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EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELD INFLUENCE ON RAT BODY MASS

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Abstract *— In this study, the influence of power frequency electromagnetic field on body mass was investigated. Experiment was performed on male rats during the first three months of their postnatal life. The obtained results indicated to small changes in body mass and significant alterations of mass gain in exposed animals, compared to controls.*

1. INTRODUCTION

During the last decades of the 20th century the constant enhancement of electrical power use led to the increased exposure of living organisms, especially the human population, to a variety of artificially produced electromagnetic fields (EMFs). These fields originate from a number of different sources and are characterized by various frequencies and intensities. EMFs present in living and working environment can be classified into static fields, extremely low frequency fields, intermediate frequency fields and radiofrequency fields. Among the numbered EMFs, the influence of an extremely low frequency electromagnetic field (ELF-EMF) has particularly drown a considerable attention among scientific community, since they are wide spread in the human environment and originate from sources as trains for public transport, any device involved in the generation, distribution or use of electric power (normally 50 or 60 Hz).

To date, a number of *in vivo* and *in vitro* investigations as well as epidemiological ones have shown that ELF-EMF influences learning and memory processes [1, 2, 3], neuroendocrine system [4, 5, 6], immune system [7, 8], cardiovascular system [9, 10, 11, 12], reproductive system [13, 14, 15] and, also, the structure and function of cellular membranes [16, 17], enzyme activity [18, 19, 20, 21], neurotrasmitter release and metabolism [22, 23], alteration of Ca^{2+} flux through the cell membrane [24, 25, 26], DNA molecule [27, 28] etc.

Previous investigations in our laboratory revealed alterations in thyroid gland follicles and interfollicular space after postnatal exposure of rats to ELF-EMF during two, three, four, five and six months [29, 30, 31]. In continuation to these experiments, as the aim of the present study we set out to determine the possible influence of ELF-EMF on rat body mass after three months of exposure and to monitor this parameter in three chosen periods following the exposure.

2. MATERIALS AND METHODS

Experiment was performed on 89 male rats of Mill Hill strain. Animals were housed in laboratory conditions with 22±2°C temperature and subjected to a natural photoperiod. Access to tap water and pelleted food was unlimited. A total of forty-seven animals were exposed to the influence of ELF-EMF from 24 h after birth, 7 hours a day (from 07:00 A.M. to 14:00 P.M.), 5 days a week for a period of three months. Forty-two animals served as controls and were maintained in the same environment as their analogous exposed animals, but without the presence of artificially produced ELF-EMF.

The exposure system, by which ELF-EMF was produced, was made of a single coil of 2.5 mm thick copper wire placed on a wooden frame in 1320 turns. The coil was energized from standard 220 V, 50 Hz and 16 A via an autotransformer. The autotransformer provided 60 V output and was used in order to reduce the electric field, which was measured to be less than 10 V/m. Cages with animals were placed symmetrically on both sides of the coil. The coil produced the EMF of decaying intensity along the cages with 500 uT value on the side of the cage near the coil to 50 uT on the opposite side.

Body masses of animals were measured after the first and second postnatal month. Furthermore, since the investigation of EMF affect on body mass was a part of a larger study comprising the influence of EMF on selected organs and their possible recovery after the period of exposure, animals were divided into four groups after the third postnatal month. The first group of animals was sacrificed starting at 08:00 A.M. the next day following the last day of exposure. The rest of animals were subjected to recovery evaluation and sacrificed after one week, two weeks and three weeks after three months of ELF-EMF exposure. Control animals were sacrificed with their corresponding ELF-EMF exposed animals. The body mass of animals was measured immediately before sacrifition. The mass gain during the second postnatal month was additionally calculated.

Obtained results were expressed as mean±SE. Statistical significance of differences between body masses of control animals and ELF-EMF exposed animals were determined using Student's t-test.

3. RESULTS

Results of body mass measurements after first postnatal month showed that rats exposed to ELF-EMF are slightly, but significantly, heavier than the control group (Fig. 1a), although the total mass gain calculated for each animal of both groups pointed to actual mass loss of the exposed group for approximately 12%, compared to the control (Fig. 1c). After the second and third postnatal month, body masses of exposed animals were decreased, as seeing on Fig. 1a. Following the initial overlap of body mass values of exposed and control animals after the first recovery week, the decreased values of masses were noted after both second and third recovery week.

4. DISCUSSION

Results obtained in this study demonstrated small alterations of rat body mass after the influence of 50 Hz EMF. This effect was more emphasized in the first month of rat's postnatal life, when the evident decrease in mass gain was recorded in exposed animals.

The results of investigation provided by Sandrey et al. [32] also showed that young rats exposed to 60 Hz, 0.1 mT EMF for 4 h/day over 21 days lost more mass and, even more, they recovered it more slowly compared to controls than did older EMF exposed rats. On the contrary to our results, the investigation of body weights on 2280 female mice exposed to 60 Hz, 1.4 mT magnetic field reveled the greater weight gain in exposed mice relative to sham-exposed controls during the young adult growth phase [33]. Also, the reduction of body weight in dwarf Siberian hamsters exposed to 60 Hz, 0.1 mT magnetic field for 3 h a day during 42 days [34] were opposite to our results. Using 12 week old rats for the investigation of biological effects of 50 Hz, 5 uT magnetic field, Margonato et al. [35] demonstrated no influence of the field on rat body weight, using the experimental protocol similar to ours, comprising the daily exposures of 22 h, 7 days a week, for 32 consecutive weeks. Svedenstal et Johanson [36] have, as well, failed to observe any significant changes in the weights of the body in 4 or 6 weeks old mice exposed continuously to 50 Hz, 14 uT for 24 h/day and a total of 54 h of exposure.

Apart from exposures of experimental animals to EMF in various stages of postnatal development, the prenatal and perinatal exposures to EMF and its influence on body mass were investigated as well. Sienkiewicz et al. [37] studied the effect of prenatal exposure of mice to 50 Hz, 2 mT magnetic field on their postnatal development and demonstrated that exposed males were significantly lighter in weight at 30 days of age, but this alteration did not referred to the exposed females. In a similar experiment of prenatal exposure of rats to 60 Hz, 100 uT, 20 h/day during 22 days and additional 8 days of postnatal exposure showed no difference among field exposed and sham exposed rats in terms of body mass [38].

In summary, it can be stated that the biological effect of a power frequency field (50/60 Hz) is often different in respect to magnetic field intensity used in experimental protocol. Therefore, the existing utilization of a broad range of various EMF intensities has made the adequate comparison of results from different laboratories very difficult. Moreover, the frequency of mass measurements also varies in a great extent among experiments. The USA National Institutes for Health [39] recommended the body mass recording at least once a week or more often in small animals such as rodents. It has already been concluded, in the paper of Sandrey et al. [32] that differences between EMF exposed and control animals are present, but over a short duration, which can only be detected by frequent measurements. According to this conclusion, it could be presumed that differences found in our investigation would probably be more accurate with a larger number of measurements.

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