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Changes in Enzymes Activity in the Blood and Hepatic Tissue Homogenats of Ovariectomised Female Rats after Exposure to an ELF Magnetic Field

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The aim of this study was to estimate the influence of long-lasting exposure to extremely low frequency (ELF) magnetic fields on enzyme activity in blood serum and in rat hepatic tissue homogenats in ovariectomized female rats. The experimental material consisted of 35 female Wistar rats: 27 animals bilaterally ovariectomized in the 6th month of age constituted the experimental group exposed to a magnetic field, and 8 unovariectomized rats was a control group in which sham-exposure was made. In ovariectomized group, 10 rats were exposed to a rectangular magnetic field at a frequency of 5 Hz and magnetic flux density of 10 mT rms, 9 rats were exposed to a sinusoidal magnetic field at a frequency of 40 Hz and magnetic flux density of 10 mT rms, and 8 animals were exposed to a sham-exposure 1 hour a day for 40 days. Then the rats were exsanguinated in ether narcosis and enzymes activities of ALAT, ASPAT, LDH, SDH in blood serum and the amount of FDAP-aldolase, ASPAT, ALAT, SDH, GLDH, MDH, LDH in hepatic tissue homogenats were measured. A significant increase in the serum activity of ASPAT and ALAT in the group exposed to a rectandular magnetic field at a frequency of 5 Hz was observed. In hepatic tissue homogenats a significant decrease in LDH content in both groups exposed to the magnetic field and increase in GLDH content in the group exposed to a sinusoidal magnetic field at a frequency of 40 Hz as compared to sham-exposed group was observed Results of the present study proved the incidence of

distinct changes of enzymes activity in blood serum and hepatic tissue homogenats of ovariectomized female rats exposed to extremely low frequency magnetic field.

Key words: enzymatic activity, extremely low frequency magnetic field, ovariectomised female rats, hepatic tissue homogenats, blood serum.

Introduction

Extremely low frequency (ELF) magnetic fields affect processes of replication and transcription of nucleic acids resulting in stimulation of protein synthesis and activation of various metabolic processes in cells [1, 2, 3, 4] They also influence magnetic properties of paramagnetic components of many coenzymes and processes of membraneous transport [1, 3, 4, 5]. All these effects can change enzymatic activity and amount of enzymes in a living organism. There are some papers in which changes in enzymes activity in blood and various tissues were examined, but their results are not univocal depending on experimental material and model [3, 6, 7, 8, 9]. Since hormonal changes during menopause affect many metabolic processes specially in hepar the aim of the study was to estimate the influence of long lasting exposure to an ELF magnetic field on serum activity and hepatic tissue amount of some enzymes in an experimental model of experimentally ovariectomised female rats.

Material and Methods

The experiment was carried out on 35 female Wistar rats (age 10 month, weight 300 ± 50 g). The animals were housed in optimal environmental conditions (constant temperature and humidity of air) in a reverse 12:12 h light-dark cycle. They were fed with standard laboratory food and had free access to water.

The source of ELF magnetic field was a unit Ambit 2000 (Poland) consisting of variable magnetic field generator producing magnetic fields of different physical parameters, and a cylindrical applicator which enables whole animal body exposure.

The animals were randomly divided into 4 groups.

I group "5" consisted of 10 rats ovariectomised in the 6^{th} month of age and subsequently exposed to a rectangular magnetic field at a frequency of 5 Hz and magnetic flux density of 10 mT rms.

II group "40" consisted of 9 rats ovariectomized in the 6th month of age and subsequently exposed to a sinusoidal magnetic field at a frequency of 40 Hz and magnetic flux density of 10 mT rms.
III group "O" consisted of 8 rats ovariectomized in the 6th month of age and subsequently exposed to a sham-exposure.
IV control group consisted of 8 non-ovariectomised rats exposed to a sham-exposure.

In all groups the whole body exposure lasted 1 hour daily for 4 month.

After the end of the exposure cycle animals were exsanguinated in ether narcosis. In specimens of obtained serum activity of aspartate aminotransferase (ASPAT), alanine aminotransferase (ALAT), lactic dehydrogenase (LDH) and sorbitol dehydrogenase (SDH) was determined with use of a routine kinetic method developed by IFCC (reagents POINTE, United States). Then segments of hepar were taken to prepare 10% tissue homogenats. After centrifugation in obtained samples of supernatant content of ASPAT, ALAT, LDH, SDH, glutamate dehydrogenase (GLDH), malate dehydrogenase (MDH) and FDPA aldolase was estimated with use of colorimetric method [10].

The results from each group were statistically analysed with a STATISTICA programme using the Kruskal-Wallis rang ANOVA test and the post-hoc U Mann-Whitney test.

Results

The activity of ASPAT, ALAT, LDH and SDH in the blood serum in an experimental group of ovariectomised, sham-exposed female rats did not differ significantly as compared to the control group of non-ovariectomised female rats (Figures 1, 2).

The exposure to a rectangular magnetic field at a 5 Hz frequency caused a significant increase in ASPAT ($p = 0.041$) and ALAT ($p = 0.049$) serum activity as compared to the sham-exposed group (Figures 1, 2). The activity of LDH and SDH in serum of rats from this group showed upward trend, but the differences were not significant. No significant changes in the serum activities of ASPAT, ALAT, LDH and SDH were observed in the group of rats exposed to a sinusoidal magnetic field at a 40 Hz frequency as compared to the sham-exposed group.

A significant increase in LDH ($p = 0.012$) (Figure 3) and significant decrease in ALAT ($p = 0.027$) and GLDH ($p = 0.001$) content (Figure 4) in hepatic tissue homogenats in the group of ovariectomised, sham-exposed female rats was observed

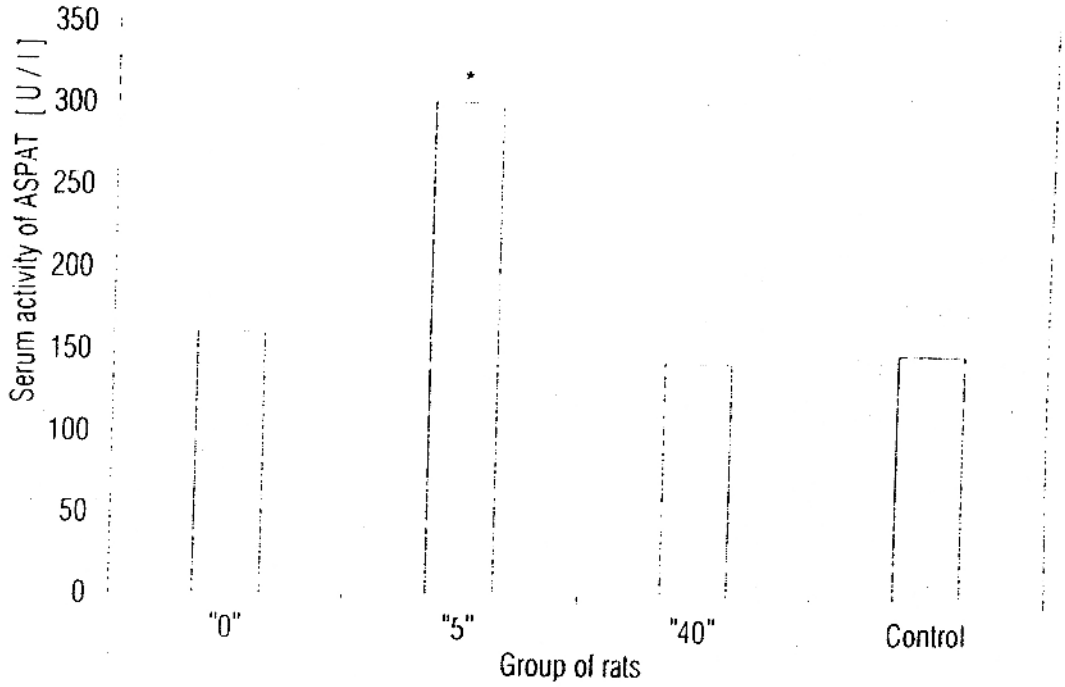

Figure 1. The activity of aspartate aminotransferase ASPAT in blood serum in the control group of non-ovariectomised female rats and in both groups: "5" and "40" of ovariectomised female rats exposed to a magnetic field of different parameters as compared to the sham-exposed group "0", with statistical evaluation (* — $p < 0.05$)

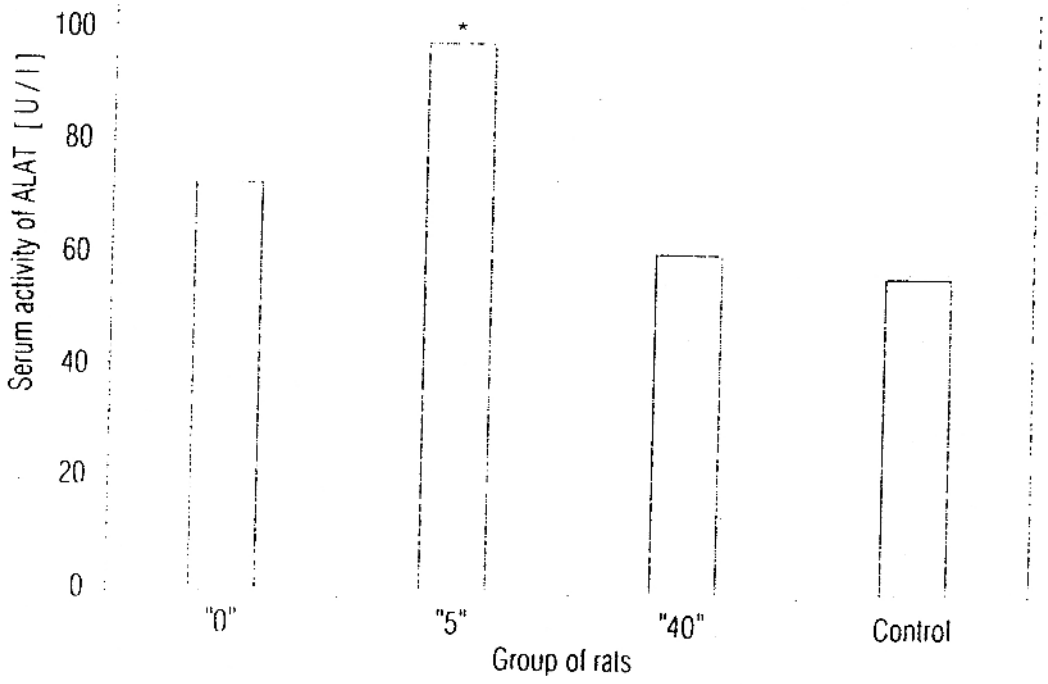

Figure 2. The activity of alanine aminotransferase ALAT in blood serum in the control group of non-ovariectomised female rats and in both groups: "5" and "40" of ovariectomised female rats exposed to a magnetic field of different parameters as compared to the sham-exposed group "0", with statistical evaluation (* — $p < 0.05$)

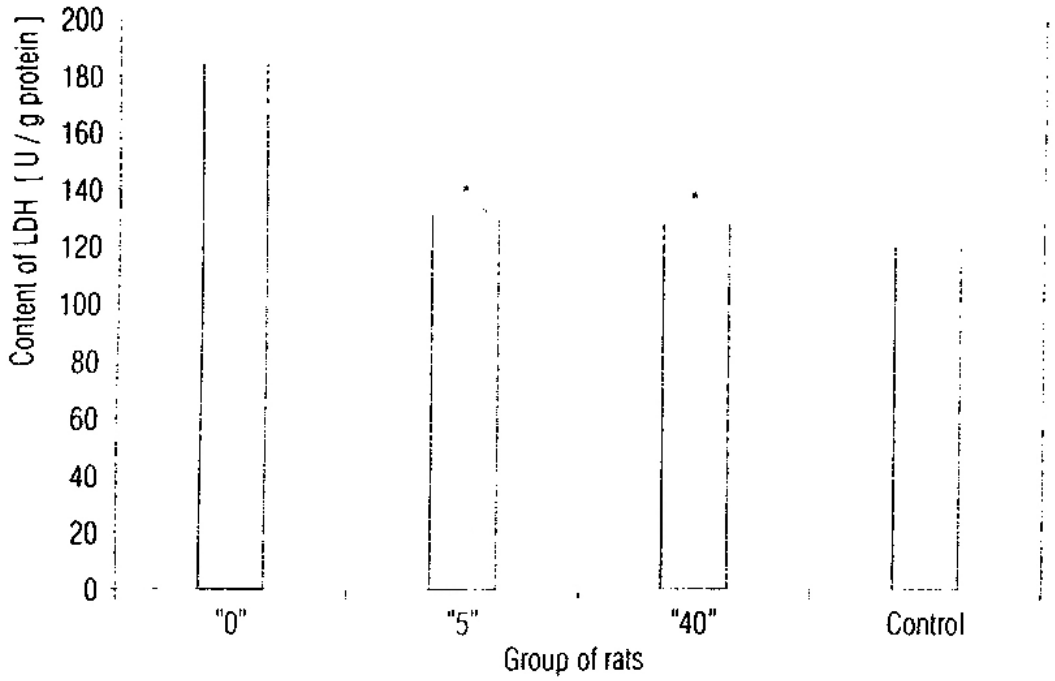

Figure 3. The content of lactate dehydrogenase LDH in hepatic tissue homogenats in the control group of non-ovariectomised female rats and in both groups: "5" and "40" of ovariectomised female rats exposed to a magnetic field of different parameters as compared to the sham-exposed group "0", with statistical evaluation (* — $p < 0.05$)

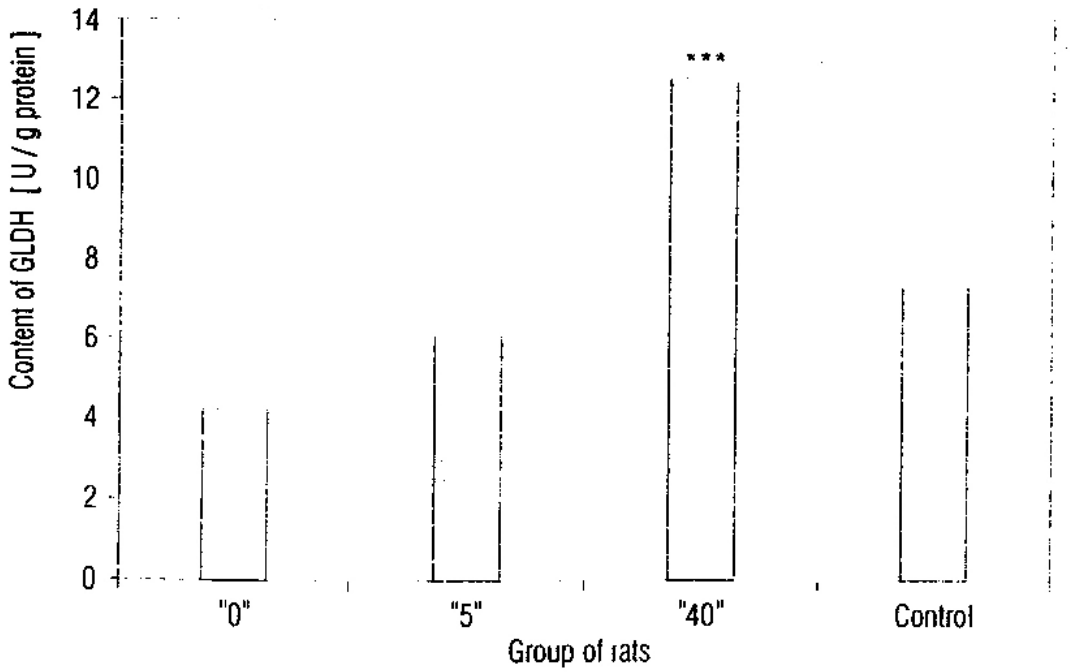

Figure 4. The content of glutamate dehydrogenase GLDH in hepatic tissue homogenats in the control group of non-ovariectomised female rats and in both groups: "5" and "40" of ovariectomised female rats exposed to a magnetic field of different parameters as compared to the sham-exposed group "0", with statistical evaluation (*** — $p < 0.001$)

compared to the control group of non-ovariectomised female rats. No significant differences in tissue content of ASPAT, SDH, MDH and FDAP-aldolase were observed between these groups.

In both groups of rats exposed to a magnetic field no significant changes in tissue content of ASPAT, ALAT, SDH, MDH and FDAP-aldolase were observed as compared to the sham-exposed group. The exposure to a magnetic field caused significant decrease in tissue LDH content in both groups exposed to a magnetic field as compared to group in which a sham-exposure was made (group "5" — $p = 0.026$, group "40" — $p = 0.034$) (Figure 3). The tissue content of GLDH in the group of rats exposed to a sinusoidal magnetic field at a 40 Hz frequency increased significantly ($p = 0.001$) as compared to the sham-exposed group, while no significant change of tissue content of this enzyme was observed in the group of rats exposed to a rectangular magnetic field at a 5 Hz frequency (Figure 4).

Discussion

The results of the present study indicate that ovariectomy and subsequent inhibition of estrogen function cause changes in enzymatic activity of hepatocytes of experimental animals. The data also confirm that long lasting exposure to an ELF magnetic field produces distinct changes in enzymatic activity in ovariectomised female rats.

Changes in serum activity of aminotransferases can be related either to stimulation of their synthesis in cells or to a lesion in hepatic and muscular tissues. The increased activity of aminotransferases in the serum of rats exposed to a magnetic field without increase in their content in hepatic tissue indicates intensification of the releasing process rather than stimulation of their synthesis in hepatocytes, since the increased activity was observed only in the serum of rats exposed to a rectangular magnetic field at a 5 Hz frequency. Physical properties of such a field with rapidly varying values of the magnetic flux density evoke stronger effect on the properties of liquid crystals in cellular membranes resulting in activation of membranous transport and excretion of these enzymes from hepatocytes. The practical significance of this effect is difficult to determine as in other studies a decrease in serum activity of aminotransferases during exposure to variable magnetic field was also observed [8].

Glutamate dehydrogenase (GLDH) is the enzyme involved in the proteolysis with subsequent production of amines and urea. The observed significant increase in GLDH

content in the hepatic tissue of rats exposed to a magnetic field indicates that long lasting exposure to a variable magnetic field causes stimulation of catabolic processes in hepatic tissue. Activation of catabolism by exposure to a magnetic field resulting in decrease in protein blood concentration, increase in glutamine and urea blood concentration and intensification of glycogenolysis processes in hepar was also confirmed in other experiments [11]. The different reaction of GLDH activity in both groups exposed to a magnetic field is difficult to explain. It is probably related to different physical properties of the fields used.

A significant decrease in the previously increased LDH content in the hepatic tissue of rats from both groups exposed to a magnetic field indicates a favourable effect of long lasting exposure on the functional status of hepatocytes in ovariectomised female rats as the higher content of LDH is related to toxic lesions in many tissues. The interpretation of this phenomenon is difficult since in our previous experiment, in which young rats were exposed to a magnetic field of different parameters only for 15 days, a distinct increase in diffusible histochemical reaction of LDH in hepatocytes was observed [9].

As the results of the present studies are unequivocal the final estimation of the effect of the magnetic field on the enzymatic activity in living organisms needs further research with use of other experimental models.

Conclusions

1. Long lasting exposure to a rectangular ELF magnetic field causes a significant increase in ASPAT and ALAT serum activities in ovariectomised female rats while exposure to a sinusoidal magnetic field does not change the serum activity of enzymes investigated.
2. Long lasting exposure to both rectangular and sinusoidal ELF magnetic fields causes a significant decrease in LDH tissue content in ovariectomised female rats.
3. Long lasting exposure to a sinusoidal ELF magnetic field causes a significant increase in GLDH tissue content in ovariectomised female rats, while the exposure to a rectangular magnetic field does not change the tissue content of this enzyme.