The effect of the low energy electromagnetic radiation of cell phone and Wi-Fi frequency on the calcium concentration in the exfoliated human buccal epithelium cells

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Abstract— The influence of electromagnetic radiation with frequency of 1.8 GHz and 2.4 GHz on the concentration of calcium in exfoliated cells of buccal epithelium was studied. The cells were exposed to microwave radiation at two frequencies (frequency 1.8 GHz, surface power density 2.5 μW/cm^2, as well as frequency 2.4 GHz, surface power density 2.3 μW/cm^2). After exposure to microwaves for 1, 2 and 3 hours immediately or after a delay of 1 or 2 hours, the calcium concentration in cells was assessed by means of staining with fluorescent dye Fluo-3. The phenomenon of cells with microwaves caused a decrease in calcium. Biological and medical implications are discussed.

Keywords: cell nucleus, cytoplasm, calcium, microwave radiation

1. Introduction

Electromagnetic fields (EMF) of radio frequency radiation of natural origin, coming to Earth from space, are effectively screened by the ionosphere. In the frequency range from 100 kHz to 300 GHz, at the Earth surface the intensity of natural EMF is low [1]. The level of radiofrequency (RF) EMF connected with human activity may be sufficiently higher. For instance, the 10,437 direct measurements in RF range made in Sweden show the mean level of the total RF radiation 0.4293 μW/cm^2 (4,293 μW/m^2). In some places it is higher, for instance in Stockholm Old Town in April 2016 the mean level of RF EMF power density was 5,371.4 μW/m^2 (median, 701.8 μW/m^2) [2].

The increased EMF exposure evokes a considerable public concern is connected partly with reported [3] increased risk of brain tumors among mobile phone users. Nevertheless, the epidemiologic studies, in overall, do not demonstrate a raised risk within approximately ten years of mobile phone use for any tumor of the brain or any other head tumor, in opinion of authors of the review [4]. On the other hand, epidemiological data on connection between a mobile phone use and the risk of tumors developing, especially brain tumors, are accumulating [5]. Genotoxic effects of EMF are reported in [6]. In addition, EMF could activate ion movements thus allowing the activation of calcium channels, activating NAD(P)H oxidase and inducing signal transduction for oncogene expression [7].

2. Materials and Methods

The experiments were carried out on exfoliated cells of human buccal epithelium. The cells were scraped off from the inner surface of the donor cheek by the sterile spatula. This procedure is absolutely painless and bloodless. Cells were placed in a buffer solution: 3.03 mM phosphate buffer supplemented with 2.89 mM CaCl2. Cells in suspension were exposed to EMF of 2.3 μW/cm2 and 2.5 μW/cm2. After exposure, the cells were stained with a calcium-sensitive probe – the fluorescent dye Fluo-3 in concentration 2 μM .

After 10 min of staining with 2 μM Fluo-3, the cells were examined and calcium radiation was assessed in the nucleus and cytoplasm by Confocal Laser Scanning Microscope LSM 510 META (Carl Zeiss)

The amount of calcium was evaluated in 10 nuclei, the experiment was carried out in a triplet, and the mean value for one nucleus and the cytoplasm was calculated as the standard mean error. Statistical processing of the experimental data was carried out by Student's method.

As a source of microwave radiation, was used a generator created at the Department of Theoretical Radiophysics of the Kharkov National University. The generator was connected to a computer and the additional software developed in the same department was used. Irradiation was carried out at a distance of 20 cm from the edge of the irradiating antenna. A sample of cell suspension in the buffer solution, described above - 10 μl of cell suspension, was placed on a microscope slide (layer thickness of about 0.1 mm) and exposed to microwave irradiation. The radiation flux density at the surface of the irradiated object was 2.3 μW/cm^2 at a frequency of 1.8 GHz and 2.5 μW/cm^2 at a frequency of 2.4 GHz. In different experiments the cells were exposed to microwaves for different times: 1 hour, 2 hours and 3 hours with a delay after exposure for 0, 1, 2 hours. The cells were exposed to microwaves at room temperature (25 C^o). To prevent drying of the cell samples on the microscope slides, slides were placed in Petri dishes with water poured onto the bottom of each Petri dish.

All experimental data are processed by Student t-statistics. In Figures 1-4 the mean values of 30 measurements and the SE are presented.

3. Results and Discussions

The results of the investigation of the effect of low energy electromagnetic radiation of the frequency of 1.8 GHz and 2.4 GHz on the concentration of calcium in the human buccal epithelium cells are shown in Fig. 1 - 4. Variants of experiment are indicated at the abscissa. First number represents the exposure time to microwaves, second number (after slash "/") represents the delay time after cell exposure and cell staining by Fluo-3. The control levels of Ca^{2+} for every separate experiment are represented as Control 1-4.

As it can be seen from Fig. 1, the effect of radio-frequency radiation on the frequency of 1.8 GHz immediately after the action of the cells caused decrease in calcium content in the nucleus.

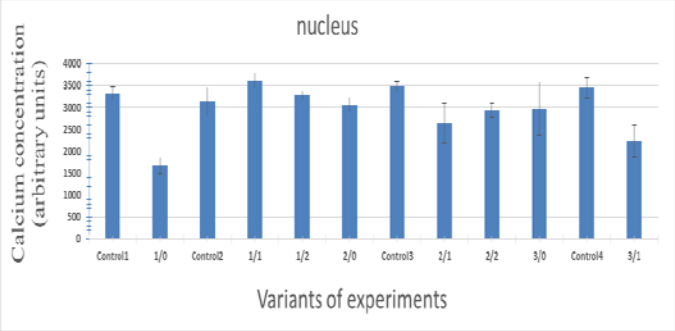

Figure 1. Calcium content in arbitrary units in the cell nucleus. Cells were exposed to microwaves at frequency 1.8 GHz, power density 2.3 μW/cm^2. Variants of experiment are indicated at the abscissa.

Exposure to microwaves for 1 hour caused a significant decrease in Ca^{2+}, and a longer exposure to microwaves and the more exposure time (2 and 3 hours of exposure) caused a more pronounced

decrease in Ca^{2+}. If the cells were examined 1 and 2 hours after exposure to microwaves for 2 and 3 hours, the Ca^{2+} content is further decreased.

In the Figure 2 the calcium content in the cytoplasm in cells exposed to microwaves of frequency 1.8 GHz and power density 2.3 μW/cm^2 is shown.

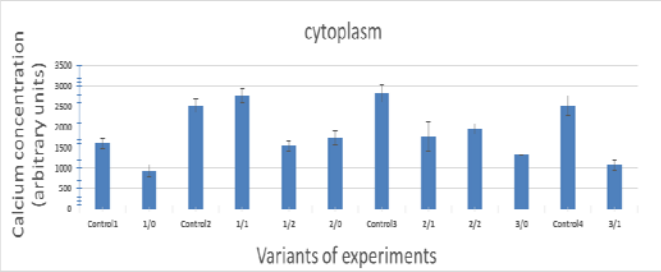

Figure 2. Calcium content in arbitrary units in the cytoplasm. Cells were exposed to microwaves at frequency 1.8 GHz, power density 2.3 μW/cm^2. Variants of experiment are indicated at the abscissa.

As Figure 2 shows, the calcium content in the cytoplasm changes in the same manner as in cell nucleus. It decreases after cell exposure to microwaves.

Calcium content in the cell nucleus after cell exposure to microwaves at frequency 2.4 GHz, power density 2.5 μW/cm^2 is presented in Figure 3.

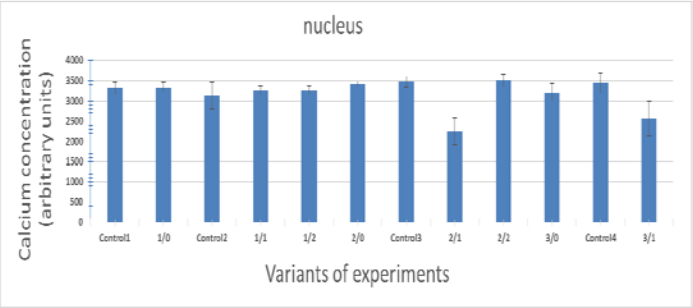

Figure 3. Calcium content in arbitrary units in the cell nucleus. Cells were exposed to microwaves at frequency 2.4 GHz, power density 2.5 μW/cm^2. Variants of experiment are indicated at the abscissa.

As one can see from Figure 3, the effect of microwave exposure (2.4 GHZ) is less pronounced, than to 1.8 GHz exposure.

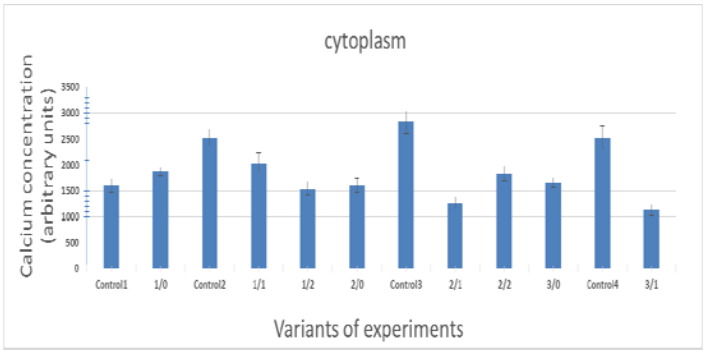

Figure 4. Calcium content in arbitrary units in cytoplasm. Cells were exposed to microwaves at frequency 2.4 GHz, power density 2.5 μW/cm^2. Variants of experiment are indicated at the abscissa.

Figure 4 shows the more pronounced effect of microwave exposure (2.4 GHz) on calcium concentration in cytoplasm, as compare to cell nucleus.

In overall, our results indicate the microwave-induced calcium decrease. The difference with known results of EMF-induced calcium increase [8], in our opinion, is connected with difference in cell exposure time to EMF. In our experiments the EMF exposure is longer, and we register late answer of cells damaged by long EMF exposure.

4. Conclusion

Thus, after irradiating the cells of buccal epithelium with low-energy radiation in the GSM band (1.8 GHz, 2.4 GHz), we observed a decrease in calcium in the nuclei and in the cytoplasm of cells, indicating a loss of calcium by the cell over time. The data obtained indicate a significant effect of microwave irradiation on the state of calcium in human cells. The decrease in calcium, observed in our experiments, is associated with a cellular response to the stress caused by microwaves.

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