Effect of Duration of Exposure to Personal Listening Devices on Hearing Thresholds in Young Adults

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Abstract To analyze the effect of duration of use of personal listening devices on hearing impairment in young adults. Hospital-based cross-sectional study. Department of ENT, NEIGRIHMS, India. 50 consenting undergraduate medical students. This study was conducted over a period of 2 months. After eliminating all previous and current otological pathologies, Pure Tone Audiometry was conducted on each subject for both air and bone conducted sound stimuli. The subjects were divided into different groups based on duration of exposure. The audiograms were then closely evaluated for the existence of an association between the duration of personal listening devices (PLD) use and hearing impairment. The data was then evaluated by Chi Square test and Mann–Whitney U test using GraphPad InStat 3 software for the existence of an association between the duration of PLD usage and hearing impairment. The hearing thresholds varied only in isolated frequencies irrespective of the categorisation of duration of exposure to PLDs. There was no significant association between duration of use of personal listening devices and hearing impairment in young adults.

Keywords Mobile phone · Personal listening device · Pure tone audiometry · Sensorineural hearing loss · Deafness

Introduction

In this era of superfast communication and high tech gadgets, the mobile phone has become a quintessential part of our lives. Today's youth is engrossed in their cell phones more than ever before. The use of personal listening devices (PLDs) like mp3 players and iPods is on a dramatic rise as well. With the prices falling and the need to stay connected becoming more and more important for the present generation, cell phones have in fact become a way of life now. As a matter of fact, the minimum age of mobile phone users has drastically fallen in recent times, with even school goers being exposed to such devices. Studies have revealed negative impacts on social and psychological health, among others [1].

According to the Highlights on Telecom Subscription Data, Telecom Regulatory Authority of India (TRAI) states that India has the fastest growing telecommunication network in the world with an estimated number of mobile phone users at 930.20 million as of September 2014 [2]. Earlier studies have reported an association between mobile phone use and otological complaints [3, 4]. A WHO report also includes PLDs among the causes of hearing impairment on account of unsafe volumes at which these might be used [5].

Children as young as 7 years have reported hearing loss on account of mobile phone use [6]. Hearing loss has also been associated with mobile phone use in adults [7, 8]. However, there are also other studies that state that exposure to mobile phones has no immediate or long term effect on hearing threshold or inner ear and brainstem functions [9–11].

Since mobile phones and PLDs have become an essential part of our lives, it is now a matter of widespread concern about the possible risks this may pose to public

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health. There are two possible ways that prolonged mobile phone use may affect health- the emission of electromagnetic radiation causing thermal effects, mainly in the form of heating due to holding the device close to the ears, or because of constant noise due to prolonged use of the device. Based on these thermal and non thermal effects, Meo et al. concluded from a study on the Saudi population a possible association between mobile phone use and otological complaints, of which 34.59% were related with otological complaints including hearing loss [4].

These studies have tried to find an association between hearing loss and long term use of PLDs. The effect of duration of exposure is not as well documented, though some studies have reported variable results [6, 12, 13]. Hence, this study makes an attempt to analyse the association between the duration of use of PLDs and hearing loss in young adults and analyse the effect of variable duration of use of mobile phones and PLDs.

Methods

This study was carried out in the Department of ENT, North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences, Shillong, India from June 2015 to July 2015, after acquiring clearance from the Institutional Ethics Committee (Letter no NEIGR/IEC2013/101).

The participants were undergraduate medical students of NEIGRIHMS, and consequently were between 18 and 25 years of age. Individuals outside this age range were excluded from the study to eliminate the confounding effect of age. After obtaining informed consent, willing participants were asked to fill up a proforma to analyse their eligibility for the study. Individuals with previous history of external or middle ear disorder or those with previous history of acute acoustic trauma were excluded from the study. They were then examined to rule out any other otological pathology. The participants were then selected randomly out of the individuals fulfilling the inclusion criteria. Following this, Pure Tone Audiometry was conducted by an audiologist on each of these 50 subjects which involved transmitting pure tones of frequencies ranging from 250 to 8000 Hz into the subject's ears, one side at a time. The hearing status of participants for each ear was measured for both air (250–8000 Hz) and bone (250–4000 Hz) conducted sound stimuli. A clinical audiometer (Amplivox Diagnostic Audiometer 270, Amplivox Ltd. United Kingdom) was used to obtain standard audiograms for all subjects. High quality earphones (Telephonics TDH-49P, Telephonics, New York, USA) and bone transducer (B71, Radioear, MN, USA) were used for auditory stimulus delivery.

The audiograms were then closely evaluated by using GraphPad InStat 3 (GraphPad Software, Inc. California, USA) software for the existence of a probable association between the duration of PLD usage and hearing impairment.

During data analysis the subjects were divided into three groups based on hours of exposure per day:

Group labelling	Hours of use (h/day)
1	≤ 1
2	1–3
3	> 3

Based on years of exposure to PLDs, the subjects were categorised as:

Group labelling	Years of use (years)
X	< 5
Y	≥ 5

Based on a combination of number of hours of use per day and number of years of use, the subjects were categorised as:

Group labelling	Hours of use per day	Years of use (years)
A	≤ 1	< 5
B	≥ 3	≥ 5

Results

Out of 70 willing participants, 50 subjects (100 ears) were included in the study, out of which 23 (46 ears) were male and 27 (54 ears) were female with a mean age of 21.36 ± 1.10 years. None of the subjects showed conductive hearing loss on PTA. Hence no subject was eliminated at this stage.

With rising daily exposure, the hearing thresholds increased somewhat significantly at 2000 and 4000 kHz only (Table 1). However, the hearing thresholds were highest only in Group 2.

Table 1 Air conduction thresholds based on number of hours of exposure to PLDs per day (One Way ANOVA)

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Group 1 (n = 32) (≤ 1 h/day)	16.40 $\pm$ 5.98	14.22 $\pm$ 4.93	13.43 $\pm$ 4.65	9.84 $\pm$ 4.30	10.78 $\pm$ 4.77	10.15 $\pm$ 5.88
Group 2 (n = 50) (1–3 h/day)	17.8 $\pm$ 5.45	16.7 $\pm$ 5.40	14.4 $\pm$ 4.59	11.5 $\pm$ 3.94	11.7 $\pm$ 4.91	13.46 $\pm$ 9.69
Group 3 (n = 18) (> 3 h/day)	15.55 $\pm$ 5.11	15.55 $\pm$ 5.65	14.44 $\pm$ 4.81	9.16 $\pm$ 3.53	8.61 $\pm$ 4.47	10.83 $\pm$ 9.59
<i>P</i> value	0.27	0.12	0.62	0.05	0.07	0.21

On the basis of years of exposure, the thresholds varied significantly only at one frequency, that of 2000 kHz. The hearing threshold was lower in Group Y than in Group X (Table 2). In assessing the effect of duration of exposure to PLDs on the basis of number of years as well as number of hours per day, although the mean auditory thresholds for both ears were found to be higher in group B as compared to group A, on carrying out Mann–Whitney Test, the difference was found to be significant at 500 Hz only ($P = 0.049$) (Table 3).

Discussion

In the current study, the variation of mean auditory thresholds with exposure to PLDs was analysed by studying the data in three ways: firstly, on the basis of exposure in terms of number of hours per day; secondly, on the basis of exposure in terms of number of years; and finally, on the basis of a combination of number of hours per day and number of years of exposure. On the basis of exposure in terms of number of hours per day, the hearing thresholds changed somewhat significantly only at 2000 and 4000 Hz. On the basis of exposure in terms of number of years the thresholds changed significantly only at 2000 Hz, whereas on the basis of exposure in terms of number of hours per day and number of years the thresholds changed significantly only at 500 Hz.

PLDs are generally used with earphones/headphones. Only mobile phones may be used directly against the ear. Hence, inclusion of dominant ear was not feasible in the current study.

In all groups, the mean hearing thresholds were within normal limits. However, it was noted that hearing thresholds in the group with exposure between 1 and 3 h per day (group 2) were higher than groups have exposure ≤ 1 h per

day or more than 3 h per day (groups 1 and 3), with significant differences only at 2000 and 4000 Hz. Though higher frequencies are expected to have higher degree of hearing loss, the pattern was not maintained at 8000 Hz. Also, higher duration of daily exposure did not reveal further deterioration in hearing thresholds. Similarly, on considering the exposure in terms of number of years, the thresholds varied significantly only at 2000 Hz, and at that frequency, paradoxically, the hearing threshold in group having exposure more than or equal to 5 years (group Y) was less than the group with exposure < 5 years (group X). The more comprehensive comparison on basis of a combination of exposure in terms of hours per day and number of years also revealed a significant increase in hearing threshold only at 500 Hz. Sulaiman et al. reported early stage hearing damage in a study on 35 young PLD users. However, as in the current study, the routine audiometry did not reveal any significant hearing impairment. It was only on subjecting the subjects to high frequency audiometry and otoacoustic emissions that hearing impairment was revealed [14]. Panda et al. also reported similar findings with insignificant changes in audiograms, but significant impairments on high frequency audiometry, brainstem response audiometry (BERA) and distortion product otoacoustic emissions in subjects exposed to PLDs compared to non-user control group [7]. However, another similar study on 60 subjects revealed higher hearing thresholds among subjects using mobile phones for more than 2 h per day compared to non-users at only two frequencies. But BERA in the subjects did not reveal significant differences. The authors attributed the hearing impairment to electromagnetic radiation rather than noise [8]. Sievert et al. also could not prove any effect of mobile phones on the brainstem and vestibular system [10]. Therefore, the results of the current study do not reveal any pattern in the variation of hearing thresholds with

Table 2 Number of years of exposure to PLDs (Mann–Whitney Test)

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Group X (n = 62) (< 5 years)	16.77 $\pm$ 5.51	15.56 $\pm$ 5.66	14.27 $\pm$ 4.94	11.29 $\pm$ 4.33	11.048 $\pm$ 4.89	11.23 $\pm$ 7.83
Group Y (n = 38) (≥ 5 years)	17.23 $\pm$ 5.78	15.92 $\pm$ 4.91	13.81 $\pm$ 4.10	9.34 $\pm$ 3.32	10.52 $\pm$ 4.90	13.02 $\pm$ 9.90
<i>P</i> value	0.37	0.31	0.39	0.01	0.35	0.33

Table 3 Mean auditory thresholds on the basis of combined duration of exposure in years and hours per day. (Mann–Whitney Test)

	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Group A (n = 23) (≤ 1 h/day; < 5 years)	15.87 $\pm$ 5.96	13.48 $\pm$ 5.31	13.04 $\pm$ 4.70	10 $\pm$ 5	9.13 $\pm$ 3.58	10 $\pm$ 6.03
Group B (n = 29) (≥ 3 h/day; ≥ 5 years)	17.41 $\pm$ 5.61	16.21 $\pm$ 5.61	13.62 $\pm$ 3.98	8.96 $\pm$ 3.10	9.31 $\pm$ 4.37	13.10 $\pm$ 11.05
P value	0.21	0.049	0.29	0.36	0.46	0.41

increasing exposure to PLDs. The use of PLDs also did not reveal any deleterious impact on hearing thresholds.

The results of the current study can be attributed to multiple reasons. The study was done by using only pure tone audiometry as an investigative procedure. Audiological test battery consisting of high frequency audiometry, BERA and otoacoustic emissions is essential to provide more conclusive insights into this potential public health issue. Also, it was not possible to obtain a representative group of non-users as a control, given the widespread use of PLDs. It was also not possible to quantify the exact degree of exposure in terms of volume of sound the subjects were exposed to due to the multiplicity of devices. Ambient noise exposure at various times in the subjects' lives could also not be taken into account. Laboratory conditions, therefore, cannot be made available in such a study. A larger number of subjects in a multicentric study are required to reach definite conclusion about the effect of PLDs on hearing. Such conclusive studies would provide deeper insights into the potential public health problem due to use of PLDs and would enable suitable measures to be suggested for its control, if needed. A systematic review of the available literature would also provide much needed insights.

Conclusion

The current study did not reveal any adverse impact of use of personal listening devices, including mobile phones on hearing thresholds. The hearing thresholds also did not show any significant and consistent variations with varying durations of exposure to personal listening devices except at isolated frequencies.

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