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Original Article

EFFECTS OF RADIATION FROM MOBILE PHONES ON FERTILITY AND THE QUALITY OF SEMEN IN REGULAR MOBILE PHONE USERS

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ABSTRACT

Objective: The use of mobile phones over extended periods of time is associated with genotoxicity. The Specific Absorption Rate (SAR) values of mobile phones indicate that they release less radiofrequency radiation, which is discovered to be within a safer limit. This is the case because SAR values can be measured. The use of mobile phones for extended periods of time may also cause DNA damage in human cells.

Methods: The purpose of this study is to analyse the impact that radiation from mobile phones have on fertility by analysing the quality of the sperm of people who use their phones often.

Results: The research was carried out on a total of 150 people who were between the ages of 20 and 40 and divided into three groups (frequent mobile users, moderate mobile users and less mobile phone users). Prior to collecting samples from the subjects, permission was obtained from them. The researcher conducted individual interviews with each participant in the study in order to collect information for filling out a structured questionnaire. Analyses and comparisons were made between the three groups on the properties of the sperm, including their motility and shape.

Conclusion: The findings of a number of research indicate that radiations released by mobile phones have an effect on male fertility by causing permanent alterations in the morphology of the semen. The current research demonstrates that there is a problem with the fertilising ability of sperm due to defects and changes in sperm morphology. According to the findings of this research, radiations released by mobile phones will have an effect on male fertility. The genotoxic impact may be brought to the attention of regular users of mobile phones and the required measures can be taken via the use of biosensors, which offer a warning signal or alarm when the radiations level exceeds the usual limit.

Keywords: Mobile phone radiations, Semen parameters, Sperm morphology, Male Infertility

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INTRODUCTION

Around 15% of couples experience infertility, with male infertility accounting for half of those occurrences. Many organs, including the testes, are harmed by mobile phone radiation in one of two ways: directly or thermally [1]. It lowers testosterone levels, which hinder spermatogenesis and destroy sperm DNA. Male infertility and radiation from the devices have not been conclusively linked, according to [2, 3]. Male reproductive systems have previously been shown to be harmed by mobile phone radiation in rats, but human research have been limited and conducted on a smaller population [3, 4]. Several studies have shown that mobile phone radiation has a deleterious impact on semen parameters. On the other hand, researchers found that the quality of 371 men's sperm was negatively correlated to how often they used their mobile phones. Ionizing and non-ionizing radiations may be divided into two major categories: ionizing and non-ionizing.

Extremely Low Frequency (ELF) and Radio Frequency (RF) EMFs are two types of non-ionizing radiation that may be distinguished. The link between mobile phone use and male infertility has not yet been established [5, 6]. The quality of sperm is significantly reduced as a result of harmful radiations released by mobile phones interfering with spermatogenesis [7, 8]. Human sperm motility has been shown to be affected by mobile phone use in studies [4, 9]. Thermal or non-thermal impacts of mobile phone radiation may influence reproductive function [4]. Cell phones are extensively used by people of all ages, and they are used for extended periods of time for a variety of reasons. Low-level radiofrequency electromagnetic waves (EMW) are emitted by these mobile phones and span from 800 to 2200 MHz [10].

Men are more likely than women to keep their cell phones in places like their pants pockets or holders near their genitals. Male infertility has been linked to excessive use of mobile phones in epidemiological research [4, 8]. The quality of sperm is diminished as a consequence of the thermal and non-thermal impacts of mobile phone radiation on the genital [1, 11]. Researchers studying fertility have recently been interested in the effects of mobile phone radiation on the semen characteristics of healthy volunteers. Infertility or sub-fertility in males is most often caused by sperm motility or DNA damage defect [12]. Mobile phone use has been linked to lower levels of some quality indicators in men's sperm, according to epidemiologic research [3, 13].

Cell phone use may cause sleep difficulties, weariness, cognitive impairment, headaches, and an increased risk of tumours in the future [14-16]. It also has an effect on the cardiovascular system by raising the level of resting blood pressure in people [17]. Men's reproductive health degradation may be attributed to a variety of reasons, including environmental, social, and psychological issues [18, 19]. According to a number of studies, cell phone usage has a negative impact on semen parameters, decreasing the likelihood of male fertility [3, 20, 21]. Analysis of mobile phone radiation's influence on semen parameters is the focus of this research.

The main aim of this study was to evaluate the impact of mobile phone radiations on fertility by analysing the sperm quality of mobile phone users who make frequent calls.

MATERIALS AND METHODS

The present study was done on 150 participants of age group 20-40 y by grouping them based on their mobile phone usage (frequent mobile users, moderate mobile users and less mobile phone users) in and around Salem population.

Study design

Cross-sectional study–The present study is approved by Institutional Human Ethical Committee of VMKV Medical College and Hospitals, Salem. (VMKVMC and H/IEC/20/44).

Study population

A total of 150 participants were recruited for the study

- Group A (50 high mobile users) (>5 y 10 h/week)
- Group B (50 moderate mobile users) (<5 y 3 h/week)
- Group C (50 mild mobile phone users) (3 y 2 h/week)

Inclusion criteria

Age between 20-40 y and individuals without any history of medications for illness in the last three months before recruitment to the study.

Exclusion criteria

Participants with habits of smoking and alcohol consumption, with a viral or bacterial infection that causes orchitis, varicocele and other metabolic disorders like diabetes mellitus, hypertension, cardiac, neural, or nephrotic disease, and also participants with family history of genetic disorders were excluded from the study.

A structured and validated questionnaire was completed by each participant at the beginning of the study. The semen was collected as per standard protocol. The following semen parameters like motility, morphology, volume, viscosity, sperm concentration, liquefaction time and pH, were analyzed. The Chi-Square test and percentage analysis was done and to find out the significant difference one way ANOVA with Tukey's Post-Hoc test was done.

RESULTS

The study shows the adverse effect of mobile phone radiations results in the decreased fertilizing potential of sperm along with abnormal morphology. The collected data were analysed with "IBM SPSS Statistics for Windows, Version 23.0.". The level of significance is 0.05. The p-value was considered highly significant at $p<0.01$, significant at $0.01 \leq p \leq 0.050$ and no significant at $p>0.050$.

Table 1: Demographic data-age

	N	Mean	Std. deviation	Std. error	95% C. I Mean		Minimum	Maximum
					LB	UB		
Group A	45	33.978	5.9333	.8845	32.195	35.760	23.0	46.0
Group B	45	34.422	5.2850	.7878	32.834	36.010	23.0	43.0
Group C	45	36.733	5.5161	.8223	35.076	38.391	23.0	46.0
Total	135	35.044	5.6738	.4883	34.079	36.010	23.0	46.0

Table 2: Age ANOVA

	Sum of squares	df	Mean square	F	p-value
Between groups	196.978	2	98.489	3.158	.046
Within groups	4116.756	132	31.188		
Total	4313.733	134			

Table 3: Multiple comparisons of age by post HOC test tukey HSD

(I) Groups		Mean difference (I-J)	Std. error	p-value	95% C. I	
					LB	UB
Group A	Group B	-.4444	1.1773	.925	-3.235	2.346
	Group C	-2.7556	1.1773	.050	-5.546	.035
Group B	Group C	-2.3111	1.1773	.126	-5.102	.480

Table 4: Semen volume-descriptive

	N	Mean	Std. deviation	Std. error	95% C. I Mean		Minimum	Maximum
					LB	UB		
Group A	45	1.404	.7428	.1107	1.181	1.628	.2	3.0
Group B	45	1.044	.4500	.0671	.909	1.180	.5	2.5
Group C	45	1.978	.5431	.0810	1.815	2.141	1.0	3.5
Total	135	1.476	.7024	.0605	1.356	1.595	.2	3.5

Table 5: Semen volume-ANOVA

	Sum of squares	df	Mean square	F	p-value
Between groups	19.941	2	9.971	28.507	.0005
Within groups	46.168	132	.350		
Total	66.109	134			

Table 6: Semen volume-multiple comparisons posthoc test

(I) Groups		Mean difference (I-J)	Std. error	p-value	95% C. I	
					LB	UB
Group A	Group B	.3600*	.1247	.013	.064	.656
	Group C	-.5733*	.1247	.0005	-.869	-.278
Group B	Group C	-.9333*	.1247	.0005	-1.229	-.638

*The mean difference is significant at the 0.05 level. The above tableS (table 1-6) shows a significant increase in semen volume in group-C when compared to other groups.

Table 7: Semen liquefiction time-descriptives

	N	Mean	Std. deviation	Std. error	95% C. I mean		Minimum	Maximum
					LB	UB		
Group A	45	30.111	5.4657	.8148	31.469	34.753	20.0	45.0
Group B	45	31.333	3.4378	.5125	30.301	32.366	30.0	40.0
Group C	45	32.800	3.0793	.4590	29.875	31.725	30.0	45.0
Total	135	31.748	4.2174	.3630	31.030	32.466	20.0	45.0

Table 8: Semen liquefiction time-ANOVA

	Sum of squares	df	Mean square	F	p-value
Between Groups	131.793	2	65.896	3.863	.023
Within Groups	2251.644	132	17.058		
Total	2383.437	134			

Table 9: Multiple comparisons-semen liquefiction time

(I) Groups		Mean difference (I-J)	Std. error	p-value	95% C. I	
					LB	UB
Group A	Group B	1.7778	.8707	.106	-.286	3.842
	Group C	2.3111*	.8707	.024	.247	4.375
Group B	Group C	.5333	.8707	.814	-1.531	2.597

*The mean difference is significant at the 0.05 level. The liquefication time was found to be less in group A when compared to other groups in the above table (table 7-9).

Table 10: Sperm count/million/ml-descriptive

	N	Mean	Std. deviation	Std. Error	95% C. I Mean		Minimum	Maximum
					LB	UB		
Group A	45	6.311	2.7702	.4129	5.479	7.143	1.0	10.0
Group B	45	15.222	2.7210	.4056	14.405	16.040	12.0	20.0
Group C	45	44.156	13.2938	1.9817	40.162	48.149	28.0	75.0
Total	135	21.896	18.0527	1.5537	18.823	24.969	1.0	75.0

Table 11: Sperm count/million/ml-ANOVA

	Sum of squares	df	Mean square	F	p-value
Between groups	35231.215	2	17615.607	275.527	.0005
Within groups	8439.333	132	63.934	-	-
Total	43670.548	134	-	-	-

Table 12: Sperm count-multiple comparisons

(I) Groups		Mean difference (I-J)	Std. Error	p-value	95% C. I	
					LB	UB
Group A	Group B	-8.9111*	1.6857	.0005	-12.907	-4.915
	Group C	-37.8444*	1.6857	.0005	-41.840	-33.849
Group B	Group C	-28.9333*	1.6857	.0005	-32.929	-24.938

*The mean difference is significant at the 0.05 level. The sperm count of group C was observed to be more than the other group and was found to be statistically significant (table 10-12).

Table 13: Sperm motility-descriptive

		N	Mean	Std. deviation	Std. error	95% C. I mean		Minimum	Maximum
						LB	UB		
Progressive	Group A	45	15.844	4.7047	.7013	14.431	17.258	4.0	27.0
	Group B	45	18.956	3.5288	.5260	17.895	20.016	14.0	28.0
	Group C	45	25.244	4.5235	.6743	23.885	26.603	17.0	30.0
	Total	135	20.015	5.7860	.4980	19.030	21.000	4.0	30.0
Non-Progressive	Group A	45	14.689	2.8748	.4286	13.825	15.553	6.0	20.0
	Group B	45	16.067	2.9341	.4374	15.185	16.948	12.0	22.0
	Group C	45	18.733	3.4667	.5168	17.692	19.775	13.0	27.0
	Total	135	16.496	3.5109	.3022	15.899	17.094	6.0	27.0
Immotile	Group A	45	69.556	6.5177	.9716	67.597	71.514	58.0	90.0
	Group B	45	65.644	6.4001	.9541	63.722	67.567	53.0	74.0
	Group C	45	57.356	7.8975	1.1773	54.983	59.728	44.0	77.0
	Total	135	64.185	8.5990	.7401	62.721	65.649	44.0	90.0

Table 14: Sperm motility-ANOVA

		Sum of squares	df	Mean square	F	p-value
Progressive	Between groups	2063.837	2	1031.919	56.237	.0005
	Within groups	2422.133	132	18.349		
	Total	4485.970	134			
Non-Progressive	Between groups	380.504	2	190.252	19.755	.0005
	Within groups	1271.244	132	9.631		
	Total	1651.748	134			
Immotile	Between Groups	3492.637	2	1746.319	35.929	.0005
	Within Groups	6415.733	132	48.604		
	Total	9908.370	134			

Table 15: Sperm motility-multiple comparisons

Dependent variable			Mean difference (I-J)	Std. error	p-value	95% C. I	
						LB	UB
Progressive	Group A	Group B	-3.1111*	.9031	.002	-5.252	-.970
		Group C	-9.4000*	.9031	.0005	-11.541	-7.259
	Group B	Group C	-6.2889*	.9031	.0005	-8.430	-4.148
Non-Progressive	Group A	Group B	-1.3778	.6542	.093	-2.929	.173
		Group C	-4.0444*	.6542	.0005	-5.595	-2.494
	Group B	Group C	-2.6667*	.6542	.0005	-4.218	-1.116
Immotile	Group A	Group B	3.9111*	1.4698	.024	.427	7.395
		Group C	12.2000*	1.4698	.0005	8.716	15.684
	Group B	Group C	8.2889*	1.4698	.0005	4.805	11.773

*The mean difference is significant at the 0.05 level. Non-progressive and immotile sperms were found in group BandC when compared to group-A and found to be statistically significant.

Table 16: Sperm morphology-descriptive

		N	Mean	Std. deviation	Std. Error	95% C. I Mean		Minimum	Maximum
						LB	UB		
Normal	Group A	45	3.756	.5703	.0850	3.584	3.927	1.0	4.0
	Group B	45	4.044	.5203	.0776	3.888	4.201	2.0	6.0
	Group C	45	4.489	.6613	.0986	4.290	4.688	4.0	6.0
	Total	135	4.096	.6565	.0565	3.985	4.208	1.0	6.0
Abnormal	Group A	45	94.244	.5703	.0850	96.073	96.416	96.0	99.0
	Group B	45	95.956	.5203	.0776	95.799	96.112	94.0	98.0
	Group C	45	95.511	.6613	.0986	95.312	95.710	94.0	96.0
	Total	135	95.904	.6565	.0565	95.792	96.015	94.0	99.0

Table 17: Sperm morphology-ANOVA

		Sum of squares	df	Mean square	F	p-value
Normal	Between groups	12.281	2	6.141	17.828	.0005
	Within groups	45.467	132	.344		
	Total	57.748	134			
Abnormal	Between groups	12.281	2	6.141	17.828	.0005
	Within groups	45.467	132	.344		
	Total	57.748	134			

Table 18: Sperm morphology-multiple comparisons

Dependent variable			Mean difference (I-J)	Std. error	p-value	95% C. I	
						LB	UB
Normal	Group A	Group B	-.2889	.1237	.055	-.582	.004
		Group C	-.7333*	.1237	.0005	-1.027	-.440
	Group B	Group C	-.4444*	.1237	.001	-.738	-.151
Abnormal	Group A	Group B	.2889	.1237	.055	-.004	.582
		Group C	.7333*	.1237	.0005	.440	1.027
	Group B	Group C	.4444*	.1237	.001	.151	.738

*The mean difference is significant at the 0.05 level. Abnormal sperm were found to be more in group-A when compared to other groups (table 13-18).

Table 19: Defects of sperm morphology-descriptive

		N	Mean	Std. deviation	Std. error	95% C. I Mean		Minimum	Maximum
						LB	UB		
Head	Group A	45	35.733	1.5869	.2366	35.257	36.210	34.0	38.0
	Group B	45	35.489	1.4557	.2170	35.052	35.926	34.0	40.0
	Group C	45	32.867	1.3246	.1975	36.469	37.265	34.0	40.0
	Total	135	36.030	1.5690	.1350	35.763	36.297	34.0	40.0
Mid	Group A	45	31.111	2.6818	.3998	30.305	31.917	25.0	45.0
Piece	Group B	45	30.822	1.0065	.1500	30.520	31.125	28.0	32.0
	Group C	45	30.800	2.0516	.3058	30.184	31.416	28.0	33.0
	Total	135	30.911	2.0240	.1742	30.567	31.256	25.0	45.0
Tail	Group A	45	33.156	2.4491	.3651	32.420	33.891	20.0	38.0
	Group B	45	33.689	.8481	.1264	33.434	33.944	31.0	35.0
	Group C	45	31.667	2.3645	.3525	30.956	32.377	24.0	34.0
	Total	135	32.837	2.1861	.1882	32.465	33.209	20.0	38.0

Table 20: Defects of sperm morphology-ANOVA

		Sum of squares	df	Mean square	F	p-value
Head	Between Groups	48.637	2	24.319	11.414	.0005
	Within Groups	281.244	132	2.131		
	Total	329.881	134			
Mid Piece	Between Groups	2.711	2	1.356	.328	.721
	Within Groups	546.222	132	4.138		
	Total	548.933	134			
Tail	Between Groups	98.859	2	49.430	12.048	.0005
	Within Groups	541.556	132	4.103		
	Total	640.415	134			

Table 21: Defects of sperm morphology-multiple comparisons

Dependent variable			Mean difference (I-J)	Std. error	p-value	95% C. I	
						LB	UB
Head	Group A	Group B	.2444	.3077	.707	-.485	.974
		Group C	-1.1333*	.3077	.001	-1.863	-.404
	Group B	Group C	-1.3778*	.3077	.0005	-2.107	-.648
Tail	Group A	Group B	-.5333	.4270	.427	-1.546	.479
		Group C	1.4889*	.4270	.002	.477	2.501
	Group B	Group C	2.0222*	.4270	.0005	1.010	3.034

*The mean difference is significant at the 0.05 level.

Table 22: Impresssion *groups cross tabulation

			Groups			Total
			Group A	Group B	Group C	
Impresssion	Oligo astheno terato zoospermia	Count	4	1	0	5
		%	8.9%	2.2%	0.0%	3.7%
	Astheno Zoospermia	Count	0	8	26	34
		%	0.0%	17.8%	57.8%	25.2%
	Mild Astheno Zoospermia	Count	0	0	19	19
		%	0.0%	0.0%	42.2%	14.1%
	Oligo Astheno Zoospermia	Count	15	34	0	49
		%	33.3%	75.6%	0.0%	36.3%
	Severe Oligo Astheno Terato	Count	4	0	0	4
	Zoospermia	%	8.9%	0.0%	0.0%	3.0%
	Severe Oligo Astheno Zoospermia	Count	22	2	0	24
		%	48.9%	4.4%	0.0%	17.8%
Total		Count	45	45	45	135
		%	100.0%	100.0%	100.0%	100.0%

Table 23: Chi-square test

	Value	df	p-value
Pearson Chi-Square	155.045[a]	10	.0005
Likelihood Ratio	180.388	10	.000
N of Valid Cases	135		

Group-A showed various defects in spermatozoa and sperm count also was found to be reduced (table 20-23).

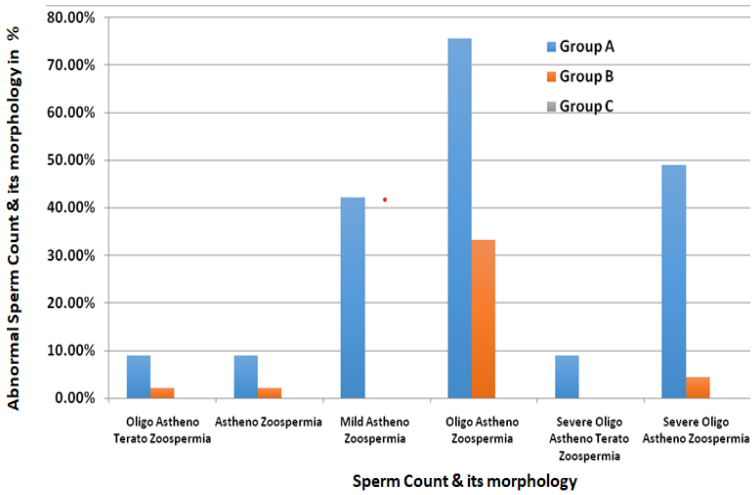

Fig. 1: Sperm count and its morphology impressions

Fig. 1 shows the sperm count and its morphplogy-Oligozoospermia (low number of sperm), Asthenozoospermia (Poor sperm movement), Teratozoospermia (abnormal sperm shape).

DISCUSSION

Semen characteristics show no positive link with cell phone users based on their daily usage, and there is no significant difference between guys who use cell phones for more than one hour each day, according to a research of 262 men [22]. The research also indicated that males who used cell phones for more than one hour per day had lower semen volume, reduced vitality, and a poor sperm morphological index than those who used cell phones for less than one hour per day, which correlates with the current study (table 4, 18). Gutschi *et al.* reported that cell phone use had no negative impact on sperm count, however, the current investigation shown that the sperm count was lower in frequent mobile phone users compared to light mobile phone users (table 10) [23]. In a separate research including 63 healthy, fertile males, none of the standard sperm parameters were affected by daily mobile phone use [24]. Another research found no significant change in sperm parameters between phone users and non-users, and the findings of this study are incongruent with those of the current study [25]. The study by Fejas *et al.* revealed that sperm concentration and motility are the most influential factors in male infertility and that the duration of mobile phone use correlates negatively with the proportion of rapidly progressive motile sperm and positively with the proportion of slowly progressive motile sperm [4]. Prolonged mobile phone use was related with a substantial rise in the proportion of defective sperm cells and a reduction in the percentage of sperm motility [26]. Comparatively, second research found that normal sperm morphology, sperm count, sperm motility, and sperm viability were significantly altered after four hours per day of mobile phone use, compared to males who never use cell phones [3]. In their research, Boulos *et al.* [27] found that mobile phone use in males is related with lower sperm quality, which is dependent on the length of exposure to cell phone radiations. Earlier findings are comparable to the current investigation. People living or working within one kilometre of the telecommunications towers had reduced sperm count. The number of sperm is lowered among individuals who send frequent texts for 20 min every day. The same research found that males who carry their cell phones closer to their genitalia had a greater proportion of immobile sperm. The current investigation likewise demonstrated the same conclusion as the previous one. The impact of cordless phone use on sperm parameters has not yet been researched and must be investigated and reported. Also investigated were the effects of mobile phones on testicular cancer [28, 29]. The quality of sperm has not been tested in relation to extended and frequent texting [30]. Bhat *et al.* conducted research on the impact of mobile phone towers radiation and found that radiation released by mobile phones and towers pose a health risk to those living in close proximity to towers, who should be aware of this [31]. Dahat. *et al.* found that persons living within the range of 50 to 300m are more likely to be exposed, and direct contact with the towers would have harmful effects, particularly for those who reside in tall buildings [32]. Kilgallon *et al.* evaluated the impact of mobile phone radiations on the semen quality parameters depending on the carrying of mobile phones [33]. The research found that males who carried their mobile phones near their genitalia had a lower sperm count than those who carried their phones elsewhere. Agarwal *et al.* found that holding a mobile phone close to the genitalia when in conversation mode may have a deleterious impact on sperm, hence diminishing male fertility [34]. EMW with a particular effect, thermal molecular effect, or a mix of the two are among the processes that influence male reproduction. These substances may impair spermatogenesis by injuring Leydig cells [35]. Radiation may potentially impair the process of spermatogenesis via an increase in body temperature [36]. Reduced melatonin synthesis or increased reactive oxygen species (ROS) generation correlated negatively with sperm destruction [10].

The effect of RF-EMF exposure on sperm parameters

Frequent mobile phone use has been associated with a decline in sperm viability and motility due of increases in ROS [4, 34, 37]. Recent data indicates that Wi-Fi from laptops has a deleterious impact on sperm quality [38]. RF-EMF is one of the confounding factors responsible for the reduction in conception rate [39], spermatogenic cell counts, and by hormonal changes in the testis [4] and may lead to foetal loss and developmental abnormalities throughout the embryonic phase, which cause apoptosis [40-43].

Sperm count

Radio-frequency electromagnetic field exposure impacts male fertilizing potential of sperm [37]. There are numerous approaches available for the measurement of sperm count that including flow cytometry, cell counters and hemocytometer. The sperm count is adversely associated in the current research resulting in low sperm count among regular mobile phone users.

Sperm motility and morphology

Various studies indicates the negative effect of RF-EMF on sperm morphology [44]. Kesari *et al.*, showed that men, when use mobile phones for prolonged time period closer to their genitals, exhibit increased rates of abnormal sperms [45]. Several adds on to this reports where male exposed to mobile phones radiations were found to have decreased sperm count, and abnormal sperm morphology [2, 46, 47]. The correlation between the exposure to radiations which produces testicular pathologies resulting in poor sperm quality is due to oxidative stress that results in increased levels of free radicals/super-oxide anion that decrease sperm

motility [34]. The free radicals acts on the plasma membrane of sperm by reducing its fluidity and that results in impaired motility.

CONCLUSION

The RF-EM radiation emitted by mobile phones is detrimental to male fertility. Mobile phones have thermal or non-thermal impacts on the male genital system, which interferes with the normal processes of spermatocytogenesis and spermiogenesis, resulting in low sperm quality. Men who use mobile phones less often and for longer durations (10 h per week) had substantially reduced sperm count, motility, and viability, as well as aberrant sperm morphology, according to the current research. Extensive research has been conducted to determine the aneugenic and clastogenic effects of mobile phone radiations. Future research will be conducted in more detail, with additional participants and factors, in order to establish the function of oxidative stress in sperm motility and viability reduction.

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AUTHORS CONTRIBUTIONS

All the authors have contributed equally.

CONFLICT OF INTERESTS

Declared none

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