



Effect on hearing by long term headphone and amplification device exposure on hearing thresholds among undergraduate students.

Article History:

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Received: 12-10-2025

Revised: 22-10-2025

Accepted: 06-11-2025

Published: 10-11-2025

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Abstract: **Background:** The widespread use of personal listening devices (PLDs), including headphones, earphones, and earbuds, has raised concerns regarding unsafe listening practices and their potential impact on hearing among young adults. This study aimed to evaluate the effect of long-term use of headphones/amplification devices on hearing among undergraduate students. **Methods:** A cross-sectional study was conducted at Jinnah Medical and Dental College from August 2023 to February 2024. A total of 351 undergraduate students aged ≥ 18 years who had used PLDs for at least one year were enrolled. Data regarding socio-demographic characteristics, PLD usage patterns, and hearing-related symptoms were collected using a structured questionnaire. Hearing assessment was performed using pure-tone audiometry. Data were analyzed using SPSS version 26.0. Descriptive statistics were calculated, and associations between PLD use and hearing status were assessed, with $p < 0.05$ considered statistically significant. **Results:** The mean age of participants was 22.84 ± 2.41 years, and 53.6% were female. Earbuds were the most commonly used PLDs (47.0%), while 36.5% had used PLDs for more than five years. Most participants listened for 2–4 hours daily (37.3%), and 25.4% preferred high listening volumes ($>70\%$). Tinnitus (19.7%) was the most frequently reported hearing-related symptom. Pure-tone audiometry revealed normal hearing in 84.3% of participants, mild hearing loss in 12.0%, and moderate hearing loss in 3.7%. Hearing impairment was significantly associated with longer duration of PLD use ($p = 0.005$), prolonged daily listening time ($p < 0.001$), higher listening volume ($p < 0.001$), and listening in noisy environments ($p = 0.006$). **Conclusion:** Long-term and unsafe use of personal listening devices is significantly associated with hearing impairment among undergraduate students

Keywords: Personal listening devices; Headphones; Hearing loss; Pure-tone audiometry; Noise-induced hearing loss; Undergraduate students.

INTRODUCTION

With the prevalence of smartphones, laptops and digital media, the use of personal listening devices (PLDs), such as headphones, earphones, earbuds and other amplification devices, has increased considerably. University students widely use these devices for online learning, music streaming, gaming and communication, resulting in prolonged daily exposure to recreational noise. PLDs provide convenience and greater access to educational and entertainment resources but overuse and unsafe use of PLDs has become a rising public health concern due to its negative effects on hearing health [1,2].

Hearing loss is among the most ubiquitous sensory disabilities across the globe. More than 1 billion adolescents and young adults are at risk of preventable hearing loss from unsafe listening practices, such as prolonged use of personal listening devices at high volumes, according to the World Health Organization (WHO) [3]. Prolonged exposure to sound levels greater than 85 dB can damage the cochlear hair cells of the inner ear, causing noise-induced hearing loss (NIHL), tinnitus, reduced speech discrimination, and difficulty hearing speech in noisy environments. Cochlear hair cells have a limited capacity to regenerate, and the resulting hearing loss is often permanent and irreversible [4,5].

Undergraduate students are highly vulnerable to unsafe listening habits, as they frequently use headphones for academic and recreational purposes. With the growing dependency on virtual learning platforms, online lectures, and digital communication, they wear headphones on their ears for prolonged hours. Music streaming, gaming and social media also drive long listening times, often at unsafe volume levels. In noisy environments, listening encourages users to increase the volume, raising the risk of auditory damage [6,7].

Several studies have reported a significant association between long-term headphone use and hearing-related symptoms among university students. Kaur et al. reported that the prevalence of tinnitus, temporary hearing difficulty and ear discomfort was significantly higher among regular headphone users compared to occasional users [5]. Similar findings were observed by Ali et al. who showed that extended use of headphones and higher levels of listening were significantly associated with self-reported symptoms of hearing loss among medical students [6]. Those who use headphones regularly have also shown increased high-frequency hearing thresholds on objective audiometric assessments, suggesting early cochlear damage before clinical hearing loss manifests [7,8].

In addition to hearing loss, long-term exposure to recreational noise has been associated with tinnitus, auditory fatigue, and reduced speech perception in noise. There is also recent evidence to suggest that there may be 'hidden hearing loss', where synaptic damage occurs despite normal pure-tone audiometric thresholds and leads to difficulty understanding speech, especially in challenging listening situations [3,9]. These findings indicate that early auditory damage may be missed if proper hearing assessments are not performed.

The World Health Organization recommends safe listening practices to reduce the risk of hearing impairment, including keeping the listening volume below 60% of the maximum device output, limiting the duration of continuous listening, taking frequent listening breaks, and using noise-canceling headphones instead of increasing the volume in noisy environments [10]. However, these recommendations are not fully implemented and safe listening awareness among young adults, especially in developing countries, is still insufficient.

Although several international studies have investigated the relationship between prolonged headphone use and hearing health, evidence among undergraduate students in developing countries remains limited. Considering the increasing dependence on personal listening devices for educational and recreational activities, it is important to assess their long-term effects on hearing. Therefore, the present study aims to evaluate the effect of long-term use of headphones/amplification devices on hearing among undergraduate students and to promote awareness regarding safe listening practices for the prevention of noise-induced hearing loss..

METHODOLOGY

This study was conducted in Jinnah Medical and Dental College over a period of six months from August, 2023 to February, 2024. 351 Undergraduate students aged 18 years and above who had been using headphones or other personal amplification devices for at least one year and who provided written informed consent were included in the study. Students with a known history of congenital hearing loss, chronic otitis media, previous ear surgery, exposure to occupational noise, use of ototoxic medications, or diagnosed neurological disorders affecting hearing were excluded. The sample size was calculated based on estimating the prevalence of headphones use by considering $P=35.4\%$, $d=0.05$ and confidence interval= 95%, then minimum required sample size was 351.

Data were collected using a structured, pretested questionnaire comprising three sections. The first

section recorded socio-demographic characteristics, including age, gender, academic discipline, and year of study. The second section assessed headphone and amplification device usage patterns, including type of device used (headphones, earphones, earbuds), duration of use (years), average daily listening time, preferred listening volume, purpose of use (academic, entertainment, communication), and listening habits in noisy environments. The third section documented hearing-related symptoms, including tinnitus, ear pain, temporary hearing difficulty, reduced speech understanding, and a feeling of blocked ears.

Hearing assessment was performed using pure-tone

audiometry in a sound-treated room by a qualified audiologist following standard audiometric procedures. Air-conduction hearing thresholds were measured at frequencies ranging from 250 Hz to 8000 Hz. Hearing status was classified according to the World Health Organization criteria, with a pure-tone average (PTA) of ≤ 20 dB considered normal hearing and values > 20 dB regarded as hearing impairment. Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26.0. Continuous variables were reported through mean + SD, whereas, frequency and percentages were calculated for qualitative variables.

RESULTS

A total of 351 participants were included in the study. The mean age of the participants was 22.84 ± 2.41 years. There were 188 (53.6%) females and 163 (46.4%) males. Regarding the type of personal listening device (PLD) used, earbuds were the most commonly used device (165, 47.0%), followed by earphones (108, 30.8%) and headphones (78, 22.2%). With respect to the duration of PLD use, 145 (41.3%) participants had been using PLDs for 3–5 years, 128 (36.5%) for more than 5 years, and 78 (22.2%) for 1–2 years. Daily listening time revealed that 131 (37.3%) participants used PLDs for 2–4 hours/day, 97 (27.6%) for 4–6 hours/day, 64 (18.2%) for less than 2 hours/day, and 59 (16.8%) for more than 6 hours/day. Regarding preferred listening volume, 176 (50.1%) participants listened at a moderate volume (50–70%), while 89 (25.4%) preferred a high volume ($> 70\%$), and 86 (24.5%) used a low volume ($< 50\%$). The most common purpose of PLD use was entertainment (154, 43.9%), followed by academic purposes (118, 33.6%) and communication (79, 22.5%). Additionally, 214 (61.0%) participants reported using PLDs in noisy environments, whereas 137 (39.0%) did not (**Table#1**).

Regarding hearing-related symptoms, tinnitus was reported by 69 (19.7%) participants, making it the most common symptom, followed by blocked ear sensation in 61 (17.4%), ear pain in 55 (15.7%), temporary hearing difficulty in 47 (13.4%), and difficulty understanding speech in 38 (10.8%) participants (**Table#2**).

Pure tone audiometry demonstrated that 296 (84.3%) participants had normal hearing, while 42 (12.0%) had mild hearing loss and 13 (3.7%) had moderate hearing loss (**Table#3**).

The association between baseline characteristics and hearing status showed that the duration of PLD use was significantly associated with hearing impairment ($p = 0.005$). Hearing impairment was more common among participants who had used PLDs for more than 5 years (31 participants) compared with those using them for 3–5 years (19 participants) or 1–2 years (5 participants). Similarly, daily listening time demonstrated a highly significant association with hearing impairment ($p < 0.001$). Participants listening for more than 6 hours/day had the highest frequency of hearing impairment (20 participants), followed by those listening for 4–6 hours/day (18 participants), 2–4 hours/day (14 participants), and less than 2 hours/day (3 participants). A significant association was also observed between preferred listening volume and hearing impairment ($p < 0.001$). Hearing impairment was most frequent among participants who preferred high listening volumes ($> 70\%$) (28 participants), followed by those using moderate volumes (22 participants) and low volumes (5 participants). Furthermore, listening in noisy environments was significantly associated with hearing impairment ($p = 0.006$). Hearing impairment was observed in 43 participants who reported listening in noisy environments compared with 12 participants who did not, indicating that exposure to noisy surroundings while using PLDs was associated with a greater prevalence of hearing impairment. (**Table#4**).

Table#1: Baseline Data of the Patients

Baseline Data	n(%) / (mean ± SD)
Age	22.84 ± 2.41
Gender	
• Male	163 (46.4)
• Female	188 (53.6)
Device Type	
• Earbuds	165 (47.0)
• Earphones	108 (30.8)
• Headphones	78 (22.2)
Duration	
• 1–2 years	78 (22.2)
• 3–5 years	145 (41.3)
• >5 years	128 (36.5)
Daily Listening Time	
• <2 hours	64 (18.2)
• 2–4 hours	131 (37.3)
• 4–6 hours	97 (27.6)
• >6 hours	59 (16.8)
Preferred Listening Volume	
• Low (<50%)	86 (24.5)
• Moderate (50–70%)	176 (50.1)
• High (>70%)	89 (25.4)
Purpose of Personal Listening Device Use	
• Academic	118 (33.6)
• Entertainment	154 (43.9)
• Communication	79 (22.5)
Listening in Noisy Environments	
• Yes	214 (61.0)
• No	137 (39.0)

Table#2: Hearing Related Symptoms

Hearing related symptoms	n(%)
Tinnitus	69 (19.7)
Ear pain	55 (15.7)
Temporary hearing difficulty	47 (13.4)
Difficulty understanding speech	38 (10.8)
Blocked ear sensation	61 (17.4)

Table#3: Pure Tone Audiometry Findings

Pure Tone Audiometry Findings	n(%)
Normal hearing	296 (84.3)
Mild hearing loss	42 (12.0)
Moderate hearing loss	13 (3.7)

Table#4: Pure Tone Audiometry Findings with respect to the Baseline Data of the Patients

Baseline Data	Hearing impairment		P-value
	Yes (n=296)	No (n=55)	
Duration • 1–2 years • 3–5 years • >5 years	73 126 97	05 19 31	0.005
Daily Listening Time • <2 hours • 2–4 hours • 4–6 hours • >6 hours	61 117 79 39	03 14 18 20	<0.001
Preferred Listening Volume • Low (<50%) • Moderate (50–70%) • High (>70%)	81 154 61	05 22 28	<0.001
Listening in Noisy Environments • Yes • No	171 125	43 12	0.006

DISCUSSION

The present study evaluated the association between long-term use of personal listening devices (PLDs) and hearing status among undergraduate students. Although the majority of participants had normal hearing thresholds (84.3%), mild and moderate hearing loss was detected in 15.7% of students. More importantly, hearing impairment was significantly associated with longer duration of PLD use, prolonged daily listening time, higher listening volume, and listening in noisy environments. These findings suggest that unsafe recreational listening habits may contribute to early auditory damage among young adults.

In the present study, earbuds were the most commonly used PLDs, and entertainment was the primary purpose of use. Similar usage patterns have been reported in studies from India, Saudi Arabia, and China, where earbuds and earphones were the preferred devices because of their portability and compatibility with smartphones.¹¹⁻¹³ The increasing dependence on PLDs for both educational and recreational activities following the expansion of digital learning has further increased daily sound exposure among university students.¹⁴

Pure-tone audiometry demonstrated hearing impairment in 15.7% of participants. This prevalence is comparable to that reported by Kaur et al., who found audiometric abnormalities among approximately 13% of university students with regular headphone use.⁵ Likewise, Peng et al. reported that prolonged recreational noise exposure was associated

with elevated hearing thresholds, particularly at higher frequencies, even in otherwise healthy young adults.¹⁵ Although most participants in our study had normal hearing, these findings indicate that early hearing impairment is already evident in a considerable proportion of frequent PLD users.

A significant association was observed between duration of PLD use and hearing impairment. Participants using PLDs for more than five years exhibited significantly higher rates of hearing loss than those with shorter durations of use. Similar observations were reported by Byeon, who demonstrated that cumulative years of headphone use significantly increased the likelihood of hearing impairment among adolescents and young adults.¹⁶ Long-term exposure to recreational noise is known to induce progressive cochlear hair-cell damage through oxidative stress and metabolic exhaustion, ultimately resulting in permanent threshold shifts.¹⁷ Therefore, cumulative duration of exposure appears to be an important determinant of hearing health.

Daily listening time was another important predictor of hearing impairment. Students listening for more than six hours per day had the highest prevalence of hearing loss, which is consistent with previous studies demonstrating that prolonged daily exposure substantially increases the risk of noise-induced hearing loss.^{13,18} A recent systematic review by Dillard et al. estimated that more than one billion adolescents and young adults worldwide are at risk of hearing loss because of unsafe listening practices, particularly prolonged use of PLDs at high sound

levels.¹⁹ These findings reinforce the importance of limiting continuous listening time and adopting regular listening breaks.

Listening volume showed one of the strongest associations with hearing impairment in the present study. Participants preferring high listening volumes (>70%) experienced significantly greater hearing impairment than those using lower volume settings. Comparable findings have been reported in another study., who observed significantly poorer hearing thresholds among young adults who regularly listened to music at high volumes.¹⁰ Experimental evidence suggests that excessive sound intensity causes irreversible damage to cochlear hair cells and synapses between inner hair cells and auditory nerve fibers, resulting in both conventional noise-induced hearing loss and early cochlear synaptopathy.¹¹ Consequently, listening volume remains one of the most important modifiable risk factors for hearing preservation.

Another noteworthy finding was the significant association between listening in noisy environments and hearing impairment. More than 60% of participants reported using PLDs in noisy surroundings, and these students had significantly higher rates of hearing impairment. Similar findings have been reported by Carter et al., who noted that background environmental noise encourages listeners to increase device volume, thereby substantially increasing total sound exposure.¹² This observation supports current World Health Organization recommendations advocating the use of noise-cancelling devices instead of increasing listening volume in noisy settings.¹³

Among hearing-related symptoms, tinnitus was the most frequently reported complaint. Similar findings have been described in several studies where tinnitus was identified as the earliest symptom of recreational noise exposure before measurable hearing loss became evident.^{12,20} The presence of tinnitus despite largely normal audiometric findings suggests that subtle cochlear injury may precede clinically detectable hearing impairment, emphasizing the importance of early preventive measures.

The findings of this study have important public health implications because the identified risk factors—including prolonged listening duration, excessive listening volume, and listening in noisy environments—are largely preventable. Educational campaigns promoting safe listening habits, adherence to the WHO safe-listening recommendations, and periodic hearing screening among university students may reduce the future burden of noise-induced hearing loss.

Despite the strengths of using objective pure-tone audiometry and including a relatively large sample of undergraduate students, this study has certain limitations. The cross-sectional design does not establish causality, and listening habits were self-reported, making recall bias possible. Longitudinal studies incorporating advanced audiological tests, including extended high-frequency audiometry and otoacoustic emissions, are recommended to detect early cochlear damage before conventional hearing loss develops.

CONCLUSION

The present study demonstrates that prolonged and unsafe use of personal listening devices is significantly associated with hearing impairment among undergraduate students. Although the majority of participants had normal hearing, approximately one in six exhibited mild-to-moderate hearing loss, with tinnitus being the most common hearing-related symptom. Longer duration of PLD use, extended daily listening time, higher listening volumes, and the use of PLDs in noisy environments were all significantly associated with hearing impairment. These findings highlight the importance of increasing awareness regarding safe listening behaviors and implementing educational interventions to encourage healthy listening habits among young adults. Early screening and adherence to recommended listening practices may help prevent noise-induced hearing loss and preserve hearing health in this vulnerable population.

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