Applied Biological Research 13 (2): 113-116, 2011 **Short communication**

EFFECT OF PRROLONGED EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELD ON PLASMA CORTISOL, GLUCOSE, CHOLESTEROL AND TRIGLYCERIDES IN MALE RATS

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ABSTRACT

Extremely low frequency electromagnetic fields (EMFs) produce both positive and negative effects on biological processes and the present study was aimed to evaluate the effect of low frequency EMF on some biochemical parameters in rats. Forty five rats in 3 groups viz., control group (kept under normal conditions in animal room), group 2 (exposed for 135 days and under 50 Hz, 1 mT emitted from solenoid for 24 h daily), and group 3 (sham group kept under conditions similar to group 2, except in off solenoid). Blood samples were collected to determine the concentration of cortisol, glucose, cholesterol and triglycerides in plasma. In EMF exposed group plasma levels of cortisol, glucose, cholesterol and triglyceride were significantly lower than those of other groups revealing that long term exposure to EMF has potential clinical use with no immunosuppressive effect.

Keywords: Colesterol, cortisol, electromagnetic field, glucose, long term exposure, rat, triglycerides

Electromagnetic fields (EMFs) not only stimulate some important biological processes (Blank and Goodman, 2002) but also influence carbohydrate metabolism (Laitl-Kobierska *et al*., 2002), produce response to stress energy metabolism and plasma levels of glucose and ACTH in stressed rat (Harakaw *et al*., 2005) and increase plasma cortisol level (Sedghi *et al*., 2006). Extremely low frequency magnetic fields are defined as those having frequencies up to 300 Hz, which is a non-ionizing radiation having photon energy too weak to break the atomic bonds (Lee *et al*., 2004). There are contradictory reports about the effects of magnetic fields on animal and human health, attributable to the differences in exposure conditions, population and the parameters studied. Cortisol is released from adrenal gland whereas ACTH from pituitary. Blank *et al*. (1995) have reported exaggerated rise in Na rate, K-ATPase and stress level in population when an organism is subjected to EMF of 60 Hz. One of the stress indicators is cortisol (Radon *et al.*, 2001). Extremely low frequency EMFs reportedly increase cortisol concentration in the serum of animals including man (Zare *et al.*, 2006; Shahryar and Lotfi, 2009; Vangelova *et al.*, 2007). Contrarily, other studies reveal that exposure to EMF does not affect the concentration of cortisol secretion (Thompson *et al.*, 2001; Sarookhani *et al.*, 2011). EMF in living organisms also trigger key biochemical processes in various metabolic pathways including the synthesis of acetyl coenzyme A (Kubinyi *et al.*, 1998; Forgacs *et al.*, 1998). Suppression of acetyl coenzyme A synthesis may lead to decrease in lipogenesis, especially in liver (Kula and Drózdz, 1996). Reports indicate significant decrease in plasma triglyceride and cholesterol in EMF exposed animals (Amara *et al.*, 2006; Invanova *et al.*, 2007; Hosseini *et al.*, 2010). In contrast others have reported increase in serum levels of triglycerides due to extremely low frequency EMF (Smialowicz *et al.*, 1981). The present study was, therefore, aimed to evaluate the influence of long-term exposure to low frequency EMF on the energy metabolism in rats.

EMF exposure unit (at a frequency of 50 Hz and 1 mT) was an open wooden box 100×100×35 cm size. The distribution of EMF flux density was measured using a gauss meter. The experimental animals consisted of 45 male rats (strain Wistar), 12 weeks old, each weighing 234.4±12.6 g. The animals were randomly divided into three equal groups of 15 rats each. The rats were kept in either magnetic field chamber (EMF exposed group, exposed for 135 days and under 50 Hz, 1 mT emitted from solenoid for 24 h daily) or in a similar chamber without a magnetic field (sham group), or in ordinary cages (control group) in the same animal room under controlled conditions (temperature 21-22°C) for 135 days. The lighting was turned off or on under a 12 h cycle. The rats were fed with standard granulated feed and had free access to water. The local Ethics Committee approved the study. After 135 days animals were weighed and anaesthetized with ethyl ether. The blood samples (5 ml) were obtained from the right ventricle of heart, decanted and centrifuged. The plasma was used to determine cortisol, glucose, cholestrol and triglyceride concentrations. Cortisol was determined by radioimmunoassay method [Tabeshyarnoor Co., Hamedan, Iran] (Sroczynski *et al*., 1988). Glucose, cholesterol and triglycerides were measured using automatic analyzer (Technicon, RA-1000, America) and related kits by glucose oxidase method using PAP-glucose kit-Labtest Diagnostic-Iran and CHOD-PAP and GPO-PAP methods with Bohringer reagents, respectively (Sedghi *et al*., 2006). The data was statistically analyzed using analysis of variance.

The long-term exposure to extremely low frequency EMF resulted in considerable decrease in plasma level of cortisol, glucose, cholesterol and triglycerides (Table 1). In concordance to our study, it has been shown that exposure to extremely low frequency EMF caused decrease in serum triglycerides and cholesterol (Hosseini *et al*., 2010). Torres-Duran *et al.* (2007) have observed reduction in serum total lipids in human beings with most pronounced changes in steelworkers with longest exposure of over 10 years to EMFs. Low cholesterol and triglyceride levels were also observed by Bellosi *et al*. (1996) in rat serum exposed to electromagnetic radiations. The decrease in cholesterol levels in EMF exposed group in present study suggests decreased energetic demand. It may be argued that EMF either affected the absorption of triglyceride from digestion system or intervened the formation and movement of chilo-microns to liver. Further investigations are required to determine the precise mechanisms involved. In present study increase in insulin plasma concentration was also observed (Gholampour *et al*., 2011). Hosseini *et al*. (2010) have reported that insulin increases gene expression of lipoprotein lipase in different organs especially liver, and one of the insulin actions in plasma is activating apo-CII that is activator of lipoprotein lipase. It may be deduced that increase in insulin in plasma results in the elevation of lipoprotein lipase efficiency in plasma and lowers triglyceride in plasma.

Table 1: Cortisol, glucose, cholesterol and triglyceride concentration in the plasma of EMF exposed male rats (mean ± SEM)

Groups	Cortisol ($ng\ ml^{-1}$)	Glucose ($mg\ dl^{-1}$)	Cholesterol ($mg\ dl^{-1}$)	Triglycerides ($mg\ dl^{-1}$)
Control	4.14 ± 0.18^a	236.9 ± 4.52^a	75.73 ± 3.90^a	87.80 ± 4.69^a
Sham operated	3.93 ± 0.19^a	234.9 ± 7.71^a	76.33 ± 3.94^a	90.20 ± 4.29^a
EMF exposed	1.83 ± 0.20^b	152.8 ± 5.13^b	53.53 ± 3.55^b	71.13 ± 4.64^b

The means values within the same column with same superscripted alphabet do not significantly differ from each other at $P_{0.05}$ level

In present study cortisol plasma concentration was measured as stress indicator. Cortisol as a representative glucocorticoid is produced in Zona fasiculata of adrenal cortex and is required at stress time to maintain blood glucose levels and prevent shock. Cortisol regulates its own secretion by a negative feedback effect (Pamela and Richard, 2007). The cortisol has immune-suppressive effect (Karow and Lang, 1995), and EMF exposures reportedly lead to transient increase in serum cortisol levels in animals (Sedghi *et al*., 2006; Vangelova *et al*., 2007) and in many cases did not show such effect (Thompson *et al*., 2001; Djeridane *et al*., 2008; Sarookhani *et al*., 2011). Our study revealed a significant decrease in cortisol plasma concentration at EMF exposed group in comparison to other groups. Thus, it seems that long term exposure to EMF decreases the cortisol plasma concentration probably via reduction in the activity of hypothalamus-hypophysis-adrenal axis. In present study plasma concentration of glucose (other blood factor of stress) in EMF exposed group was significantly low as compared to other groups (Gholampour *et al*., 2011), which is in agreement with Laitl-Kobierska *et al*. (2002). Decrease in cortisol and glucose levels revealed that the effects of EMF (50 Hz, 1mT) on the immune system, if present at all, do not appear to be pronounced. It may be concluded that extremely low frequency EMF has some impact on energy metabolism parameters without any immune-suppressing effect. More studies are needed to elucidate the association of EMF with the energy metabolism system.

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REFERENCES

Blank, M. and Goodman, R. 2002. Low-frequency electromagnetic fields evoke the stress response: mechanism of interaction with DNA and biomedical applications. *IEEE Transactions on Plasma Science,* **30**: 1497-1500.

Blank, M., Soo, L. and Papstein, V. 1995. Efeito dos campos magnéticos de baixa freqüência na atividade do Na, K-ATPase. *Bioelectrochemistry and Bioenergetics*, **38**: 267-273.

Djeridane, Y., Touitou Y. and De Seze, R. 2008. Influence of electromagnetic fields emitted by GSM-900 cellular telephones on the circadian patterns of gonadol, adrenal and pituitary hormones in men. *Radiation Research*, **169:** 337-343.

Gholampour, F., Javadifar, T.S., Owji, S.M. and Bahaoddini, A. 2011. Prolonged exposure to extremely low frequency electromagnetic field affects endocrine secretion and structure of pancreas in rats. *International Journal of Zoological Research*, published online: 13 July 2011 [DOI: 10.3923/ijzr.2011; *http://scialert.net/fulltext/?doi=ijzr.0000.31459.31459&org=10*]

Hosseini, E., Nafisi, S., Athari, S.S., Zare, S., Rezazadeh, L., Nasiri, S. and Baseri, M. 2010. The effects of whole body exposure to extremely low frequency triangular pulsed electromagnetic fields on serum lipids in male rabbits with normal diet. *Iranian Journal of Diabetes and Lipid Disorders,* **9**: 1-5.

Karow, T. and Lang, R. 1995. *Allgemeine und spezielle Pharmakologie und Toxikologie* (3rd edn.) F. Hansen, KoÈln, Thomas Karow, Bergisch-Gladbach, Germany.

Kubinyi, G., Thuroczy, G., Sinay, H. and Szabo, D.L. 1998. Magnetic field and the initial phase of the protein synthesis in newborn and adult mice. *Electro- and Magneto-biology.* **17**: 161-169.

Kula, B. and Drózdz, M. 1996. A study of magnetic field effects on fibroblasts cultures. Part 2: The evaluation of effects of static and extremely low frequency (ELF) magnetic fields on free-radical processes in fibroblasts cultures. *Bioelectrochemistry Bioenergetics,* **39**: 27-30.

Laitl-Kobierska, A., Cieslar, G., Sieron, A. and Grzybek, H. 2002. Influence of alternating extremely low frequency ELF magnetic field on structure and function of pancreas in rats. *Bioelectromagnetics,* **23**: 49-58.

Lee, J.S., Ahn, S.S., Jung, K.C., Kirn, Y.W. and Lee, S.K. 2004. Effects of 60 Hz electromagnetic field exposure on testicular germ cell apoptosis in mice. *Asian Journal of Andrology,* **6**: 29-34.

Radon, K., Parera, D., Rose, D.M., Jung, D. and Vollrath, L. 2001. No effects of pulsed radio-frequency electromagnetic fields on melatonin, cortisol and selected markers of the immune system in man. *Bioelectromagnetics*, **22**: 280-287.

Sarookhani, M.R., Asiabanha Rezaei, M., Safari, A., Zaroushani, V. and Ziaeiha, M. 2011. The influence of 950 MHz magnetic field (mobile phone radiation) on sex organ and adrenal functions of male rabbits. *African Journal of Biochemistry Research*, **5**: 65-68.

Sedghi, H., Zare, S., Hayatgeibi, H., Alivandi S. and Ebadi, A.G. 2006. Biological effects of power frequency magnetic fields on serum biochemical parameters in guinea pigs. *Pakistan Journal of Biological Sciences*, **9**: 1083-1087.

Shahryar, H.A. and Lotfi, A. 2009. Effects of 900 MHz electromagnetic fields emitted from cellular phone on T_3, T_4 and cortisol hormones of Syrian hamsters (*Mesocricetus auratus*). *European Congress of Endocrinology*, 25-29 April 2009, Istanbul, Turkey.

Smialowicz, R.J., Weil, C.M., Marsh, P., Riddle, M.M., Rogers, R.R. and Rehnberg, B.F. 1981. Biological effects of long-term exposure of rats to 970-MHz radiofrequency radiation. *Bioelectromagnetics*, **2**: 279-284.

Sroczynski, J., Twardowska, K., Gorska, J., Wieja, A., Chelmecka, E., Suit, M. 1988. The influence of power frequency electric fields of 400 and 220 kV on some chemical blood components. *Ann. Acad. Med. Siles*., 16–17, 89–95.

Thompson, J.M., Stormshak, F., Lee, J.M. Jr, Hess, D.L. and Painter, L. 2001. Cortisol secretion and growth in ewe lambs chronically exposed to electric and magnetic fields of a 60-Hertz 500-Kilovolt AC transmission line. *Journal of Animal Science*, **73**: 3274-3280.

Torres-Duran P.V., Ferreira-Hermosillo, A., Juarez-Oropeza1, M.A., Elias-Viñas, D. and Verdugo-Diaz, L. 2007. Effects of whole body exposure to extremely low frequency electromagnetic fields (ELF-EMF) on serum and liver lipid levels in the rat. *Lipids in Health and Disease*, **6**: 31.

Vangelova, K., Israel, M., Velkova, D., Ivanova, M. 2007. Changes in excretion rates of stress hormones in medical staff exposed to electromagnetic radiation. *Environmentalist*, **27**: 551-555.

Zare, S., Hayatgeibi, H., Alivandi, S. and Ebadi, A.G. 2006. Effects of 50 Hz magnetic field on some factors of the immune system in male guinea pigs. *The Internet Journal of Medical Technology*. 3 (1): (*www.ispub.com/journal/the_internet_journal_of_medical_technology)*