Andrology Unit, Dept. of Obstetrics and Gynaecology, University of Szeged, Hungary

Is there a relationship between cell phone use and semen quality?

Imre Fejes MD

Zoltán Závaczki MD

János Szöllosi MD PhD

Sándor Koloszár MD PhD

József Daru MD PhD

László Kovács MD PhD DSc

Attila Pál MD PhD

Keywords: cell phone, electromagnetic field, male fertility, sperm

Corresponding author: Imre Fejes MD

E-mail: fejesimi@yahoo.com

Andrology Unit

Dept. of Obstetrics and Gynaecology

University of Szeged

Semmelweis u. 1

H-6725, Szeged

Hungary

Abstract

Our aim was to determine a possible relationship between regular cell phone use and different human semen attributes. Accordingly, the history-taking of male patients in our university clinic was supplemented with questions concerning cell phone use habits, including possession, daily standby position and daily transmission times. Semen analyses were performed by conventional methods. Statistics were calculated with SPSS statistical software. A total of 371 were included in the study. The duration of possession and the daily transmission time correlated negatively with the proportion of rapid progressive motile sperm (r=-0.12 and r=-0.19, respectively), and positively with the proportion of slow progressive motile sperm (r=0.12 and r=0.28, respectively). The low and high transmitter groups also differed in the proportion of rapid progressive motile sperm (48.75% vs. 40.62%). We therefore suggest that the prolonged use of cell phones may have negative effects on the sperm motility characteristics.

Introduction

The prevalence of infertility among couples of reproductive age has been estimated as up to 15%, with a tendency to increase in recent decades. In about half of these cases, the male partner exhibits some disturbance in the spermiogram [25, 31]. Idiopathic infertility is defined as a decreased sperm quality with no organic, genetic or endocrine alteration in the background, and no infection affecting the genital tract. Various environmental factors, such as heat or certain chemical agents, can deteriorate semen quality [25]. The use of cell phones has become widespread. The analogue NMT (Nordic Mobile Telephone) system introduced in the 1980s operated at an electromagnetic resonance of 902.5 MHz. A decade later, the GSM (General System for Mobile Communication) succeeded it, with a radiofrequency of 902.4 MHz, pulsing at 217 Hz. The recent DCS (Digital Cellular System), which uses a radiofrequency of 1,800 MHz, has spread rapidly [26]. Cell phones have a wide range of specific absorption rate (SAR): depending on the model used, it is approximately 0.1-2 W/kg. The emission level of cell phones is below the defined safety thresholds; however, the effects of the electromagnetic resonance emitted by cell phones on living cells and organs are still unclear. There have been publications concerning effects on the central nervous system, such as alterations in the EEG pattern, the sleeping pattern or even the neuroendocrine functions [1, 4, 15, 20]. There have also been reports on the breakage of DNA as the cause of tumours [12, 13, 14, 17, 24], but the role of cell phones in engendering tumours is debated [2, 3, 8, 11, 19, 29, 30].

Dasdag *et al.* [5] recently reported no effects of cell phone use on the testis of rats, whereas Davoudi *et al.* [6] observed declining levels of rapid progressive spermatozoa among a small study group of cell phone users. As far as we are aware, this is the first human study of the possible relationship between cell phone use and semen quality; more than 300 males were examined.

Materials and methods

Localization: Andrology Division of Department of Obstetrics and Gynaecology, University of Szeged, Hungary.

Our study involved consecutive male patients of reproductive age, who presented at our clinic because of infertility problems in their marriage. We supplemented the history-taking with questions concerning cell phone use habits. The main aspects were: duration of possession (in months), duration of standby position closer than 50 cm to the patient (in hours) and duration of daily transmission (in minutes).

The semen analysis and evaluation process was performed in accordance with the WHO 1999 standards criteria [32]. Sperm samples were produced by masturbation into a sterile, wide-mouthed calibrated glass container following a standardized 5 days of abstinence. After a 30-minute liquefaction period, the semen characteristics were quantified by using a Makler semen counting chamber (Sefi-Medical Instruments, Israel) under the 200x magnification of an Olympus CH 2 phase contrast light microscope (Olympus Optical Co. Ltd. Japan). The sperm concentration (10^6/ml) and the motile sperm ratio (%) were assessed by the same independent qualified assistant. The categories of motility were as follows: percentage of rapid progressive motile sperm (grade A), percentage of slow progressive motile sperm (grade B), percentage of non-progressive motile sperm (grade C) and percentage of immotile sperm (grade D), according to the WHO standards [32]. The total sperm count (ejaculate volume x sperm concentration), the total number of motile sperm cells (ejaculate volume x sperm concentration x motility/100) and the rapid progressive motile sperm count (ejaculate volume x sperm concentration x grade A motility/100) were calculated. After a 3-week period, sample taking was repeated under the same conditions. The better findings were analysed.

Exclusion criteria were: (1) some other potentially subfertility-causing factor in the patient's history, such as smoking (over 10 cigarettes/day), regular alcohol consumption (over 1 U/day) or drug abuse. (2) Any severe acute or chronic systemic non-gonadal illness (especially febrile illnesses) or trauma in the previous 6 weeks. (3) Some detectable organic alteration in the

reproductive organs on physical examination, such as varicocele, obstruction or absence of the deferent duct, the absence of testes or a testis volume below 12 ml, or any abnormal localization of the testes. (4) Some alteration in the levels of the spermatogenesis-related hormones. The normal levels were as follows: follicle stimulating hormone = 0.7-9.0 IU/l, luteinizing hormone = 0.8-7.6 IU/l, prolactin = 0.11-0.45 IU/l, testosterone = 6.9-28 nmol/l, sexual hormone binding globulin = 7.2-33 nmol/l. (5) Signs and symptoms of genital tract infection: cultures were made from every examined semen sample. In the event of the presence of pathogenic aerobic or anaerobic bacteria or fungi in the semen, the patient was excluded from the study.

Statistics were calculated with SPSS 11.0 for Windows statistical software (SPSS Inc. Chicago, IL, USA). The parametric t-test and the Pearson correlation tests were applied. Results are given as correlation coefficients or means ± SD. p values <0.05 were considered significant.

Control group 1 was subdivided into those who used a cell phone for less than 15 minutes/day (low transmitters) and those who used it for over 60 minutes/day (high transmitters). Control group 2 was subdivided into those patients who kept their cell phone in the standby position within a distance of 50 cm for less than 1 hour daily (short-standby group) and those who kept their cell phone in the standby position within a distance of 50 cm for more than 20 hours daily (long-standby group).

Results

A total of 611 consecutive Caucasian male patients were examined during the study period between 1 November 2002 and 31 March 2004. 39% of them (n = 240) did not meet the study criteria, and therefore the results on 371 of them were analysed. The mean age was 30.8±4.4 years (range 17-41). The subjects were from every social class.

The semen parameters of the study population are presented in Table 1 and the regression results in Table 2.

The duration of possession correlated negatively with the proportion of rapid progressive motile sperm, and positively with the proportion of slow progressive motile sperm ($r = -0.12$, $p = 0.023$, and $r = 0.12$, $p = 0.024$, respectively).

There was no significant correlation between the duration of the standby position and any of the semen parameters.

Although we found no changes in the total motility, the characteristics of the motile sperm had changed markedly. The results revealed a significant decrease in the proportion of rapid progressive motile sperm (grade A) with increase of the daily transmission time ($r = -0.19$; $p < 0.01$) (Figure 1), while the proportion of slow progressive motile sperm increased with increase of the duration of the daily transmission time (grade B) ($r = 0.28$; $p<0.01$) (Figure 2).

The low and high transmitter groups differed significantly in the proportion of rapid progressive sperm (48.75% vs. 40.62%, $p = 0.01$, $n = 195$ vs. $n = 58$). There was no difference in any characteristic between the short- and long-standby groups (Table 1).

We found no occupational hazard in the background of the deteriorated semen parameters among the high-transmitters.

Discussion

The number of couples presenting with infertility problems is increasing worldwide. In about 30% of the cases of male infertility, there is no obvious cause of the deteriorated semen parameters defined as idiopathic infertility [31]. The factors in the background of this state remain unknown.

As far as we are aware, there has been no previous study of the effect of the electromagnetic field of cell phones on human semen on such a large population *in vivo*.

Our results suggest that standby communication signals do not have a significant effect on the sperm parameters. Conversely, the prolonged daily use of mobile phones may abrogate the motion characteristics of spermatozoa. The overall motility does not change, but the observed moderate decrease in grade A motility, together with the observed moderate increase in grade B motility, may be a consequence of the electromagnetic radiation emitted from cell phones. These findings are similar to those of Davoudi *et al.*, who observed a reduction in the proportion of rapid progressive sperm from 32.3% to 26.1% after 1 month of cell phone use for 6 hours daily [6]. Makler *et al.* examined the effects of 27 MHz electromagnetic resonance on human sperm velocity and survival *in vitro*, and found a decreased percentage motility and velocity, but no effect of UV light or X-rays [23].

The correlation between cell phone use and the changes in the motility parameters suggests that these effects accumulate.

Electromagnetic radiation has both thermal and non-thermal effects on living cells. There is no consensus among authors as to which effect predominates [5, 30]. We believe that the thermal effects possibly low at such low SAR levels as the cell phone emits.

We have formulated two hypotheses with which to interpret our results; however, both are in need of evidence.

First, as the brain region is close to the transmitting cell phone, the admittance is obvious: electromagnetic radiation affects the testis by changing the levels of hormones produced by glands inside the cranium. De Seze *et al.* found no alterations in the levels of pituitary hormones in

association with prolonged cell phone use [7]. According by we excluded those subjects who exhibited such an alteration. Burch *et al*. demonstrated a reduced 6-OHMS level in the urine among those using a cell phone for over 25 minutes/day; 6-OHMS is the urinary metabolite reflecting the therefore referring serum level of the pineal hormone melatonin [1]. Melatonin is known to be an antioxidant agent that protects against lipid peroxidation in the retina, brain, liver cells and even human sperm [9].

Secondly, the electromagnetic radiation of cell phones may cause DNA breakage in cells in the male genital tract, which can occur in a low-frequency electromagnetic field. *In vitro* studies appear justified to investigate the increased numbers of chromosome aberrations of the micronuclei in human leucocytes and DNA breaks [18, 21, 22]. A moderate correlation has been found between the sperm motility and the sperm chromatin structure which are probably brought about by distorted epididymal protamination [10].

A possible connection of the two theories is reactive oxygen species (ROS) production. ROS cause DNA fragmentation in somatic cells reducing protamination [28]. Melatonin inhibits ROS production.

A sedentary lifestyle and other occupational factors can lead to deteriorated semen parameters [25, 27]. These effects are mostly occupation-related. We found no specific profession among the high transmitters in our population to suggest that some particular occupation might be responsible for the deteriorated semen parameters rather than excessive cell phone use.

Our study has some limits: the effects of the non-ionizing radiation emitted by cell phones depend on a number of factors besides the duration of transmission, e.g. the type of cell phone and the distance from the cell phone tower [16]. We examined only the duration of use not specified to other variables, as this covered a fairly wide cross-section of males from the whole population.

The function of the accessory glands was not examined. Their secretion can improve sperm motion, and also affect the function in other ways.

Further, prospective, controlled studies on a larger population are required to prove whether the electromagnetic emission from cell phones affects the male fertilizing capacity, and to establish the mode of action of such a possible deteriorating effect.

References

1. Burch JB, Reif JS, et al. (2002): Melatonin metabolite excretion among cellular telephone users. Int J Radiat Biol 78:1029-1036

2. Christensen HC, Kosteljanetz M, et al. (2004): Cellular telephone use and risk of acoustic neuroma. Am J Epidem 159 :277-283

3. Cook A, Woodward A, et al. (2003): Cellular telephone use and time trends for brain, head and neck tumours. N Z Med J 116:u457-

4. D'Costa H, Trueman G, et al. (2003): Human brain wave activity during exposure to radiofrequency field emissions from mobile phones. Australas Phys Eng Sci Med 26:162-167

5. Dasdag S, Zulkuf Akdag M, et al. (2003): Whole body exposure of rats to microwaves emitted from a cell phone does not affect the testes. Bioelectromagnetics 24:182-188

6. Davoudi M, Brössner C, et al. (2002): Der Einfluss elektromagnetischer Wellen auf die Spermienmotilität. J Urol Urogynäkol 9:18-22

7. de Seze R, Fabbro-Peray P, et al. (1998): GSM radiocellular telephones do not disturb the secretion of antepituitary hormones in humans. Bioelectromagnetics 19 :271-278

8. Elwood JM (2003): Epidemiological studies of radio frequency exposures and human cancer. Bioelectromagnetics Suppl 6:s63-73

9. Gavella M, Lipovac V (2000): Antioxidative effect of melatonin on human spermatozoa. Arch Androl 44:23-27

10. Giwercman A, Richthoff J, et al. (2003): Correlation between sperm motility and sperm chromatin structure assay parameters. Fertil Steril 80:1404-1412

11. Hansson Mild K, Hardell L, et al. (2003): Mobile telephones and cancer: is there really no evidence of an association? (review). Int J Mol Med 12:67-72

12. Hardell L, Mild KH, et al. (2001): Ionizing radiation, cellular telephones and the risk for brain tumours. Eur J Cancer Prev 10:523-529

13. Hardell L, Mild KH, et al. (2002): Case-control study on the use of cellular and cordless phones and the risk for malignant brain tumours. Int J Radiat Biol 78:931-936

14. Hardell L, Mild KH, et al. (2003): Cellular and cordless telephones and basal cell carcinoma: a case report. Arch Environ Health 58:380-382

15. Huber R, Treyer V, et al. (2002): Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG. J Sleep Res 11:289-295

16. International Commission on Non-Ionizing Radiation Protection (ICNIRP) (1998): Guidlines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz). Health Physics 74:494-522

17. Ivancsits S, Diem E, et al. (2002): Induction of DNA strand breaks by intermittent exposure to extremely-low-frequency electromagnetic fields in human diploid fibroblasts. Mutat Res 519:1-13

18. Ivancsits S, Diem E, et al. (2003): Intermittent extremely low frequency electromagnetic fields cause DNA damage in a dose-dependent way. Int Arch Occup Environ Health 76:431-436

19. Johansen C, Boice JD Jr, et al. (2002): Mobile phones and malignant melanoma of the eye. Br J Cancer 86:348-349

20. Kramarenko AV, Tan U (2003): Effects of high-frequency electromagnetic fields on human EEG: a brain mapping study. Int J Neurosci 113:1007-1019

21. Lai H, Singh NP (1995): Acute low-intensity microwave exposure increases DNA single-strand breaks in rat brain cells. Bioelectromagnetics 16:207-210

22. Lai H, Singh NP (1996): Single- and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation. Int J Radiat Biol 69:513-521

23. Makler A, Tatcher M, et al. (1980): Factors affecting sperm motility. III. Influence of visible light and other electromagnetic radiations on human sperm velocity and survival. Fertil Steril 33:439 -444

24. Mashevich M, Folkman D, et al. (2003): Exposure of human peripheral blood lymphocytes to electromagnetic fields associated with cellular phones leads to chromosomal instability. Bioelectromagnetics 24:82-90

25. Nieschlag E, Behre HM (2000): Andrology: male reproductive health and dysfunction. Berlin, Heidelberg, New York, Barcelona, Hong Kong, London, Milan, Paris, Singapore, Tokyo: Springer-Verlag.

26. Roelandts R (2003): Cellular phones and the skin. Dermatology 207:3-5

27. Stoy J, Hjollund NH, et al. (2004): Semen quality and sedentary work position. Int J Androl 27:5-11

28. Sun JG, Jurisicova A, et al. (1997): Detection of deoxyribonucleic acid fragmentation in human sperm: correlation with fertilization in vitro. Biol Reprod 56:602-607

29. Warren HG, Prevatt AA, et al. (2003): Cellular telephone use and risk of intratemporal facial nerve tumor. Laryngoscope 113:663-667

30. Weisbrot D, Lin H, et al. (2003): Effects of mobile phone radiation on reproduction and development in *Drosophila melanogaster*. J Cell Biochem 89:48-55

31. World Health Organisation (2000): WHO manual for the standardised investigation, diagnosis and management of the infertile male. Cambridge, UK: Cambridge University Press.

32. World Health Organization (1999): WHO Laboratory Manual for the Examination of Human Semen and Sperm-Cervical Mucus Interaction. Cambridge, UK: Cambridge University Press.

Tables

	Total population Mean± S.D.	Control group 1 Mean± S.D.	High-transmitters Mean± S.D.	Control group 2 Mean± S.D.	Long standby Mean± S.D.
Sperm concentration (10^6/ml)	68.38±48.86	67.6±44.56	68.47±46.43	69.32±45.97	63.77±42.3
Proportion of rapid progressive motile sperm (%)	47.17±21.21	48.75±20.62	40.47±21.62	47.85±21.4	46.17±20.65
Proportion of slow progressive motile sperm (%)	12.38±9.23	11.4±7.13	16.98±15.53	11.72±6.79	13.58±9.98
Proportion of non-progressive motile sperm (%)	7.99±5.4	8.34±5.76	7.73±4.37	9.12±5.67	7.59±4.94
Motility (%)	59.56±18.85	60.15±18.8	57.46±17.26	59.58±19.13	59.75±16.58

Table 1. Main semen characteristics of the study population (n=371), control group 1 (n=195), the high-transmitter group (n=59), control group 2 (n=106) and the long-standby group (n=88).

	Volume (ml)	Sperm conc. (10^6/ml)	Proportion of rapid progressive motile sperm (%)	Proportion of slow progressive motile sperm (%)	Proportion of non-progressive motile sperm (%)	Proportion of immotile sperm (%)	Total motility (%)	Total sperm count (10^6/ejaculate)	Total motile sperm count (10^6/ejaculate)	Total rapid progressive motile sperm count (10^6/ejaculate)
Duration of possession (months)	-0.02 p=0.64	-0.01 p=0.91	**-0.12 p=0.02**	**0.12 p=0.02**	0.07 p=0.15	0.06 p=0.28	-0.08 p=0.14	-0.01 p=0.81	-0.03 p=0.53	-0.06 p=0.26
Duration of daily standby (hours)	0.05 p=0.42	-0.01 p=0.39	-0.05 p=0.41	0.05 p=0.37	-0.05 p=0.37	0.04 p=0.47	-0.03 p=0.64	-0.05 p=0.41	-0.07 p=0.22	-0.08 p=0.15
Duration of daily transmission (min)	-0.01 p=84	0.04 p=0.84	**-0.19 p<0.01**	**0.28 p<0.01**	-0.03 p=0.56	0.08 p=0.12	-0.07 p=0.16	0.03 p=0.58	0.00 p=0.54	-0.08 p=0.14

Table 2. Correlations between parameters of cell phone use and semen characteristics (n=371). Bold numbers denote a significant correlation.

Figures

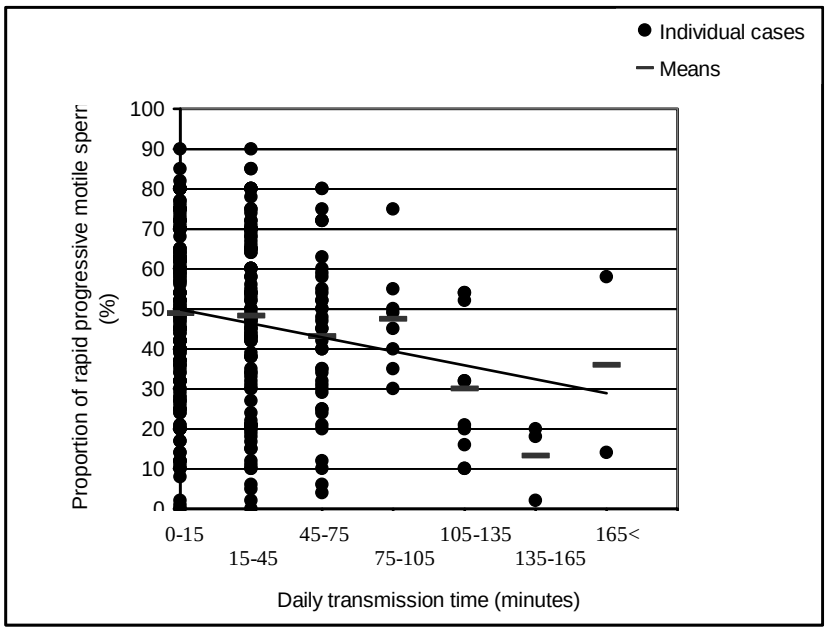

Figure 1. Correlation between daily transmission time and percentage of rapid progressive motile sperm ($r = -0.19$; $p<0.01$; $n = 372$)

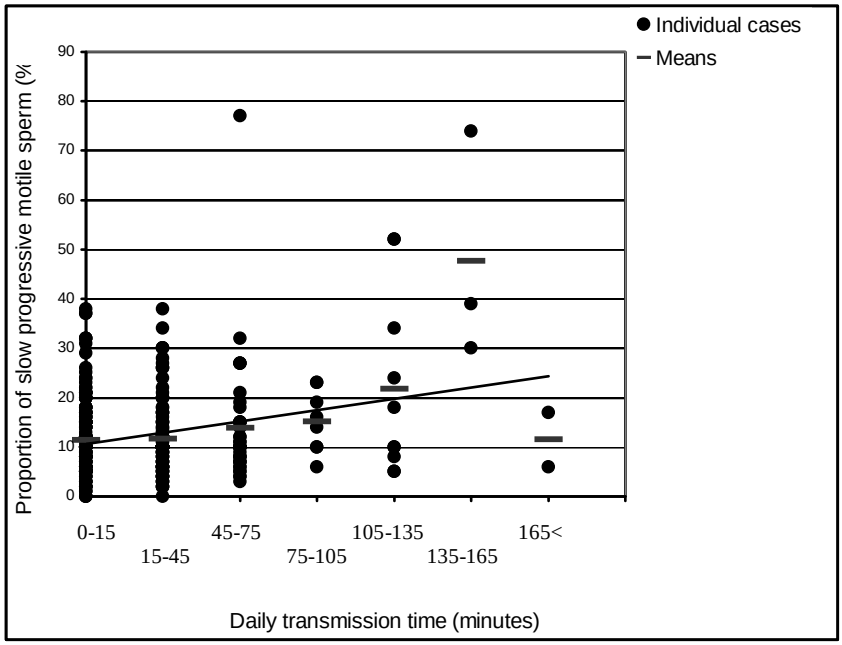

Figure 2. Correlation between daily transmission time of cell phone and proportion of slow progressive motile sperm ($r = 0.28$; $p<0.01$; $n = 372$)

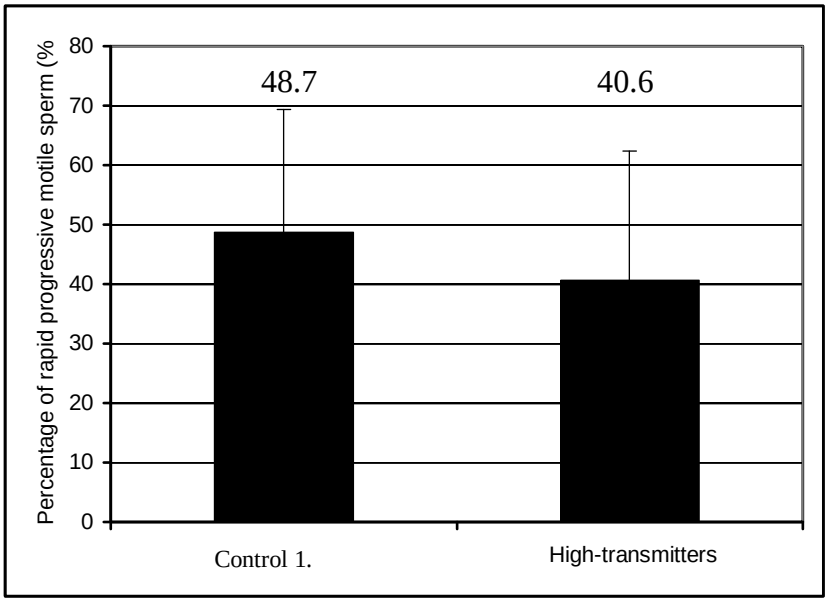

Figure 3. Comparison of proportion of rapid progressive motile sperm in low and high-transmitters (n = 195 vs n = 58; p = 0.01)