of mobile phone use but not statistically significant [16]. Another meta-analysis on animals studies; have identified histopathological alterations in testicular tissue caused by phone radiation, such as reduced seminiferous tubule diameter, tunica albuginea and germinal epithelial thickness, leydig cell hypoplasia, and increased intertubular space. Consistent exposure to phone radiation has been shown to significantly reduce sperm count, motility, and viability while also increasing abnormal sperm morphology in male rats, mice and rabbits [17]. However, a few other researchers derived at results discordant to this study. Amin et al. found statistically insignificant inverse correlation between time spent on phone in hours (<2hours or >2hours) with sperm concentration and motility [10]. Similarly Al Bayyari et.al. found that there is decline in semen quality in terms of sperm concentration, volume, viscosity, motility and abnormal morphology but not significant p-value >0.05 [18].

5.2 Effect of frequency of mobile phone use per day on semen parameters:

In our study we found that there were significant differences in semen parameters among groups of different frequency of mobile phone usage per day in terms of total sperm count, progressive motility, abnormal morphology, and vitality with overall p-value 0.001. On groups comparison, there was significant differences in semen quality when mobile phone was more than 40 times per day with p-value 0.001. Similar study was performed by Rahban et.al. in 2023 on 2759 participants; found higher frequency of mobile phone use (>20times/day) was associated with 30% and 21% increased risk for sperm concentration and total sperm count to be below WHO references, respectively. Assessing frequency of mobile phone usage is more valid to check effect of mobile phones as it is surrogate of RF-EMWs energy absorbed from mobile phones. Energy absorbed by body depends mainly on transmission duration, source's strength, and distance to source [19].

5.3 Effect of mobile phone position on semen parameters:

In our study, when mobile phones were kept in pocket, there was statistically significant decline in semen quality in terms abnormal morphology (p-value 0.001) and vitality (p-value 0.004). These changes can be explained by thermal effect of RF-EMWs devices. The rise of 0.5degree Celsius temperature is noticed in groins when phones are kept in trouser pockets which is directly impairing spermatogenesis [20]. Zilberlicht et.al. found that among men who reported holding their phones ≤50cm from groin, a non-significantly higher rate of abnormal sperm concentration was found (47.1%vs11.1%) [14]. Al Bayyari et.al. found carrying mobile phone in

trouser pocket was significantly associated with increasing means of immotile sperms [18]. However, a few other researchers derived at contradictory findings to our study as keeping a mobile phone in trouser pocket was not found to be associated with lower semen parameters [10,13,19]. Blay et.al. in 2020 conducted study involving 80 healthy adult found that active sperm motility and viability showed significant increase (p-value 0.002 and 0.009) in participants who kept phone in side pocket. The contradictory results may be due to huge disparity in the percentage of participants that stored mobile phones in side pockets (85%) compared to other places [3].

5.4 Effect Of Total Duration Of Mobile Phone Use On Semen Parameters:

In our study, there was a significant effect of total duration of mobile phone on progressive motility (p-value 0.03), head defect (p-value 0.001), and vitality (p-value 0.007) . But, these findings were not following any order. These results may be due to huge disparity in percentage of participants (81.80%) used mobile phone for 10-20years. Similar results were found in one more study by Amin et al as slight reduction in normal morphology over 5years duration but not significant [10].

5.5 Effect Of Internet Used On Semen Parameters:

In this study, there was a significant decline in semen quality with internet usage per day in terms of total sperm count (p-value 0.001), progressive motility (p-value 0.001), abnormal morphology (p-value 0.001), and vitality (p-value 0.001). We observed a trend indicating that increased internet usage duration is linked to reduced semen quality. There are a few studies performed on usage of internet like in 2015 by Yildirim et.al. found negative correlation between wireless internet usage duration and total sperm count (p-value 0.032) and motility (p-value 0.033) [21]. Even though there are some studies performed on effects of RF-EMW and cell phones on male fertility, there is not so much scientific data about the association between Wi-Fi internet usage and male fertility. Moreover, in an in-vitro study performed with motile spermatozoa from 29 healthy donors, according to results of this study; Wi-Fi showed significant decrease in progressive sperm motility and an increase in sperm DNA fragmentation [22].

5.6 Effect of Proximity to Telecommunication Tower on Semen Parameters:

In this study we noticed significant decline in semen quality in form of abnormal morphology (p-value 0.005) in participants who stayed within 1kilometer of telecommunication tower. Contradictory to our study, Amin et.al. could not find any significant effect on semen quality by telecommunication tower within 1km proximity of their domicile in 11%(16 cases) [10]. Hence, to confirm these effects more studies need to be performed. However, some jurisdictions have already prohibited placement of phone towers near schools or hospitals, as in India [23] and placement of base stations should be kept as far away as possible to minimize exposure of public to RFWs and it should not be located less than 500meter from population, and at a height of 50meter [24].

6.Limitations of the Study

It is a single centre study which was conducted on the male partner of couples attending infertility clinic. Hence, possibility of cross-over with some element of male subfertility is already there. Another limitation was that there was no consistency with use of networks among participants as they were switching network (2G/3G/4G/5G) as dose radiation varies. Last limitation was that there can be recall bias as it was questionnaire based study. Therefore, a follow-up large multicentric studies are needed to exclude regional and ethnic variations and to validate findings of study.

7.Conclusion

In conclusion, we suggest that average daily cell phone use duration may affect sperm parameters. Therefore, we recommend that men should avoid prolonged usage of mobile phones for calls, message or internet, keep device away from groin and stay 1kilometer away from telecommunication tower to preserve their fertility. In addition, more well-designed multicentre cross-sectional investigations and mechanistic studies are needed in future to clarify effects of RF-EMW produced by phones on male semen quality.

Disclosures

Conflict of interest: None.

Human rights statement and informed consent: All patients were well informed and written informed consent was obtained prior to the treatment period.

The statement of approval from Institutional Review Board: All procedures in this study were in accordance with the ethical standards of the Ethical Committee in accordance with the ethical principles that have their origin in the Declaration of Helsinki 1964 and its later amendments. This study was approved by Institutional Ethics Committee(IEC) with reference number AIIMSA1273/03.05.2024

Authorship contribution statement:

The study was conceptualized by NS and N. and designed by NS, N. and SK. N. and RR were responsible for obtaining clinical data and informed consent. NS and N. were responsible for protocol implementation. NS supervised the overall study. AU, NS and N. analyzed and interpreted the data. N. and NS drafted the first manuscript. SK, RR, N. and NS were responsible for critically editing the manuscript. All authors contributed to the patient management and follow-up. All authors contributed to manuscript writing and critical evaluation of the final manuscript.

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