Effect of Magnetic Field on Cells

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ABSTRACT

The effect of the electromagnetic field at high frequencies on cells was investigated *in vitro*. Rat's fibroblasts were cultured and exposed to the electromagnetic field continuously generated from a cellular phone for five days. The experimental results show only minor effects of the electromagnetic field from cellular phone of 10 W/m2 at 800 MHz on proliferation of cells and on destruction of cells. The results also indicate possible effects of the electromagnetic field on arrangement of cells and on synthesis of protein in cells.

Keywords: Bio-measurement, Electromagnetic field, Cells, Cellular phone, Proliferation, Arrangement, Synthesis of protein

1. INTRODUCTION

The effects of a magnetic field on a living body have been discussed in many reports. Some epidemiological investigations show possible effects of the magnetic field on human health. Some animal tests were also performed in the previous studies. Some studies evaluated the effects on cells [1]. Another experiment shows that the molecules of collagen orient along the static magnetic field.

The authors reported the effect of the magnetic field at the low frequency on arrangement of cells in the previous study [2]. The effect of the magnetic field at the low frequency on synthesis of protein was also discussed [3].

Thermal effects of the electromagnetic field at high frequencies on a human brain, on the other hand, have been reported in some researches. The possible effects of the magnetic field of a cellular phone were discussed in the previous studies [4-6]. In the present study, the effect of the magnetic field at high frequencies on cells was investigated *in vitro*.

2. METHODS

Sequence control

An experimental apparatus was manufactured to expose cells to the magnetic field at high frequencies with a cellular phone during cell culture (Fig. 1). A state of generating signals at the mobile phone was kept with sequence

control technique. To repeat the signal-generating state of three minutes, the start and the redial switches were turned on alternatively with a sequence controller (Fig. 2).

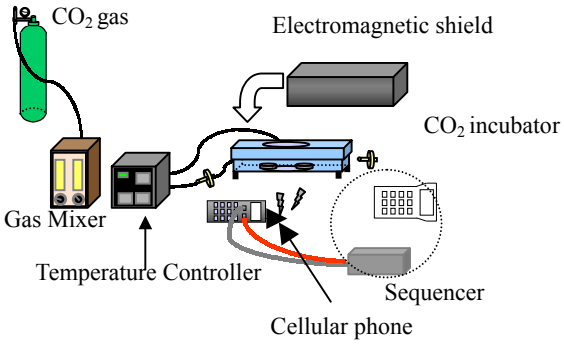

Fig. 1: Experimental system.

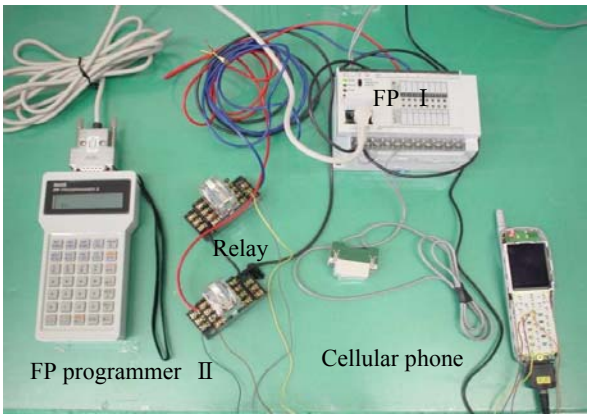

Fig. 2: Sequence controller.

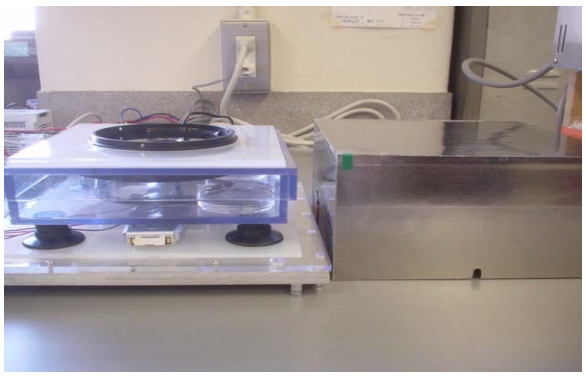

Fig. 3: Chamber of incubation (left), Electromagnetic shield (right).

Incubation

A dish with radius of 35 mm was placed near a cellular phone, which generates the magnetic field at 800 MHz. The dish was enclosed in a plastic chamber of incubation (Fig. 3). The chamber was connected to the gas-control line to keep the concentration of carbon dioxide at five percent in the vapor around the dish. The heater was equipped around the chamber to maintain temperature at thirty-seven degrees centigrade around the dish. The experimental system was enclosed with a flexible sheet of metal to shield the experimental space from the surrounding magnetic field [2].

Cell culture

The types of cells used in the experiment were rat's fibroblasts L929. The cells were seeded in two dishes and cultured simultaneously in the medium (Eagle's MEM) including ten percent of fetus bovine serum for five days. One dish is exposed to the electromagnetic field in electric-power density of 10 watt per square meter with the cellular phone, and the other is enclosed in the sheet of metal for shielding as control.

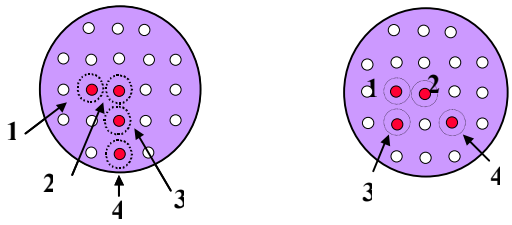

Fig. 4: Plate to trace the same position for observation in the dish.

Evaluation

The results were evaluated with a proliferation rate of cells, destruction of cells, arrangement of cells, and synthesis of protein in cells.

After the seeded cells become implanted on the bottom of the dish in 12 hours, the population of cells in the fixed area was counted every 24 hours with a phase contrast microscope. To trace the same area, the plate, which has twenty-one holes of 0.7 mm diameter, was attached on the bottom of the dish as a marker (Fig. 4). The population of cells increases exponentially with time. The rate of multiplication was calculated from the slope.

LDH (lactate dehydrogenase) is released from a destroyed cell. Concentration of LDH was measured with P-L method (Wroblewski method) in the culture medium collected every twenty-four hours from each dish during the test. The medium was refreshed every twenty-four hours.

The angle between the longitudinal axis of the cell and the cellular phone was measured with the microscope (Fig. 5). The direction of the dish was fixed according to the direction of the antenna.

After twenty-four hours of exposure, distribution of protein was observed by immunofluorescence technique with a co-focus scanning laser microscope (BX50, Olympus).

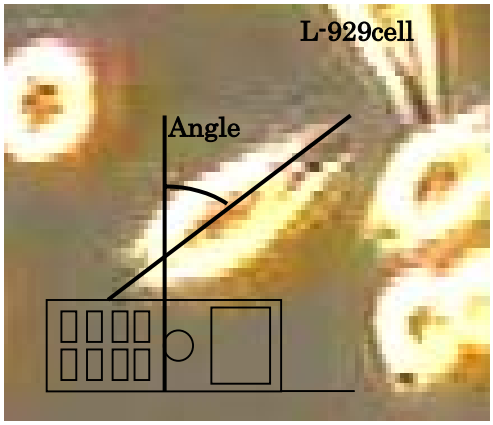

Fig. 5: Angle between cellular phone and cell.

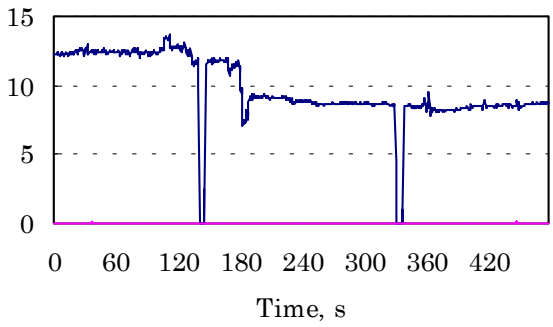

Fig. 6: Electromagnetic power from cellular phone kept by sequence controller.

3. RESULTS

The state of generating signals at the cellular phone was successfully kept with intervals of few seconds (Fig. 6).

The slopes of eight lines are similar (Fig. 7), which shows the similar proliferation rate in two kinds of magnetic conditions. Mean values are 0.034 per hour for exposure to the magnetic field and 0.036 per hour for shielding from the magnetic field.

Concentration of LDH was low, and does not significantly vary with two magnetic conditions (Fig. 8).

Figure 9 shows distribution of angles of 500 cells classified into every fifteen degrees after 72 hours cultivation. The results show that the cells tend to tilt to the direction of the antenna (75-90 degrees in Fig.9) under exposure of the electromagnetic field.

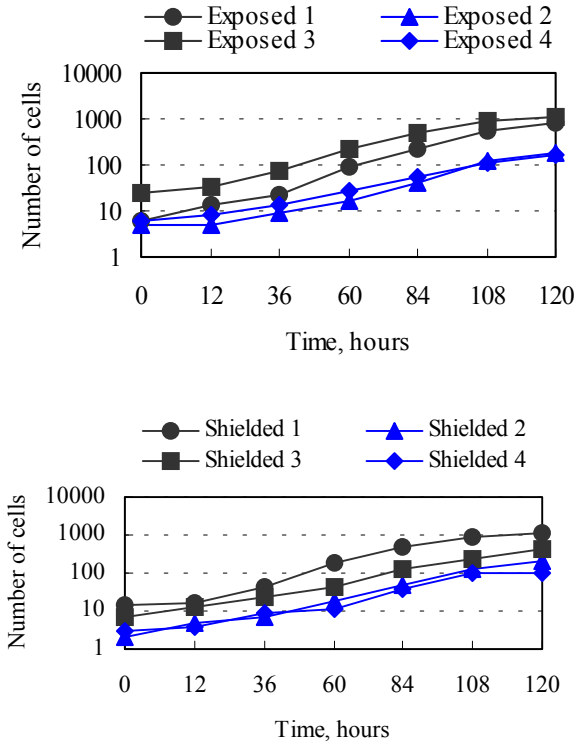

Fig. 7: Proliferation rate.

Figures 10-12 exemplify the microscopic view in which the color shows distribution of the inmunologically stained protein. The colored lines in cells indicate that many actin filaments might be synthesized in the cells exposed to the electromagnetic field (Fig. 11).

The intensity of surrounding magnetic fields sufficiently decreased with the flexible sheet of metal. Temperature was maintained thirty-seven degrees centigrade in the medium during the test.

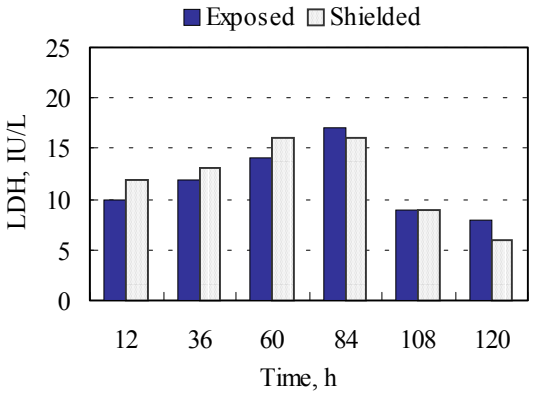

Fig. 8: Concentration of LDH.

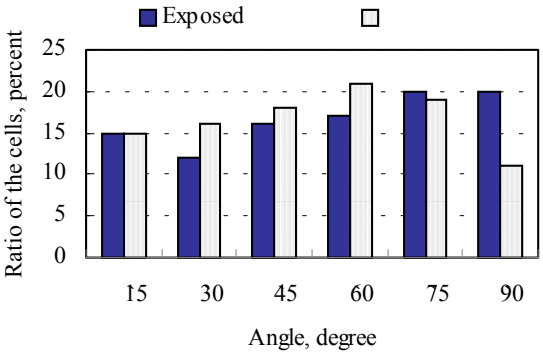

Fig. 9: Distribution of angles of the cells.

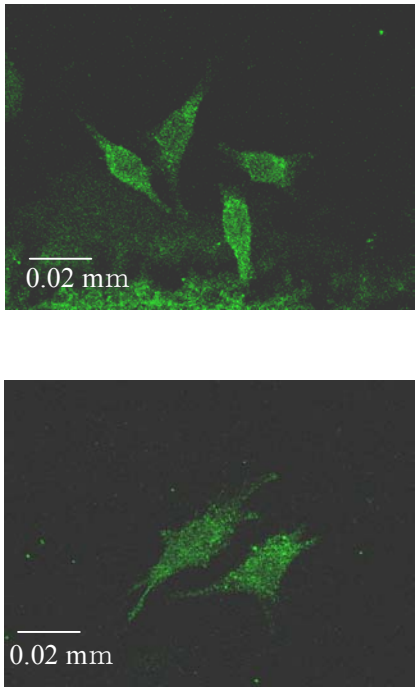

Fig. 10: Distribution of Vinculin after 24 hours of cultivation: exposed (upper) and shielded (bottom)

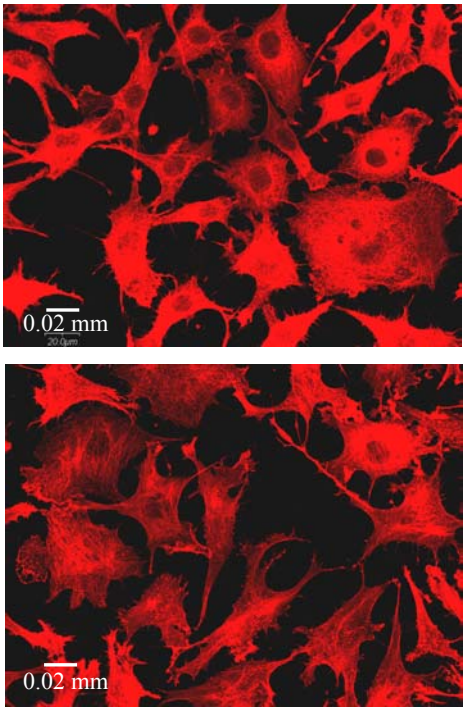

Fig. 11: Distribution of F-actin after 24 hours of cultivation: exposed (upper) and shielded (bottom).

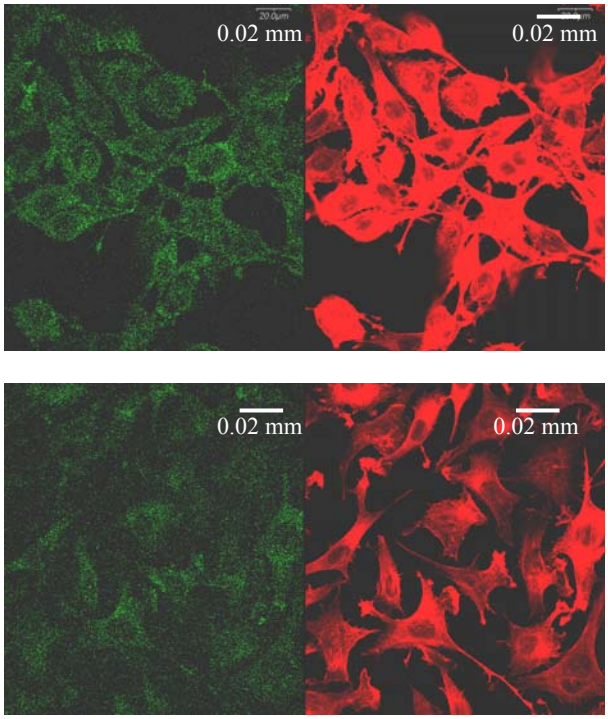

Fig. 12: HSP27 and F-actin after 24 hours of cultivation: exposed (upper) and shielded (bottom).

4. DISCUSSION AND CONCLUSION

The effects of electromagnetic fields were under discussion. The relation of cause and effect is not clear in epidemiological and animal experiments. The present study evaluates the effect of electromagnetic field on cells. The intensity of electromagnetic fields in the present study is not so high as accelerated experiments in the previous studies [1]. The present experimental results, however, indicate a possible effect on protein sysnthesis in cells.

The lactate dehydrogenase is released from cells during their destruction process, and used as an index for destruction of cells. The concentrations of lactate dehydrogenase in the medium replaced every 24 hours were in the same low level in the present experiments. The results show constant little destruction of cells regardless of the magnetic field conditions.

Distribution of alignment of cells in control group might show the effect of another magnetic fields from cellular phone, e.g. the geomagnetic field, which is parallel to the direction of antenna in the present study (Fig.9).

Thermal effects of the electromagnetic field at high frequencies on human body were reported in many researches. The temperature was not elevated with exposure to electromagnetic fields during the present experiment *in vitro*. Thermal effect might be small in the present experimental system.

5. CONCLUSION

The present experiments show only minor effects of the electromagnetic field of 10 W/m2 at 800 MHz on proliferation of cells. The results also indicate possible effects of electromagnetic field on arrangement of cells and on synthesis of protein in cells.

5. ACKNOWLEDGMENT

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