Ann Med Res 2020;27(9):2489-92

Annals of Medical Research

DOI: 10.5455/annalsmedres.2020.01.075

Original Article

Investigation of the effect of radiofrequency-electromagnetic field (RF-EMF) composed of mobile phone on brain EEG delta rhythms

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Abstract

Aim: The widespread use of mobile phones causes concern. The purpose of the study was to evaluate the effect of talking on the mobile phone for a short time on the brain EEG delta wave.

Material and Methods: A total of twenty healthy medical students were included in the study. Bipolar EEG recordings of experimental and control groups were obtained in the study. For EEG delta wave, domain measurements, fast fourier transform (FFT) and power spectral density (PSD) analyzes were evaluated with the SPSS program.

Results: As a result of the study, the values of the mean delta wave of all variables (value, FFT max, FFT max F, PSD Max F and PSD Max Power) were given between those using and not using mobile phones. There was a significant change in the EEG delta value ($p<0.05$) and no significant difference was found in the FFT and PSD values ($p>0.05$).

Conclusion: Short-term cell phone exposures did not cause any significant change in frequency and power spectral densities, which may cause changes in delta value. However, long-term effects should be examined and studies are needed to monitor possible changes of the EEG recording during the phone call.

Keywords: EEG; electromagnetic field; delta; mobile phone; radiofrequency

INTRODUCTION

With the use of electrical energy, we are exposed to the electromagnetic field (EMF) emitted from these device every day (1). Radiation is divided into two components; these are; a) ionizing, b) non-ionizing radiation. Non-ionizing radiation exists in three frequency bands; static (0 Hz) and extremely low frequency (ELF) range (<300 Hz), intermediate frequency range (300 Hz - 10 MHz) and frequency range for radiofrequency (RF) and microwaves (10 MHz to 300 GHz) (2). Mobile phones operate in different frequency ranges. The effects of the electromagnetic source on the biological material depend on the frequency of the source (3). Evidence is growing that pulse-modulated radio frequency electromagnetic fields (RF-EMF) affect brain physiology by cell phones. It has been reported that radiofrequency electromagnetic fields lead to changes in electroencephalogram (EEG) and regional cerebral blood flow as well as changes in intracortical excitability and cognitive function (4). The widespread use of smart phones in the community, particularly Global System for Mobile Communication (GSM), has recently started a discussion about the possible health effects. The effects of the electromagnetic field are propagated by these phones. Mobile phones are kept very near to the head by the users and the energy emitted is absorbed in the user's head. Thus, it is significant to examine the possible effects of radiofrequency electromagnetic fields on the brain and behavior (5). EEG signals contain rhythmically different patterns (alpha, beta, delta, and theta). One of them, the delta wave, is between 1-4 Hz, and is seen during deep sleep, unconscious state of the brain (6).

This study aimed to determine the effect of short-term cell phone use on the parameters of the brain EEG delta wave, especially due to the increased availability of mobile phones.

MATERIAL and METHODS

This study was carried out in the biophysics department of Kırşehir Ahi Evran University Faculty of Medicine. The study included randomly healthy twenty medical students with a mean+std age range of 21.15±2.10 years without any neurological disorder and no medication. Informed consent forms were filled in before the study and consent of the subjects was obtained. The study was approved by the Ethics Committee of Kirsehir Ahi Evran University

Received: 29.06.2020 **Accepted:** 21.08.2020 **Available online:** 23.09.2020
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Faculty of Medicine. The experiment was conducted according to the Helsinki Declaration.

Exposure system

A standard and commercial smartphone was used (HTC Corporation, Desire 610n, Taoyuan, Taiwan). Specific SAR information for this device is; head: 0.346 W/kg for 10 g, for body, 0.336 W/kg for 10 g. The subjects used their mobile phones to talk with their right hand on their right ears. Two groupings were performed. These; Group 1 (experimental group=phone, 3 minutes) and Group 2 (control group=no phone, 3 minutes) were created.

Data collection and procedure

This study was carried out in the Biophysics research laboratory of the Faculty of Medicine of Kırşehir Ahi Evran University. Biopac MP36 was performed using Student Lab Software (BIOPAC Systems Inc., Goleta CA, USA) and AcqKnowledge 4.1 software. The Biopac electrode set (SS2L) was connected to CH1 of the MP36. Bipolar electrode positioning was performed. Electrodes were performed on the left head area, and the mobile phone on the right ear. Domain measurements, FFT and PSD concentrations of EEG delta signals were measured.

Statistical analysis

The normality hypothesis was tested by the Kolmogorov-Smirnov and the Shapiro-Wilk tests. Descriptive statistics of the variables are given as Mean-Standard error, Median (IQR, interquartile ranges at the 25 - th and 75 - th percentiles). Paired t test and Wilcoxon matched-pair test were used for univariate analysis of dependent variables. Statistical analysis of the study was performed by using Statistical Package for Social Sciences version 21.0 software for Windows (SPSS Inc., Chicago, IL., USA).

RESULTS

The raw EEG data obtained in our study were subdivided with the Biopac system. Average parameters of 20 subjects are shown in Table 1 as a result of appropriate filtering and analysis. Raw EEG data was recorded. FFT was applied for frequency analysis. For FFT, 65536 point of FFT, pad with zeros, windows: hamming was taken. PSD was investigated for time-independent signals and power analysis.

Table 1. The domain measurements, FFT and PSD measurements of the average Delta wave measured from 20 subjects are given when speaking with mobile phone (3 minutes)

	Domain measurements						FFT		PSD	
	Mean μV	Min μV	Max μV	Std dev μV	Skew μV	Kurtosis μV	Max value μV	Max F Hz	Max F Hz	Max Power $(\mu V)^2$/Hz
Phone	-0.0026	-35.178	29.1939	4.5208	-0.1596	11.0571	0.163	1.184	1.225	0.169
no - phone	0.0074	-25.3055	29.6399	5.0628	0.1135	5.0753	0.164	1.234	1.243	0.185

FFT, Fast Fourier Transform; PSD, Power Spectral Density; F, Frequency; Min, Minimum; Max, Maximum; Stddev, Standard Deviation
Skew is a statistical measure of the degree of asymmetry in a distribution. (right tail has a positive skew and left tail has a negative skew)
Kurtosis indicates the degree of peakedness in a distribution

Table 2. Statistical comparison between FFT and PSD between mobile phone conversation (group 1) and fixed recording (group 2)

Variables and unit	Group 1 (cell phone) Median (IQR)	Group 2 (no phone) Median (IQR)	P
Value μV	-0.0005 (-0.0025~0.0016)	0.0015 (-0.0020~0.0092)	0.032
FFT Max μV	0.1525 (0.1110~0.1957)	0.1530 (0.1285~0.1890)	0.588
FFT Max F Hz	1.1350 (1.0422~1.3132)	1.1360 (1.0590~1.3795)	0.390
PSD Max F Hz	1.110 (1.025~1.3727)	1.1990 (1.0490~1.3072)	0.809
PSD Max Power $(\mu V)^2$/Hz	0.1860±0.0264	0.185±0.0137	0.586

IQR, Interquartile Ranges; FFT, Fast Fourier Transform; PSD, Power Spectral Density; F, Frequency; Min, Minimum; Max, Maximum

The median result for the value parameter in group 1 (cell phone) was lower than group 2 (no phone) and a statistically significant difference was found ($p<0.05$). No significant difference was found when all other variables (FFT Max, FFT F, PSD F and PSD Power) were compared between the two groups ($p>0.05$). Statistical comparisons are given in Table 2.

DISCUSSION

With the development of technology, artificial electromagnetic fields are increasing with the presence of electrical equipment in the society. The frequency of using mobile phones from these sources is remarkable. Research reports on their health effects are increasing.

The effect of a relatively low frequency electromagnetic field on EEG parameters on different parts of the human brain was investigated. Exposure at different frequencies was created, and 100 micro Tesla magnetic field was reported to increase delta power spectral value (7). The effects of radiofrequency electromagnetic field (900 MHz, -1800 MHz) on brain functions of 19 volunteers were investigated. In the EEG analysis, it caused a significant change in the absolute power of the delta band (8). In the study conducted on 30 subjects, brain EEG recording was obtained before, during and after talking on a mobile phone. It was observed that the mean value of the delta wave increased during and after the phone calls (9). The effect of 4G mobile phones on EEG activity was investigated on 7 healthy volunteers. In the study, it was reported that real-time EEG data can pose risks to the human brain in short-term exposures (10). Researchers applied RF-EMF at different frequencies on rats. In the study, they reported increased oxidative DNA damage formation in the frontal lobe of rat brain tissues (11). In our study, control and experimental groups were compared. There was a decrease in the mean and minimum parameters of the experimental group and an increase in the kurtosis. The experimental group (group 1) and the control group (group 2) were compared and an increase in the power spectral parameter was observed in the experiment group.

Although, mobile cell phones have an effect on the bioelectric activity of the brain or not, the researchers maintained the undergraduate students by recording the EEG. In their study, they collected EEG data using Biopac MP36 systems. It was emphasized that exposures for 15 minutes did not cause a change in brain bioelectrical activity (12). There are many research reports on brain electrical activity of radiofrequency electromagnetic fields originating from mobile phones before and after exposure. Some of these research reports report changes in EEG parameters, while some reports do not cause any changes. For this reason, it is seen that positive controls are needed in these studies, they may contain spike artifacts, and that most studies do not perform power analysis (13). In addition, important scientific reports are needed on the effect of electromagnetic exposure of long-term mobile phones on brain function (14). In our study, frequency and power spectral parameters were examined and no statistical difference was found between the groups. In our study, short-term exposure was created and no significant change was observed.

CONCLUSION

In particular, there are concerns over the effects of talking on mobile phones on human health in recent years. In this study, the effect of short-term cell phone conversation on brain EEG delta wave was investigated. We determined that there may be some small changes in the study, but they did not cause a significant change on the bioelectrical parameters of the brain. Therefore, long-term studies are needed regarding its effect on brain EEG parameters.

Competing interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports.

Ethical approval: The study was approved by the Kırsehir Ahi Evran University Clinical Research Ethics Committee (2019-07/85).

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