

EFFECTS OF 900 MHz ELECTROMAGNETIC FIELDS EMITTED FROM A CELLULAR PHONE ON THE T₃, T₄, AND CORTISOL LEVELS IN SYRIAN HAMSTERS

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Abstract

The effects of exposure to a 900 MHz electromagnetic field (EMF) on the serum cortisol and triiodothyronine–thyroxine (T₃–T₄) levels in adult male Syrian hamsters were evaluated. Seventy two hamsters were used in three independent groups: 24 served as controls (without exposure to stress and EMF), 24 were exposed to a 900 MHz EMF for 10 d, and 24 were exposed to a 900 MHz EMF for 50 d. The exposures were performed 1 h/d to a 900 MHz EMF emitted by cellular phones. The levels of cortisol and T₃–T₄ were measured by using an immunoradiometric assay (IRMA) method. The results revealed the cortisol values of the group, which was exposed to 900 MHz EMF for 50 d, were higher than those of the other groups ($P < 0.01$). The levels of T₃ in the control group were higher than that of the long-term exposure group ($P < 0.01$), and levels of T₄ in the 900 MHz EMF group for the long-term and short-term exposure groups, were higher than that of the control group ($P < 0.01$). These results indicate that a 900 MHz EMF emitted by cellular phones, especially in the case of long-term exposure, increased the serum cortisol and T₄ levels and decreased the T₃ level, and suggest that it can destroy the endocrine system in general.

Key words: hamster, cortisol, T₃–T₄, electromagnetic field.

Nowadays, with the growth in mobile communications, exposure to non-ionising electromagnetic fields (EMF) has increased due to the mobile handset and base station antennas. Electromagnetic fields penetrate the animal's body and act on all the organs, altering the cell membrane potential and the distribution of ions and dipoles. These alterations may influence the biochemical processes in the cell (10). It has been shown that microwaves (especially waves from the electromagnetic fields of cellular phones) produce a temperature and energy distribution in living tissues (4, 5). Furthermore, these waves with extremely low frequency (in the long-term) cause some variations in the structure and biochemical properties of tissues (10, 12).

In relation to EMFs and their effects on the nervous and endocrine systems, a wealth of experiments has been conducted (5, 6, 8). Temperature is an important factor in the regulation of the release of endocrine hormones. For example, cold temperature increases the activity of thyroid hormones; acute psychological stress increases TSH secretion from the pituitary, and increases the release of T₃ and T₄ from the thyroid (16). It has been reported that magnetic fields (MFs) cause an increase in lipolysis and glycogenolysis, and also increase hormones such as glucagons, cortisol, and

thyroxine in rats (1, 3). Hormone of particular interest is cortisol. Cortisol is secreted by the adrenal glands, and is a stress indicator (9). Based on human studies, it has been confirmed that serum cortisol increases as a result of EMF exposure (13).

Vangelova *et al.* (13) reported significant differences in the cortisol levels of physiotherapists due to long-term electromagnetic field exposure, as well as in the cortisol levels of nurses. They stated that physiotherapists display high levels of stress hormones due to long-term exposure to EMFs. The negative effects of electromagnetic fields emitted by cellular phones on endocrine glands and the hormonal balance have been studied in the short-term, yet the number of investigations on the long-term effects are limited (7).

The aim of this study is to review the biological effects of electromagnetic fields, emitted by cellular phones (900 MHz), on the excretion of T₃, T₄, and cortisol, in the long or short term, in the Syrian hamster.

Material and Methods

Seventy two male Syrian golden hamsters (each weighing 150–160 g at the time of the experiment) were

used. They were acclimated for 1 week prior to use, maintained on a 12 h light: 12 h dark cycle in a temperature-regulated (22–23°C) animal room with continuous free access to water and feed. The animal studies were carried out in adherence to the guidelines established in the “Guide for the care and use of Laboratory Animals, US Department of Health and Human Resources (NIH1985)”. The hamsters were kept in conditions similar to pet housing systems.

The study was conducted in summer 2007. The animals were divided into three groups: group 1 - the control group without any EMF exposure; group 2 - the short-term EMF exposure; and group 3 - the long-term EMF exposure. The animals were selected, and each of the exposed animals was maintained concurrently with those not exposed to EMF in separate cages. The animals included in the group 2, which were kept in separate aquarium-like glass cages covered with aluminium sheets, were under a 900 MHz EMF emitted by the antenna of cellular phones (Sony Ericsson® K750i, specifics: ON, SAR: 0.66w/kg) 1 h daily for 10 d. The animals included in the group 3, which were also kept in separate cages, were under a 900 MHz EMF 1 h daily for 50 d. The scheme of the exposures is presented in Fig. 1.

At the end of the experiment, the animals were anaesthetised with chloroform, and blood samples were drawn from the heart ventricle into syringes (without anticoagulants), from all the experimental groups. The

serum cortisol, T_3 , and T_4 levels were measured by chemiluminescence immunoassay (Liaison Co®, Italy) and the values of the exposure groups (groups 2 and 3) were compared with those of the control group (group 1).

Statistical analysis. The data collected were subjected to an analysis of variance, and any significant differences were determined. When the ANOVA revealed significant differences, Duncan's multiple range tests was performed to establish where such means differed. All the data were analysed by ANOVA using the general linear model (GLM) procedures of the SAS Institute (15).

Results

In Table 1, the blood serum T_4 , T_3 , and cortisol levels of all the groups of hamsters are given. There was a significant difference in the serum levels of T_4 ($P<0.01$) and T_3 ($P<0.01$) hormones between the hamsters in the group 3 (exposed long-term to EMF) and the control group (without any EMF exposure). The serum T_3 levels in the group 2 with short-term exposure (73.00 ng/dL) did not change significantly, in comparison to the control group (73.03 ng/dL) ($P<0.01$). The differences in the T_3 and cortisol levels were significant among the groups with long-term EMF exposure and the control group ($P<0.05$).

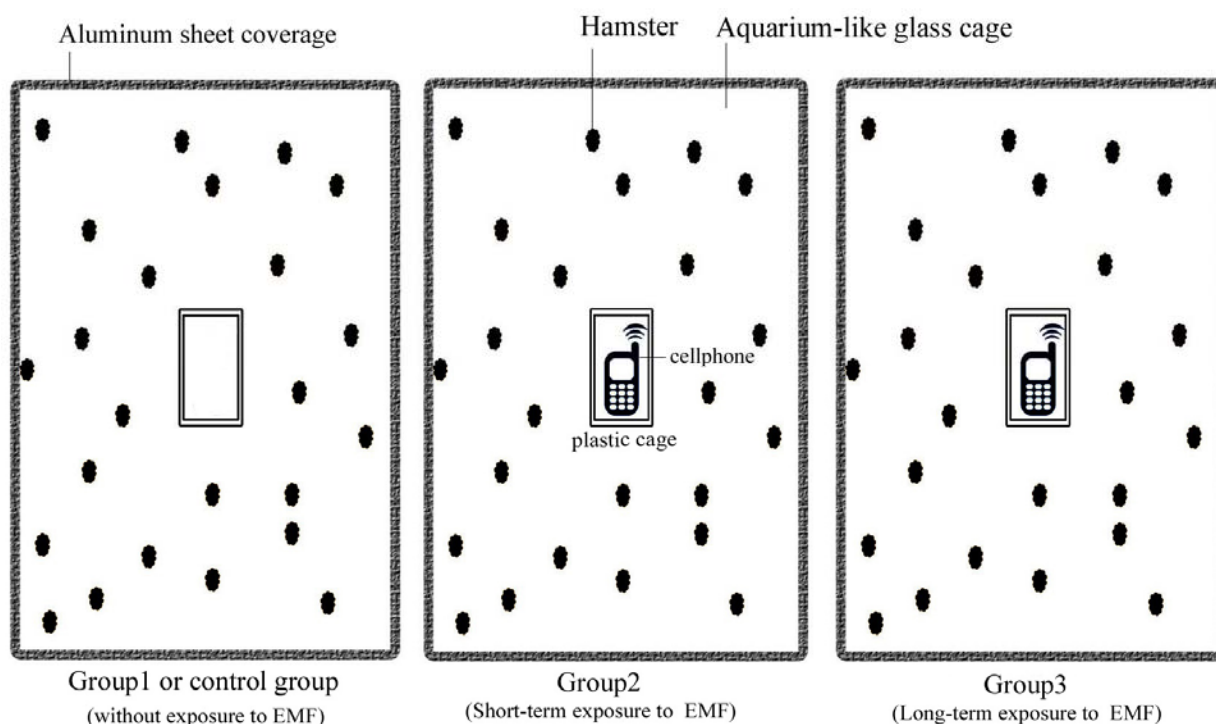


Fig. 1. Schema of conditions of exposure to cellular phone EMFs.

Table 1Serum concentrations of T₃, T₄, and cortisol in Syrian hamsters exposed to electromagnetic field (900 MHz)

Experimental groups	Exposure time	T ₃ (ng/dL)	T ₄ (µg/dL)	Cortisol (µg/dL)
Control	without exposure	73.03 ^a	2.52 ^b	0.39 ^b
Short-term exposure	10 d exposure	73.00 ^a	2.94 ^a	0.58 ^b
Long-term exposure	50 d exposure	50.35 ^b	2.87 ^a	1.05 ^a
SEM ¹	-	1.23	0.54	0.09

¹ SEM, based on pooled estimate of variance and n: 3^{a,b} Means within columns with no common superscript differ significantly (P<0.05)**Table 2**

Effect of EMFs on serum cortisol level of rodents in different studies

Reference number	Rodent	EMF Exposure time	Control group (without EMF) µg/dL	Exposure group µg/dL
(6)	Rat	900 MHz 30 min/d, 5 d/week, 4weeks	1.73	2.51
(7)	Rat	1,800 MHz 30 min/d, 5 d/week, 4weeks	1.73	4.24
This study	Syrian hamster	900 MHz 60 min/d, 50 d	0.39	1.05

Discussion

Cellular phones are placed beside the thyroid gland during phone calls. Therefore, the thyroid gland is one of the organs, which is exposed to EMFs. The effects of EMFs on hormonal excretion are variable with time (11). In our study, cortisol levels increased significantly with the 60-min daily exposure to a 900 MHz electromagnetic field for 50 d. Sadeghi *et al.* (14) reported increased glucose and cortisol levels in guinea pigs when exposed to 50 Hz MF (after 5 d and a daily 4 h exposure). They indicated that the MF causes an increase in the stress factors of the blood serum.

In this study, the T₃ serum level decreased with the increasing EMF exposure time. This result was in accordance with the reports of Koyu *et al.* (5) on the decrease in T₃ levels. The T₄ levels displayed significant differences in the groups 2 and 3 (2.94 and 2.87 µg/dL) compared to the control group (2.52 µg/dL). Our results on the T₄ level differed from those reported by Koyu *et al.* (5), with 900 MHz. However, these results were in agreement with those obtained with 1,800 MHz electromagnetic fields (7). The researchers mentioned reported that stress affects thyroid gland activity. The increase in the excretion of glucocorticoids constitutes an obstacle for the conversion of T₄ into T₃ (16). Therefore, according to these results, which are in agreement with each other, as the T₄ hormone increases, T₃ decreases. As a matter of fact, this is not related to the conversion of T₄ into T₃ due to EMF-induced stress. Koyu *et al.* (7) reported significant differences in T₃, T₄,

and cortisol levels upon exposure to a 1,800 MHz EMF. In another study carried out by these researchers, the levels of these same hormones were determined to decrease as a result of exposure to a 900 MHz EMF (Table 2) (5). These authors also reported that no significant difference occurs in the thyroid hormone levels, as stress is very common. It has been shown that long-term stress increases cortisol levels (Table 2) (13).

Other stress factors in blood (such as glucose) were reported by Sadeghi *et al.* (14) to increase. The results of the present study on the cortisol are in agreement with those reported by Radon *et al.* (13), Koyu *et al.* (6, 7), Sadeghi *et al.* (14), and Vangeleva *et al.* (17). Based on these results, EMFs emitted by cellular phones, especially in the long-term, can cause stress in hamsters and increase serum cortisol levels. The conversion of T₄ into T₃ decreases, destroying the thyroid hormonal balance in general.

Djeridane *et al.* (2), in a similar study conducted with a 900 MHz EMF, reported that a 900 MHz EMF (2 h/d, 5 d/week, for 4 weeks) did not cause any significant changes in serum cortisol levels. However, according to previous studies (Table 2), a 900 MHz EMF may cause increased cortisol levels in rodents. Further experiments are needed to clarify whether the cortisol levels of humans can be influenced in the long-term as a result of exposure to a 900 MHz EMF emitted by cellular phones.

In conclusion, based upon the results obtained in the present study (using common hamster housing conditions and without being forced in being exposed to high intensity EMF), short-term exposure to a 900 MHz

electromagnetic field was determined to exhibit negative effects on the cortisol and T4 levels in hamsters, and long-term exposure was ascertained to negatively influence the T₃, T₄ and cortisol levels, thereby suggesting that the exposure time constitutes a significant factor in the indicated hormones.

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