Effect of Exposure of Smartphone Use on Visually Evoked Potential (VEP) in Healthy Adults

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Abstract

Aims: To assess and compare VEP parameter (amplitude and latency of P100) in healthy adults (MBBS students) using smartphone.

Objectives:

- To record P100 (latency, amplitude) in 1st year MBBS students using smartphone for less than three hours and for more than three hours after sunset
- To record P100 (latency, amplitude) MBBS students using smartphone for duration of less than three years and for more than three years
- To Compare P100 (latency, amplitude) 1st year MBBS students using smartphone for less than three hours and for more than three hours after sunset
- To Compare P100 (latency, amplitude) MBBS students using smartphone for duration of less than three years and for more than three years

Settings and Design: Neurophysiology Lab at the department of Physiology, JNMC, Sawangi (Meghe), Wardha.

Method and Material: A cross sectional study was done in 50 healthy MBBS studentsfrom JNMC.

Results: There is significant difference in the mean values of P100 latencies of right and left eye and in the mean values of P100 amplitude of right and left eye in individuals with exposure of less than three and more than three hours per day after sunset.

Conclusions: We conclude that nocturnal use of mobile phones especially in the bright light exposes an individual to the blue light resulting in various deleterious effects.

Keywords: *Nocturnal smartphone use, VEP (visually evoked potential), Latency.*

Introduction

Use of mobile phone as a token of electronic century and digital world has risen to a very high scale in humans and, especially nowadays, has become an integral part of the young generation. The technology has transformed mobile phones extensively since its inception as analogue phones and later being replaced, over the years, by digital ones, more precisely, the smartphones. Smartphone has voided the tools like calculator, mp3 player, Microsoft office, dextop browsers, book readers etc., and has taken over their places. Thus using smartphone has indirectly become the essential commodity.

The operating power of analogue phones is higher than digital phones, emitting more electromagnetic radiation (EMR). Operating frequencies of mobile phone are 450- 900MHz (analogue systems), 1800-1900MHz (digital systems) and 1900-2200MHz (Universal Mobile Telecommunications System).(1) Peak power output of mobile phone antenna ranges from 8-15 W (450 MHz), 2W (900 MHz) and 1W (1800 MHz).[2] The "Specific Absorption Rate" (SAR) is the rate at which energy is absorbed by the human body. In the USA and India, the maximum level of SAR for smartphones set by governmental regulating agencies is 1.6W/Kg, averaged over a volume of 1g of tissue.[3,4]

Younger generation has become habitual to the smartphone and the usage starts from the morning till the person goes to sleep. Thus the smartphone is used almost continuously throughout the day and also after the sunset. During the use of smartphone, especially in the dark condition than the illuminated environment, electromagnetic radiations from antenna during a phone call and electromagnetic waves and bright light (especially the blue light) from the screen of smartphone during browsing causes more photo-mechanical damage, photo-thermal damage, and photo-chemical damage[5,6] make eyes more vulnerable to adverse effects because of their anatomy and composition (they are having a few blood vessels).[7,8] Blue light is an important factor emitted from smartphone and is known to generate poisonous molecules in the light sensitive cells of the eye and leads to macular degeneration and age related changes.[9] So it becomes a need of time to determining the deleterious effects of electromagnetic radiations generated from smartphone on the human visual system.

P100 latency prolongation appears to be the most reliable indicator of clinically significant abnormality, being least affected by technical factors and degree of patient co-operation. It appears to be generated by the pyramidal cells in layer IV of area 17.[10] Imaging studies point to the source of the early phase of the P100 peak as being in dorsal extrastriate cortex of the middle occipital gyrus, whereas the late phase of P100 appears to be generated by the ventral extrastriate cortex of the fusiform gyrus.[11] These results suggest the cortical generation of VEP waveforms. Thus VEP is useful in detecting the site of lesion when the conduction disturbance is in the anterior visual pathway.

The present study was planned to assess the effect of duration of usage of MP on human visual system by recording of pattern reversal visual evoked potentials (PRVEP).

Aim: To assess and compare VEP parameter (amplitude and latency of P100) in healthy adults (MBBS students) using smartphone.

Objectives:

1. To record P100 (latency, amplitude) in 1st year MBBS students using smartphone for **less than three hours and** for **more than three hours** after sunset
2. To record P100 (latency, amplitude) MBBS students using smartphone **for duration of less than three years and for more than three years**
3. To Compare P100 (latency, amplitude) 1st year MBBS students using smartphone for **less than three hours and** for **more than three hours** after sunset
4. To Compare P100 (latency, amplitude) MBBS students using smartphone **for duration of less than three years and for more than three years**

Materials and Method

Study Set-up: The present study was undertaken in the Neurophysiology Lab at the department of Physiology, JNMC, Sawangi (Meghe), Wardha.

Study Design: It was a cross sectional study, in which effect of exposure of smartphone was assessed in MBBS students using visually evoked potential (VEP).

Sample Size: A total of 50 subjects were studied.

Study Protocol: The subjects were selected by random method of sampling and studied after obtaining the approval from institutional ethics committee to carry out the research work at Jawaharlal Nehru Medical College (JNMC) and Acharya Vinoba Bhave Rural Hospital (AVBRH), Sawangi (Meghe), Wardha. The study group consisted of MBBS students from JNMC. Every Subject included in the study was examined in details after taking a detailed clinical history and brief general examination.

Inclusion Criteria:

- Apparently healthy MBBS students including Males and females.
- Age group between 18-23 years.
- Subjects with normal visual acuity or corrected by the glasses.

Exclusion Criteria:

- Presence of any illness that could influence visual evoked potentials.

- Best corrected visual acuity worse than 6/60.
- Extreme pupil sizes.
- History of major illness like diabetes, hypertension, etc.
- Any evidence of diabetic retinopathy, optic atrophy, glaucoma, etc.
- Alcoholics, smokers, tobacco users or with any other addictions.

Subjects were grouped in four categories based on duration of exposure of smartphone as

Group IA: Duration of exposure of smartphone less than three hours after sunset

Group IB: Duration of exposure of smartphone more than three hours after sunset

Group IIA: Duration of exposure of smartphone less than three years

Group IIB: Duration of exposure of smartphone more than three years

All the subjects selected for study were subjected to a detailed history taking by means of planned questionnaires including special enquiries regarding complaints of dimness of vision, tingling, paresthesia, addiction to alcohol, smoking, tobacco chewing. All the subjects underwent brief ocular examinations like general examination of eyes, recording of visual acuity and ocular tension. Subjects underwent careful systematic neurological examination for the evidence of peripheral neuropathy. Motor power and reflexes were checked for motor neuropathy. Previous reports, if any, for any ailment were assessed.

For the best results of VEP testing, subjects were explained about the test in a language he/she can understand to ensure the full co-operation. The usual glasses were, if any, were asked to put on during the test. The results of ocular examination were reviewed before starting the test. Subjects were advised to come without applying oil to the scalp. Preparation of the scalp skin was done with 'Nuprep® skin prep gel' before the study. The subjects were instructed to avoid any meiotic or mydriatic drug, if any, 12 hours before the test.

Running the Test: VEP was performed on Neuro-**MEP-4 : 4-channel NCS, EMG and Multi-modality EP system Neurosoft** machine.

Stimulus parameter (Pattern Reversal Stimulus):

- **Type and method of generation** – Computer generated patterns on a video monitor.
- **Type of pattern** – Black and white checkerboard pattern
- **Size of pattern element** – 32 minutes
- **Size of stimulus field** – 20 degrees
- **Stimulus type** – Full field stimulation with fixation point in the centre and pattern extending to both the sides equally.
- **Mode of pattern presentation** – Mode of stimulus presentation was pattern reversal in which dark and light pattern elements were alternately reversed
- **Stimulus rate** – 1.71 Hz (cycles per second)
- **Mono-ocular versus Binocular stimulation** – Mono-ocular stimulation was performed with each eye tested separately
- **Distance between the subject and the screen** – 100cms

Recording Parameters:

System Bandpass – 2-200 Hz

Analysis Time – 250 ms

Amplifications- 20,000-1,00,000

Recording Electrodes – Standard disc surface electrodes

Electrode placement – International 10-20 system placement with Active electrode (Oz), Reference electrode (Fz) and Ground electrode (Fpz)

Number of Epochs – 100

Replications – Two responses were recorded and superimposed for the reproducibility of the waveform. The replicated response measurements with P100 latency, within a 2.5 ms difference and peak-to-peak amplitude of N75-P100 or P100-N145, within 15% difference were accepted. (12, 13)

Methodology

The subject was explained about the procedure. After the preparation of scalp skin by abrading and degreasing properly, the electrodes were placed at O, Fz, and Fpz sites using the 'Nuprep® skin prep gel' as per 10-20 international system. Uniform illumination was maintained for every subject studied. Distance between the TV screen and the subjects eye was kept constant at 100 cms. Subject was instructed to fix his gaze at the central spot on the TV screen. Mono-ocular stimulation was done and each eye tested separately with an eye-patch covering the other eye. With the preset stimulus and recording conditions as mentioned above and keeping the electrode impedance <5 KΩ, the recording procedure was started. Two responses from each eye were recorded and superimposed to ensure the reproducibility.

Statistical Analysis: All the data was expressed as mean ± S.D. The significance of difference between groups was calculated by Fisher's Exact Test of analysis on SPSS software version 24.

Observations and Results

Table 1. Comparison of Latency and amplitude in individuals with exposure of smartphone for less than three and more than three hours per day after sunset

Parameters	Duration of exposure in Hours per day		Significance
	<3Hrs/day Exposure	>3Hrs/day Exposure	
P100 Latency (Right Eye)	98.41	109.56	0.000
P100 Latency (Left Eye)	98.72	110.12	0.000
P100 Amplitude (Right Eye)	7.96	4.56	0.004
P100 Amplitude (Left Eye)	7.96	4.13	0.000

Table 2. Comparison of Latency and amplitude in individuals with exposure of smartphone for less than three and more than three years.

Parameters	Duration of exposure in years		Significance
Duration of exposure	<3Years of Exposure	>3 Years of Exposure	
P100 Latency (Right Eye)	103.41	104.24	0.696
P100 Latency (Left Eye)	103.86	104.72	1.000
P100 Amplitude (Right Eye)	6.67	6.00	0.741
P100 Amplitude (Left Eye)	6.48	5.72	1.000

Table 3. Inter-ocular differences in Latency and amplitude

Parameters / Duration of exposure	P100 Latency (Right Eye)	P100 Latency (Left Eye)	P100 Amplitude (Right Eye)	P100 Amplitude (Left Eye)
<3Hrs/day Exposure	98.41	98.72	7.96	7.96
>3Hrs/day Exposure	109.56	110.12	4.56	4.13
<3Years of Exposure	103.41	103.86	6.67	6.48
>3 Years of Exposure	104.24	104.72	6.00	5.71

From the results, it is obvious that there is significant difference not only in the mean values of P100 latencies of right and left eye as well as in the mean values of P100 amplitude of right and left eye in individuals with exposure of less than three and more than three hours per day after sunset. Our study is consistent with the findings of a study done to assess the effect of exposure of smartphone for less than three per day after sunset.[14-18] But our study couldn't find any significance in comparing the mean values of P100 latencies of right and left eye as well as in the mean values of P100 amplitude of right and left eye in individuals with exposure of less than three and more than three years of exposure.

Also we could find the inter-ocular differences in the values P100 latencies and P100 amplitude and the findings are consistent with many studies. [19-23]

Discussion

VEP stands to be an important procedure for assessing visual function. Though VEP can detect abnormality along the visual pathway ranging from the eye, retina, the optic nerve, optic radiations, upto the occipital cortex,[24] it appears to be highly sensitive to lesions of the optic nerve and anterior chiasm[25] *i.e.* to optic neuropathies (26), demyelination[27], multiple sclerosis [28, 29]. The activation of visual cortex primarily occurs by the central visual field.

The latency of VEP components is indicative of extrastriate source of defects rather than primary visual pathways. For instance, difficulties in motion detection, or "optic flow", seem to be especially prominent and may be explained by parallel defects in primary magnocellular stream and extrastriate visual processing. [30-31] The commonest cause of prolonged P100 latency is demyelination in the optic pathways.[32] A power density dependent decrease in latency of some of the late components of thalamic evoked potentials by affecting multisynaptic neural pathways. The amplitude of P100 has a wide inter-individual variability reducing its clinical utility.Conditions leading to axonal loss such as ischemic optic neuropathy produce decreased amplitude.

The inter-ocular asymmetry can be attributed to small differences in visual acuity, dominance of eye, changes in the alertness, and eye movement during the recording. These differences are usually small. Intraocular amplitude and peak latency analysis increases the sensitivity of the VEP to monocular diseases since each subject serves as his own control and may reveal abnormality.[19,20] The disparities between the dominant and the non-dominant eyes seem to be the presence of lateralization in the Central Nervous System [21] and neuro-anatomic asymmetries of the human striate cortex. [22] Proximity of the right eye to the cell phone and feeling greater heat and more radiation power also has been found to be the reason for inter ocular asymmetry.[23] (Table no. 3).

That blue light has a greater tendency to affect living organisms by disrupting biological processes that rely on natural cycles of day and night Therefore, light rich in short-wavelength (blue) light should be avoided in the late evening to promote a healthy night-time lighting environment. Apoptosis plays a major role in retinal visual cell loss.[38-44] The caspase-dependent as well as caspase-independent pathways, over stimulation of Poly [ADP-ribose] polymerase 1 (PARP-1) through oxidant-induced DNA damage, cleavage of PARP-1 inhibiting the enzyme responding to DNA damage along with Retinal endo-illuminator toxicity can induce apoptotic cell death.

Conclusion

Thus we conclude that nocturnal use of mobile phones especially for more than three hours per day for more than three years at least and especially in the bright light exposes an individual to the short wavelength light (blue light) resulting in various deleterious effects. Hence, combating the unhealthy effect of blue light from smartphone displays at night does not simply mean turning off the smartphone, but rather using well designed surge protection devices (SPDs), using smartphone at the proper distance, optimally adjusting the brightness setting in a dark room and the proper intensity of smartphone displays to see better where and when required while protecting people's health and circadian rhythm. Similarly if the blue light in smartphone displays in the night, if controlled finely, can have a greater impact on reducing the unhealthy effect like disturbed circadian rhythm due to decreased melatonin secretion. As this is a pilot study and sample size is small, further research in this regards is necessary.

Ethical Clearance: Taken from institutional ethics committee.

Source of Funding: Self.

Conflict of Interest: Nil.

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