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Investigation of the Behavior of Electric Current in Human Cells under the Impact of a Pulsating Magnetic Field

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ABSTRACT:

The human body works by means of electrical conduction and humans are able to move due to this conduction. Some neurological diseases can arise due to the troubles experienced in electrical conduction. One of those diseases is Cerebral Palsy (CP). This disease is the result of irregularities in the electrical activity of the human body and weaknesses in the cerebellum. When this poor electrical conduction and irregularity ceases to exist, the symptoms of the disease begin to fade. The electrical shock therapy applied for the treatment of the disease works but is a short-term treatment and does not give long-term results.

It was aimed to increase the electric current on the cells without a physical effect and was worked to obtain an induction on the cells by the pulsating magnetic field. Through induction, it is aimed to increase the current on the cells via a pulsating magnetic field. During our controlled experiments, low electrical currents were applied to the HeLa cells in culture. Cell cultures were also exposed to the pulsating magnetic field and the effect of the magnetic field on the cells' electric current was investigated. The current over the induced cells is increased and electrical activity irregularity is eliminated. Under the constant potential difference, the frequency of the magnetic field applied to the coil is systematically changed and the optimal frequency value is found.

As a result of the experiments, applying different frequencies to the cells with constant potential difference enabled us to work on a wide spectrum of magnetic field. It has been observed that at an optimal frequency, the electric current is increased. The values found may be used as pioneering work in order to overcome electrical conduction problems in organs such as the brain, the cerebellum and the spinal cord.

Key Words: Pulsating magnetic field, electrical conduction, cellular conduction, HeLa cells

Introduction

Cerebral Palsy is the result of irregularities in the electrical activity of the human body and weakness in the cerebellum. It is not definitive but it is estimated that the brain remains oxygen free.[1] Cerebral Palsy is a condition that prevents posture and physical movements. Although there is no known definite treatment, patients are supported with treatment methods and rehabilitation techniques to reduce their effects.[1]

There are known studies about pulsed magnetic fields' use for therapeutic purposes. Several methods are being used for this purpose. In such methods, the most important condition is the use of correct frequencies and strengths of magnetic fields according to the disease.[7] Magnetic fields at very low frequencies have been used in studies such as wound healing and rehabilitation. To create a pulsed magnetic field, it is necessary to use a square wave generator. The square waves provide a sharp change of the magnetic field and therefore a pulsed magnetic field is formed.[4]

In the procedures developed to date, magnetic field strength has been maintained at 0.1 to 1.2 mT and this interval was preferred because it was harmless to the human body. In spite of these studies and the use of magnetic field for therapeutic purposes, the relationship between both magnetic field and frequency values has not been yet investigated. In this study, the constant potential difference applied to the coil was applied at different frequencies and the results were evaluated.[5]

HeLa cultures were used in these experiments since the human body and living tissues could not be studied.

Materials

- HeLa cell culture. (T75 Flask - 15 ml medium.)
- 2000 coil copper coil. (Internal diameter 10.1 cm ± 0.05cm - External diameter 20.2 cm ± 0.05cm)
- Magnetic Field Sensor (± 6.4 mT Accuracy: 0.004 mT)
- Electric Current Sensor (Max 10 V - Max 0.6250 A - Accuracy: ± 0.0001A)
- Dual Channel Signal Generator (50MHz - 250MS/s sampling rate and 1μHz frequency resolution)
- Power Supply (Max 300 V ± 0.5V)
- Electronic circuit to produce square wave.
- Data recorder computer to save data.
- Calipers. (Used for precise length measurements.)
- Table Clamp (Used for fixing the coil, sensors, electronic circuit and cell culture.)
- Extension Clamp. (Used to adjust the position of the elements in the layout.)
- 100 cm ruler. (Used to calculate the distance between the elements.)

Method

The procedure of the experiment is divided into two separate parts: the set-up and the collection of data.

The Set-Up

HeLa cells in the petri dish were placed into the magnetic coil in order to be subjected to the pulsating magnetic field. Afterwards, the coil was fixed upright and provided with the required electronic circuit connections. The petri dish containing the HeLa cells was fixed to the center of the coil with the help of caliper measurement, before the magnetic field sensor was placed

parallel to the petri dish. The power supply was adjusted to the required values and the HeLa cells inside the petri dish were supplied with electrical current. (The voltage values taken from the power supply are connected to the current sensor to provide more accurate current values.) The values of the signal generator were adjusted and the generator was connected to the electronic circuit.

The Collection of Data

Different frequency values and current and magnetic field values were recorded on the data logger computer. HeLa cell culture was observed during the use of different frequency values with the signal generator. The experiment was conducted in a closed laboratory environment. The laboratory was away from external magnetic fields and was isolated. The magnetic field of the medium was measured to be 0.284 mT. The working environment has been standardized in every trial by reducing the external factors that could cause data errors to a minimum.

	Cell Current (Ampere)	Strength of Applied Magnetic Field (mT)
Control Group	0,031	0,284
0.5 Hz	0,043	0,901
0.6 Hz	0,044	0,905
0.7 Hz	0,072	0,911
0.8 Hz	0,137	0,901
0.9 Hz	0,143	0,905
1.0 Hz	0,153	0,900
1.1 Hz	0,129	0,900
1.2 Hz	0,115	0,900
1.3 Hz	0,095	0,897
1.4 Hz	0,082	0,898
1.5 Hz	0,071	0,898
1.6 Hz	0,071	0,890
1.7 Hz	0,068	0,896
1.8 Hz	0,066	0,897
1.9 Hz	0,060	0,901
2.0 Hz	0,058	0,901

(Data Collection Table)

The Process

The experiment was initiated with the set-up phase of the method. The coil which was be the source of the magnetic field was fixed perpendicularly. HeLa cells in the T75 Flask were inserted into the petri dish and placed in the experimental setup. The height of the coil was measured as 10.1 cm from the ground and the HeLa cells were fixed at this height. The reason for fixing the coil to its exact center is to reach the highest value of magnetic field and create magnetic field lines parallel to each other in this region. The square wave converter connected on a perforated copper plate was connected to the electronic circuit board. The signal generator was connected to the electronic circuit by setting a frequency of 1 Hz, at 7.5V. The waveform output from the pulse generator was then set to square wave form.

(The magnetic coil, the petri dish containing the HeLa cell culture and the signal generator are visible.)

In the data collection phase, firstly, data types to be used in data analysis were determined. The magnetic field sensor data was recorded in mT. The power supply was adjusted so that the current passing through the hela cells was noticeable at about 58 volts, at about 0.1 A current. Afterwards, computer recording the sensor data was set to receive data every 1/10

seconds. By providing constant potential difference at different frequencies, only the effect of frequency has been observed. Although all frequency values were scanned, the range of 0.5 - 2.0 Hz was used for analysis, for these values were found to provide the most suitable increase in current.

Although the data collection in all experiments was carried out for 10 seconds and data had been taken every 1/10 seconds, the experiments were repeated 5 times in order to increase the accuracy of obtained data. An advantage of increasing the number of experiments is that the disturbance in a wide range of data types, such as the magnetic field strength, caused by external factors has been reduced.

Results and Discussion

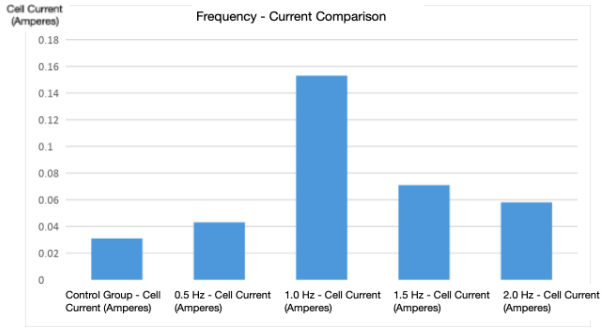
The results of our experiment can be summarized as following:

1. The frequency does not affect the magnetic field, but directly affects the current flowing through the HeLa cells.

2. The value of the electrical current on the HeLa cells increases up until the frequency value of 1.0 Hz, while the value of the current decreases if larger values than 1.0 Hz frequency are sent.

3. Even though the value of the magnetic field does not change during transmission in the cells, the frequency has an important effect. We have shown that frequency is a more important factor for us to obtain the constant magnetic field at different frequencies.

4. Magnetic fields with a wide frequency spectrum will not work and may have harmful results on the human cells. Only the magnetic fields at certain frequency values increase the intensity of the electrical current on the HeLa cells, indicating that frequency is important in regulating and increasing the irregular or low currents on the cells and that the frequency value of 1.0 Hz gives maximum efficiency.



(Data Collection Graph)

When experimental results were obtained, the sensitivity of the magnetic field was measured as 10^{-3} mT. This showed the variability of the magnetic field. For this reason, especially when operating with magnetic fields at very low currents and frequencies, the environment must be as far away from other magnetic field sources as possible. Despite the laboratory being underground and phones/WiFi internet not receiving signal, even the slightest movement affected the value of magnetic field. Because of this reason, all the electronic equipments have been kept out of the laboratory room (our watches, phones, laptops etc.). However it must be noted that conducting the experiment within a large faraday cage could provide more precise data. As mentioned before, these experiments had to be conducted with HeLa culture because working with true nerve cells had been ethically forbidden in the institution. The effects of frequency and magnetic field can be more precisely examined by repeating the experiments with nerve cells.

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