The Effects of Whole Body Exposure to Extremely Low Frequency Triangular Pulsed Electromagnetic Fields on Serum Lipids in Male Rabbits with Normal Diet

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Abstract

Background: The main goal of this study was to evaluate the possible effects of whole-body electromagnetic field (EMF) exposure on the lipid profile (total cholesterol, triglycerides, VLDL and HDL) in 16 adult male white New Zealand rabbits.
Methods: In two separate experiments, sham exposed group (control group) male rabbits were exposed to sham stimulated (without electromagnetic stimulation) for 5 days, 2 hours per day and the rabbits of treatment group were treated with triangular form 10 Hz of electromagnetic field for 5 days, 2 hours per day.
Results: At the end of the study, after 12 hours fasting period, blood samples were isolated and levels of total cholesterol (TC), triglycerides (TG), VLDL and HDL were measured by Auto analyzer. We found significant decrease in the plasma triglyceride, total cholesterol, VLDL and significant increase in HDL levels in rabbits that were exposed to 10 Hz extremely low frequency electromagnetic field (ELF-EMF). P-values in all cases were equal to 0.001.
Conclusion: Our results indicated the effects of whole body EMF exposure on levels of plasma lipids. We conclude that 10 Hz pulsed electromagnetic field favorably alters metabolism of lipoproteins, TG and TC which are associated with the risk of atherosclerosis and coronary heart diseases.

Keywords: Pulsed electromagnetic field, Lipid parameters, Rabbit, Normal diet

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Introduction

Some recent epidemiologic studies have suggested that the exposure to extremely low frequency (ELF) electromagnetic fields (EMF) affect human health, because of the incidence of certain types of cancer, depression, and miscarriage have been increased among individuals living or working in environments exposed to such fields (1-3). Some of these studies have shown associations between exposure to power-frequency (50–60 Hz) magnetic fields and increased health risk (4,5); but other studies have not shown such a link (6). The results described above are not completely conclusive, since in several cases they are contradictory. Extremely low-frequency electromagnetic fields exposure is generally believed to be innocuous for human health due to their low-level energy exposition, which is of a magnitude well below that required to affect the metabolic rate of the human body (3, 7, 8). However, an increasing number of studies have reported that ELF-EMF exposure is capable to eliciting in vivo and in vitro bioeffects (9-12).

The arterial diseases are the result of coronary arterial blockage problems. The prevalence of arterial diseases is rapidly growing in the world secondary to some disadvantages of the industrial life. Regarding the high prevalence of arterial diseases worldwide and their deleterious consequences on quality of human life, it is necessary to understand the parameters involved in developing and progression of the disease. Studies showed that alteration in serum levels of the lipids and lipoproteins, such as triglyceride, cholesterol, LDL and HDL results in atherosclerosis and arterial diseases (13). On the other hand, beneficial effects of ELF-EMF have also been reported; as shown in diet-induced hypercholesterolemic rabbits which pulses of EMF lowered total cholesterol and triacylglycerol levels (14). Similar results have been found in rats (15) and mice (16), both fed on control diets. In this study, the effects of 10 Hz extremely low frequency electromagnetic fields on the serum levels of cholesterol, triglyceride, VLDL and HDL in white New Zealand rabbits were investigated.

Methods

Animals

All procedures were performed in strict accordance with the international guidelines for care of experimental animals. Sixteen male New Zealand white rabbits aged 6 to 8 months weighing 2± 0.5 kg were randomly selected and divided into two equal groups. Both the control and case groups were fed on standard chow diet (Normal diet). The animals were housed individually in polycarbonate cages with sawdust bedding. Rabbit were kept in a 25˚C room with a 12h light/dark cycle and had free access to food and clean water ad libitum and stabilized for two weeks before the start of the experiment. The rabbits were either exposed to 2 hours/day stimulation of ELF-EMF (Treatment group) or 2 hours/day sham-stimulated (control group) for 5 days. All exposures were conducted during the light phase of the cycle, between 07:00 and 12:00 A.M. (5th day) of study. The data expressed as mean± SEM.

Electromagnetic stimulation unit

One low-intensity magnetic field exposure apparatus (made in PHYWE German factory) was applied to generate pulsed magnetic field. In this apparatus, one paired of identical Helmholtz coils, each of which contained 600 turns of enameled copper wire with diameters of 0.8 mm, were mounted coaxially at a distance of one coil radius (14.5cm) from each other to produce a highly uniform horizontal field between them. The coils were connected to an amplifier driven by a pulse generator. This was set to produce a pulsed triangular form with a frequency of 10 Hz.

Serum analyses

The effects of the ELF-EMF exposure on serum lipid concentrations were assessed after 5days (2hours/day). The animals were fasted twelve hours before the end of experimental period. At the end day of experimental period, the over-night fasting animals were anesthetized with ketamin/xylazine combination and blood samples for sera preparation were collected from marginal ear vein into sterile plain tubes. The plasma was immediately separated at 4°C by centrifugation at 3000 rpm for 10 minutes and promptly frozen at 70°C until analysis. Control

Determinations of lipid parameters were performed using an automated biochemical analyzer (Chemistry analyzer photometer DANA-4500). Total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C) and triacylglycerols (TAG) were assessed by enzymatic kits (Man).

Statistical analyses

The results were expressed as mean ± SEM. Differences between means analyzed using one-sample T-test. P-values of 0.05 or less were considered as statistically significant. Data were analyzed using version 15 of SPSS software.

Results

Both plasma high density-lipoprotein cholesterol (HDL-c) and very low- density lipoprotein cholesterol (VLDL-c), were considerably affected by the administration of ELF-EMF (Extremely Low Frequency Electromagnetic Field) (P=0.001), in such a way that HDL-C was increased and conversely VLDL was decreased. Total cholesterol in rabbits underwent ELF-EMF decreased significantly (P=0.001). Triglyceride also was affluence falling significantly (P=0.001).

Table 1- Serum lipid profile of normal adult rabbits in two groups

Group	Total cholesterol(mmol/L)	Triglyceride(mmol/L)	HDL-C(mmol/L)	VLDL-C(mmol/L)
Sham	0.64± 0.015	0.57±0.018	0.15±0.007	0.047±0.0041
Treatment	0.33±0.016*	0.37±0.026*	0.19±0.004*	0.024±0.009*

Values are expressed as mean ± SEM. The significance level was 0.05 or less. *P<0.05

Discussion

The most studies of the effect of electromagnetic fields on living organisms showed that the initial effect of an electromagnetic field is the triggering of key biochemical processes in various metabolic pathways (17-20). The synthesis of acetyl coenzyme A is one of these biochemical processes. Suppression of acetyl coenzyme A synthesis can lead to decrease in lipogenesis, especially in the liver (21-25). In the present study, we found a dramatic decrease in plasma total triglyceride in treatment groups. Beischer *et al.* reported that serum triglycerides of blood samples decreased 14 h after dinner when human subjects were exposed to a low-intensity magnetic field. However, higher serum levels of triglycerides were observed (Smialowicz *et al.*) after rats were exposed to 970-MHz electromagnetic radiation. We also found a considerable decrease in VLDL. Probably decreased lipogenesis contribute in falling VLDL formation in liver that can describe decreasing VLDL observed in treatment group of our study. On other hand, diminishing plasma total triglyceride will lead to decreasing in VLDL formation and their size (26). Our study indicate that exposing to extremely low frequency electromagnetic fields can resulted in a considerable elevating in serum HDL level and also a considerable decrease in serum TC level. In concordance to our study, Eping Luo *et al.* showed that exposure to extremely low frequency electromagnetic fields caused decreasing in serum triglycerides and TC and increasing in HDL levels. It is not unusual to see low HDL-C levels in patients with high TG. VLDL particles that do not undergo rapid catabolism linger in the plasma which leads to elevating apoB levels and increase risk of cardiovascular diseases. Another event is that TG and cholesterol esters (CE) are exchanged between HDL, LDL and VLDL, via CETP. The longer the half-life of VLDL, the more time they have to swap TG for CE from HDL using CETP. The HDL particles become TG-rich and cholesterol-poor, thereby reducing HDL-C levels, conversely with decreasing TG, this process will be inversed (27- 29). Therefore decreased TG can be result in high amount HDL-C levels in plasma that is obvious in our study. This sort of electromagnetic field may affect the absorption of triglyceride from digestion system. One another reason to reduction of triglycerides in plasma can be intervention of this electromagnetic field with formation and movement of chilomicrons to liver that let us investigate presumably relevant disturbance of this electromagnetic field on formation and movement chilomicrons to the liver in next studies. It is proposed that these fields are able to change the cell membrane potential and ions distribution. These changes may affect some biochemical processes and result in changing some serum biochemical parameters and enzymes (30, 31). One of that changes caused by extremely low frequency electromagnetic field is increasing calcium influx into the pancreatic beta cells that can be increase insulin secretion to the plasma (32). Insulin increases gene expression of lipoprotein lipase in different organs especially liver. One of the insulin actions in plasma is activating apo-CII that is activator of lipoprotein lipase. It is obvious increasing insulin in plasma can be results in elevating lipoprotein lipase efficiency in plasma and the more efficient is lipoprotein lipase, the less triglyceride and VLDL is in plasma.

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