EVALUATION OF EFFECTS OF ACUTE EXPOSURE TO THE ELECTROMAGNETIC WAVES EMITTED FROM MOBILE PHONE ON VISUAL EVOKED POTENTIALS

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Abstract: **Background & Objectives:** Electromagnetic waves (EMW) emitted from mobile phone (MP) have the potential to damage eye tissues. Eyes having fewer blood vessels than other organs are more vulnerable to heat. Currently, very little information is available on the effects of acute exposure to the EMW emitted from MP on the human visual system. Therefore, the present study was planned to evaluate the same by recording of pattern reversal visual evoked potentials (PRVEPs). **Material and Methods:** The present study was conducted in 50 healthy subjects of either sex in the age group 18-40 years using MP for more than 5 years. PRVEPs were recorded before and after exposure to the MP (Samsung wave II GSM 900) on RMS EMG EP MK2 machine using 10-20 system of electrode placement. Duration of exposure was 10 minutes. Each eye was tested separately. Latencies and amplitude of waves were measured and data so obtained was subjected to statistical analysis. **Results:** Our study revealed longer latencies and smaller amplitude of all the VEP waves in both eyes following acute exposure to the MP. The changes were statistically significant. Inter-eye comparison revealed statistically insignificant difference in VEP parameters both before and after exposure. **Interpretation &Conclusion:** From the findings of our study, it can be reasonably concluded that even a single acute exposure to the EMW emitted from MP influences human visual system. Prolongation of latency especially of the wave P100 suggests delay in the conduction of impulses along visual pathways.

Key Words: Electromagnetic waves (EMW), mobile phone (MP), pattern reversal visual evoked potentials (PRVEPs).

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Introduction:

The Mobile Phone (MP) is a modern day invention which has become very commonly used throughout the world within a short period of time.The mobile phone industry has been one of the fastest growing industries in modern history[1].

They are now an essential part of business, commerce and communication. Mobile phones are low power radio devices that transmit and receive electromagnetic radiation through an antenna used close to the user's head[2].Concerns continue to be raised about potential adverse health impacts associated with their use.

The proximity of a mobile phone to the human eye raises the question as to whether the electromagnetic waves (EMW) emitted from mobile phone affect the visual system[3].Eyes having fewer blood vessels than other organs are more vulnerable to heat. Some statistical evidences have found that mobile phone may cause blurring of vision, inflammation in the eyes and lacrimation of the eyes[4]. There is no doubt today that microwave radiation via thermal effects may lead to cataract[5]. So, there is a strong rationale for determining the deleterious effects of EMW emitted from MP on the human visual system. Currently, very little information is available on theeffects of acute exposure to the EMW emitted from MP on the human visual system. Thus, the present study was conducted to evaluate the same by recording of pattern reversal visual evoked potentials (PRVEPs).

Material and Methods:

The present study was conducted in 50 healthy subjects of either sex in the age group 18-40 years in the department of Physiology, Pt. B.D. Sharma PGIMS, Rohtak. Subjects were recruited from staff members and healthy attendants accompanying the patients coming to the institute. Pattern Reversal Visual Evoked Potentials (PRVEPs) were recorded in MP users, using it for more than 5 years with daily usage of atleast 30 minutes. VEP results were compared before and after a short acute exposure to the EMW emitted from a MP.

Inclusion Criteria: Healthy subjects of either sex in the age group 18-40 years willing for the test.

Exclusion Criteria:

- Presence of any illness that could influence Visual evoked potentials(VEPs)
- Best corrected visual acuity worse than 6/60
- Extreme pupil sizes
- History of major illness like diabetes, hypertension

Written consent was taken from each subject and whole procedure was explained to them.PRVEPs were recorded in a condition of rest before exposure to the MP. Then subjects were exposed to EMW emitted from MP (mobile phone was of GSM type, SAMSUNG model WAVEII S8530) for a period of 10 minutes (average duration of a common phone call). During that time examiner read a fixed text from newspaper into another MP. PRVEPs were recorded again after the exposure to MP.

The recording was done using RMS EMG EP MK2 machine using the following settings:

Stimulation:

- Black and white checkerboard
- Contrast – 70%
- Full field size > 8^o
- Size of pattern – 8x8 min
- Rate of stimuli – 1.5Hz
- Mean luminance of the central field – 50cd/m^2
- Background luminance – 30cd/m^2

Recording conditions:

- Low filter - 2Hz
- High filter - 100Hz
- Sweep duration -300ms
- Number of epochs - 100
- Sweep speed - 50ms/division
- Sensitivity - 2microvolt/division

The volume conducted evoked responses were picked up from scalp by using disc type of Ag/AgCl electrodesplaced as per 10-20 international system of placement. An active electrode was placed on the scalp over the visual cortex (O_z) with ground electrode on the forehead (F_z). Two reference electrodes were attached to right and left mastoid designated as O1 and O2 respectively. All the electrodes were plugged to a junction box. Skin to electrode impedance was monitored and kept below 5Kohms[6].

Recommended montage for PRVEPs:

Channel 1: O_z-O1

Channel 2: O_z-O2

Ground Electrode: F_Z

Pretest instructions:

- Subject was explained all about the procedure and consent was taken.
- Hairspray or oil not to be applied on the scalp before the test.
- Avoid any miotic or mydriatic drugs 24 hrs before the test.
- The usual glasses if any, to be put on during the test

Procedure for recording of PRVEPs:

The subject was asked to sit on a table in relaxed position about 100 cm from the monitor. The visual stimuli consisting of black and white checks generated by a TV system reversing at the rate of 1.5 Hz was presented to one eye with other eye being covered. The subject was instructed to focus on a rectangle displayed at the centre of the screen. Total 100 stimulations were presented monocularly. The signals were picked up by the electrodes and filtered, amplified, averaged, displayed on the screen of RMS EMG EP MK2 and recorded.

The normal recording of PRVEPs consisted of 3 waves: N75, P100 and N145.Latencies of waves N75, P100 and N145 and amplitude of P100 from the preceding N75 peak was measured from the recordings.

Statistical Analysis:

The mean and standard deviation for latencies and amplitude of VEP waves was calculated. The data was analyzed statistically using student t-test and p-values were obtained. The statistical analysis was carried out using SPSS PC software version 13.0.

P value > 0.05 was considered as not significant.

P value < 0.05 was considered as significant.

P value < 0.01 was considered as highly significant.

P value < 0.001 was considered as very highly significant.

Result:

The present study was conducted in 50 healthy subjects of either sex in the age group 18-40 years in the department of Physiology, Pt. B.D. Sharma PGIMS, Rohtak. Pattern Reversal Visual Evoked

Potentials (PRVEPs) were recorded before and after an acute exposure to the EMW emitted from MP. The study group comprised of 35 (70%) males and 15 (30%) females healthy subjects. Demographic characteristics of the study group are as in table 1.

Table 1: Characteristics of the subjects included in the study

	Average Age (Yrs) (Mean ± SD)	Average Height (cm) (Mean ± SD)	Average Weight (Kg) (Mean ± SD)
Males	23.77 ± 6.29	168.77 ± 4.92	62.77 ± 7.36
Females	27.27 ± 8.46	155.06 ± 7.04	53.20 ± 8.60

Comparison of VEP in study group revealed longer latency and smaller amplitude of all the VEP waves in both the eyes following acute exposure to the MP. The change was statistically very highly significant ($p < 0.001$) for the latency of the waves P100 and N145 and statistically significant ($p < 0.05$) for the latency of the wave N75 and amplitude of P100-N75 (table2, table3).

Table 2: Comparison of Latency and Amplitude of VEP waves in Right Eye Before and After Exposure to MP

Parameters	Before Exposure (Mean ± SD)	After Exposure (Mean ± SD)	P value
N75 (ms)	68.31 ± 5.18	70.24 ± 6.61	**< 0.05**
P100 (ms)	102.03 ± 6.85	107.84 ± 9.10	**< 0.001**
N145 (ms)	149.95 ± 14.63	158.13 ± 15.95	**< 0.001**
P100-N75 (μV)	3.96 ± 2.15	3.58 ± 2.01	**< 0.05**

Table 3: Comparison of Latency and Amplitude of VEP waves in Left Eye Before and After Exposure to MP

Parameters	Before Exposure (Mean ± SD)	After Exposure (Mean ± SD)	P value
N75 (ms)	67.22 ± 5.67	70.04 ± 7.41	**< 0.05**
P100 (ms)	101.47 ± 6.72	107.75 ± 9.62	**< 0.001**
N145 (ms)	149.32 ± 13.11	155.31 ± 16.57	**< 0.001**
P100-N75 (μV)	4.15 ± 2.15	3.74 ± 2.03	**< 0.05**

Inter-eye comparison showed statistically insignificant difference in the latencies and amplitude of VEP waves in both eyes both before and after exposure (table4, table5).

Table 4: Inter-Eye comparison of Latency and Amplitude of VEP waves Before Exposure to MP

Parameters	Right Eye (Mean ± SD)	Left Eye (Mean ± SD)	P value
N75 (ms)	68.31 ± 5.18	67.22 ± 5.67	> 0.05
P100 (ms)	102.03 ± 6.85	101.47 ± 6.72	> 0.05
N145 (ms)	149.95 ± 14.63	149.32 ± 13.11	> 0.05
P100-N75 (μV)	3.96 ± 2.15	4.15 ± 2.15	> 0.05

Table 5: Inter-Eye comparison of Latency and Amplitude of VEP waves After Exposure to MP

Parameters	Right Eye (Mean ± SD)	Left Eye (Mean ± SD)	P value
N75 (ms)	70.24 ± 6.61	70.04 ± 7.41	> 0.05
P100 (ms)	107.84 ± 9.11	107.75 ± 9.62	> 0.05
N145 (ms)	158.13 ± 15.95	155.31 ± 16.56	> 0.05
P100-N75 (μV)	3.58 ± 2.01	3.74 ± 2.03	> 0.05

Discussion:

The 21st century is undoubtedly the era of mobile phone communications.They have become indispensable as communication tools[7].The tremendous use of MPs has drastically increased the amount of electromagnetic radiation (EMR) exposure in our daily lives. Therefore any consequent biological effects should be considered as a high-priority environmental health issue[8].Due to its natural sensitivity to radiation, eye has been the focus of many research programs. However, very few studies have been done to assess the effects of acute exposure to the EMW emitted from MP on visual evoked potentials (VEPs)[16,17].

Visual evoked response testing has been one of the most exciting clinical tools to be developed from neurophysiologic research in recent years and has provided us with an objective method of identifying abnormalities of visual pathways. VEPs offer reproducible and quantitative data on the function of visual pathways and visual cortex[9].Pattern reversal VEPs are less variable in waveform and timing than the VEPs elicited by other stimuli and is the preferred stimulus for most clinical purposes[10].Therefore, in our study PRVEPs were chosen.

In our study, it was found that latencies were prolonged and amplitude was decreased following acute exposure to the MP and the changes were statistically significant. The latency and shape of P100 depend upon the surviving fastest conducting fibres. The commonest cause of prolonged P100 latency is demyelination in the optic pathways[11]. It has been calculated that a demyelinating plaque of 10mm size would result in VEP delay of 25ms[12].Conditions leading to axonal loss such as ischemic optic neuropathy produce decreased amplitude. The amplitude of P100 has a wide inter-individual variability reducing its clinical utility[6].

There are animal studies reporting morphological changes in neural tissue following exposure to EMR. Baranski et al reported edema and heat lesions in the brain of guinea pigs exposed in a single 3-h session to 3000-MHz radiofrequency radiation (RFR) at a power density of 25 mW/cm^2 (SAR 3.75 W/kg)[13].Switzer and Mitchell also reported an increase in myelin degeneration of neurons in the brain of rats at 6 weeks after repeated (5 h/day, 5 day/week for 22 weeks) exposure to continuous wave 2450-MHz RFR (SAR 2.3 W/kg)[14].

The above mentioned studies could indirectly explain the observations obtained in our study; however, these studies employed a prolonged exposure to RFR of high intensity in animals in contrast to 10 minute exposure to RFR of low intensity in humans in our study.

Henry Lai investigated the neurochemical effects of RFR including those on concentrations and functions of neurotransmitters, receptor properties, energy metabolism and calcium efflux from brain tissues. These neurochemical effects could lead to alterations in neural functions[15].

There are few human studies directly evaluating the acute effects of EMR on visual evoked potentials. Urban et al performed a pilot study to observe the influence of single acute exposure to the EMR emitted by MP on VEP. Duration of exposure was 5 minutes. No statistically significant influence of above described exposure on latencies and amplitude of VEP was observed[16].Hladky et al also reported that cell phone use did not affect VEP[17]. In contrast to above mentioned studies, a statistically significant effect on latencies and amplitude of VEP waves was observed following single acute exposure in our study. This might be because of larger sample size (50 subjects) and greater duration of exposure (10 minutes). However the same results need to be obtained in a follow-up study before arriving on any definite conclusion.

Findings of the inter-eye comparison in our study were consistent with the fact that only those subjects whose visual acuity were comparable between two eyes and were more than 6/60 were included in the study.

Conclusion:

From the observations it can be concluded that even a single acute exposure to the EMR emitted from MP influences human visual system. Prolongation of latency especially of the wave P100 suggests delay in the conduction of impulses along visual pathways. The underlying mechanism responsible for these findings could not be defined due to paucity of data in the literature exploring the acute effects of EMR on VEPs. So, it is advised that further research be done to conclusively

establish the findings of this study and also to develop an underlying mechanism explaining these findings.

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