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ELF MAGNETIC FIELD EFFECTS ON SOME HEMATOLOGICAL AND BIOCHEMICAL PARAMETERS OF PERIPHERAL BLOOD IN MICE

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ABSTRACT

In this work we have studied some hematological and biochemical parameters of peripheral blood, as well as some histological aspects of liver and spleen during chronic exposure (1, 6, and 8 months) to extremely low-frequency magnetic fields (ELF-MF). Balb/C mice were exposed to an experimental sinusoidal magnetic wavefield of 60 Hz with a 0.11-mT intensity, generated in a system of Helmholtz coils. The results have shown no ELF-MF–cancer relationship during our experimental exposure time. However, leukopenia, hemoglobin decrease, and liver and spleen weight increase were observed. The bioeffects described could be correlated with spleen hyperfunction, which could have been produced by chronic exposure to this ELF-MF.

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INTRODUCTION

Most of the concern about power lines and cancer stems from epidemiological studies on people living near power lines and people working in ''electrical occupations.'' Some of these studies seem to show a relationship between exposure to power-frequency (50- or 60-Hz) magnetic fields and an increased health risk (1–10). However, other studies have not shown such a link (11,12). Experimental laboratory studies have shown little evidence of a correlation between power-frequency fields and cancer. The results described so far have shown that a connection between power line fields and cancer is not theoretically possible in light of biophysical considerations.

Nonionizing electromagnetic fields, especially at extremely low frequencies (ELF), are generally believed to be innocuous to human health due to their low-level energy deposition, which is of a magnitude well below that required to affect the metabolic rate of the human body (13). However, an increasing number of studies report that ELF-MFs are capable of eliciting in vitro and in vivo bioeffects (1–10). The results previously described are not completely conclusive, since in several cases they are contradictory.

The aim of the present study was to try to establish whether or not any bioeffects could be induced in several hematological, biochemical, and histopathological parameters under our chronic ELF-MF experimental conditions.

MATERIALS AND METHODS

Animals

Balb/C male mice 7 and 8 weeks old, weighing 18–22 g, were used [Laboratorio de Animales y Biomodelos Experimentales (LABEX), Santiago de Cuba, Cuba]. The animals were placed in plastic cages (48 × 24 × 14 cm) free of metallic material and maintained under a 12/12 h light schedule at a constant temperature of 23 ± 2°C and a relative humidity of 65%.

Experimental Model

Sixty mice were introduced into experimental magnetic sinusoidal wavefields of 60 Hz, with a 0.11-mT intensity, generated in a system of Helmholtz coils [designed at the Centro Nacional de Electromagnetismo Aplicado (CNEA)]. The applied field was perpendicular to the N–S static geomagnetic field (0.048 mT) and was generated by an autotransformer (Variac) followed by a voltage-reducing transformer with a variable resistance in series for fine adjustment of the coils' excitation current. This system consisted of two parallel horizontal flat circular coils of 0.65-m radius, with a common axis, and separated by 0.65 m.

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The magnetic field was monitored with a Hall-effect Gaussmeter with an axial probe (AC accuracy ± 0.1 mT, band width = 20 kHz).

Sets of 20 mice were sacrificed after 1, 6, and 8 months of exposure, respectively. The biochemical and hematological parameters of peripheral blood as well as histopathological changes in the liver and spleen were analyzed. Out of 20 mice, 10 were used for blood biochemical analysis and 10 for blood hematological analysis. In both cases, liver and spleen histopathological studies were performed. Control groups of 10 mice were maintained in the local ambient magnetic field.

Hematological Assay

To sacrifice the mice, profound inhalation ether anesthesia was administered. Blood was extracted from the retroorbital sinus in 0.2% EDTA. The hematocrit was determined by centrifugation of blood in sets of 24 JANETZKI TH12 (1.5 × 80 mm) microhematocrit capillary tubes at 10,733 g for 5 min.

The cyanometahemoglobin method was used for the determination of hemoglobin. White blood cells (WBCs) were counted in a Neubauer chamber.

Leukocyte differential counts were determined by microscopic examination of preparations of peripheral blood after May–Grünwald–Giemsa staining of slides. Leukocytes were counted (200 cells/mouse) and classified in order to calculate the different cell type percentages.

Biochemical Assay

A volumetric method was used for chloride determination. Sodium and potassium were determined by flame photometry. Calcium was determined by the Alizarin method. The biuret method was used for protein determination, and the glucoxidase method was used for glucose determination.

Statistical Analysis

Statistical differences were evaluated using a one-tailed Wilcoxon–Mann–Whitney rank sum test.

RESULTS

Hematological Parameters

After 1 month of exposure to ELF-MF, there were no statistical differences ($p > 0.05$) in hematocrit, hemoglobin, polymorphonuclear neutrophils, or lym-

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Table 1. Hematological Parameters Measured in Peripheral Blood

Hematological parameters	Control group ($n = 10$)	Exposed group	
		1 month ($n = 10$)	6 months ($n = 10$)
Hemoglobin (g/L)	136.6 ± 8.3	148.8 ± 8.1	116 ± 6.63
Hematocrit (%)	47 ± 0.03	51 ± 0.03	38 ± 0.04
WBC ($\times 10^9$ cell/L)	9.24 ± 1.42	5.79 ± 1.18	5.97 ± 0.82
Neutrophils (%)	48 ± 12	38 ± 5	34 ± 9
Lymphocytes (%)	50 ± 13	61 ± 5	66 ± 9
Monocytes (%)	2 ± 0	1 ± 0	0 ± 0

WBC: white blood cells.

phocytes between the control and exposed groups (Tab. 1). However, after 6 months of exposure to ELF-MF, we observed statistical differences ($p < 0.05$) in these parameters. The hematocrit, hemoglobin, and polymorphonuclear neutrophil (PMN) figures decreased significantly with respect to the control group. We consider the lymphocyte increases observed to be due to the PMN decrease. There were no statistical differences in monocytes between the control and exposed groups.

Neither size nor pathological modifications of red blood cells in exposed groups were observed. A significant leukopenia in the exposed mice was detected. Morphological alterations of WBCs in the exposed mice were not detected (Tab. 1).

Biochemical Parameters

After 1 month of exposure to ELF-MF, there were no statistical differences ($p > 0.05$) in biochemical parameters between the control and exposed groups (Tab. 2). However, after 6 months of ELF-MF exposure there were statistical

Table 2. Biochemical Parameters Measured in Peripheral Blood

Biochemical parameters	Control group ($n = 10$)	Exposed group		
		1 month ($n = 10$)	6 months ($n = 10$)	8 months ($n = 10$)
Chloride (mM/L)	105.83 ± 8.06	106.5 ± 4.3	102.9 ± 2.1	133.0 ± 2.1
Sodium (mM/L)	133.3 ± 2.82	131.1 ± 6.64	129 ± 7	143 ± 13
Potassium (mM/L)	6.15 ± 0.45	6.04 ± 0.81	7.55 ± 1.16	6.0 ± 0.8
Calcium (mM/L)	2.36 ± 2.27	2.45 ± 0.24	2.06 ± 0.50	1.75 ± 1.56
Proteins (g/L)	55.9 ± 4.8	56.2 ± 4.3	47.4 ± 4.0	48.7 ± 7.4
Glucose (mM/L)	8.68 ± 1.22	8.98 ± 1.45	8.51 ± 1.84	5.2 ± 1.8
Potasium/sodium ratio	0.046	0.046	0.058	0.042

Table 3. Weights of Studied Organs, in Grams

Organ	Control group ($n = 20$)	Exposed group		
		1 month ($n = 20$)	6 months ($n = 20$)	8 months ($n = 20$)
Heart	0.10 ± 0.02	0.12 ± 0.03	0.13 ± 0.02	0.17 ± 0.04
Lung	0.13 ± 0.05	0.14 ± 0.05	0.13 ± 0.04	0.19 ± 0.06
Liver	1.08 ± 0.13	1.30 ± 0.24	1.46 ± 0.11	1.58 ± 0.17
Spleen	0.06 ± 0.02	0.08 ± 0.02	0.15 ± 0.03	0.16 ± 0.06
Kidney	0.13 ± 0.03	0.20 ± 0.03	0.20 ± 0.02	0.23 ± 0.02
Brain	0.29 ± 0.06	0.35 ± 0.07	0.29 ± 0.03	0.32 ± 0.07

differences ($p < 0.05$) in proteins between control and exposed groups. After 8 months of ELF-MF exposure, there were statistical differences ($p < 0.05$) in chloride, calcium, glucose, and proteins between control and exposed groups, respectively.

There were no statistical differences in sodium and potassium parameters as well as in the potassium/sodium ratio betwen control and exposed groups (Tab. 2).

Histopathological Studies

We observed statistical differences in spleen and liver weights between the control and exposed groups (Tab. 3). Pathological modifications of other organs were not observed in the exposed mice.

DISCUSSION

The experimental design of this study has allowed us to assess the effect of ELF-MF exposure on hematological and biochemical parameters of peripheral blood, as well as on the histopathological variables of mice spleens and livers exposed for 1, 6, and 8 months to ELF-MF. Ten mice died after 6 months of ELF-MF exposure.

All exposed mice exhibited spleen weight increases (Tab. 3) after 1, 6, and 8 months of exposure to ELF-MF. These increases could be explained as a result of spleen hyperfunction, since we did not observe any other histopathological modifications in this organ. Spleen hyperfunction increases the rate of destruction of red blood cells, leukocytes, and platelets. This could explain the hemoglobin and hematocrit decreases and leukopenia (Tab. 1) in exposed mice after 6 months. Cadossi et al. (14), Picazo et al. (15) and Cossarizza et al. (16) have reported similar results.

If spleen hyperfunction is induced, a platelet decrease is to be expected (not quantified). Picazo et al. (15) reported platelet changes. In spite of the leukopenia seen in exposed mice, qualitative alterations of WBCs were not seen. The results show that the observed leukopenia does not induce the appearance of leukemic forms during the study period.

The observed variations in hematological and biochemical parameters were within the normal ranges for this experimental biomodel (17).

We observed no changes in our histopathological studies of other organs. This shows the lack of an ELF-MF–cancer relationship, at least for the period under study.

Tumors show a low potassium/sodium ratio, and as a result, higher mitosis and cell replication. Our results do not show a significant decrease in potassium/sodium ratio, which could explain the lack of an ELF-MF–cancer relationship (Tab. 2).

The results described have shown that ELF-MF can induce bioeffects in living organisms that do not necessarily lead to the appearance of cancer.

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