Short Communication

FOOD CONSUMPTION OF MICE IN THE STATIC MAGNETIC FIELDS OF MODERATE STRENGTH

弱磁場におけるマウスの摂食反応

Large-scale apparatuses applied with magnetism such as synchrotrons, infusion reactors and magnetic levitated trains are being put into practice in increasing wider prospect. The number of workers engaged in their operation and exposed to magnetic fields is increasing, but there do not seem to be sufficient data indicating what influences the magnetism has on man and how to deal with them. Our experimental exploratory studies have revealed that magnetic fields produce changes in behavior of animals when their whole body are subjected to the magnetism for a relatively extended period of time.¹⁻³⁾ Under those conditions, an experiment was attempted in a search for the threshold values of biological effects of the magnetism on the behavior of mice. A special attention was paid to the intake of food and water and others.

Materials and methods

Horizontally set homogeneous magnetic fields of 200 and 300 Oe made by permanent magnets were used for the experimental exposure. Metabolic cages, based on Hanneman *et al.*,⁴⁾ of the internal size of 44×100×100 mm were used for the experiment, each mouse inside the cages having free access to food and water.

After introductory feeding for two weeks, six-week-old ddy strain female mice were put into the cages and measurements were made as to intake amount of food and water, volume of urine, sodium and potassium levels in the 24-hour urine. Being practiced for the cage feeding for a week, the mice were subjected to a magnetic field of 200 or 300 Oe for ten days continuously while those indices were measured every day. Electrolytes concentrations in the urine were determined by an atomic absorption spectrophotometer (Shimadzu AA-610), applying the standard annexing method for potassium.

Fig. 1. Changes in food intake of mice exposed to magnetic fields of 200–300 Oe and of control mice. Symbols are the same in the following figures.

Fig. 2. Changes of urination by exposure level and by exposure period.

Fig. 3. Changes of potassium in urine by exposure level and by exposure period.

Results

For each of the indices measured, the mean of values of the last four days in the pre-exposure period was designated as the zero-day value. In indicating the values during the exposure day, the mean values of every two days period were calculated and compared with the above initial amount. In order to know the effects of exposure to the magnetism, the rate of change from the corresponding initial amount on the zero-day was computed for each value of a given exposure period and the analyses of variance were done by two ways of conditions and exposure period for each index. The number of observations per cell was six.

Figure 1 shows the mean values and standard errors of the rate of change for food intake by exposure conditions. Food intake of the control group indicated a clearly increasing pattern with a peak on the 5–6 exposure day, probably due to the mice to be restricted in a narrow cage, which was different from the patterns of the exposure groups.

Changes of urination of the mice are shown in Fig. 2, and changes of urinary potassium excretion are given in Fig. 3. Urination and the amounts of electrolytes in urine responses of the animals varied widely, since the strength of the magnetic fields used were near the lowest limit value for detection of the biological effects by our method.

Discussion

In our previous experiments we could find an increase in water intake by continuous exposure to the 3,000 Oe magnetic field, but not in the 300 Oe magnetic field. Also by intermittent exposure (six hours a day) to 300 Oe, significant increase of the potassium excretion in urine and weight gain were detected.²⁾

Because the biological effects of the 300 Oe magnetic field was relatively slight, we assumed that the limit value for biological effect as detectable by this method would be situated between 200 and 300 Oe. In the present study, the trend of increase in urination and in the urinary amounts of electrolytes was also noted for continuous exposure to the 300 Oe magnetism, with significant increase in the potassium amount in urine on the 7-8 day of exposure. With respect to the increase of food and water intake of the control group, it is suggested that the narrow space of the metabolic cage affected the mice as a stressor, and the exposure to the moderate magnetism might weaken the stress of animals or depress the function of the central nervous system.^{2,3,5)} But as for the urination or urinary amounts of electrolytes, magnetism might affect on the active transport through biomembrane or on the diuretic center without affection on the emotional center. On this point, the pattern of food and water intake of the mice in 200 Oe could affect the food consumption of the animals to a limited extent.

The present result showed that changes of these indices were found after 5-6 or 7-8 days of continuous exposure, whereas we were not able to detect these changes within the 48-hour exposure period in our previous studies. Because we did not confirm any specific effect on rats even in the 6,000 Oe magnetism except for decrease in food intake at the exposure conditions of six hours a

day,⁶⁾ we suggest that detection of biological effects of the magnetism would require more prolonged time of exposure of animals.

For the evaluation of the effects of magnetism on man, it is necessary to consider the total time of exposure in a day for workers in magnetic environment. The values of 200 Oe recommended by the Stanford Linear Accelerator Center⁷⁾ would be practicable as the safety standard for those workers whose whole body is in the magnetic environment for within several hours a day.

References

- 1) Nakagawa, M. and Hosoya, M.: Effect of magnetic fields on the levels of electrolytes in urine of the mouse, *Med. Biol. (Tokyo)*, 90: 307-311, 1975.
- 2) Nakagawa, M., Hosoya, M. and Tsukamoto, H.: Biomagnetic effects on taking food and water, urination and the levels of electrolytes in urine of animals, *Bull. Railway Lab. Sci. Res. Inst.*, 32: 15-28, 1978.
- 3) Nakagawa, M.: Effects of magnetic fields on fertility, general reproductive performance and growth of mice, *Jap. J. Hyg.*, 34: 488-495, 1979.
- 4) Hanneman, G.D., Gilmartin, J.N. and Hendrick, H.G.: Apparatus for metabolic studies on mice in high magnetic fields, *Bioscience*, 14: 43-44, 1969.
- 5) Friedman, H., Becker, R.O. and Bachman, C.H.: Effect of magnetic fields on reaction time performance, *Nature*, 213: 949-950, 1967.
- 6) Nakagawa, M., Tsukamoto, H. and Hosoya, M.: Reactions of rat intermittently exposed to magnetic field of 6,000 Oe, *J. Transport. Med.*, 33: 225-231, 1979.
- 7) Kaufman, G.E. and Michaelson, S.M.: Critical review of the biological effects of electric and magnetic fields. in "Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields" (ed. by J.G. Llauro et al.) 49-61, C.C. Thomas Pub., Springfield, 1974.

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