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Effects of electromagnetic waves emitted from mobile phone on auditory evoked potential in school children.

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Abstract

Electromagnetic radiations are emitted from mobile phone. Part of these radiations is absorbed by recipients' body which is in close proximity to the mobile phone. It has been hypothesized that children absorbs more radiation. This is attributed to their thinner skull and small head size. It might have some debilitating effect in children. Hence, purpose of our study was to assess hearing ability of children, age group ranging from 6- 12 years, before and after 10 min exposure to mobile phone which receives and transmits radiation of 1900 MHz and 850 MHz frequencies respectively. Consented by parents, 30 healthy children having normal hearing level (below 25 dB) were recruited for the study. Auditory brainstem response (ABR) of each child was recorded before and after 10 min exposure to mobile phone. ABR was recorded giving rarefaction, condensation and alternate (rarefaction-condensation) click stimulus for consecutive 3 days, restricting to one stimulus a day. Statistically significant increase in latency of wave III and Interpeak latency (III-V) was recorded with alternate click stimulus, showing some effects on hearing ability of children. However, no measurable changes were observed with rarefaction and condensation click stimulus. Further study is suggested to explore the mechanism of latency change due to alternate click stimulus, and whether it is within physiological range or beyond.

Keywords: Auditory Brainstem Response, Electromagnetic radiation, children.

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Introduction

Mobile phones are the integral part of modern telecommunications. It has been estimated that more than 4 billion person around world uses mobile phone [1]. It receives and emits electromagnetic radiation. The radiations emitted are absorbed by the body tissue and converted into heat. Thus, widespread use of mobile telephones has given rise to concern about the potential influences of radiation on human health. Many studies were done to see possible effects of electromagnetic radiation in electroencephalogram, auditory brainstem response and various other aspects of the health.

As stated, part of radiation emitted by mobile phone handset is absorbed by human head. Hypothetically, these areas would be of a higher risk for tumors in subjects that use mobile phones regularly. The rate at which radiation is absorbed by the human body is measured by the specific absorption rate (SAR). The SAR is expressed in power (watts) by tissue mass (Kg). The SAR is determined by the highest certified power level in laboratory condition. Guidelines were developed by the independent scientific organizations that include safety margins designed to assure the protection of all persons, regardless of age and health. One of the organizations, International commission on Non Ionizing Radiation Protection (ICNIRP) stated SAR limit 2.0 watts/ Kg (W/Kg) averaged over ten gram of tissue. SAR of different mobile phones varies depending on the models.

Many studies done to evaluate the effect of electromagnetic radiation emitted from mobile phone on hearing of adult revealed no effects [2, 3]. However, due to smaller head size and thinner skull, children are hypothesized to absorb more energy [4]. This increases the vulnerability of children towards its possible effect on hearing or cognitive function.

Material and Methods

Subjects and sample size

Thirty healthy consented children were allowed to participate in the study. Of the thirty, twenty two were male and eight were female and their age group ranging between 6-12 years. Female volunteers who had not attained menarche were only enrolled in the study. Prior consent of parents, children and school authority was taken. Also, ethical clearance for the study was obtained from the Ethical Committee of Institute.

Auditory brainstem response recording

Auditory brainstem response was recorded using Nihon Kohden machine (NM-40205; H636, Japan made). Three electrodes were used for recording ABR of right ear of children. By using electrode paste or conducting jelly, recording electrode was placed on mastoid region of right ear and reference electrode was placed over the vertex (Cz of the international 10 -20 system). The ground electrode was placed on the forehead over nasion. ABR was recorded at intensity of 80 dB with stimulus rate being 30 Hz. It was averaged over 2000 stimulus clicks.

Before recording ABR, hearing threshold level of all children were examined by clinical audiometer, Madson Electronics (Orbitor 922, version-2). Subjects having hearing threshold not more than 25 dB were enrolled in the study.

Exposure Setup

Electromagnetic radiation was administered in right ear of children by using mobile model Nokia 2600, type-RH-59 for 10 min without removing setup for recording ABR. This mobile receives and emits radiation at frequency of 1900 MHz and 850 MHz respectively. SAR value for this model is 0.80 W/Kg body weight, according to standard guideline [5]. During exposure to radiation, children were instructed to avoid unnecessary movements. Mobile phone was mounted on headset in normal use position to right ear. The headset was made of plastic material. During exposure children were not allowed to converse with anyone. Immediately after 10 min exposure ABR was recorded.

Data collection and Data analysis

Peak ABR latencies (I, II, III, IV and V) were measured and interpeak intervals (I-III, III-V and I-V) were calculated digitally. For the measurement of peak of ABR latencies, the cursor was placed at each peak of ABR waves I, II, III, IV and V and the duration of latencies was displayed on the monitor (Fig. 1). Then, interpeak intervals I-III, III- V and I-V were obtained by subtracting interval III from interval I, interval III from interval V and interval V from interval I, respectively .The data analysis was done using SPSS software version 10.0. ABR waves and interpeak latencies before and after exposure were compared using student paired t-test. Probability value less than 0.05 was considered as statistically significant.

Result

ABR waves and interpeak latencies compared with before and after 10 min exposure to mobile phone with rarefaction clicks stimulus (Table 1) does not demonstrate any significant changes in the variables related to wave latencies or interpeak latencies.

Similar observations about ABR waves and interpeak latencies were found with no significant changes in the variables related to wave latencies or interpeak latencies when compared with before and after 10 min exposure to mobile phone with condensation clicks stimulus (Table 2).

However, after the children were exposed to mobile phone with alternate click stimulus for 10 min, the ABR waves and interpeak latencies when compared before and immediately after 10 min of exposure to mobile phone (Table 3), significant increase were observed in the latency of the following: wave III (before exposure, 3.74±0.20; after exposure, 3.83±0.25, $p<0.05$) and inter-

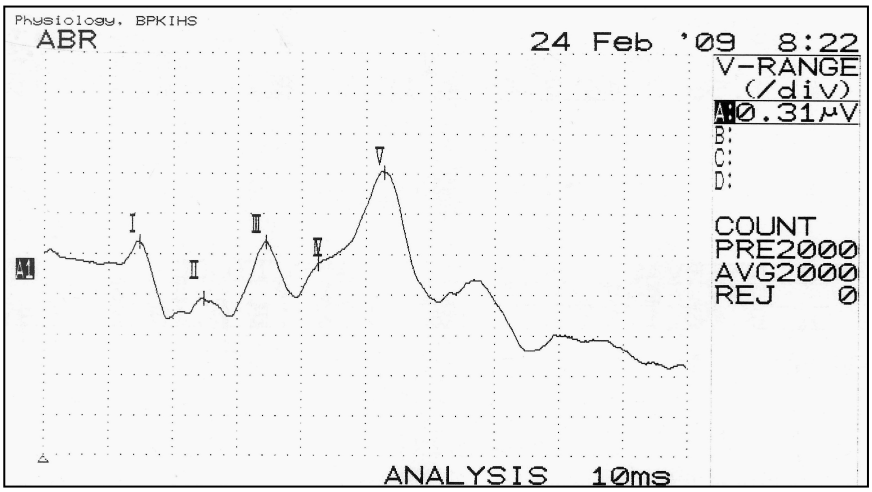

Figure1. *Auditory brainstem response (ABR) of right ear*

Table 1. *ABR waves and interpeak latencies before and after 10 min mobile phone exposure with rarefaction click stimulus (ms : millisecond)*

Variables	**ABR waves and interpeak latencies, ms (n=30)**		**p value**
	Before exposure (mean±SD)	**After exposure (mean±SD)**	
Wave latency I	1.57 ± 0.13	1.57 ± 0.15	0.70
Wave latency II	2.5 ± 0.22	2.55 ± 0.22	0.79
Wave latency III	3.79 ± 0.26	3.77 ± 0.24	0.70
Wave latency IV	4.80 ± 0.30	4.89 ± 0.36	0.06
Wave latency V	5.58 ± 0.29	5.61 ± 0.27	0.24
Interpeak latency I-III	2.21 ± 0.61	2.20 ± 0.21	0.80
Interpeak latency III-V	1.78 ± 0.28	1.84 ± 0.12	0.22
Interpeak latency I-V	4.00 ± 0.26	4.04 ± 0.25	0.24

No significant changes in ABR wave latency variable in I, II, III, IV, V. and interpeak latency between I-III, III-V,I-V were observed while comparing before and after 10 min mobile phone exposure to children with rarefaction click stimulus, .

Table 2. *ABR waves and interpeak latencies before and after 10 min mobile phone exposure with condensation click stimulus*

Variables	**ABR waves and interpeak latencies, ms (n=30)**		**p value**
	Before exposure (mean±SD)	**After exposure (mean±SD)**	
Wave latency I	1.62 ± 0.13	1.61 ± 0.15	0.65
Wave latency II	2.54 ± 0.24	2.57 ± 0.24	0.16
Wave latency III	3.70 ± 0.24	3.79 ± 0.2	0.46
Wave latency IV	4.86 ± 0.42	4.96 ± 0.34	0.12
Wave latency V	5.61 ± 0.22	5.63 ± 0.21	0.41
Interpeak latency I-III	2.08 ± 0.22	2.18 ± 0.22	0.08
Interpeak latency III-V	1.91 ± 0.27	1.84 ± 0.16	0.22
Interpeak latency I-V	3.99 ± 0.23	4.02 ± 0.24	0.25

No significant changes were observed with condensation click stimulus in the ABR wave latency variable in I, II, III, IV, V and interpeak latency between I-III, III-V, I-V before and after 10 min exposure to mobile phone.

Table 3*. ABR waves and interpeak latencies before and after 10 min mobile phone exposure with alternate click stimulus*

Variables	**ABR waves and interpeak latencies, ms (n=30)**		**p value**
	Before exposure (mean±SD)	**After exposure (mean±SD)**	
Wave latency I	1.62 ± 0.18	1.6 ± 0.14	0.53
Wave latency II	2.63 ± 0.21	2.58 ± 0.23	0.34
Wave latency III	3.74 ± 0.20	3.83 ± 0.25	0.02*
Wave latency IV	4.89 ± 0.30	4.91 ± 0.35	0.67
Wave latency V	5.60 ± 0.20	5.65 ± 0.28	0.13
Interpeak latency I-III	2.13 ± 0.18	2.23 ± 0.26	0.04*
Interpeak latency III-V	1.85 ± 0.21	1.81 ± 0.03	0.30
Interpeak latency I-V	3.98 ± 0.21	4.05 ± 0.14	0.14

** Statistically significant value (p<0.05)*

Significant increase in the latency of ABR wave III (p=0.02) and in interpeak latency I-III (p=0.04) after exposure of mobile phone to children with alternate click stimulus. Whereas, there were no significant differences in other wave latencies variable in I, II, IV, V and interpeak latencies III-V, I-V.

Discussion

Use of mobile phones by children are increasing with rapidity as parents feel secure by giving mobile phones to children as they perceive that children can communicate at times of emergency and needs to seek early help from parents. Detrimental effects of continuous exposure to radiation are more likely to be seen in children as they are in the various developmental stages of life, due to their thinner skull and small head size and also in exerting less judgmental sense of discretion over usage of mobile phone for a prolonged period.

Of all the anatomical structure, brain is in close proximity to mobile phone. Early consumer had complaints of health problems like fatigue, headache, dizziness, tension and sleep disturbances [6, 7, 8]. Absorption of radiation by brain is reported to have influence on wellbeing, cognitive function, various response times and also hypothesized as causal factor of tumors like acoustic brain tumor [9, 10]. Several studies regarding changes in electroencephalogram (EEG) waves were endorsed. During and after exposure, when compared with prior to electromagnetic radiation, diverse results were revealed. This diversity ranged from decrease in alpha activity[11] or increase in alpha activity post exposure[12] and during exposure[13] to no any significant changes on EEG, after exposure[14,15].

Like brain, auditory apparatus is also not resistant from exposure to radiation. Thus our study was conducted to assess effects of radiation on auditory pathway of children, before and after exposure to mobile phone. In our study we recruited children between 6-12 years of age. This study was done only in right ear, assuming that there is no left and right latency difference on ABR [16].

For exposure, as aforementioned we used mobile model Nokia 2600, type-RH-59 since it is widely used and popular in this part of the world as it is cheap in terms of value for money and long lasting reliability. Mobile with higher SAR limit is not popular and these mobiles are available sporadically worldwide. Activated mobile phone (which transmits electromagnetic radiation) was mounted on right ear in normal use position. Mobile phone was held in normal use position with the help of plastic headset. This ensured exposure to ear only and not the hand. The plastic headset also avoided the possible increase in specific absorption rate of radiation by use of metallic substances [17, 18, 19]. Conversation avoidance prevented the possibilities of negative acoustic effects on outer hair cells and hence in auditory pathway.

In our study, there was no significant effect of 10 min electromagnetic radiation exposure for rarefaction and condensation click stimuli on the latencies of wave I, II, III, IV and V and the interpeak latencies I-III, III-V and I-V. This result confirms result of earlier investigation done in adults demonstrating, 10 min of GSM mobile phone exposure does not induce measureable changes in ABR [2]. Negative result in our study might be possibly due to shorter exposure of only 10 minute or could be attributed to less absorption of radiation by cochlea, as they are shielded by very compact bone [3].

Unlike, insignificant results with rarefaction and condensation clicks, there was significant increase in latency of wave III and interpeak latencies I-III with alternate click stimulus. Wave III represents electrical activity of superior olivary nucleus and the interval represents electrical activity from cochlear nerve to superior olivary nucleus [20].

Effects of electromagnetic radiation on hearing using alternate click stimulus showed increase in wave and interval latencies. This result raises the questions whether alternate click is more sensitive than rarefaction and condensation click stimulus.

Scientific research articles concerning sensitivity of different click stimuli have revealed diverse results. Some have reported rarefaction better than other [21], while others have revealed condensation better than other [22]. Likewise, some articles have also reported that there is no difference in different click stimulus and neither provides advantages over other for the diagnostic purpose [23, 24]. However, according to our result, we can conclude that alternate click is better than rarefaction and condensation click.

Regarding the biological effects of electromagnetic radiation, exact mechanism of changes in ABR is still unknown. Though increase in latency with alternate click suggests us to become vigilant about its effect on hearing of children, it is still unknown that whether or not the perturbation observed can be directly related to negative effect. To rule out this, study with large sample size exploring the mechanism of increase in latency is recommended.

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