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ORIGINAL PAPER

Effect of radiofrequency electromagnetic waves of mobile phone stations on male fertility

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Summary ***Purpose: To determine the effect of electromagnetic waves of mobile phone stations on several sperm parameters and the male reproductive system.***
Methods: This observational study was performed on 216 subjects, aged 18-60 years. Two equal groups of subjects were assigned to group A (study group) if they were living close to cell phone tower stations for at least 6 months and group B (control group) formed from individuals living 100 meters away from cell phone tower stations. Every subject underwent a comprehensive history taking, a clinical assessment, and laboratory testing.
Results: Regarding morphology index in the studied groups, the exposed group exhibited a trend of reduced percentage of normal morphology compared to the non-exposed group, with no statistical difference between the two groups. Regarding the total sperm motility (A+B+C) and progressive sperm motility (A+B) in the studied groups, the exposed group showed a trend of decreased total sperm motility and of progressive sperm motility in contrast to the non-exposed group, with no statistical difference between the two groups.
Conclusions: Personal wrong lifestyles with exposure to electromagnetic waves have shown a trend towards a reduced percentage of normal morphology and reduced motility although non-statistically significant compared with non-exposed populations.

KEY WORDS: *Electromagnetic waves; Mobile phone stations; Male infertility.*

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INTRODUCTION

In recent decades, the estimated prevalence of infertility among couples of reproductive age has risen to 15% (1). A decline in sperm count, a mobility issue, or a structural issue can all be signs of male infertility disorders that may be brought on by ionizing radiation, electromagnetic waves, stress, and other biochemical variables (2).
With an average of thirty minutes a day spent chatting on mobile phones, people are consequently exposed to a significant amount of *radiofrequency electromagnetic radiation* (RF-EMR) from these devices (3). Although the effects of RF-EMR from cell phones on semen quality have received attention recently, the conclusions are still debated. The public now believes that mobile phone RF-EMR is a significant risk factor for the deterioration in sperm quality. Using a mobile phone is one of the main ways to be exposed to RF-EMR (4).
La Vignera et al. (5) showed that RF-EMR hurts seminal tubules, testicular stromal cells, and particularly sperm. When it comes to harm, tissues near mobile devices are more vulnerable than those farther away from cellular antennae. Furthermore, long-term cell phone use may negatively impact sperm motility (6).
Sperm malfunction, which results in male infertility and DNA damage in the male germ line, is mostly caused by oxidative stress (7). This oxidative stress condition affects spermatozoa primarily because of an increase in *reactive oxygen species* (ROS) generated by the mitochondria, with complex III of the *electron transport chain* (ETC) serving as the primary target of this radiation (8). Previous research demonstrated that men's testicular and germ cell function may be negatively impacted by a range of harmful effects from EMWs (9).
In this study, our goal was to determine the effect of electromagnetic waves from mobile phone stations on several sperm parameters and the male reproductive system.

MATERIALS AND METHODS

This observational study involving 216 subjects aged 18 to 60 years, was conducted at the *Urology Clinic of University Hospitals* from December 2022 to July 2023. All procedures performed in this study were in accordance with the ethical standards of the *Institution and/or National Research Committee* and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. It received approval from ethical committee of the *Faculty of Medicine of Benha University, Faculty of Medicine* (cod number:RC 40-11-2022) on November 04, 2022. All subjects provided written informed consent.
The establishment of portable mobile phone towers in villages raised the concerns of many people neighboring the towers about the harmful effects of these towers and their negative impact on health. On this basis, many of

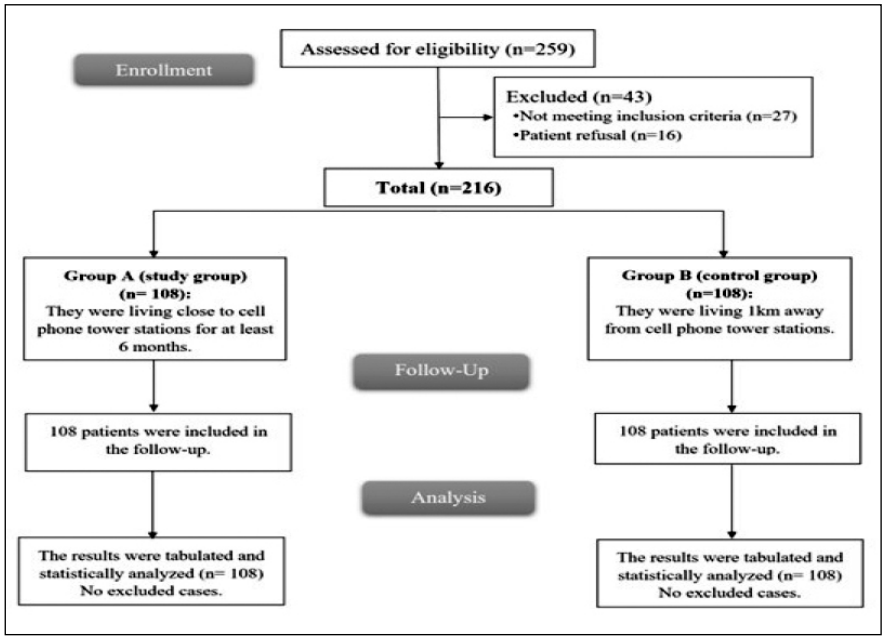

Figure 1.
Algorithm of the enrolled patients.

the normal people neighboring these towers volunteered to participate in the study.
Subjects with hydrocele, varicocele, orchitis, testicular or epididymal trauma, or any other condition potentially affecting semen quality, as well as those unable to complete sperm extraction through masturbation and individuals with diabetes mellitus, hypertension, cardiac, neurological, liver, renal diseases, or other serious systemic chronic diseases, and smokers were excluded.
Participants were divided into two equal groups: Group A (study group) included subjects who by history taking resulted residing close to or within 100 meters from cell phone tower stations for at least 6 months of daily exposure of at least 12 hours per day, and Group B (control group) was composed of individuals living 100 meters away from cell phone tower stations, matched with the study group in terms of age and sex. Each subject underwent a thorough history-taking, clinical assessment, and laboratory testing.

Semen collection

Semen was collected in a wide-mouth container. Semen appearance and liquid condition was primarly assessed by visual evaluation. A pre-weighed container determined semen volume, and microcell slides with 10 µL semen samples were used to examine six fields or a minimum of 200 spermatozoa. Technicians, using *computer-aided semen analysis* (CASA), verified results for semen concentration, *total sperm count* (TSC), vitality (%), pH, motility, and morphology.

Statistical analysis

Statistical analysis was performed utilizing SPSS v28 (*IBM Inc., Armonk, NY, USA*). Unpaired Student's t-test was utilized to compare the two groups based on quantitative data that were reported as mean and *standard deviation* (SD). Both the chi-square test and, when applicable, Fisher's exact test was utilized to analyse the frequency and percentage (%) of the qualitative variables. For statistical significance, a two-tailed P value less than 0.05 was utilized.

Results

In this study, 259 subjects were assessed for eligibility, 27 subjects did not meet the criteria and 16 subjects refused to participate in the study. The remaining 216 subjects were divided into two groups (108 subjects in each). All subjects were followed up and analyzed statistically (Figure 1).

Regarding age of the studied groups, mean age was lower in the exposed group compared to the non-exposed group, with no statistically significant difference between both groups (Table 1).
Regarding seminal volume, sperm count, sperm vitality, and pH, the exposed group had higher mean seminal volume and higher pH compared to the non-exposed group, with no statistical difference between both groups; the exposed group had also lower sperm count and sperm vitality compared to the non-exposed group, with no statistically significant variation between the two groups (Table 2).

Table 1.
Age of the studied groups.

		Group A (Exposed) (n = 108)	Group B (Non-exposed) (n = 108)	P value
Age (years)	Mean ± SD Range	37.6 ± 11.73 18-60	38.5 ± 12.9 18-58	0.605

Table 2.
Seminal fluid characters of the studied groups.

		Group A (Exposed) (n = 108)	Group B (Non-exposed) (n = 108)	P value
Volume (ml)	Mean ± SD Range	2.5 ± 0.81 1.5-4	2.4 ± 0.65 1.6-4	0.432
Count (million/ml)	Mean ± SD Range	21.5 ± 4.89 15-32	22.5 ± 4.12 18-35	0.088
Vitality (%)	Mean ± SD Range	57.2 ± 3.73 48-66	58.1 ± 4.36 50-65	0.095
PH	Mean ± SD Range	7.8 ± 0.18 7.5-8	7.7 ± 0.17 7.5-8	0.674
Morphology index (%)	Mean ± SD Range	13.7 ± 12.08 4-40	16.5 ± 11.99 6-45	0.083

Table 3.
Different types of sperm motility of the studied groups.

		Group A (Exposed) (n = 108)	Group B (Non-exposed) (n = 108)	P value
Rapid progressive motility (%) (A)	Mean ± SD Range	19.7 ± 2.81 15-23	20.5 ± 3.02 16-27	0.057
Slow progressive motility (%) (B)	Mean ± SD Range	30.8 ± 3.44 27-39	31.6 ± 3.64 27-40	0.085
Non progressive motility (%) (C)	Mean ± SD Range	26.7 ± 6.18 15-44	25.4 ± 4.01 15-31	0.056
Immotility (%) (D)	Mean ± SD Range	26.8 ± 3.72 21-36	25.8 ± 4.42 12-32	0.076
Total motility (A+B+C) (%)	Mean ± SD Range	77.3 ± 6.77 67-90	79.1 ± 6.97 70-93	0.056
Progressive motility (A+B) (%)	Mean ± SD Range	50.7 ± 4.79 42-63	52 ± 5.14 44-64	0.052

Regarding the morphology index, the exposed group had a lower percentage of normal morphology compared to the non-exposed group, with no statistical difference between the two groups (Table 2).
Concerning non-progressive motility, immotility, slow progressive motility, and rapid progressive motility in the groups under study, the exposed group had a reduced rapid progressive motility and slow progressive motility in contrast to the non-exposed group, with no statistical difference between the two groups; the exposed group had higher percentage of non-progressive motility and immotility compared to the non-exposed group, with no statistical difference between the two groups (Table 3).
Regarding the total sperm motility (A+B+C) and progressive sperm motility (A+B) in the studied groups, the exposed group possessed a decreased total sperm motility and progressive sperm motility in contrast to the non-exposed group, with no statistical difference between the two groups (Table 3).

Discussion

Recent years have seen a rise in the number of individuals who own cell phones which use electromagnetic waves. As a result, it is now easier to analyse how phone use affects semen quality (11).
In the present study, sperm count, sperm vitality, and pH in the exposed group had a trend of lower seminal volume along with lower pH comared with the non-exposed group; the exposed group had a trend of lower sperm count and sperm vitality, a lower percentage of normal morphology, reduced rapid progressive motility and slow progressive motility, in contrast to the non-exposed group, with no statistical difference between the two groups.
Male fertility depends on sperm motility, which has been the subject of earlier studies on the impact of RF-EMR from mobile phones on the quality of male semen (12).
Mobile phones emit *radiofrequency-electromagnetic waves* (RF-EMWs), which consist of a range of frequencies between 800 and 2200 MHz. These waves possess the capacity to penetrate different parts of the human body and could pose risks to several physiological systems (13). Previous research has investigated a notable reduction in the quantities, viability, and mobility of sperms due to being subjected to RF-EMWs released by cellular devices (14). It can be concluded that cigarette smoking and exposure to electromagnetic waves significantly reduced sperm count, motility, morphology, fertilization rate, and embryo quality (15).
Semen samples exposed to a mobile device for only 10 minutes showed a significant decrease in sperm motility, suggesting that subfertile males may be especially susceptible to RF-EMR (16). Regarding the type of motility impairment, RF-EMR seems to mostly affect spermatozoa's ability to maintain forward progressive motility. A study conducted by *Erogul and coworkers* (17) proved that after an extremely short five minutes exposure to RF-EMR, human spermatozoa lost their capacity to maintain both rapid and slow progressive motility. Reduced progressive motility seems to be a common side effect of RF-EMR exposure, in contrary to other researchers who have shown that larger exposure durations (hours or days) are necessary to produce significant reductions in sperm motility (18, 19).
Al-Quzwini et al. (20) investigated the relationship between environmental risks and male fertility as indicated by *seminal fluid analysis* (SFA) that showed that lower semen parameters could result from environmental risks like those found in the home or place of employment. They discovered that there is a notable difference in the exposition to environmental risks of subfertile and fertile groups. For example, the subfertile group is exposed to mobile phone towers at a larger proportion (29%) than the fertile group (12%) ($p = 0.003$). It was concluded that an increased risk of SFA anomalies (teratozoospermia) was linked to exposure to environmental hazards. These results are consistent with those published by *Makker et al.* (21) who stated that the parameters of semen analysis can be impacted by the *electromagnetic radiation* (EMR) released by mobile phones and their base station. It is now known that the pathophysiological basis for the detrimental effects on spermatozoa is caused by increased mitochondrial reactive oxygen species generation brought on by EMR, which lowers sperm vitality while promoting the DNA base adduct formation, which ultimately leads to DNA fragmentation and more abnormalities in sperm shape (22).
In *Zhang et al.* (11) study, they discovered a negative correlation between the average daily duration of mobile phone use and the rates of gradually motile spermatozoa, quick increasingly motile spermatozoa, and total motile spermatozoa. *Fejes et al.* (23) discovered that there was a positive correlation between the amount of time spent on mobile phones and the slow increasingly motile spermatozoa rate, and an inverse correlation between the two. Mobile phone use was linked to the overall motile spermatozoa rate but not to other semen characteristics, according to two prior meta-analyses (24).
Zhang et al. (11) found that the primary reason for the decrease in sperm motility could be cell phone RF-EMR. Given the expanding tendency of the male reproductive system's degradation, these findings imply that current worries about long-term exposure to RF-EMR from mobile

phones should be treated more seriously. Therefore, it is recommended that people cut down on their daily use of mobile phones to prevent additional decreases in sperm motility, which could impact fertility, particularly in men who are of reproductive age and have asthenospermia.
Additionally, a study using 358 semen samples from men who were representative of the general male population revealed that sperm motility was the most important factor in determining the likelihood of a natural conception (25). Further investigation found that carrying mobile phones in back pant pockets or using them for more than four hours per day led to a marginal elevation in the *DNA fragmentation index* (DFI) (26). However, Zhang et al. (10) found no variation in the DFI based on the amount of time spent using a mobile phone.
Similarly to our findings, *Zhang et al.* (10) discovered no statistically significant variations in the proportion of normal forms and also volume, sperm concentration, or total quantity of sperm in relation to the length of time spent using a mobile phone. A cross-sectional study revealed that as daily mobile phone talking time increased, there was a modest drop in the mean semen volume, sperm concentration, and total sperm quantity (10).
Darvish et al. (27) outcomes demonstrated that RF negatively affects semen parameters. Other systematic review studies have shown that exposure to RF is a risk factor for sperm motility and viability and that exposure to mobile phones was linked to decreased sperm motility and viability but not to decreased sperm concentration (24).
Limitations of our study included the limited sample size and the brief follow-up period. In particular the insufficient sample size may explain statistically insignificant results.

Conclusions

Personal wrong lifestyles as exposure to electromagnetic waves have been associated to a trend towards a reduced percentage of normal morphology and reduced motility of sperm cells although differences with normal population were non-statistically significant.

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