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Effects of Short-Term Exposure to Near-Zero Geomagnetic Field on Behavior of Laboratory Mice

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Abstract. The aim of the study was to determine the short-term effect of geomagnetic field (GMF) variation on mice. A total of 12 BALB/c mice were divided into two equal groups kept under hypomagnetic conditions (GMF vertical component below 20 nT) and two control groups kept free of field disturbances (GMF vertical component approx. 38000 nT). With geomagnetic field being shielded, significant changes of activities were observed in mice, which behaved nervously or restlessly. We conclude that short-term geomagnetic variation is closely linked to the biological activities.

Keywords: geomagnetic field, mice, behaviour, environment

1. Introduction

Geomagnetic field is a magnetic field associated with the Earth and is an ever-changing phenomenon that influences human activity and the natural world in a myriad of ways. Before the appearance of life, GMF has been formed for billions of years. It played a crucial role in the origin and development of life. The life on the earth has existed under the effects of GMF and the GMF has been an important environmental condition of life existence. Bogatina et al. (1986) reported that the GMF takes part in the orientation of the root system and Bieljavskaja et al. (1992) showed that it makes an effect on the metabolism of root meristem cells. The GMF also plays a considerable role in the spatial orientation of birds (Muheim et al. 2006) and other animals (Wajnberg et al. 2005) Moreover, prokaryotic organism can be affected by the GMF. Pradel et al. (2006) found that magnetiotactic bacteria can be navigated along the GMF in aquatic environments.

Contamination is one of the most prominent impacts on environment. When contaminations are mentioned, physical, chemical or biological contamination of soil, water and air are coming to our minds immediately, but much less often about "contamination" in the form of electromagnetic and geomagnetic field disturbances. With the development of industry and technology, the static GMF is often disturbed by various metal components or interior design elements, for example, steel elements in almost every building and conveyance. Exposure to a disturbed GMF may lead to dysfunction of body, including death. Various experimental studies carried out over the last several decades have examined the effects of the chronic or acute exposure of laboratory animals to static magnetic fields. Four main areas of investigation have been covered, for instance, nervous system and behavioral studies, cardiovascular system responses, reproduction and development, and genotoxicity and cancer. These studies showed that sun activity can disturb the GMF and these disturbances may have negative effects on human health, causing more frequent convulsive seizures (Rajaram and Mitra 1981) and disorder in heart rate (Stoupel, 2002), and are a potential cause of the sudden infant death syndrome (Persinger and Psych 1995) Furthermore, magnetic shielding is a potential cause of anatomical and physiological abnormalities during early stages of growth in amphibians (Asashima

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et al. 1991) and mammals (Tombarkiewicz et al. 2004). Previous studies found that variation of the geomagnetic field (GMF) interferes with the normal brain functions and common behavior. Dupont et al (2004) showed that disturbances of magnetic fields, when applied in a specific direction, might interact with the local geomagnetic field to affect cell migration in structures within the brain stem that modulate vestibular-related arousal and respiratory or cardiovascular stability and Zhang et al (2007) However, there was few study revealing short-term effects of elimination of GMF on animals. The aim of present study was to determine if short-term deprivation of GMF affects the behavior of laboratory mice.

2. Material and Methods

2.1 Animals and Geomagnetic Shielding Procedure

The experiment was carried out on female BALB/c mice purchased from the animal facility of the Fourth Military Medical University in Xi'an and housed in natural light conditions with free access to food and water. Twelve animals up to five weeks of age were fed in the natural GMF. They were divided into four groups (two control groups and two experimental groups) with three per group. Control groups (C and D) were housed in chambers (420×300×270cm) in which the GMF was common (about 38 000nT). Experimental groups (A and B) were housed in shielded AFPG-II shielded chambers (Beijing Anfang technological center of magnetic shield, China) in which the GMF was reduced to below 20 nT. Light conditions and the other environmental parameters in shielded chambers were similar to those in the control groups.

All mice were kept in identical conditions (temperature 25±1 ℃, RH 55±5%), fed the same food (provided with the animal facility of the Fourth Military Medical University) for mice of the foundation stock, and the only factor distinguishing the experimental group from the control group was the presence or absence of the GMF.

2.2 Behavior Tests

Four transparent cages were placed in the each chamber and kept balance and horizon. Mice were housed in the cages for one day (three mice per cage, one cage per group). Horizontal-activities and vertical-activities of mice were detected by BASILE-7431 animal behavior analytical equipment (UGO Company, Italy). The equipment is a typical arena consists of a Plexiglas cage lined with infrared photobeams. A second set of infrared photobeams placed above the first allows rearing to be recorded. Photobeams allow behavioural recording without the experimenter being present in the testing room; especially important when measures of anxiety are being assessed. Movements are recorded when the animal, by exploring the arena, breaks new photobeams. The distance travelled and active times, calculated from the photobeam breaks, are measures for the exerted motor activity. The time of detection was set to ten minutes for once and the detection of each group was repeated for six times. All experiments were completed during daytime (group A: 10:00~11:00, group B: 12:00~13:00, group C: 11:00~12:00, group D: 13:00~14:00).

2.3 Statistical Analysis

All the data were expressed as the mean±SD. One-way ANOVA was performed in the experiment. LSD test (equal variances assumed) and Dunnett's T3 test (equal variances not assumed) were used to compare the values between every two groups. The critical level was set to 0.05. All analyses were carried out with the SPSS for Windows (version 10.0, SPSS, Inc.,Chicago, IL).

3. Results and Discussion

Of the four groups included in the study, group A and B were experimental groups which were exposed in low-GMF. The horizontal activities (HA) of group A was 1865.2±92.6 and the HA of group B was 1890.8±130.1. According to the statistical analysis, there were no significant differences of VA between two experimental groups (Table.1, Figure.1). Meanwhile, the vertical activities (VA) of group A was 94.0±11.5 and the VA of group B was 95.2±10.8. The statistical analysis revealed no significant differences of VA between group A and group B (Table.1, Figure.2). The data showed that the behavior of mice in the experimental groups was statistically similar. The other two groups (C and D) were control groups which were exposed in normal GMF. The HA of group C was 1427±56.3 and the HA of group D was 1389.5±47.4. The VA of group C was 70.7±6.2 and the VA of group D was 66.3±5.6. The statistical analysis also demonstrated that there were no significant differences between group C and group D (Table.1, Figure.1, and Figure.2). The data recorded from control groups revealed that the behavior of mice did not change under the natural GMF condition. Thus, we concluded that the similarity of mice behavior under the same GMF could indicate that the variation but the change of GMF had no significant effect on the results of experiment.

Compared with control groups, however, mice of experimental groups behaved more restlessly. The statistical analysis revealed significant differences between experimental groups and group control groups. The HA and VA of experimental groups were significantly higher than those of control groups (Table 1, Figure.1, and Figure.2). In addition, the analysis above had explained that the disturbance of GMF was the most effective variation in this experiment. Thus, we concluded that the variation of GMF affected the behavior of mice significantly.

With the rapid development of industrialization and technology, more and more electric equipment emitting waves of different frequency that disturb the GMF is been using in the daily life. After discovers of various metal and inventions of metal alloys, these materials have been widely used in the different aspects. However, these materials also disrupt the balance of the natural GMF. Environmental scientists have presented a notion of electromagnetic smog in the field of environmental sciences (Rajkovic et al. 2003). It is therefore believed that disturbances of the natural GMF are not neutral to living organism. The anatomical and physiological change of the living organism may occur under the variation of GMF, but they can not be observed directly. Behavior is the most distinct change which can be noticed immediately.

In our study, the open field test was used to observe the change of mice behavior and the data of HA and VA was recorded. According to the previous studies, there are three common tests in research of mice behavior: open field, elevated plus maze, and acoustic startle (Meer and Raber 2005). The open field test is one of the most prevalent tests used to examine general motor activity, exploratory behavior and degree of anxiety (Wilson et al. 1976; Tremml et al. 1998; Meyer and Caston 2004). Previous study (Zhang et al. 2007) had found that the disturbances of the GMF affected the natural behavior of laboratory mice in the long-term. The mice were housed in the near-zero magnetic environment for a long time and the data recorded at the beginning was compared with the data in the end. The results show that the long-term exposure to the near-zero magnetic environment contribute to the abnormal behavior and anxiety. However, we can not conclude that the time played a crucial role in these results. Because this study did not exclude the possibility that these result might occur in a relatively short time and the remnant time contributed to results little. According to the results of our study, they showed that HA and VA of experimental groups were significantly higher than control groups. Thus, we believed that behavior and mood of laboratory mice were sensitive to the disturbances of the GMF and could be changed in the short-term exposure to near-zero GMF.

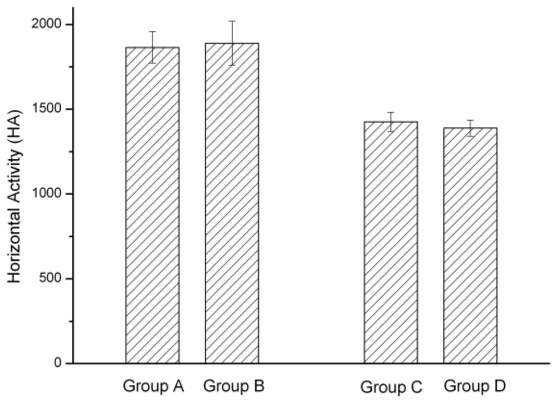

Fig.1 Horizontal activities (HA) represented the movement of mice on the horizontal plane. The group A and group B were two experimental groups which were exposed to the low-GMF. The HA of group A was 1865.2±92.6 and the HA of group B was 1890.8±130.1. The group C and group D were two control groups which were kept in the natural GMF. The HA of group C was 1427±56.3 and the HA of group D was 1389.5±47.4.

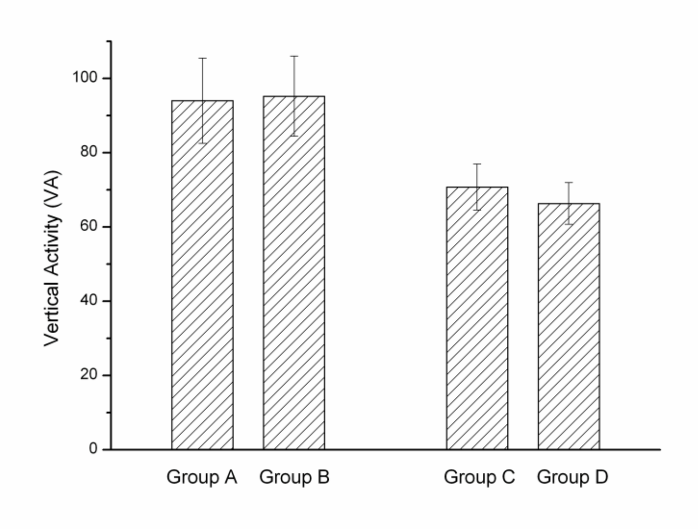

Fig.2 Vertical activities (VA) represented the movement of mice on the vertical plane. The group A and group B were two experimental groups which were exposed to the low-GMF. The VA of group A was 94.0±11.5 and the VA of group B was 95.2±10.8. The group C and group D were two control groups which were kept in the natural GMF. The VA of group C was 70.7±6.2 and the VA of group D was 66.3±5.6.

Table.1 Comparison of HA and VA among each group (n=6, $\bar{x} \pm s$)

Group	HA	VA
A	1865.2 ± 92.6^{cd}	94.0 ± 11.5^{cd}
B	1890.8 ± 130.1^{cd}	95.2 ± 10.8^{cd}
C	1427.0 ± 56.3^{ab}	70.7 ± 6.2^{ab}
D	1389.5 ± 47.4^{ab}	66.3 ± 5.6^{ab}

^{a}P<0.05 *vs* Group A; ^{b}P<0.05 *vs* Group B; ^{c}P<0.05 *vs* Group C; ^{d}P<0.05 *vs* Group D.

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5. References

[1] Asashima M, Shimada K, Pfeiffer CJ (1991) Magnetic shielding induces early developmental abnormalities in the newt, Cynops pyrrhogaster. Bioelectromagnetics 12: 215–224

[2] Bieljavskaja NA, Fimichjova VN, Govorun RD, Danilov VI (1992) Structural and functional organization of meristem cells of pea, flax and lentil roots under conditions of the geomagnetic field shielding. Biofizika 37: 745–749

[3] Bogatina NI, Litvin VM, Travkin MP (1986) Wheat roots orientation under the effect of geomagnetic field. Biofizika 31: 886–890

[4] Dupont MJ, McKay BE, Parker G, Persinger MA (2004) Geophysical variables and behavior: XCIX. Reductions in numbers of neurons within the parasolitary nucleus in mice exposed perinatally to a magnetic pattern designed to imitate geomagnetic continuous pulsations: implications for sudden infant death. Percept Mot Skills 98: 958-66

[5] Meer PV and Raber J (2005) Mouse behavioural analysis in systems biology. Biochem J 389: 593-610

[6] Meyer, L. and Caston, J. (2004) Stress alters caffeine action on investigatory behaviour and behavioural inhibition in the mouse. Behav Brain Res 149: 87–93

[7] Muheim R, Moore FR, Phillips JB (2006) Calibration of magnetic and celestial compass cues in migratory birds--a review of cue-conflict experiments. J Exp Biol 209: 2-17

[8] Persinger MA and Psych C (1995) Sudden unexpected death in epileptics following sudden, intense, increases in

geomagnetic activity: prevalence of effect and potential mechanisms. Int J Biometeorol 38: 180–187

[9] Pradel N, Santini CL, Bernadac A, Fukumori Y, Wu LF (2006) Biogenesis of actin-like bacterial cytoskeletal filaments destined for positioning prokaryotic magnetic organelles. Proc Natl Acad Sci USA 2006 103: 17485-17489

[10] Rajaram M and Mitra S (1981) Correlation between convulsive seizure and geomagnetic activity. Neurosci Lett 24: 187–191

[11] Rajkovic V, Matavuli M, Gledic D, Lazetic B (2003) Evaluation of rat thyroid gland morphophysiological status after three months exposure to 50 Hz electromagnetic field. Tissue Cell 35: 223–231

[12] Stoupel E (2002) The effect of geomagnetic activity on cardiovascular parameters. Biomed Pharmacother 56: 247–256

[13] Tombarkiewicz B, Roman A, Niedzi´ołka J (2004) Effect of magnetic disturbance caused by metal elements on body growth and selected physiological blood parameters in laboratory mice. Annu Anim Sci Suppl. 1: 243–246

[14] Wajnberg E, Alves OC, Harada AY, de-Souza-Esquivel DM (2005) Brazilian ants diversity and the local geomagnetic field: a ferromagnetic resonance study. Biometals 2005 18: 595–602

[15] Wilson RC, Vacek T, Lanier DL, Dewsbury DA (1976) Open-field behavior in muroid rodents. Behav Biol 17: 495–506

[16] Tremml P, Lipp HP, Muller U, Ricceri L, Wolfer DP (1998) Neurobehavioral development, adult openfield exploration and swimming navigation learning in mice with a modified beta-amyloid precursor protein gene. Behav Brain Res 95: 65–76

[17] Zhang X, Li JF, Wu QJ, Li B, Jiang JC (2007) Effects of hypomagnetic field on noradrenergic activities in the brainstem of golden hamster. Bioelectromagnetics 28: 155-8