Institute of Experimental Morphology and Anthropology

Acta morphologica et anthropologica, 5
Sofia • 2000

Studies on the effect of 50 Hz electromagnetic field on the structure of the rat thyriod gland

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The purpose of this study was to determine the effect of low frequency electromagnetic field (LF-EMF) on thyroid morphology. Five animals were exposed to the influence of LF-EMF (50 Hz, 500 µT-50µT) 7 hours per day for a week, beginning from 24 h after birth until the end of second month, five animals until the end of fifth month, and ten animals until the end of sixth month of postnatal life. Two months exposure increased significantly index of activation of the thyroid gland (Ia), the volume density of thiroid follicles (Vvf), volume density (Vve) and thickness (τ) of follicular epithelium, while volume density of colloid (Vvk) as well as the capillary network (Vvs) was significantly decreased. Present results indicate that exposure to LF-EMF produce an impairment in the thyroidal structure as measured by stereological parameters. Further studies are needed to clarify the mechanisms by which EMF disrupts the hypothalamic-pituitary-thyroid axis.

Key words: thyroid gland, low frequency electromagnetic field, stereology, morphological alterations.

Introduction

Considerable advance have been made during the last decade in characterizing the numerous sources of EMF to which humans are exposed in the occupational and residential environments and in defining the interaction of fields with living systems. It is generally accepted that EMFs are capable of producing effects at the organismal, tissue and cellular levels [7, 9, 10]. It is well-known that thyroid gland is one of the most sensitive organs to ionizing radiation. The effects of non-ionizing radiation

This work was supported by Serbian Ministry of Science and Development.

as an EMF on this gland has been suggested [17, 18], but has not been supported with sufficient data.

The purpose of present study to determine the effects of exposure to LF-EMF of intensities to which humans can be exposed in their home and work environment, on the rat thyroid structure during two, five and six months of postnatal life.

Material and methods

A total of 35 male Mill Hill rats were used in these experiments. They were maintained under controlled laboratoty conditions. Five animals were exposed to the influence of LF-EMF 7 hours per day for a week, beginning from 24 h after birth until the end of second month, five animals until the end of fifth month, and ten animals until the end of sixth month of postnatal life. Five control animals for each group were housed to identical conditions excepting the LF-EMF. The exposure system, by which the LF-EMF vas produced, was made of the single coil of 4 mm thick were placed in 1320 turns. The coil was energized from standard 220 V, 50 Hz and 16 A outlets via autotransformer. The auototransformer provided 60 V output and was used in order to reduce the electric field which was measured to be less than 10 V/m everywhere in the room. One half of the coil had a southeast/north-west orientation of axes, and the other half orthogonal to that direction. Cages with animals were placed symmetrically on both sides of the coil. The coil produced magnetic field of a decaying intensity along the animal cages from 500 μT to 50 μT. After sacrificing, thyroids were removed and fixed in Bouin's solution. Paraffin-embedded thyroids were cut serially in fourmicrometer sections stained after the method of PAS alcian blue and Florentine. For stereological analysis every fourth section was used from the middle of the gland to the periphery. We determined the volume density of follicles (Vvf), follicular epithelium (Vve), colloid (Vvk) , interfollicular tissue (Vvi), capillary network (Vvs) with grid M42 [27]. Some other characteristics were derived from the above mentioned parameters: thyroidal activation index (Ia) defined by the ratio of the Vve to the Vvk[14, 15], and thickness of the follicular epithelial cells (τ) was estimated by the formula described in Bogataj et al. [2]. The results were statistically analyzed by Student's t-test.

Results

The most prominent cytological changes in the follicular cells after two monts of exposition to LF-EMF were the appearance of variously shaped apical protrusions and numerous intracellular colloid droplets (Fig. 1). Two months exposure to LF-EMF also increase significantly the volume density (Vve) ($p<0.01$) and thickness (τ) ($p<0.05$) of follicular epithelium, index of activation of the thyroid gland (Ia) ($p<0.01$) as well as the capillary network (Vvs) ($p<0.01$), while volune density of colloid (Vvc) ($p<0.01$) was significantly decreased. Volume density of interfollicular tissue (Vvi) was also decreased compared to the control, but statisticaly insignificant (Fig. 4-9). Thyroid gland of animals exposed to the LF-EMF five and six months shows less regular arrangement of follicles, with large and small follicles scattered throughout the gland. Colloid in the follicles was generally homogeneous, whereas there were numerous follicles with areas of darker staining, explicitly PAS-positive colloid. The most prominent cytological changes in these thyroid follicular cells were absence of apical protrusions, rare presence of intracellular colloid droplets and ex-

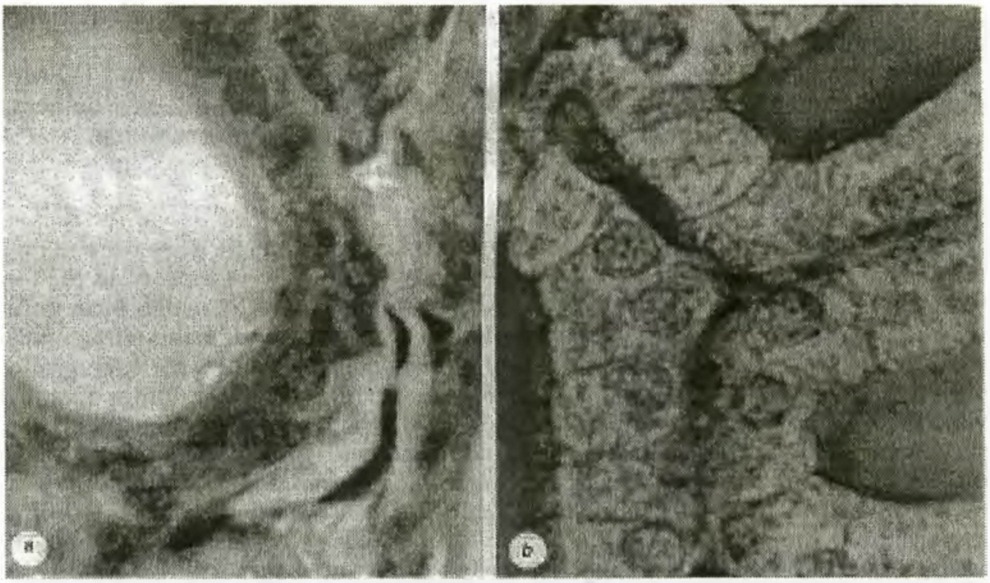

Fig. 1. Thyroid gland, follicular epithelium
a) - control animal; b) - animal after two months of exposition to LF-EMF Florentine (×1600)

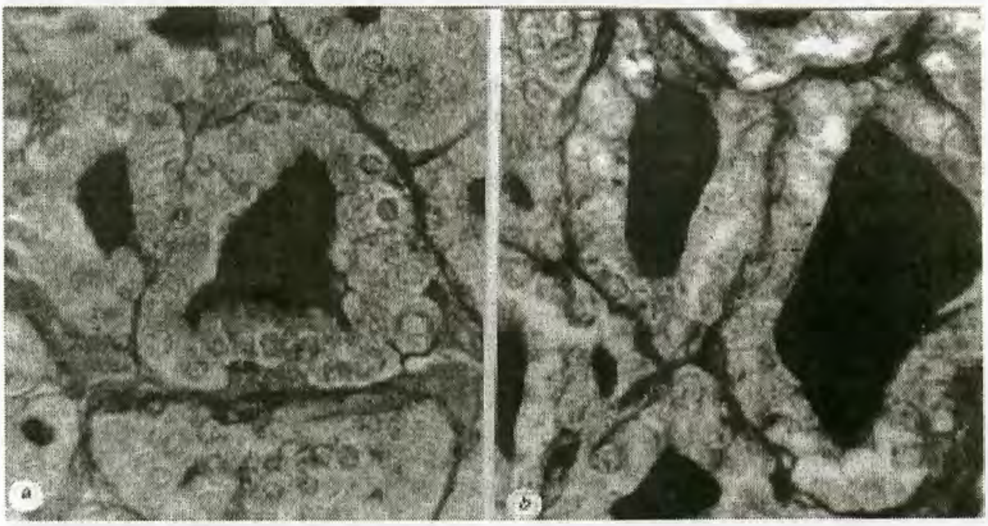

Fig. 2. Thyriod gland, follicular epithelium
a) - control animal; b) - animal after five months of exposition to LF-EMF Florentine (×640)

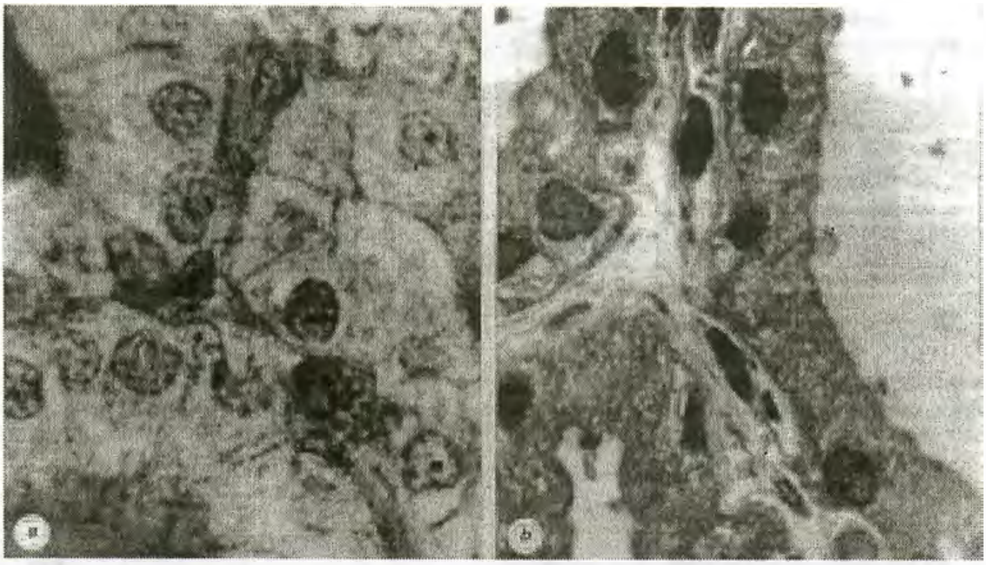

Fig. 3. Thyriod gland, follicular epithelium
a) - control animal; b) - animal after six months of exposition to (×1600)

tremely low follicular epithelium in some areas of the glands (Fig. 2 and 3). Five months exposure to the LF-EMF decreased significantly the volume density (Vve) ($p<0.01$), thickness (τ) ($p<0.01$) of follicular epithelium and index of activation of the thyroid gland (Ia) ($p<0.01$), while volume density of colloid (Vvk) ($p<0.01$) as well as the inter-follicular tissue (Vvi) ($p<0.05$) was significantly increased. Volume density of capillary network (Vvs) was also increased compared to the control, but not significantly (Fig. 4-9). Six months exposure to the LF-EMF decreased significantly τ ($p<0.01$), Vve ($p<0.01$) and Ia ($p<0.01$), while Vvk (0.01), Vvi ($p<0.01$) as well as Vvs ($p<0.01$) were significantly increased.

Discussion

Our results show that long-term exposure to the LM-EMF can disturb the normal structure of the thyroid gland. After two months of exposition this substantiated by the significant increase in the thyroidal activation index which reflect the significant decrease in volume density of colloid and increase in volume density of epithelium. After five and six months this is substantiated by the significant decrease in the thyroidal activation index which reflect the significant increase in volume density of colloid and decrease in volume density of epithelium in rats exposed to EMF compared to the control animals. Previous studies have indicated that EMF interrupt many biological processes by effecting on some essential metabolic substances as ATR, cAMP, DNA, mRNA, proteins [1], and cell respiration processes [8]. On account of these reasons mechanisms of the observed effects in present study could be very different. A question arises: are the morphological changes of the thyroid gland the consequence of direct EMF influence on one of the hypothalamic-pituitary-thyroid axes levels or indirect consequence of changes in some other organs corralled

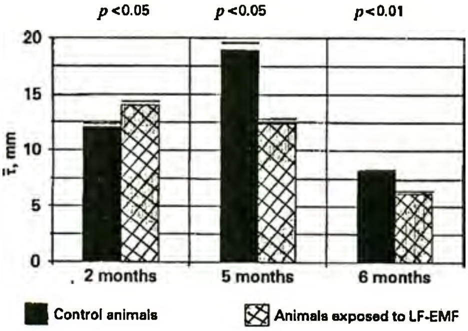

Fig. 4. Thickness of epithelium of thyroid follicles (τ) in control animals and animals exposed two, five and six months to LF-EMF. The mean + SE are given

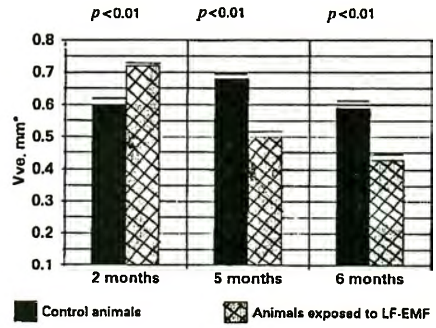

Fig. 5. Volume density of the follicular epithelium (Vve) in control animals and animals exposed two, five and six months to the LF-EMF. The mean + SE are given

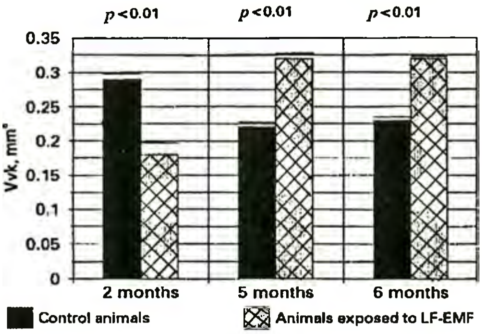

Fig. 6. Volume density of colloid (Vvk) in control animals and animals exposed to the LF-EMF. The mean + SE are given

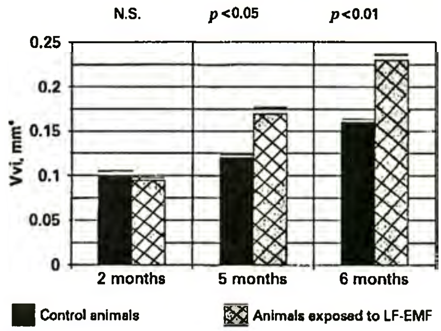

Fig. 7. Volume density of interfollicular (Vvi) in control animals and animals exposed two, five and six months to the LM-EMF. The mean + SE are given

with thyroid. The greater sensitivity of thyroid gland to EMF observed after two months may, in part, involves thyroid dependent mechanisms that are absent in long-term exposure. However, it is also clear that other non-thyroidal mechanisms are involved, in particular those associated with release of a number neurotransmitters [19]. Since the thyroidal activation index, which has positive correlation with TSH level in plasma [14, 15] significantly decreased after five and six months of exposition to LF-EMF, observed morphological changes as the rare presence of intercellular colloid droplets as well as the absence of apical protrusion, wnich are the signs of decreased endocytic process, can be considered as a result of a decrease in TSH level relationally of absence of its stimulative effects on follicular epithelium. These morphological signs of the decrease in thyroid function are in agreement with earlier observations that constant EMF caused siqnificant decrease in thyroxine concentration [18].

On the basis of several findings that implicate the plasma membrane as a primary site of interaction between EMF and cell [3, 4, 11, 20, 21, 22] we have considered the possibility that follicular cell membrane could also be target for LF-EMF influence. This is particulary important for their apical membrane. It is well knoun

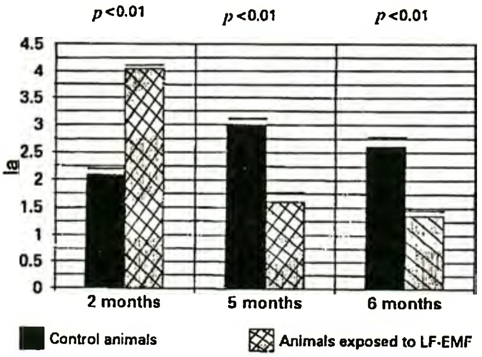

Fig. 8. Activation index of thyroid gland (Ia) in control animals and animals exposed two, five and six months to the LM-EMF. The mean + SE are given

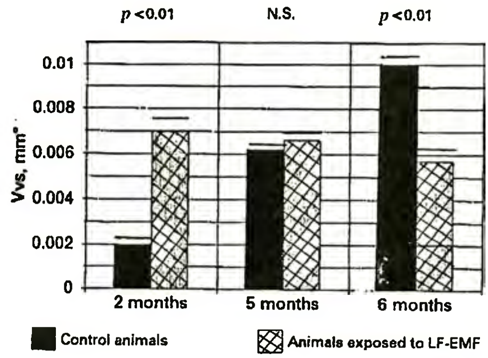

Fig. 9. Volume density of blood vessels (Vvs) in control animals and animals exposed two, five and six months to LF-EMF. The mean + SE are given

that disturbance of its normal structure leads to the chanqes of exo- and endocytotic processes which enhance the sensitivity if thyroidal cell to TSH stimulation [5, 6].

Long-term exposure to the LF-EMF can also be considered as a cpecific stress situation. Electric field (50 Hz, 40 kV/m) effecting on the whole organism during the postnatal ontogeny in mice, resulted in stress of all the systems of hormonalregulation: thyroid and gland and testes [16]. As a results of such stress, the hormonal control for development processes was weakened, that delayed the maturation of animal organism. Similarly to this, exposition to the electric field postnatally every day during 7 months showed an increased lipid content in zona glomerulosa of the adrenal cortex [13] what acts as a proof of these animals being exposed to chronic stressor [24]. In this regard, there is a possibility to interpret our results from stressogenic aspect of this experimental procedure. It is also of interest that EMFs have been shown to influence the levels of a number of neurotransmitters [25] and these effects may involve actions on the thyroid gland too. Our findings that EMF increase volume of interfollicular connective tissue are in accordance with previous studies which have been shown that EMF modify the membrane transport and affect both the proliferative and functional capacity of connective tissue cells and genetic transcription can be altered by pulsatile EMF stimulation with a resultant massive increase in DNA and messenger RNA production [12, 23].

In summary, present results indicate that exposure to LF-EMF produces an impairment in the thyroidal structure as measured by stereological and cytological parameters. In view of the broad range of functions in which thyroid hormones are involved, alterations in thyroid activity induced by EMF could initiate a wide spectrum of subtle biological effects. Further studies are needed to clarify the mechanisms by which EMF disrupts the hypothalamic-pituitary-thyroid axis.

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