Prevalence and Pattern of Hearing Loss among Young Adults in Tertiary Institutions with Habitual Headphone/Earphone Usage in Kaduna Metropolis

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Abstract

Background: World Health Organisation estimates that 1.1 billion young people worldwide could be at risk of hearing loss due to unsafe listening practises and nearly half of the teenagers and young adults are exposed to unsafe levels of sound from the use of personal audio devices. **Aim:** This study aimed to determine the prevalence and pattern of hearing loss among students with habitual use of headphone/earphone in tertiary institutions in Kaduna. **Participants and Methods:** This was a prospective cross-sectional study of young adults with prolonged headphone/earphone usage in Kaduna and a group of nonheadphone/earphone users matched for age and sex as controls. Ethical approvals were obtained from relevant bodies and informed consent was also obtained from all participants. Data were obtained by clinical interview and audiometric evaluation of the participants and the data obtained were descriptively analysed using SPSS version 20.0. Frequency tables were generated and chi-square test and Student's t test were used to test for a possible association of variables. The level of significance was set at $P < 0.05$. **Results:** Two hundred and seventy-two prolonged headphone/earphone users with same number of controls participated in this study. The mean age for subjects and controls was 22.6 ± 3.4 and 23.2 ± 4.2, respectively. Using the better hearing ear, 48 and 20 of the subjects and controls, respectively, had hearing loss, giving a prevalence of 17.6% and 7.4% among the subjects and controls, respectively. Of the 48 subjects with hearing loss, 89.6% had a mild hearing loss. Majority, 91.7% had sensorineural hearing loss and the hearing loss was bilateral in all the participants (both subjects and controls). High frequencies were the most affected (64.6%). **Conclusion:** This study revealed that hearing impairment was more common among prolonged headphone/earphone users. In the majority of the prolonged headphone/earphone users, the hearing impairment was bilateral, mild, sensorineural, and mostly affects higher frequencies.

Keywords: *Headphone/earphone, hearing loss, Kaduna State, noise-induced hearing loss*

Introduction

Earlier reviews concluded that leisure noise was unlikely to be a significant threat to hearing compared to occupational noise, they noted a need for more good data and research.[1,2] The documentation of dangers of recreational noise including personal music players (PMPs) to hearing have been difficult because of a lack of consensus in the literature, studies showed divergent findings. Many papers published over the years estimated the risk of hearing loss due to the use of PMPs, as well as the actual incidence of hearing loss and tinnitus in exposed population. The studies were carried out in, among others, American, Canadian, Dutch, Italian, Israeli, Chilean, Brazilian, and Malaysian teenagers and young adults.[3,4] World Health Organisation estimates that 1.1 billion young people worldwide could be at risk of hearing loss due to unsafe listening practises.[2] A study reported that nearly half of all teenagers and young adults in middle- and high-income countries are exposed to unsafe levels of sound from the use of personal audio devices and some 40% of them are exposed to potentially damaging sound levels.[5]

The global prevalence of disabling hearing loss in adults has been estimated to be 16%, but this varies from 7% to 21% in various subregions of the world.[6,7] In adulthood, disabling hearing impairment can lead to social isolation and stigmatisation, psychiatric disturbances, difficulties in

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relationships with partners and children, poor knowledge acquisition, occupational stress, and relatively low earning.[8,9] Investigations about the possible hazardous effects of headphone sound exposure have yielded different results.[10] Some researchers conclude that personal stereo systems pose a risk,[10] whereas others claimed that their effect is not so harmful.[11,12] An Indian study on the effects of PMPs and mobile phones with earphones on hearing in students found significant increase in hearing threshold among the study group that use portable music players with earphones on daily basis compared with the controls.[3] In general, it is agreed that there is some level of possible risk to hearing in certain conditions such as prolonged exposure and listening at high-volume setting.[13,14]

The European Union's Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) has estimated that 5%–10% of PMP users could develop permanent hearing loss if they listen to their devices at high volume for more than an hour a day.[1] In a study conducted in three cities in England, the UK Royal Institute for the deaf found that 72 out of 110 PMP users were listening at volumes above 85 decibels.[15] A survey of predicted hearing damage in young people using headphone/earphone to listen to music on students of the University of Jos revealed that more than 62% of the students were overexposed to various doses of the noise menace from listening to music from headphone/earphone capable of causing noise-induced hearing loss when the average sound pressure at the earphone was determined.[16] Similarly, a study in Zaria on the effects of headphones on hearing acuity of students of Ahmadu Bello University, Zaria also found significant increase in hearing thresholds among the subjects.[17]

In a survey, Chung *et al.*[18] concluded that young individuals consider recreational noise-induced hearing loss a low-priority health risk. To prevent NIHL, the United States require workers wear protective devices when exposed to noise more than 85 dB.[19] As the technological functions of PMPs improved, it has been observed that there is a continuous increase in the number of young people who expose their hearing systems to loud sounds.[20] The hearing disability caused by this recreational noise is irreversible but entirely preventable. It is important to determine the contribution of recreational noise to the burden of hearing loss in this environment. This study aimed to determine the prevalence and pattern of hearing loss among young adults with prolonged headphone/earphone usage in selected tertiary institutions in Kaduna Metropolis.

Participants and Methods

This is a cross-sectional study of hearing thresholds of young adults with prolonged headphone/earphone usage (using headphone/earphone for at least 1 h/day for 1 year) at tertiary institutions in Kaduna (State University and Kaduna Polytechnic). An age- and sex-matched controls were also recruited from the same institutions.

Ethical approval was sought and obtained from the Kaduna State Ethical Review Board and the Ethics Committee of National Ear Care Centre, Kaduna (ref no. MOH/ADM/744/VOL.1/467 and NECC/ADM/214/III/8). Informed consent was obtained from participants (both subjects and controls) who satisfied the selection criteria and participation was voluntary. The study was conducted between May 2017 and January 2018. Participants with discharge, loud noise exposure other than through headphones/earphones, and those above 35 years or below 18 years of age were excluded.

Fisher's formula: $n = Z^2 pq / d^2$ was used to obtain the desired sample size [d = degree of precision, $q = 1 -$ prevalence, p = prevalence, which is 0.2,[17] z = 1.96 standard deviation, and n = desired sample size]. Thus, the desired sample size is $n = 1.96^2 \times 0.8 \times 0.2/0.05^2 = 3.8416 \times 0.16/0.0025 = 246$. Therefore, the minimum sample required for the study was 246. So, 10% attrition was added ($246/100 \times 10 = 24.6$ which is approximately 25). Therefore, 272 prolonged headphone/earphone users from the two tertiary institutions were recruited for the study. A similar number of nonheadphone/earphone users from the same institutions, matched for age and sex, were enrolled as controls.

A multistage sampling technique was used in selecting participants from the two institutions (Kaduna State University and Kaduna Polytechnic). Two faculties were randomly selected from the seven available faculties in Kaduna State University, and two colleges were also randomly selected from the six available colleges in Kaduna Polytechnic. The selection was done at the students' affairs office of each institution where the names of the faculties and colleges were written on a piece of paper.

Two departments were randomly selected from each of the selected faculties and colleges, making up the sum total of eight departments and those who satisfied the inclusion criteria from the eight selected departments were given questionnaires that recruited subjects using headphones/earphones. Only 34 papers were marked "Yes" for each of the eight selected departments and only those that picked "Yes" from the pool were selected and this gives a total of 272 subjects from the 8 departments. These subjects were then administered questionnaires and consent form and only those that consented were recruited into the study. The same selection criteria was used in recruiting the controls.

The procedure was explained in detail to the participants and the pure tone audiometry (PTA) was performed in a sound-proof booth at National Ear Care Centre (NECC), Kaduna using a calibrated clinical audiometer (Model MAICO MA42, Japan). The participants were transported to NECC in batches. The ambient noise level of the test booth was 27.8 dB (less than 30 dB) using a sound pressure level metre, Model TES1350A made in Taiwan.[21]

The procedure was done with the patients comfortably seated in a sound-proof booth and the modified Hughson–Westlake ascending technique was used. The PTA was done at frequencies of 250–8000 Hz for air conduction and at frequencies of 500–4000 Hz for bone conduction. The pure tones were delivered via circumaural headphones for air conduction and bone vibrators for bone conduction and participants responded by pressing on the response switch/indicator. The tone presented initially at a decibel easily detected by the participant (at 30 dB, 1 kHz, and if there is no response, this was increased by 10 dB till there was a response). The tone was then reduced by 10 dB until there was no response, then increased in 5dB until there was a response. The lowest decibel at which participant consistently responded in 2/3 attempts was then taken as the threshold for that frequency. The pure tone average (PTAv) was determined by summating the thresholds for air conduction at 0.5, 1, 2, and 4 kHz and dividing it by four and the average for each ear was used to determine the hearing level for that ear.[1]

The type of hearing impairment was determined from the tracings on the audiogram. The WHO classification or grading of hearing threshold is as follows: ≤25 dB (no hearing loss), 26–40 dB (slight hearing loss), 41–60 dB (moderate hearing loss), 61–80 dB (severe hearing loss), and ≥81 dB (profound hearing loss).[1] All those with ≤25 dBHL were considered to have normal hearing thresholds, while those with >25 dBHL were considered to have abnormal hearing thresholds. Frequencies between 0.25 and 0.5 kHz were considered as low frequencies, 1–2 kHz as mid-frequencies, and 4–8 kHz as high frequencies.

The data collected was analyzed using statistical product and service solution (SPSS) software IBM SPSS Statistics for Windows, version 20.0 (IBM Corp., Armonk, New York). Qualitative data were summarised using frequencies and percentages, while quantitative variables were summarised using measures of central tendencies and dispersion (standard deviation and range). Chi-square test and Student's *t* test were used to test for a possible association of variables. Level of statistical significance was set at P value of <0.05.

Results

A total of 272 subjects and an equal number of controls participated in this study. The age range of the subjects was 18–33 years with the mean of 22.6 ± 3.4, while the controls age range was 18–35 years with the mean of 23.2 ± 4.2. Majority of the subjects and controls were in the age range of 18–23 years. There is almost equal number of males and females. Table 1 shows age and sex distribution of the participants.

Table 1: Age and gender distribution of subjects and controls

	Subjects		Controls	
	Frequency	Percent	Frequency	Percent
Age				
18–23	182	66.9	161	59.2
24–29	76	27.9	89	32.7
30–35	14	5.2	22	8.1
Total	272	100	272	100
Gender				
Male	137	50.4	143	52.6
Female	135	49.6	129	47.4
Total	272	100	272	100

Table 2: Hearing threshold of subjects and controls

HT	Subjects		Controls		χ^2	*P* value
	Freq	Percent	Freq	Percent		
NHT (≤25 dB)	224	82.4	252	92.6	13.176	<0.0001
AHT (>25 dB)	48	17.6	20	7.4		
Total	272	100	272	100		

Freq: frequency, NHT: normal hearing threshold, AHT: abnormal hearing threshold

Using the better hearing ear, 48 subjects (17.6%) and 20 controls (7.4%) had hearing loss, giving a prevalence of hearing loss among the subjects and controls of 17.6% and 7.4%, respectively. There was statistically significant difference in hearing loss between the subjects and controls ($\chi^2 = 13.176$, $P < 0.0001$). Table 2 gives detail of the hearing threshold for both subjects and controls.

The range of PTAv among the subjects using the better hearing ear was 15.0–42.5 dB with mean PTAv of 22.4 ± 6.3, while the range of PTAv among the controls in the better hearing ear was 9.8–41.2 dB with mean of 18.2 ± 4.0. The results show higher hearing threshold among the subjects (mean = 22.4, SD = 6.3) compared to the controls (mean = 18.2, SD = 4.0). The mean difference of 4.2 between the two groups was statistically significant ($t = 5.375$, $P < 0.0001$).

Of the 272 headphone/earphone users, 60 (22.0%) used the headphones/earphones for less than 2 years, 72 (26.5%) used it for 2–4 years, and the majority, 140 (51.5%) used headphones/earphones for more than 4 years.

Of the 60 subjects that used headphones/earphones for less than 2 years, 9 (15.0%) had hearing impairment. Of the 72 subjects that used headphones/earphones for 2–4 years, 16 (22.2%) had hearing impairment, and of the 140 subjects that used headphones/earphones for more than 4 years, 23 (16.4%) had hearing loss. The difference between duration of use of headphones/earphones and hearing threshold was not statistically significant ($\chi^2 = 1.469$, $P = 0.480$). Table 3

Table 3: Duration of headphone/earphone usage and hearing threshold

Duration of HP/EP usage	Hearing threshold		χ^2	*P* value
	Normal HT	Abnormal HT		
<2 years	51 (85.0%)	9 (15.0%)		
2–4 years	56 (77.8%)	16 (22.2%)	1.469	0.480
>4 years	117 (83.6%)	23 (16.4%)		
Total	224	48		

HP/EP: headphones/earphones, HT: hearing threshold

Table 4: Degree and type of hearing loss among the subjects and controls

	Subjects		Controls	
	Frequency	Percent	Frequency	Percent
Degree of hearing loss				
Mild	43	89.6	16	80.0
Moderate	5	10.4	4	20.0
Total	48	100	20	100
Type of hearing loss				
CHL	0	0.0	3	15.0
SNHL	44	91.7	13	65.0
Mixed	4	8.3	4	20.0
Total	48	100	20	100

CHL: conductive hearing loss, SNHL: sensorineural hearing

gives details of duration of headphone/earphone usage and hearing thresholds.

Of the 48 subjects with hearing loss, majority 43 (89.6%) had mild-degree hearing loss and the remaining 5 (10.4%) had moderate-degree hearing loss. None of the subjects or controls had either severe (61–80 dB) or profound (≥81 dB) hearing loss.

Of the 48 subjects with hearing loss, majority 44 (91.7%) had sensorineural hearing loss, the remaining 4 (8.3%) had mixed hearing loss. None of the subjects had conductive hearing loss, while for the 20 controls with hearing loss, 13 (65.0%) had SNHL, 4 (20.0%) had mixed hearing loss, and the remaining 3 (15.0%) had conductive hearing loss.

Using the better hearing ear, all the 48 (100%) subjects and the 20 (100%) controls with hearing loss had bilateral hearing loss. Table 4 gives the detail of the degree and type of hearing loss among the subjects and controls.

Of the 48 subjects with hearing loss, majority 31 (64.6%) had high-frequency involvement followed by low frequency (22.9%) and mid-frequency was the least affected (12.5%), while for the control group, almost half (45.0%) had high-frequency affectation. Table 5 shows detail of the frequencies affected in both the subjects and the controls.

Seventeen (6.3%) of the headphone/earphone users had audiometric dip at 4 kHz, but none of the controls had audiometric notch at 4 kHz. Table 6 gives detail of the audiometric notches among the participants, and Figure 1 shows an audiogram of a headphone/earphone user with a dip at 4 kHz.

Table 5: Frequency range involved for both subjects and controls

Frequency	Subjects		Controls	
	Frequency	Percent	Frequency	Percent
Low (0.25–0.5 kHz)	11	22.9	6	30.0
Mid (1–2 kHz)	6	12.5	5	25.0
High (4–8 kHz)	31	64.6	9	45.0

Discussion

In this study, the age of the subjects ranged from 18 years to 33 years with the mean of 22.6 ± 3.4 years. This age range forms the bulk of students' population in tertiary institutions. This population is more commonly involved in health risk behaviours such as prolonged usage of headphones/earphones.[22] This is similar to the age group studied by Aline *et al.*[23] in Brazil 18–34 years and Ogbe *et al.*[17] in Zaria, Nigeria 19–31 years. Carolina *et al.*[24] in Brazil studied 16–29 years age group, while Manisha *et al.*[25] in India used 23–30 years age range. A younger age group was studied by Sadaf *et al.*[26,27] in Pakistan 15–29 years and 19–22 years in another study.

Several studies have reported that prolonged exposure to hazardous noise level through headphone/earphone use by the subjects predisposes them more to hearing damage.[3,28,29] In this study, a higher hearing threshold was noted among the subjects ranged 15.0–42.5 dB with mean PTAv of 22.4 ± 6.3 when compared with that of the controls ranged 9.8–41.2 dB and mean PTAv of 18.2 ± 4.0. There was a statistically significant mean difference of 4.2 between the subjects and controls ($t = 5.375$, $P < 0.0001$).

The implication of this is that exposure to noise from the use of headphones/earphones may indeed be responsible for the higher hearing thresholds among the users. This finding corroborated with that by Ogbe *et al.*[17] that reported a significant increase in hearing threshold among university students who use headphones when compared with the controls. Similarly, Keppler *et al.*[30] found a significantly worse hearing threshold among PMP users when compared to non-PMP users. Sulaiman *et al.*[31,32] in separate studies reported a significant increase in mean hearing threshold especially at high frequencies among university students who use personal listening devices compared to nonusers.

In contrast to the finding in this study, Aline *et al.*[23] in Brazil study found a normal hearing threshold in both ears in the frequency range of 0.25–12 kHz among university students with at least 1 h daily use of headphones and personal stereos. This could be due to a difference in methodology, in their study, a relatively smaller sample size of 85 was used and hearing threshold was determined at extended higher frequencies in addition to conventional frequency range.

Table 6: Audiometric notch at 4 kHz for both subjects and controls

Notch at 4 kHz	Subjects		Controls		χ^2	*P* value
	Frequency	Percent	Frequency	Percent		
Yes	17	6.3	0	0.0		
No	255	93.7	272	100	17.548*	0.0001
Total	272	100	272	100		

*Yates correction was used for expected count less than 5.

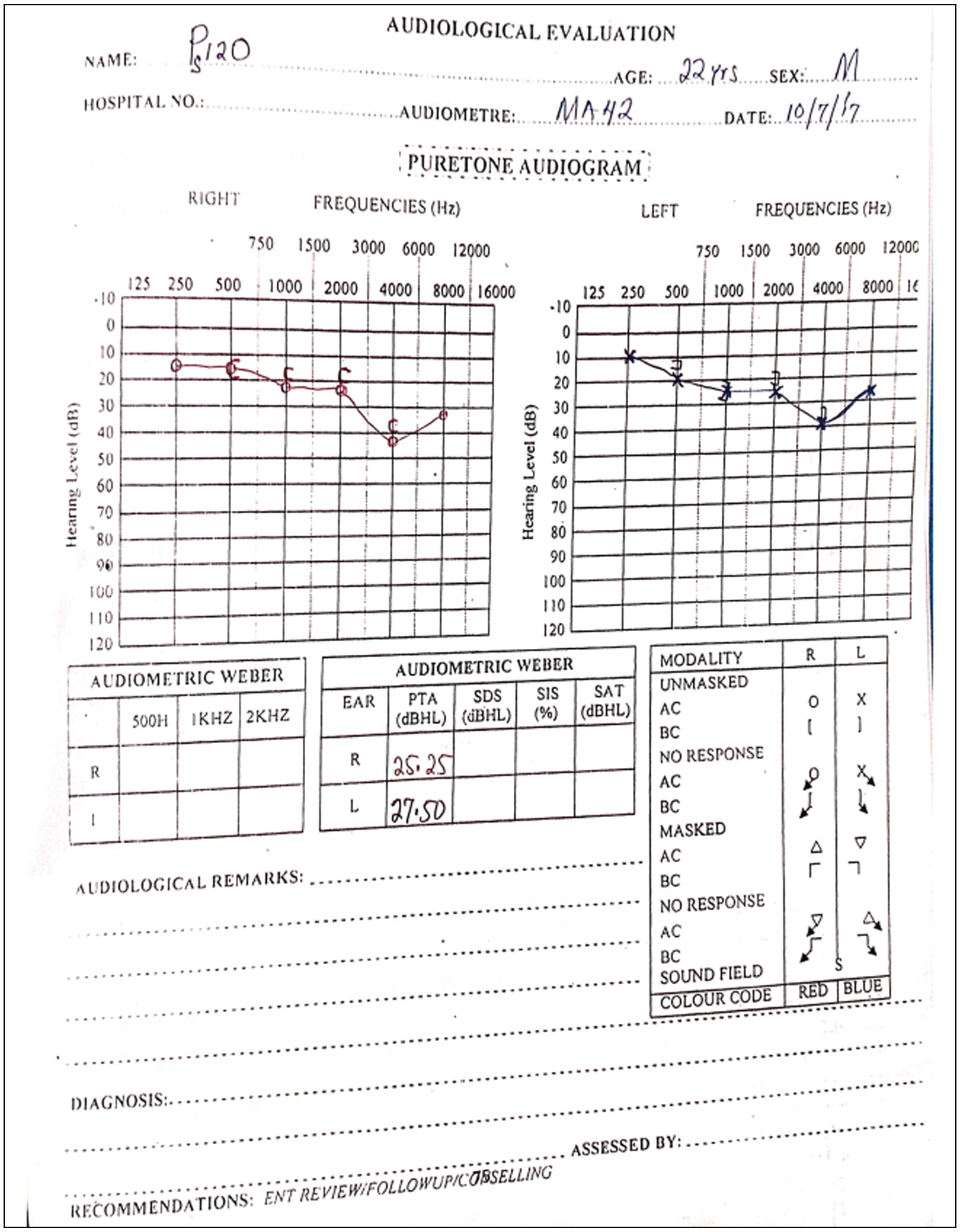

Figure 1: An audiogram of a headphone/earphone user with a dip at 4 kHz

This study found a higher prevalence of hearing loss among the subjects using headphones/earphones of 17.6% compared to the controls with prevalence of 7.4%. This finding is comparable to that by Ogbe *et al.*[17] in Zaria where the prevalence of hearing loss among the subjects was 20.3% in the right ear and 18.8% in the left ear. The finding is also similar with Ibadan study by Ahmed *et al.*[20] which reported the prevalence of 15.4% among adolescents with consistent mobile telephone usage. Similarly, a meta-analysis done by Ana *et al.*[33] on the prevalence of hearing loss in adolescents and young adults as a result of social noise exposure reported the prevalence rate of hearing loss ranging from 11.5% to 15.8%.

A higher rate of 36.1% was reported in India by Manisha *et al.*[3] They used a relatively smaller sample size (61) in that study, which may explain the higher prevalence rate reported in the study. However other studies found lower prevalence of hearing loss among headphone/earphone users. Peng *et al.*[34] in China reported a low prevalence rate of 14.1%. This could be explained in part by the difference in methodology (relatively lower sample size and lower age range of the participants). Suleiman *et al.*[35] in Malaysia found a much lower prevalence of 7.3%. A possible explanation for this lower prevalence may be because the study was carried out among high school students who were not allowed to use personal listening devices during school hours which shorten their overall listening duration.

The degree of hearing loss depends on the individual characteristics; genetic susceptibility to noise, duration of exposure, listening volume, and type of music listened to; however, most studies reported mild degree of hearing loss among the users of headphones.[34,36,37]

Mild hearing loss was the commonest pattern of hearing loss recorded in this study irrespective of years of usage of headphones/earphones. About 90% of hearing loss in this study was of mild degree and this could partly be due to relatively shorter daily exposure from the headphone/earphone use noted among majority of the subjects in this study (1–4 hours per day). The finding in this study is similar to that by Suleiman *et al.*[35] that found 92.3% of those with hearing loss to have mild form of hearing loss. Similarly, a Pakistan study by Sadaf *et al.*[27] reported 73.2% of the subjects to have mild hearing loss.

Literature has shown that noise-induced hearing loss generally affect a person's hearing sensitivity in the higher frequencies especially at 4,000 Hz.[38] This study found that majority of subjects with hearing loss, 31 (64.5%) had high-frequency loss compared to 17 subjects (35.5%) with mid/low-frequency hearing loss. More frequent affectation of higher frequencies was similarly reported by Ahmed *et al.*[20]

Similarly, several other studies have reported high-frequency loss among subjects ranging from 3 to 8 kHz.[33,39,40] Noise-induced hearing impairments are usually associated with notch-shaped high-frequency sensorineural hearing loss that is worse at 4,000 Hz, although the notch often occurs at 3,000 or 6,000 Hz as well.[38] The classical notching at 4 kHz was seen in 6.3% of the subjects in this study. This is similar to a study by Suleiman *et al.*[35] that found characteristic notched audiograms in 3.9% of the subjects. Similarly, Karthikeyan *et al.*[39] in India reported a 4-kHz dip in the audiograms of a few subjects. Aline *et al.*[23] found characteristic notching at 6 kHz.

Data from literature indicated that repeated acute exposures to PMPs at high-volume output can produce temporary threshold shift up to 30 dB at 4 kHz in some individuals after short time of exposure (one or more hours).[1] It was also reported that 5%–20% of young individuals have audiometric notching at 4–6 kHz consistent with noise exposure.[14,41] Higher frequencies have compression–decompression effect and as such more absorbed by the hair cells in the early stage of noise-induced hearing loss than mid and low frequencies.[42]

Conclusion

This study revealed that hearing loss was significantly higher among prolonged headphone/earphone users compared to the controls. The hearing impairment was mostly mild, bilateral, sensorineural with higher frequency involvement in the majority of the prolonged headphone/earphone users.

Limitations

The sound delivery into the ear by headphone use may not be of same intensity as earphone use for any given preferred listening level, this study, however, did not differentiate between whether a subject uses a headphone or an earphone.

Another limitation for this study was the inability to assess the level of noise from the headphones/earphones of the personal audio devices, which might have been the reason for the high prevalence of hearing loss amongst the subjects.

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Conflicts of interest

There are no conflicts of interest.

Authors' contributions

K.H., A.D.S., S.A.L., and M.B.F. conceived and designed the study; K.H. and M.B.F. implemented the study; A.D.S. and S.A.L. supervised the study; K.H. and M.B.F. conducted data analysis; K.H., M.B.F., S.A.L., and A.D.S. interpreted study results; K.H. and M.B.F. wrote the first draft of the manuscript; A.D.S. and S.A.L. reviewed and corrected the draft manuscript. All the authors have read and agreed to the final manuscript.

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