Effect of Pulsed Magnetic Fields on Cholesterol and Tryglyceride Levels in Rats Study of Field Intensity and Length of Exposure

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In a previous work a decrease in cholesterol and triglyceride plasma levels was observed in rats 24 hours after their exposure to a 12 Hz 6 mT pulsed magnetic field (PMF). This time, a study of intensity effects of a 12 Hz PMF for a sixty-minute exposure and of length of exposure for a 12 Hz 6 mT PMF took place. Non-linear effect-dose relationships were observed for the PMF intensity as well as for the length of exposure used. The highest decreases in cholesterol and triglyceride levels were obtained after to a sixty-minute exposure with 1.5 mT and 12 mT.

Introduction

In a previous work (Bellossi *et al.*, 1996) a decrease of cholesterol and triglyceride plasma levels in rats 24 hours after their exposure to a 12 Hz 6 mT pulsed magnetic field (PMF) was reported. Such a phenomenon was accompanied with a weight liver increase and followed by a rebinding of triglyceride level at the 48th hour. Among the five following frequencies (12, 50, 100, 300, 460 Hz) the 12 Hz one was the most efficient one. PMF intensities or exposure length effect was studied in this experiment.

Material and methods

Male Wistar rats were used throughout these experiments. The generator of PMF was a Magnobiopulse apparatus (Société ATLAS International, Paris, France). The signal consisted of unipolar asymmetrical pulses (rise time 70 ns, fall time 700 ns, width 7 μs) supplied with 90-μs pulse bursts. The repetition rate frequency was 12 Hz. The PMF was delivered through 2 discs 12 cm in diameter. During the exposure the rats were put in plastic boxes ; the bottom of a box was 11 x 8 cm ; one box contained one rat. Each box was put on an emitter disc. The controls were put in similar boxes put upon discs which were not linked to the generator this time. The rats were handled in a randomized manner. Both the controls and the exposed ones were used during the 6 months when the experiment was going on to avoid successive studies of the different frequencies.Two experimental modalities were used:

1) Only a one-hour rat exposure took place, with the following PMF 0.6, 1.5, 3, 4.5, 6, 12, 16, 20 mT.

2) A 6 mT PMF exposure of the rats took place with the following exposure times : 5, 15, 30, 45, 60, 120, 180 minutes.

Weighing of the rats took place twenty-four hours after the last exposure followed by an anaesthesia (Ether Anesthésique GIFRER) of the animals so as to collect blood samples from their eye sockets before a beheading. A weighing of their brains, thymuses, hearts, lungs, livers, spleens and kidneys was undertaken knowing that all the weight indexes were defined according to the ratios of the organ weights through the body weights and plasmas were put for the test for cholesterol and triglycerides (Automate de Biochimie, Boehringer, Hitachi 755).

For each modality 30 rats at least were used sometimes a few more. Variance ratio test was carried out on BI software (Loginserm© 1979/1987) and ADDAD software (ADDAD©).

Results

1. Strength of magnetic field

Average weight indexes and standard deviations are reported on Table I. A comparison of the exposed rats with the controls led to the following

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Table I: Average weight indexes with standard deviations. Indexes were defined according to the ratios of the weights of organs through the body weights. The rats were exposed for 1 h to a 12 Hz PMF 24 h before the sacrifice.

Field strength [mT]	0	0.6	1.5	3	4.5	6	9	12	16	20
n	30	30	37	30	36	30	30	30	31	31
Body weight [g]	266 ±35	248* ±25	241*** ±18	244* ±28	252 ±25	257 ±20	267 ±20	248 ±22	261 ±24	271 ±25
Li	45.38 ±3.82	49.31 ±3.39	48.20 ±3.24	47.65 ±3.52	47.28 ±4.05	51.11*** ±5.45	47.17 ±2.67	43.49 ±4.3	43.88 ±3.62	45.62 ±3.32
Lu	4.80 ±0.77	5.15* ±0.37	5.03 ±0.41	4.98 ±0.41	4.72 ±0.46	4.85 ±0.48	4.64 ±0.46	4.99 ±0.47	4.84 ±0.49	4.69 ±0.41
S	3.14 ±0.48	3.73*** ±0.57	3.57*** ±0.42	3.65*** ±0.43	3.44** ±0.39	3.25 ±0.42	3.14 ±0.39	3.12 ±0.64	3.13 ±0.43	3.39* ±0.37
T	2.88 ±0.70	2.92 ±0.41	2.98 ±0.49	2.99 ±0.35	2.89 ±0.56	3.12 ±0.51	2.70 ±0.47	2.92 ±0.56	2.91 ±0.53	2.96 ±0.38
B	7.03 ±0.90	7.47 ±0.69	7.73 ±0.47	7.58 ±0.80	7.36 ±0.64	7.19 ±0.50	7.02 ±0.47	7.34 ±0.71	7.08 ±0.64	6.99 ±0.58
H	3.45 ±0.49	3.62 ±0.25	3.63 ±0.23	3.66 ±0.31	3.63 ±0.23	3.64 ±0.35	3.53 ±0.35	3.56 ±0.25	3.58 ±0.21	3.54 ±0.25
K	7.52 ±0.79	7.84 ±0.58	7.63 ±0.59	7.77 ±0.49	7.43 ±0.59	7.82 ±0.79	6.97** ±0.65	7.01** ±0.46	7.00** ±0.32	7.12* ±0.43

n: numbers of rats.
*: $p < 0.05$
**: $p < 10^{-2}$
***: $p < 10^{-3}$
} with regard to the controls.

Table II: Average cholesterol and triglyceride plasma values with standard deviations according to the strength of a 12 Hz PMF. The rats were exposed to this PMF 24 h before the blood sampling.

Field strength [mT]	*n*	CHOL [mmol/l]	TRIG [mmol/l]
0	30	2.17 ±0.29	1.95 ±0.44
0.6	30	2.24 ±0.26	1.90 ±0.58
1.5	31	2.08 ±0.22	1.52*** ±0.42
3	30	2.10 ±0.31	1.69* ±0.42
4.5	30	2.10 ±0.29	1.68* ±0.39
6	30	1.97* ±0.38	1.60** ±0.40
9	30	2.21 ±0.28	1.73 ±0.56
12	30	2.06 ±0.22	1.42*** ±0.45
16	31	2.15 ±0.24	1.64* ±0.49
20	31	2.10 ±0.28	1.83 ±0.51

n: numbers of rats.
mmol/l: millimol per liter of plasma.
*: $p < 0.05$
**: $p < 10^{-2}$
***: $p < 10^{-3}$
} with regard to the controls.
CHOL: cholesterol; TRIG: triglycerides.

results. A significant increase of average spleen indexes was noticed from 0.6 to 4.5 mT and for 20 mT and a significant increase of average liver index was noticed for 6 mT. But a significant decrease in average kidney indexes was noticed from 9 to 20 mT.

Average cholesterol and triglyceride plasma levels with standard deviations are reported on Table II. The cholesterol values were significantly lighter than these of the controls for 6 mT, the triglyceride ones were lighter than those of the controls for all the intensities used but for 0.6, 9 and 20 mT, knowing that the maximum effect was obtained with 12 mT and 1.5 mT.

2. *Exposure time*

The PMF intensity was 6 mT. Average weight indexes and standard deviations are reported in Table III. In comparison with the controls, for a length of exposure ranging from 5 minutes to 120 minutes but for 60 minutes the exposed rats showed an increase in average spleen indexes. For a 5 minute-exposure they showed a significant increase in average kidney index followed by a decrease for a 180 minute-exposure. And a 5 minute-exposure as well as a 60 minute-exposure showed an increase in average liver indexes.

Table III: Average weight indexes with standard deviations. Indexes were defined according to the ratios of the weights of organs through the body weights. The rats were exposed to a 12 Hz 6 mT PMF 24 h before the sacrifice.

Length of exposure [min]	0	5	15	30	45	60	120	180
n	30	29	30	31	30	31	32	31
Body weight [g]	266 ±35	259 ±28	259 ±26	258 ±18	265 ±24	257 ±20	252* ±16	265 ±17
Li	45.38 ±3.82	49.43*** ±4.48	46.87 ±2.69	46.51 ±3.41	48.01 ±4.24	51.11*** ±5.45	47.71 ±5.22	46.25 ±3.07
Lu	4.80 ±0.77	4.65* ±0.41	4.70 ±0.42	4.73 ±0.39	4.51 ±0.49	4.85 ±0.48	4.77 ±0.40	4.83 ±0.41
S	3.14 ±0.48	3.56*** ±0.39	3.53** ±0.54	3.53*** ±0.39	3.54*** ±0.42	3.25 ±0.42	3.50*** ±0.34	3.03 ±0.27
T	2.88 ±0.70	2.84 ±0.41	2.87 ±0.63	2.81 ±0.53	3.06 ±0.68	3.12 ±0.51	2.78 ±0.53	2.82 ±0.47
B	7.03 ±0.90	7.24 ±0.67	7.35 ±0.71	7.32 ±0.55	7.16 ±0.65	7.19 ±0.50	7.33 ±0.62	6.92 ±0.44
H	3.45 ±0.49	3.49 ±0.27	3.47 ±0.24	3.46 ±0.21	3.46 ±0.29	3.64 ±0.35	3.43 ±0.26	3.46 ±0.18
K	7.52 ±0.79	7.91* ±0.66	7.85 ±0.59	7.69 ±0.48	7.83 ±0.55	7.82 ±0.79	7.84 ±042	7.06** ±0.53

n: numbers of rats.
*: $p < 0.05$
**: $p < 10^{-2}$
***: $p < 10^{-3}$
} with regard to the controls.
Li: Liver indexes; Lu: Lung indexes, S: Spleen indexes, T: Thymic indexes, B: Brain indexes, H: Heart indexes, K: Kydney indexes.

Table IV: Average cholesterol and triglyceride plasma values with standard deviations according to the length of exposure to the PMF. The rats were exposed to a 12 Hz 6 mT PMF 24 h before the blood sampling.

Length of exposure [min]	*n*	CHOL [mmol/l]	TRIG [mmol/l]
0	30	2.17 ±0.29	1.95 ±0.44
5	30	2.35* ±0.34	1.89 ±0.65
15	30	2.40** ±0.34	1.85 ±0.53
30	30	2.28 ±0.25	1.74 ±0.48
45	30	2.21 ±0.25	1.83 ±0.65
60	30	1.97* ±0.38	1.60** ±0.40
120	30	2.06 ±0.22	1.69* ±0.49
180	32	2.01 ±0.26	1.86 ±0.52

n: numbers of rats.
mmol/l: millimol per liter of plasma.
*: $p < 0.05$
**: $p < 10^{-2}$
} with regard to the controls.
CHOL: cholesterol; TRIG: triglycerides.

Average cholesterol and triglyceride plasma levels with standard deviations are reported in Table IV. With regard to the controls for a 5 to 15-min exposure an increase of cholesterol levels was noticed, whereas for a 60 minute-exposure a decrease took place. From a 60 to 120 minute-exposure a decrease in triglyceride levels was observed.

Discussion

A PMF effect on cholesterol and triglyceride plasma levels acted according to a PMF intensity and an exposure length and for those two parameters chosen a non-linear effect was noticed. In fact, we actually found here what has already been described as a «window effect» at the level of cells exposed to very weak magnetic fields, especially in a study by Bawin *et al.*, (1975) who were the first to take an interest in the calcium ion movement through membranes. Such effects have also been found in the development of chick embryos (Leal *et al.*, 1988).

In fact, those studies manage to prove the existence of efficient intensities but they did not pay any attention to the part precisely played by any

length of exposure. A complete body exposure of the rats managed in our experiment to put the emphasis on this part played by the exposure length. The part played by frequencies and the transient nature of the effects were shown in previous experiments.

Liver is the main source of lipoproteins in blood plasma. PMF were there to generate an alteration in their metabolism. Such an alteration was dependent on the exposure length chosen and any long exposure managed to suppress any effect present as if the organism could at last find again a balance disturbed at the begining by the PMF.

Moreover such a change in metabolism took only place for a few PMF intensities and not for all of them. It was as if some resonance phenomenon took place between the PMF and the living system under experiment.

All these facts will have to be taken into account for any one who will manage to set up a substantiated theory explaining biological effects of magnetic fields.

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