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Effects of 900 MHz electromagnetic field on TSH and thyroid hormones in rats

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Abstract

In this study, the effects of exposure to a 900 megahertz (MHz) electromagnetic field (EMF) on serum thyroid stimulating hormone (TSH) and triiodothronine–thyroxin (T_3–T_4) hormones levels of adult male Sprague–Dawley rats were studied. Thirty rats were used in three independent groups, 10 of which were control (without stress and EMF), 10 of which were exposed to 900 MHz EMF and 10 of which were sham-exposed. The exposures were performed 30 min/day, for 5 days/week for 4 weeks to 900 MHz EMF. Sham-exposed animals were kept under the same environmental conditions as the study groups except with no EMF exposure. The concentration of TSH and T_3–T_4 hormones in the rat serum was measured by using an immunoradiometric assay (IRMA) method for TSH and a radio-immunoassay (RIA) method for T_3 and T_4 hormones. TSH values and T_3–T_4 at the 900 MHz EMF group were significantly lower than the sham-exposed group ($p < 0.01$). There were no statistically significant differences in serum TSH values and T_3–T_4 hormone concentrations between the control and the sham-exposed group ($p > 0.05$). These results indicate that 900 MHz EMF emitted by cellular telephones decrease serum TSH and T_3–T_4 levels.

Keywords: 900 MHz electromagnetic field; TSH; T_3; T_4

1. Introduction

Biological effects of electromagnetic field (EMF) and their consequences on human health are receiving increasing scientific interest and has become the subject of great public debate. The controversy has been stimulated by some epidemiologic studies that have re-

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ported a relation between magnetic field exposure and human diseases (Selmaoui et al., 1997).

Such has been the rapid growth of mobile telecommunications that there will be about 1 billion mobile phone users before 2005. Herein, if there is any impact of mobile telephones on health, it would affect almost everyone in the world (Repacholi, 2001).

At the present, most of the mobile phones in Europe generally work at a frequency of 900 MHz in the GSM systems. The cellular responses to various forms of radiation, including ionizing, UV-radiation or exposure to electromagnetic fields are manifested as reversible or irreversible from structural to functional changes (Rothman et al., 1996; Somosy, 2000; Cox, 2003). Over the past two decades, there has been increasing interest in the biological effects and possible health outcomes of the weak, high-frequency electric and magnetic fields (Knave, 2001). Some studies on the magnetic fields and cancer, reproduction and neurobehavioral reactions have presented that different system diseases are related to the electromagnetic fields such as those similar to ones produced by mobile phones (Cox, 2003; Knave, 2001; Leszczynski et al., 2002; Bartsch et al., 2002; Bortkiewicz, 2001).

Thyroid activity is regulated by the thyroid stimulating hormone (TSH) secreted by pituitary. Elevated TSH levels induce the thyroid to elaborate triiodothronine (T_3) and thyroxin (T_4), a hormone which functions in at least 20 enzyme systems; one of its major influences involves the acceleration of protein synthesis.

Animal studies have shown that exposure to radiofrequency electromagnetic fields may alter the endocrine or the nervous systems and especially the thyrotropin secretion (Lu et al., 1981, 1985, 1987; Michaelson, 1983; Lai et al., 1987, 1989; Lai, 1992).

The aim of this study was to investigate whether the serum TSH and T_3–T_4 hormone levels of adult male Sprague–Dawley rats could be altered after exposure to the 900 MHz GSM-like EMF generator.

2. Material and methods

2.1. Study protocol

The animals used in this study were proceed, maintained and used in accordance with the Animal Welfare Act and the Guide for the Care and Use of Laboratory Animals prepared by the Suleyman Demirel University, Animal Ethical Committee. Twenty male Sprague–Dawley rats (12 weeks old, each weighing between 250 and 300 g at the start of experiment) were maintained under a 12-h light/12-h dark cycle in a temperature-regulated ($23 \pm 1\,^{\circ}$C) animal room with a continuous free access to water and food. Animals were randomly grouped as follows: control group (without stress and EMF) ($n = 10$), sham-exposed group ($n = 10$) and a 900 MHz EMF ($n = 10$). The 900 MHz EMF group was exposed to 30 min/day radiation for a period of 5 days/week. The EMF exposure period was at 10:00–11:00 a.m. in each day and lasted for 4 weeks. Sham-exposed group stayed in the experimental setup with the same conditions as the exposure groups without radiation exposure (exposure device off). Rats that were exposed to the 900 MHz EMF were compared to control rats in respect to the serum TSH and T_3–T_4. At the end of 4 weeks, the rats were sacrificed and blood samples were collected through a cardiac puncture.

2.2. Experimental setup and radio-frequency irradiation

A special exposure device with five exposure antenna was used. The Fig. 1 shows one of the antennas of the device. The exposure system consisted of a round plastic tube cage (length: 12 cm and diameter: 5.5 cm) and a dipole antenna. The whole body of the rats was positioned in close contact above the dipole antenna, and the tube was ventilated from head to tail in order to decrease the stress of the rat while in the tube. The 900 megahertz (MHz) continuous wave electromagnetic energy generator (the peak specific absorption rate, SAR, was 2 W/kg, average power density 1 ± 04 mW/cm^2) produced at the electromagnetic compatibility (EMC) Laboratory of Suleyman Demirel University was used in the study. The power density measurements were made using electromagnetic field meter (Holaday Industry Inc., Adapazari, Turkey).

2.3. Serum hormone radio-immunoassay

Blood samples were collected into the glass tubes without anticoagulant and were allowed to clot. It was centrifuged to obtain serum and stored at $-20\,^{\circ}$C until the assay. Serum TSH hormone levels were measured using TSH IRMA kit and total T_3–total T_4 hormone

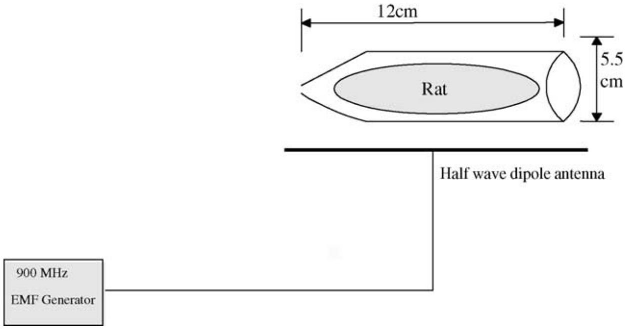

Fig. 1. Schema of 900 MHz EMF exposure device (one of the antennas of the device is shown).

levels were measured using RIA kit (Diagnostic Products Corporation, LA, USA).

Statistical analysis: "SPSS 9.00 for Windows" was used for statistical evaluation in the study. Mann–Whitney *U*-test was performed to analyze the data. The results of serum TSH and T_3–T_4 hormone levels were given mean ± S.D. The limit of statistical significance was $p < 0.01$, two-side.

3. Results

The effect of 900 EMF exposure on serum TSH and T_3–T_4 hormones levels of adult male Sprague–Dawley rats were studied in three independent experiments. Fig. 2 shows average serum TSH concentrations of the control, sham-exposed and 900 MHz EMF groups. As seen in the Fig. 2, the serum TSH concentrations of the control group were marginally lower than those of the rats sham-exposed. However, there were no statistically significant differences in serum TSH concentrations between the control and the sham-exposed group ($p > 0.05$). On the contrary, the serum TSH concentrations of the rats exposed the magnetic field were significantly lower than those of the rats sham-exposed ($p < 0.01$) The values were $0.23 \pm 0.05\ \mu\text{IU ml}^{-1}$ in control group, $0.21 \pm 0.05\ \mu\text{IU ml}^{-1}$ in sham-exposed group and $0.13 \pm 0.04\ \mu\text{IU ml}^{-1}$ in exposed group.

The average serum T_3–T_4 hormones concentrations of the control, sham-exposed and 900 MHz EMF groups are presented in Figs. 3 and 4. From these figures, it can be seen that the T_3–T_4 hormones concentrations in the rats exposed to the EMF has significantly lower than in those rats sham-exposed ($p < 0.01$). Nevertheless, the serum T_3–T_4 hormones concentrations

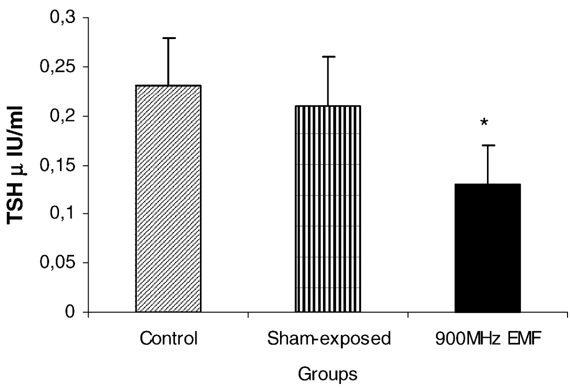

Fig. 2. A comparison of average serum TSH hormone with S.D. among control, sham-exposed and 900 MHz EMF groups. (*) Sham-exposed vs. 900 MHz EMF group ($p < 0.01$).

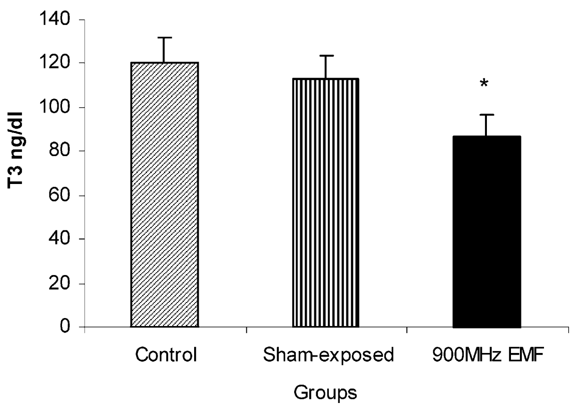

Fig. 3. A comparison of average serum T_3 hormone with S.D. among control, sham-exposed and 900 MHz EMF groups. (*) Sham-exposed vs. 900 MHz EMF group ($p < 0.01$).

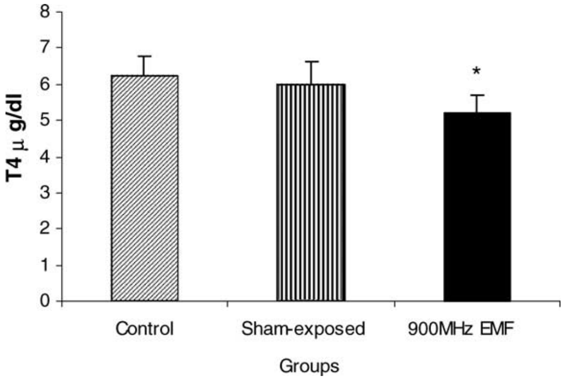

Fig. 4. A comparison of average serum T_4 hormone with S.D. among control, sham-exposed and 900 MHz EMF groups. (*) Sham-exposed vs. 900 MHz EMF group ($p < 0.01$).

of the control group were marginally lower than those of the rats sham-exposed. However, there were no statistically significant differences in serum T_3–T_4 hormones concentrations between the control and the sham-exposed group ($p > 0.05$). The values were $T_3 = 120.45 \pm 11.04$ ng dl^{-1}, $T_4 = 6.23 \pm 0.54$ µg dl^{-1} in the control group; $T_3 = 112.66 \pm 10.71$ ng dl^{-1}, $T_4 = 5.98 \pm 0.66$ µg dl^{-1} in the sham-exposed group and $T_3 = 86.67 \pm 9.79$ ng dl^{-1}, $T_4 = 5.18 \pm 0.53$ µg dl^{-1} in the exposed group, respectively.

4. Discussion

Frequency is the rate at which electromagnetic fields change direction, and is measured in hertz (Hz). One mega hertz is 1 million cycles/s. Analogue telephones use frequencies between 800 and 900 MHz; digital telephones use frequencies between 1800 and 1990 MHz; while micro wave ovens use frequency of 2450 MHz. Today's mobile telephones, with a total power output of 2 W, are estimated to produce insignificant local heating, which is unlikely to produce any deleterious effects.

An accumulated body of evidence published over the last three decades has identified, investigated and quantified the responses of mammalian neuroendocrine and intercellular hormonal control systems to radiofrequency (RF)-EMF exposure. In particular, the mechanisms for the production and control for corticosteroid, thyroid and growth hormones have been extensively investigated (Lotz and Michaelson, 1978; Lu et al., 1981; Michaelson et al., 1975; Magin et al., 1977). Hormones acting on reproductive tissues, including LH, FSH and prolactin, have received less attention. Characterization of established effects show that they result from tissue heating, and are generally similar to nonspecific stress responses (Roberts et al., 1986; Lu et al., 1981). It is known that the effect and the amount of damage caused by radiation is positively correlated with the exposure time (Moustafa et al., 2001).

We studied the effect of 900 MHz GSM-like frequency EMF on serum TSH, T_3 and T_4 hormones levels of rats. According to our results, measured serum TSH and T_3, T_4 values at the 900 MHz EMF group were significantly lower than the sham-exposed group.

Thyroid stimulating hormone acts on the thyroid gland and stimulates secretion of thyroid hormones. Magin et al. (1977) reported increased thyroxine and triiodothronine secretion when the thyroids of dogs were exposed to varying levels of 2.45 GHz RFEMF at estimated SARs of 58–190 W/kg for 2 h. A follow up study found decreased circulating thyroxine and TSH levels in rats when a rectal temperature rise to 40 °C had been caused by whole body exposure to 2.45 GHz RFEMF at 4 W/kg (Lu et al., 1980). The research previously referenced Lotz and Podgorski (1982) using rhesusmonkeys, which found an increase in serum cortisol levels with increased rectal temperature when exposed to 1.29 GHz RFEMF at 3–4 W/kg, did not report a change in serum growth hormone levels or thyroxin.

De seze et al. (1998) showed that TSH was a 21% decrease in male volunteers chronically exposed to GSM cell phone fields 2 h/day, 5 days/week for 1 month. Our TSH results in rats exposed the 900 MHz EMF magnetic field are in agreement with data reported by De seze et al.

Levels of T_3 and T_4 in rats exposed the 900 MHz EMF are in agreement with data reported by Zagorskaya and Rodina (1990). These authors found lowered concentration of thyroid hormones during 2 months after a single exposure of rats to 20 mT extremely low frequency (ELF)-EMF. Selmaoui et al. (1997) reported insignificant differences in serum T_3 and T_4 levels between sham-exposed men and men exposed to continuous and intermittent 50 Hz magnetic field of 10 T for one night. Also, one of the early studies of ELF-EMF influence on thyroid gland provided by Lafreniere and Persinger (1979), had shown that no alterations in serum T_3 and T_4 concentrations or in the number of thyroid follicles, were found in rats exposed to 0.5 Hz EMF perinataly and/or as adults. On the contrary, Udintsev et al. (1978) found increased levels of circulating T_4 and TSH in rats exposed to 50 Hz EMF of 20 mT for 18 h, but a decreased concentration of circulating thyroid hormones after a single exposure to EMF. However, differences in exposure facilities and experimental protocols among these experiments, including our study, complicate the adequate comparison of obtained results.

Whole body averaged SAR measurements are of importance to predict elevation of the core body temperature. Experimental studies suggest that core body temperature rises significantly at whole body average SAR above 1–4 W/kg (Elder and Cahill, 1984; Goldon et al., 1986; IEEE, 1992)

The current study has shown a lowering effect to TSH and thyroid hormones. This result may be possibly the result of tissue heating and may be generally similar to nonspecific stress responses induced by EMF exposure in rats. We have an idea how EMF may produce the effects we have found in our investigation as follows: EMF exposure may influence the negatively the iodine uptake in the thyroid gland, and may influence with increased temperature effect on pituitary gland.

According to this study, frequency of 900 MHz EMF produced by digital mobile radio-telephones decreases TSH and thyroid hormones under the conditions used. However, further investigations (for example, if a larger number of animals are studied or if the duration of exposure was longer) are needed in order to clearly show that the degree of TSH and thyroid hormones suppression by EMF of high-frequency.

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