Influence of a high-frequency electromagnetic field at 2.45 GHz on human interleukin 1 beta and interleukin 6 productions in macrophage-like U937 cells

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Abstract

The relationship between exposure to electromagnetic fields (EMF) and health risks is of increasing interest. Although general concern regarding the potential hazards of exposure to an EMF has led to many epidemiological investigations, the effects of EMF exposure on human cells are still controversial. In vitro study, the cellular immune effects of EMF are discussed. We investigated the effects of a high-frequency electromagnetic field (HFEMF) at 2.45 GHz on human interleukin 1β (IL-1β) and interleukin 6 (IL-6) productions in human monoblastic U937 cells. Our results showed that the exposure to a HFEMF of 2.45 GHz at SAR of 1 and 10 W/kg for 4 hours has no significant effect on IL-1β and IL-6 productions in U937 cells.
1. Introduction

The introduction of mobile telecommunication devices is a public concern regarding the potential health risks associated with radiofrequency (RF) radiation emitted in use of these devices and by their base station antennas. The possible relationship between exposure to an electromagnetic field (EMF) and human health is very important. EMF exposure has been linked to a significantly increased risk of brain tumors in some epidemiological studies, but not in all studies [1]. The immune defence system against environmental substances maintains homeostasis in humans, and a weakened immune system makes an individual prone to infections and is potentially harmful to health. Interleukin 1 and interleukin 6 are multifunctional cytokines that induces a number of biological responses and plays a role in cell growth regulation, immune host defence, angiogenesis and others [2-6]. In this study, we investigated the effects of a high-frequency electromagnetic field (HFEMF) at 2.45 GHz on human interleukin 1β (IL-1β) and human interleukin 6 (IL-6) productions in human monoblastic U937 cells.

2. Materials and Methods

We used a specially designed exposure apparatus that employs a cylindrical waveguide as a basic structure [7]. This apparatus uses $TM_{01}$ mode, which is the basic mode for a cylindrical waveguide. The end of the waveguide is terminated by a short-circuiting metallic plate, on which a culture dish was placed. The cavity in the waveguide was maintained under controlled conditions similar to those in an incubator, i.e., an atmosphere of 95% air and 5% CO$_2$ at a relative humidity of >95% and a temperature of 37°C. A continuous 2.45 GHz signal was produced by a signal generator (Agilent E4421B, Tokyo, Japan) through a power amplifier (R&K A0825-5050-R, Shizuoka, Japan). A power meter (Power Reflection Meter NRT; Rohde & Schwarz, München, Germany) was used to monitor the input power and the reflected power. The dosimetry of RF field is performed with both numerical and experimental approaches. The results agreed fairly well. The SAR distribution was obtained from temperature elevation measured by fiber optic temperature probes (Fluoroptic Thermometer 790, Luxtron, Santa Clara, CA, USA). The SAR values are defined by spacially averaged values on the bottom of the medium, where cells were located. The input power was determined by the forward transmission power minus reflected power measured with the directional power meter. The temperature of the medium in the culture dishes was monitored throughout the experiment and was maintained at 37°C using a Peltier controller (Cell TDC-1550, Kanagawa, Japan).

U937 cells were exposed to a HFEMF at average specific absorption rates (SARs) of 1 and 10 W/kg for 4 hours. Cells were then maintained in RPMI1640 medium supplemented with 10% fetal bovine serum (FBS) and phorbol 12-myristate 13-acetate (PMA) at a final concentration of 50 ng/ml. At 24 hours after differentiation treatment, the cells were stimulated to produce cytokines by addition of lipopolysaccharide (LPS) at a final concentration of 1 µg/ml. Supernatants of cell cultures were tested in duplicate using commercial ELISA kits (R&D Systems, Inc., Minneapolis, MN) after 1, 6, 18 and 24 hours of stimulation.
3. Results and Discussion

The effects of the HFEMF on production of cytokines of human IL-1β and human IL-6 are shown in Figures 1 and 2, respectively. Both IL-1β and IL-6 productions were increasing with the LPS treatment time-dependent manner. No significant difference in both IL productions was observed between sham-exposure and the HFEMF exposures at 1 and 10 W/kg of SAR. The results from these experiments suggest that 4-hour exposure to a HFEMF at 2.45 GHz with up to 10 W/kg SAR might have no significant effect on IL-1β and IL-6 productions.

![Figure 1](image-url)

**Figure 1.** IL-1β production in U937 cells. PMA-differentiated cells were stimulated with LPS (1 µg/ml) for 1 to 24 hours after the HFEMF Exposures at SAR of 1 W/kg and 10 W/kg for 4 hours.

![Figure 2](image-url)

**Figure 2.** IL-6 production in U937 cells. PMA-differentiated cells were stimulated with LPS (1 µg/ml) for 1 to 24 hours after the HFEMF Exposures at SAR of 1 W/kg and 10 W/kg for 4 hours.

4. Conclusions

The data observed in the present study suggest that the exposure to a HFEMF of 2.45 GHz at SAR of up to 10
W/kg for 4 hours might have no significant effect on IL-1\(\beta\) and IL-6 productions. In conclusion, we do not consider that the HFEMF exposure could contribute to some adverse effects on IL-1\(\beta\) and IL-6 productions in cultured U937 cells under our experimental conditions. However the possibility of the combined effects of HFEMF exposure and LPS stimulation on IL-1\(\beta\) and IL-6 production remains, and further studies are required.

5. Acknowledgment

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6. References


