

Effects of mobile phone radiation on serum testosterone in Wistar albino rats

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ABSTRACT

الأهداف: تحديد آثار إشعاع الحقل الالكتروني المغناطيسي الذي يبعثه الهاتف المحمول على معدل هرمون التوسترون في مجموعة الجراد من النوع ألبينو ويستر.

الطريقة: تم عمل هذه الدراسة الاختبارية المراقبة في قسم الفيزيولوجيا بكلية الطب، جامعة الملك سعود، الرياض، المملكة العربية السعودية وذلك خلال الفترة من ديسمبر 2006م إلى إبريل 2008م. ولقد أجريت التجربة على 34 جرذ ذكر من النوع ألبينو (فصيلة ويستر)، وكانت أعمارهم تبلغ الشهرين وأوزانهم تتراوح ما بين 150-160 غرام. لقد تم تقسيم هذه الحيوانات إلى 3 مجموعات. تحوي المجموعة الأولى على 6 جرذ وسميت مجموعة التحكم حيث لم تتعرض لإشعاع الهاتف المحمول، في حين احتوت المجموعة الثانية على 14 جرذ تم تعريضهم إلى إشعاع الهاتف لمدة 30 دقيقة يومياً خلال 3 أشهر، أما المجموعة الثالثة فقد احتوت 14 جرذ تعرضوا إلى الإشعاع لمدة 60 دقيقة يومياً خلال 3 أشهر. وبعد نهاية التجربة تم جمع عينات الدم من أجل تحليل هرمون التوسترون باستخدام طريقة (double anti-body radioimmunoassay method) وبالتحديد اختبار (Coat-A-Count).

النتائج: أدى التعرض لإشعاع الهاتف المحمول لمدة 60 دقيقة يومياً خلال 3 أشهر إلى نقص واضح في معدل هرمون التوسترون ($p=0.028$) في مجموعتي الجراد الثانية والثالثة من النوع ألبينو ويستر وذلك بالمقارنة مع مجموعة التحكم التي لم تتعرض للإشعاع.

خاتمة: يؤدي التعرض لإشعاع الهاتف المحمول على المدى الطويل إلى انخفاض معدل هرمون التوسترون. بعد التوسترون هرمونا ذكرياً مهماً وقد يؤدي أي تغيير في معدله الطبيعي إلى خلل في الخصوبة أو الصحة العامة.

Objectives: To investigate the effects of electromagnetic field radiation generated by mobile phones on serum testosterone levels in Wistar albino rats.

Methods: This experimental interventional control study was conducted in the Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia during the period December 2006 to April 2008. A total of 34 male Albino rats [Wistar strain], 2 months of age, weighing 150-160 gm were used for the experiment. These animals were divided into 3 groups. The first group containing 6 rats was assigned as a control group. The second group containing 14 rats was exposed to mobile phone radiation for 30 minutes daily and the third group containing 14 rats was exposed to mobile phone radiation for 60 minutes daily for the total period of 3 months. At the end of experimental period, blood was collected into the container, and serum testosterone was analyzed using double-antibody radioimmunoassay method by Coat-A-Count.

Results: Exposure to mobile phone radiation for 60 minutes/day for the total period of 3 months significantly decrease the serum testosterone level [$p=0.028$] in Wistar Albino rats compared to their matched control.

Conclusion: Long-term exposure to mobile phone radiation leads to reduction in serum testosterone levels. Testosterone is a primary male gender hormone and any change in the normal levels may be devastating for reproductive and general health.

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Mobile phone is one of the technological miracles of this century.¹ The numbers of mobile phone users are continuously increasing and total number worldwide have surpassed 4.8 billion. That means two-third of the world population is using this technology. Newly industrialized and developing countries are outstanding in fast growth of use of mobile phones.² Mobile phones are radio devices, transmit and receive radio frequency radiation at 900-2000 MHz.^{3,4} Radiation field strength substantially increases during active communication and data sharing with serving booster tower. Mobile phone users, most of the times, do not have even slightest consideration of health hazards posed by radiation emitted by mobile phones. Youngsters sometimes spend undue long time on tele-conversation. This phenomenon has alarmed medical researchers. Scientists have tried to evaluate the potential links between adverse health effects and mobile phone radiations. Electromagnetic field (EMF) radiation emitted by mobile phones can inflict their effects both by thermal and non-thermal impact.⁵ Despite of the fact that fair bulk of literature is published over the last decade and research work is still going on, yet objective evidence of any compelling result is lacking. It is still difficult to broadcast the apprehensions with any significant level of confidence on any international forum. Since radiation affect the biological materials posed by depositing energy at molecular levels, hence their stochastic and non-stochastic effects might be important at sub-cellular levels. Hormones and receptors might be the prime targets for worst possible health hazards to the mobile phone users and their future generations. Electromagnetic field radiation generated by mobile phones affects various organs and systems.^{6,7} Literature is available on the hazards of mobile phone radiation on various organs; however, with best of our knowledge none of the study has been conducted yet to determine the effects of mobile phone radiation on testosterone, that is a primary male gender hormone, essential for body tissues, spermatogenesis, and have a multitude of physiological roles in health. Keeping in view the common use of cell phone and significance of testosterone, we evaluated the effects of mobile phone radiation on serum testosterone level in Wistar albino rats.

Methods. This experimental interventional control study was conducted in the Department of Physiology,

College of Medicine, King Saud University, Riyadh, Saudi Arabia during the period December 2006 to April 2008.

Animal model. Thirty-four male Albino rats (Wistar Strain), 2 months of age, weighing 150-160 gm, with same genetic background, were included for the experiment. Animals were housed in 3 cages in a similar environment and were fed with standard pellet diet [Gold Mohar] and water ad-libitum. They were maintained under controlled temperature of 22-24°C and had 12-12 hours light-dark cycle [light on 06:00-18:00 hours].⁸ The animal experimental protocol was approved by the Ethics Board, College of Medicine, King Saud University, and experiment was performed according to the suggested guidelines.

Experimental protocol. Wistar albino rats (n=34) were divided into 3 groups. Group A (n=6) served as a control and the remaining 2 groups, B and C (n=14 each) were exposed to EMF radiation generated by mobile phone on a specific time of the day [during light period] for the total period of 3 months. Group A containing 6 rats was assigned as a control group. Group B was exposed to mobile phone radiation for 30 minutes daily and group C was exposed to mobile phone radiation for 60 minutes daily for the total period of 3 months. In this experiment, handsets of global system for communication (GSM) mobile phone of the same brand and model were used. A mobile phone was placed inside the cage and a call was given with another mobile phone and it was also ensured that the mobile phone inside the cage was powered-on, and with call accepting [answering] mode and the rats were in close proximity to the mobile phone.⁸⁻¹¹

Serum testosterone analysis. At the end of the experimental period [3 months], blood samples were collected at the fixed time of the day to minimize the diurnal variation. The blood samples were collected into the container with specific identification code number and serum was separated by centrifugation at 3000 rpm for 10 minutes and serum was stored at -70°C until the use. Serum testosterone hormone was analyzed using double-antibody radioimmunoassay method by Coat-A-Count.

Statistical analysis. Data was entered into the computer, SPSS version 13 was used. Data were expressed as Mean \pm Standard Error of mean (SEM). Student t-test was applied and p-value <0.05 was considered significant.

Results. Table 1 shows the serum testosterone level in Wistar albino rats exposed to mobile phone radiation compared to their matched control. Serum testosterone level was significantly lower [$p < 0.02$] in Wistar albino rats that were exposed to mobile phone

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Table 1 - Effects of electromagnetic field radiation generated by mobile phone on serum testosterone level in Wistar albino rats.

Parameters	Group A [n=6]	Group B [n=14]	Group C [n=14]
Serum testosterone [ng/ml] (mean± SEM)	6.34±1.55*	5.10±1.24	3.10±0.60*

Group A - control.
 Group B= Exposed for the period of 30 minutes/day for the total period of 3 months.
 Group C= Exposed for the period of 60 minutes/day for the total period of 3 months.
 *Asterisk represents significance level [p<0.02] between group A and C.

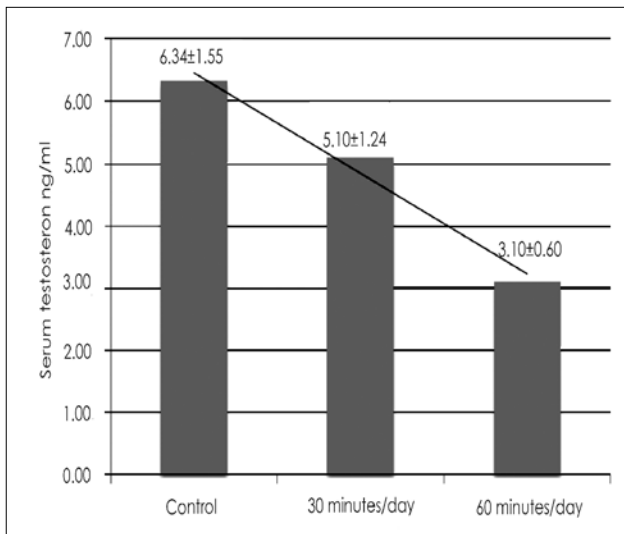


Figure 1 - Effects of electromagnetic field radiation generated by mobile phone on serum testosterone level in Wistar albino rats.

radiation for 60 minutes daily for the total period of 3 months compared to their matched control. However, there was no significant difference [$p=0.25$] between the control and Wistar albino rats who were exposed for mobile phone radiation for the 30 minutes/day for the total period of 3 months compared to their matched control.

Discussion. Human beings are exposed to the various occupational and environmental factors, which may generate radiation and impair their reproductive capabilities and can cause infertility. Infertility affects approximately 15% of couples of reproductive age, and with nearly half of these cases resulting from male factor infertility, hence this area of research is of great interest to both physicians and research scientists.¹² Electromagnetic field radiation emitted from cell phones may interfere with normal reproductive parameters and result in a male infertility. A limited number of animal studies indicated that EMF radiation have a wide range of damaging effects on the testicular function and male germ line.^{13,14} These radiations can affect the reproductive function through both thermal and non-thermal effects.¹¹ A hazardous effect on male fertility may be

manifested through variation in the serum testosterone level. Testosterone is a primary male gender hormone and plays a significant role in the spermatogenesis and is vital to general metabolism of human body as well. The causative agents may be including EMF radiation.¹⁵ The effect of EMF radiation on living organisms depends on the frequency and intensity.¹⁶ These radiations may exert an effect on the state of polarization of the cellular membranes. An inadequate polarization of cellular membrane is responsible for the process of various abnormalities of testosterone synthesis, secretion which may impair spermatogenesis and ultimately become a cause of infertility. There are few animal studies that show that EMF radiation generated by mobile phones have a wide range of damaging effects on the male reproductive system and sperm parameters.⁵ In the present study, we found that long term exposure to mobile phone can cause decrease serum testosterone level in Wistar albino rats compared to their matched control. Although decreasing pattern of serum testosterone is seen in both groups of experimental animals (Figure 1), statistical significance was only reached in group C who was exposed to EMF for 60 minutes. This is an important finding indicating dose response relationship. It has been reported that the use of mobile phones adversely affects the quality of semen by decreasing the sperm counts, motility, viability and morphology. Evidence of detrimental effect of mobile phones on male fertility is still ambiguous as studies have revealed a wide spectrum of possible effects ranging from insignificant effects to variable degrees of testicular damage and the mode of action of EMF radiation emitted from mobile phones on the male reproductive system is still unclear. Electromagnetic field can affect the reproductive system via an EMF-specific effect, thermal molecular effect or combination of both.¹⁷

The animal studies show that EMF radiation generated by mobile phones has a wide range of damaging effects on the male reproductive system and sperm parameters.⁵ Wdowiak et al¹⁵ conducted a study to determine the effects of the usage of cellular phones on the fertility in male subjects. They analyzed the effects of GSM mobile phone on the semen and it was noted that

an increase in the percentage of sperm cells of abnormal morphology is associated with the duration of exposure to the waves emitted by the GSM phone. Deepinder et al¹⁷ reported that use of cell phones adversely affects the quality of semen by decreasing the sperm counts, motility, viability, and morphology. They also mentioned that electromagnetic waves can affect the reproductive system via an EMW-specific effect, thermal molecular effect or combination of both. Furthermore, Dasdag et al¹³ found that using a conventional cellular telephone in an active mode for 3 minutes daily during 30 days decreased seminiferous tubular diameter in the testes in rats. Salama et al¹⁸ concluded that, low intensity pulsed radio frequency emitted by a conventional mobile phone kept in the standby position could affect the testicular function and structure in the adult rabbit. De Iuliis et al¹⁹ demonstrate that EMF radiation can damage the sperm function through certain mechanisms that involve the leakage of electrons from the mitochondria and the creation of oxidative stress. Similarly, Mailankot et al⁹ reported that EMF radiation generated from mobile phone in active mode disturbs free radical metabolism in reproductive tissue and thereby leads to changes in reproductive parameters. The current literature supporting our findings that mobile phone radiation impairs the reproductive physiology and the primary hormone to maintain the male reproductive physiology is testosterone. The greater part of the testosterone is produced in the interstitial cells of Leydig in the testes. Regulation of testicular production occurs via a negative feedback loop system involving the anterior pituitary gland, hypothalamus and testes.²⁰ Electromagnetic field exposure may affect the serum testosterone at any of the control levels in feedback cycle from anterior pituitary gland to serum protein binding capacity. The results of the present study ascertained that mobile phone use has long-term effects on serum testosterone levels in Wistar albino rats. As testosterone is a primary male sex hormone, essential for body tissues, spermatogenesis, and have a multitude of physiological roles in health. Decrease in serum testosterone, ultimately impair the health in general and reproductive physiology in particular.

There are a few limitations of this study. The international ethical guidelines on animal studies require that minimum possible number of animals should be used for experimentation. Therefore, we recruited the limited number of animals. In the present study, a mobile phone was placed inside the cage and a call was given with another mobile phone and it was also ensured that the mobile phones inside the cage was powered-on, and with call accepting [answering] mode and the rats were in close proximity to the mobile phone. The research methodology adopted in this study

has been already cited in highly ranked journals,⁸⁻¹¹ but currently, devices are available which can generate the specific amount of EMF radiation, hence in future studies, such devices should be utilized for experiments to achieve the specific dose such as 1000 MHz, 1500 MHz or 2000 MHz. The effects can be observed with respect to specific dose and duration of exposure. We suggest that further reasonable sample size studies on large sized animals [such as rabbits] will be conducted to further evaluate the results of EMF radiation on serum testosterone level.

In conclusion, long term exposure to mobile phone radiation can cause decrease serum testosterone in Wistar Albino rats. Based on this animal model study, such effects are also expected in humans; therefore, it is suggested that long term and/or excessive use of mobile phones should be avoided. This can be achieved by health promotion activities such as group discussions, public presentations and through electronic and print media sources.

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