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Magnetic Field Effects on Some Physiological Aspects of Male Albino Rats

Safaa, M. Abo El-Soud[1]; Hussein, A.M[2].; Rady, K.E[3]. and Allam, S.A[2].

1-Chemistry Department, Animal Health Research Institute, Dokki, Giza.
2-Plant protection Research Institute , Dokki, Giza.
3-Faculty of Engineering, Menofiya University.

Abstract

The clear effects of SMF (static magnetic field) on many organs of the body have not been known until now and have puzzled scientists. The main goal of this study was to evaluate the possible effects of the whole-body magnetic field exposure on the levels of some reproductive and thyroid hormones (estradiol, testosterone, FSH, LH, T3 and T4) and some immunoglobulins (IgG and IgM) of male rats. Twenty mature male albino rats with an average weight of 150 to 200g, randomly distributed to two groups of 10 animals each. The first group was considered as the control group. The second group was exposed to SMF of 20-25 mT (millitesla) 24h/day for 10 days. The results showed a highly significant increase in the concentration of testosterone but, estradiol, FSH, LH, T3 and T4 concentrations were significantly decreased ($P \leq 0.001$) using this MF intensity in comparison to the control group. This paralleled with a significant decrease ($P \leq 0.01$) in IgG and IgM serum levels. In conclusion, this study highlights some adverse effect of SMF on some reproductive and thyroid hormones as well as some immunoglobulins.

Introduction

Humans in modern society were exposed to an ever-increasing number of electromagnetic fields generated from the production and supply of electricity, television sets, personal computer, radio and mobile communications **(Myung and chan, 2012).** The principle of magnetic technology depends on a moving electric charge in the ion form **(Lin and Yotvat, 1989).** An electromagnetic field (EMF) consists of electrical and magnetic parts. The electrical part is produced by a voltage gradient but the magnetic part is generated by any flow of current and is proportional to the current actually flowing through the lines which depend on consumer demand **(Goldsworthy, 2007).**

Since many years, electromagnetic fields are widely used in medicine. Today, magnetic therapy is considered one of the most important physical therapies. It is experienced in many applications and accepted as a non-invasive and easily to manage treatment. The main applications in clinics are mostly addressed to the treatment of rheumatologic disease and disorders characterized by bone loss, such as osteoporosis, and also to accelerate the healing of fractures **(Thomas et al., 2007).**

A magnetic field is the area of influence exerted by a magnetic force. This field is normally focused along two poles. A wide variety of methods have been reported in the literatures which are directed to the use of magnetic energy as a diagnostic technique and also for the treatment of diseases in humans and animals **(Fouad et al., 2013).**

There are two types of magnetic field, static, and pulsed magnetic field: each one has special medical uses **(Grace, 2000).** The magnetic fields have been developed by German, which have been proved to be beneficial in wound healing **(Henry et al., 2008)**. Various living microorganisms contain tiny quantities of ferromagnetic material most commonly magnetite that orient the host in the geomagnetic field **(Blakemore, 1982; Frankel, 1984 and Spring and Schleifer, 1995).** One can demonstrate the presence of this material within the cell by observing its response to an applied magnetic field. In the past, because it's very weak magnetic moment, it was not possible to detect the magnetic field produced by the motion of a single living cell. However, the recently developed magnetic microscope based on a high-transition temperature offers unprecedented sensitivity to magnetic fields produced by nearby specimens **(Black, 1995; Clarke, 1996 and Lee et al., 1996).**

The static magnetic field, as an environmental factor which may affect biological organisms, has been widely applied in many physiological and pathological researches in the past decades **(WHO, 2007).** The magnetic technology was investigated in the plant fields, but little attention was given to animal reproductive and production application **(Coey and Cass, 2005; Al-Mufarrej et al., 2005).**

Extremely low frequency electromagnetic field (50 Hz) increased all enzyme activities and malonaldehyde (MDA) levels in both the liver and kidneys of male and female rats. In contrast, static magnetic field (0.49 T) did not produce change **(Bogusławs et al.,2000).**

The aim of this study was to evaluate the possible effects of the whole-body magnetic field exposure on some reproductive and thyroid hormones (estradiol, testosterone, FSH, LH, T3 and T4) and some immunoglobulins (IgG and IgM) of male rats.

Materials and Methods

Animals:

Twenty male albino rats (150-200gm) apparently normal were used and kept in metallic cages under good hygienic conditions as well as balanced diet and water which were provided *ad libitum*. Animals were allowed to be acclimatized for a minimum of 2 weeks prior to the experiment.

Animals were classified at random into two groups:-

Group1: 10 rats were kept as the control group without exposure to magnetic field.

Group2: 10 rats were exposed to static magnetic field (SMF) of 20-25 m T 24h/day for 10 days **(Trzeciak et al., 1993)**.

Creating and adjusting the magnetic field:

Thirty magnet units were measured in Faculty of Engineering, Menufiya University by Teslameter which determined 14.0 mT on the boles of each. These magnets were distributed on the rearing box (50×30×30 cm^3) to result 20-25 mT in the center of the rearing area.

Sampling:

At the end of the experiment, blood samples were collected from each group into small labeled dry and clean vials then centrifuged (3000 rpm, 10 min) and the serum was separated for biochemical parameters.

Hormonal determination:

Quantitative determination of serum estradiol and testosterone were carried out using DBC (Diagnostics Biochem Canada Inc.) enzyme immune assay kits, catalog No. CAN-E-430 and CAN-TE-250, respectively. Tri-iodothyronine (T3) and thyroxin (T4) were determined by using ELISA kit (Immunospec corporation, USA, catalog No. E29-229 and E29-230, respectively). The assay based on a solid phase enzyme- linked immunosorbent assay with sensitivity 10pg/mL , 0.022 ng/mL, 0.25 ng/mL and 0.5 µg/dl for estradiol, testosterone, T3 and T4, respectively. Quantitative determinations of serum Follicle Stimulating Hormone (FSH) and serum Luteinizing Hormone (LH) were carried out using Rat ELISA kits (Abnova, catalog No. KA2330 and KA2332, respectively).The minimal detectable concentration of rat FSH and LH by this assay is estimated to be 1.0 ng/mL and 0.5 ng/mL, respectively.

Immunological determination:

Quantitative determination of serum Immunoglobulins (IgG & IgM) were carried out by using Rat ELISA Quantitation Set (Bethyl Laboratories, Inc. Cat. No. E110-128 and E111-100, respectively).

Statistical analysis:

The results were subsequently analyzed following the statistical methods established by **Snedecar and Cochran (1980)** in order to determine whether a dose group was positive or negative.

Results and Discussion

The present data indicated that the measurement of hormones have shown a highly significant ($P \leq 0.001$) increase in the concentration of testosterone accompanied by a highly significant ($P \leq 0.001$) decrease in the concentration of estradiol, LH, FSH, T3 and T4 (Table1).

The potential mechanisms of the effects of magnetic fields on the secretion of hormones include their influence on the cell signal transmission, the structure of cell membrane, the ion transport process, the replication and transcription of nucleic acids and the synthesis of proteins (including enzymes). The endocrine system, which is responsible for the sexual functions, seems to be particularly susceptible to the effects produced by the long-term effects of magnetic fields. There have been numerous reports suggesting harmful influence of the environmental magnetic fields on the reproductive system **(Sieron and Cieslar., 2003)**. **Ozguner et al. (2002)** observed that EMF stimulation resulted in Leydig cell proliferation, increased testosterone level and testis weight which is in agreement with our data (Table, 1). In the same research direction **Forgacs et al. (1998)** demonstrated that exposure to sinusoidal 50 Hz, MF increased the basal testosterone production in 48h primary mouse Leydig cell culture.

Melatonin which regulates the pulse of LH Releasing Hormone (LH-RH) in the hypothalamus can alter the production of gonadal sex steroids, resulting in changes in the reproductive cycle **(Lincoln and Maeda, 1992 and Malpaux et al., 1993).** EMF exposure can affect, FSH, and LH in the pituitary gland (**Bortkiewicz, 2001)**. Most EMF-induced hormonal changes are mediated by the thermal effect of EMFs. While, long-term exposure to EMFs did not have a cumulative effect on the endocrine, serological, or immunological parameters **(Black and Heynick, 2003)**.

In contrast, **Free et al. (1991)** found that there was a reduction in plasma testosterone levels after 120 days of electric field exposure. So, they observed that alterations occurred in the secretion pattern of FSH in rats exposed to an 80 KV/m electric field for 20 to 56 days. This alteration may be due to the differences in the dose, type and duration of exposure. **Margonato et al. (1993)** have done three-year investigation on electric field conducted on the biological effects of high intensity electric field exposure of rats for up to 18% of their life span, but they did not find any differences in LH, FSH and testosterone levels between exposed animals compared with sham-exposed rats. It was shown that the diameter of seminiferous tubules and the mean height of the germinal epithelium of rat testes tissues were significantly decreased but there was an insignificant decrease in plasma FSH and LH levels in EMF exposed group compared to control group **(Ozguner et al., 2005).**

Static and electric magnetic fields have biological effects, but the magnetic field is more damaging since it penetrates living tissues more easily. In effect, the whole body can act as an efficient antenna to pick up EM radiation. There is little doubt that signals transmitted by a mobile phone, even if it is a hands-free type, will reach all parts of the body and penetrate living tissues more easily. Thus, the effects of EMF occur at the cellular level. Because of its common position (waist belt) the nearest organs to mobile radiations are sex organs and adrenal glands. Damage to these organs results in unorganized hormones which must be produced or regulated by such endocrine organs. Such changes can have an almost immediate effect on fertility and also damage offspring which may take several generations to show up **(Goldsworthy, 2007).** The biological effect of EMF is currently under debate and still a controversial issue. Studies performed on male sex organs and adrenal gland hormones are scarce and therefore future studies with a careful design are needed to determine the effect of these uses on the organs **(Sarookhani et al., 2011).** A lot of experiments have been done in relation to the effects of EMF on the endocrine system. It is reported that magnetic fields cause increases in hormonal secretions such as glucagon, cortisol and thyroxin in rats **(Gorczynska and Wegrzynowies, 1991).**

However, some experimental studies indicated that there was no relationship between extremely low-frequency magnetic field (ELF-MF) and the risks of diseases in mice model. Meanwhile, **Velizarov et al**. **(1999)** found that chemical modulation on the cell surface resulting from poor EMF was demonstrated, and the poor signal at the beginning was shown to be enhanced by the binding of hormones, antibodies and neurotransmitters to the specific binding sites, and concluded that most of the effects observed were not due to an increased temperature in tissues. Interestingly, substantial evidences have shown that ELF-MF possess significant antitumor activities *in vitro* and *in vivo* **(Koh et al., 2008).**

The results of this study (Table, 1) showed a highly significant decrease ($P \leq 0.001$) of thyroid hormones. Interference in thyroid functions may occur through a deccrease in the level of TSH, leading to a decline in the levels of T4 and T3. This is consistent with **Mortavazi et al., 2009** who recorded that there were adverse effects following the human excessive use of magnetic flux on hypothalamus or pituitary glands. Moreover, EM waves can cause stress and increase serum cortisol level which can alter the thyroid functions. Elevation of glucocorticoid secretion constitutes an obstacle to the conversion of T4 into T3 **(Aghdam et al., 2009).** **Hajioun et al (2014**) stated that in the human body exposed to cell phone radiation the concentrations of T4 and T3 hormones were lowered.

A successive awareness with the physical methods of treatments e.g. waves and magnetic flux was recently increased. **Hussein (2015)** stated that the effect of the magnetic field was already conducted on some harmful insects as *Spodoptera litteralis* to investigate duration of life cycle and rate of eggs deposition in addition to hatchability percentage. For example the magnetic flux with 0.218 mT resulted in a significant decrease in eggs hatchability of *S. littoralis* to 56.8% when compared with the group without magnetic field which was 92.2%.

Serum IgG and IgM were significantly decreased in the exposed rats (Table, 2). On the contrary of our result **Beck et al. (2005)** stated that the possible effect of Extremely low frequency (ELF) magnetic field may change the function of immunological system, because ELF magnetic field increased IgG concentration in serum of rats**.**

Conclusion

Considering the lack of consensus on the biologic effects of static magnetic field, this study highlights some adverse effects in male rats on the secretion of some reproductive hormones (estradiol, testosterone, FSH and LH) and thyroid hormones (T3and T4) as they alter their secretion. Also, SMF seem to have a similar impact on the secretion of some immunoglobulins (IgG and IgM). It was concluded that the exposure of rats to SMF (20-25) mT 24h/day for 10 days has many effects on the health. Further, the need for more concerns should be taken regarding such fields and new exposure limits have to be proposed in the future.

Table1: Effect of static magnetic field (20-25mT) on some reproductive and thyroid hormones in male rats after 10 consecutive days of exposure.

Parameters	**Control**	**Treated**
Estradiol(pg/**ml)**	**91.00±2.08**	**61.0±2.08*****
Testosterone(ng/ml)	**0.533±0.088**	**3.433±0.15*****
FSH(ng/ml)	**3.797±0.018**	**2.987±0.018*****
LH(ng/ml)	**3.193±0.085**	**2.170±0.015*****
T3(ng/ml)	**175.67±1.20**	**101.667±4.41*****
T4(µg/dl)	**19.60±0.116**	**8.367±0.233*****

Results are expressed as mean ± SE of ten rats.
*****P≤0.001**

Table2: Effect of static magnetic field (20-25mT) on IgG and IgM in male rats after 10 consecutive days of exposure.

Parameters	**Control**	**Treated**
IgG(mg/ml)	**2.846±0.018**	**1.876±0.035*****
IgM(mg/ml)	**0.477±0.012**	**0.367±0.015****

Results are expressed as mean ± SE of ten rats.
****P≤0.01 ***P≤0.001**

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