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Auditory Changes as Early Markers of Hearing Loss in Individuals Using Personal Music Devices

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Abstract: Personal Music Devices (PMDs) among young adults have raised concerns regarding early signs of auditory changes that can lead to permanent Hearing Loss (HL). The present study was aimed to investigate the frequency and severity of self-perceived auditory symptoms due to PMD use and its relationship to the duration of exposure. An online survey of 63 PMD users aged 18-30 years was carried out. Participants were divided into four groups according to the duration of PMD use per day: >5 hr/day (n = 6), 3–5 hr/day (n = 14), 1–3 hr/day (n = 17), and <1 hr/day (n = 26). The auditory symptoms included tinnitus, muffled hearing, ear fullness, difficulty hearing in noise, hyperacusis, and need for increased volume over time. Structured rating scales were used to measure the frequency and severity of the symptoms. Differences were found in the frequency of difficulty hearing in noise ($H = 8.545$, $p = 0.036$), hyperacusis ($H = 8.484$, $p = 0.037$), and need for increased volume over time ($H = 8.900$, $p = 0.031$). Severity of hyperacusis was found to have significant association with the duration of PMD use with highest severity ($H = 8.425$, $p = 0.038$) in the group with PMD usage for >5 hours per day. Tinnitus, muffled hearing, and ear fullness were found not to be significant. The results of present study indicated that prolonged PMD use is related to early signs of auditory changes that can lead to permanent HL, highlighting the necessity to consider subclinical auditory symptoms as early warning signs for the onset of Noise Induced HL (NIHL).

Keywords: personal music devices, NIHL, auditory symptoms, hyperacusis, tinnitus, young adults, hearing health

INTRODUCTION

Listening practices have undergone a substantial shift with the advent of top-notch audio systems integrated on our PMDs, resulting in the formation of an individual oriented form of listening that involves both convenience and privacy. This phenomenon has caused a surge in the use of PMDs, such as smartphones, portable audio players, and wireless headphones, which are usually played at volumes higher than those used in free-field listening conditions. It is a matter of concern for auditory health because recreational listening is largely unregulated, and there could be excessive exposure making this phenomenon a significant public health issue. One of the most significant outcomes of this phenomenon is the increased risk of Music-Induced HL (MIHL), which is a type of NIHL due to recreational exposure to music. Recent estimates reveal that more than a billion people across the globe are susceptible to hearing impairment owing to recreational noise, with a significant percentage arising from improper listening practices involving PMDs. (Chodankar and Rane, 2025; World Health Organization, 2019).

Zia, Mubashir, and Shahzad (2013) revealed the alarming fact that despite the awareness of the possible risk of NIHL among the younger population using earphones, a significant proportion were still using the devices at unsafe levels and were experiencing tinnitus, difficulties with speech understanding, and vertigo.

Sulaiman, Mahmud, and Mansor (2013) found that the presence of exposed levels that exceeded the safety limits was related to increased thresholds in the extended high-frequency ranges among young PMD

users, thereby showing the early involvement of the cochlea, despite the fact that the thresholds had not exceeded the normal limits. Further expanding on the previous findings, Sulaiman et al (2015) found that increased equivalent sound exposure levels had significant relations to the presence of tinnitus and early high-frequency threshold shifts.

Herrera, Bringas, Fuentes and García (2016) revealed that adolescents who were exposed to increased volume levels experienced tinnitus, difficulties with concentration, communication and hearing.

Båsjö, Möller, Widén, Jutengren and Skagerstrand (2016) noted objective evidence of high-frequency vulnerability among the younger population. Children who use headphones have lower hearing thresholds compared to those who did not use headphones. This implies that the effects of recreational noise exposure can be noted at a very early age, especially for high-frequency sounds.

Gopal, Champlin and Philips (2019) looked into how individuals' attitudes, perceived social pressure, and behavioral control would affect their willingness to engage in protective actions including reducing sound intensity levels and limiting the amount of time spent listening and found that positive attitude is the key determinant in exercising safe listening practices.

Choi, Park and Kim (2021) studied the psychological and behavioral effects associated with the early signs of change in the auditory system in a large matched population cohort ($n \approx 3,900$) using data from the Korea National Health and Nutrition Examination Survey (2010-2012). Earphone use was found to be significantly associated with increased odds of tinnitus (OR = 1.27), anxiety and depression symptom levels despite the lack of significant differences in pure-tone hearing thresholds between the groups. This suggests that subjective auditory changes can occur despite the lack of objective changes.

Kacprzyk, Wierzbicka, Sielska, Śliwińska and Dobrzyński (2021) conducted a systematic review on the association between the use of mobile phones and the occurrence of tinnitus and found mixed results. Although some studies suggested the association between the prolonged use of mobile phones and the occurrence of tinnitus, the results were not significant.

Balajelini, Reza, Mousavi and Hoseini (2021) in their systematic review involving 92,978 participants, found no significant association between the use of mobile phones and the occurrence of hearing impairment. However, the results suggest that the use of mobile phones, in general, might not include the use of music at high intensity and more precise criteria, such as the duration of listening and the intensity of the sounds, are needed to detect the early signs of MIHL.

Byeon (2021) revealed the association between the use of earphones in a noisy environment, tinnitus and temporary HL among individuals between the ages of 6 and 19 years. This indicates that early auditory stress may be experienced behaviorally and perceptually before structural changes occur.

Hayat, Mansoor, Hayat, Khalid and Iftikhar (2022) observed a high prevalence of tinnitus, at 73%, and hearing impairment, at 54%, among adolescent and young adult PMD users, which they emphasized, is a consequence of unsafe listening practices that can indeed cause measurable auditory damage. The privacy associated with listening to music using earphones often results in the user listening to music in a loud environment, leading to the intentional increase in the volume to compensate for ambient noise. This is consistent with the general concept of MIHL, wherein prolonged listening to loud music is a major contributor to cochlear stress and auditory impairment. Particular note is that tinnitus and difficulty of hearing are often considered precursors to conventional audiometric diagnosis thereby serving as early clinical indicators of auditory compromise.

Gajendran, Rajendiran, Prateep, Satindra and Rajendran (2025) evaluated 100 medical students using PMDs and recorded a 33% prevalence rate of high-frequency NIHL. Results also showed that increased high-frequency audiometry thresholds at 16 kHz and 18 kHz were correlated with the duration of PMD usage for recreational activities, suggesting that prolonged recreational listening could lead to early signs of HL and the misuse of PMDs is a major risk factor for early cochlear changes.

Chodankar and Rane (2025) revealed that prolonged recreational use of an audio device is consistently associated with early signs of HL, particularly in high-frequency sounds, and emphasized the growing concern about non-occupational noise exposure in young people. The literature, therefore, points to a critical truth that the changes in hearing associated with personal use of mobile phones and PMDs, such as tinnitus, muffled hearing, speech recognition in noise, temporary threshold shifts, and prolonged high-frequency loss, all precede the more commonly encountered audiometric patterns of HL.

Beha, Alshehri, Albalawi and Alqahatni (2025) in a cross-sectional study among university students found a high prevalence of headphone use, with 77.6% reporting regular usage. The most frequently reported auditory symptoms following headphone use were: tinnitus (28.3%), ear fullness/pressure (17.8%) and ear pain (16.2%) with a statistically significant association between headphone use and symptom occurrence. These findings suggest that prolonged headphone use may pose an early risk to auditory health in young adults

Clinical audiology and speech pathology's perspective suggest that the early detection of these changes is critical. Subclinical HL can affect the clarity of speech perception, academic achievement, social interactions, and overall communicative efficiency, even before the affected individuals seek any form of professional advice. Therefore, the examination of the changes in hearing, as early signs of HL among PMD users, is not only clinically significant but also socially important. By systematically analyzing the perceived symptoms, present study aims to make a significant contribution to the early identification of individuals at risk of MIHL.

Existing evidence suggests that recreational exposure to amplified music through personal mobile phones and listening devices contributes to early auditory stress, often manifesting as tinnitus, transient hearing difficulty, muffled perception, difficulty understanding speech in noise, and elevated high-frequency thresholds before clinically significant HL is detected (Hayat et al., 2022; Sulaiman et al., 2015; Gajendran et al., 2025).

Although systematic reviews indicate inconsistent associations Kacprzyk et al (2021), exposure-specific factors such as listening duration, intensity, and environmental noise conditions should be given more importance. Highlighting the need for focused primary research that examines these early auditory changes in relation to real-world listening behaviors among PMD users, particularly in populations where routine audiological screening is uncommon.

Present study was aimed to investigate auditory changes as early markers of HL in PMD users by systematically analyzing symptom occurrence frequency, symptom severity and associated functional impact. By identifying the relationship between exposure patterns and early auditory complaints, this study seeks to contribute to early detection strategies and promote evidence-based hearing conservation practices in the era of ubiquitous PMD.

METHODOLOGY

Aim

Present study was aimed to investigate auditory changes as early markers of HL among PMD users by examining the frequency and severity of self-perceived auditory symptoms - tinnitus, Muffled hearing, Ear fullness, Difficulty in noise, Hyperacusis and Need to Increase volume over time, associated with PMD use.

Objectives

1. To examine the **association between music listening duration and the frequency** of self-perceived auditory symptoms.
2. To examine the **association between music listening duration and the severity** of self-perceived auditory symptoms.

Subjects

A total of **63 young adults** aged between **18 to 30 years,** using earphones/headphones to listen to music for ≥3 days/week for the past 6 months were included in the study. Individuals with diagnosed HL, current ear infection, recent ear surgery, or professional exposure to industrial noise were excluded.

Stimulus

Structured self-administered questionnaire was used which consisted of following sections:

1. Demographics and Medical History
2. Listening Habits
3. Auditory Symptoms Experienced (including frequency, type, severity, and duration)

Procedure

Data collection was done using an online Google Form survey link which was distributed via social network. Prior to answering the survey questions, respondents were asked to give their consent to proceed and pass the inclusion criteria. The data collected was recorded using Microsoft Excel. The collected data was organized in four different groups, Group 1: >5 hours/day (n=6), Group 2: 3-5 hours/day (n=14), Group 3: 1-3 hours/day (n=17), Group 4: <1 hour/day (n=26) based on the duration of exposure or use of PMD's for listening music to cover the frequency and severity of the symptoms for further statistical analysis.

RESULTS

Present study was carried out to assess the frequency and severity of auditory symptoms in association with the use of PMDs in 63 subjects, who were divided into four groups (Table 1): Group 1: >5 hours/day (n=6), Group 2: 3-5 hours/day (n=14), Group 3: 1-3 hours/day (n=17), Group 4: <1 hours/day (n=26) according to the daily use of PMDs.

Table 1: *Distribution of Participants by Daily Listening Duration*

Daily Listening Duration	n	%
>5 hr/day	6	9.5%
3–5 hr/day	14	22.2%
1–3 hr/day	17	27.0%
<1 hr/day	26	41.3%
Total	63	100%

The frequency of auditory symptoms such as tinnitus, muffled hearing, and ear fullness, difficulty in noise, hyperacusis, and need to increase volume over time were compared and analyzed in association with the use of PMDs on the auditory system. The normality of data was checked using Kolmogorov-Smirnov and Shapiro-Wilk tests. Since the data was not normally distributed, the Kruskal Wallis test has been used for comparison of the groups.

Frequency of Auditory Symptoms in association with PMD usage

Association of PMD with the frequency of auditory symptoms (Table 2 & Figure 1) such as Difficulty in Noise was found to be significant at p=0.036, with greater occurrence in Group 1 and Group 3. Frequency of Hyperacusis was found to be significant at p=0.037, with greater occurrence in Group 1 and Group 4. Frequency of the auditory symptom: Need to Increase Volume over time was found to be significant at p=0.031, with highest occurrence in Group 1. The frequency of Tinnitus (p=0.483), muffled hearing (p=0.226), ear fullness (p=0.135) did not show any significant association.

Table 2: *Showing Mean Frequency of Self-Perceived Auditory Symptoms as a Function of Daily Music Listening Duration.*

		>5 hr/day	3-5 hr/day	1-3 hr/day	<1 hr/day
Frequency	Tinnitus	1.67	2.00	1.65	1.92
	Muffled hearing	2.00	1.21	1.35	1.65
	Ear fullness	2.17	1.36	1.71	1.73
	Difficulty in noise	3.00	1.71	2.12	1.69
	Hyperacusis	2.83	1.64	1.65	1.81
	Increase volume over time	3.17	1.43	1.94	1.65

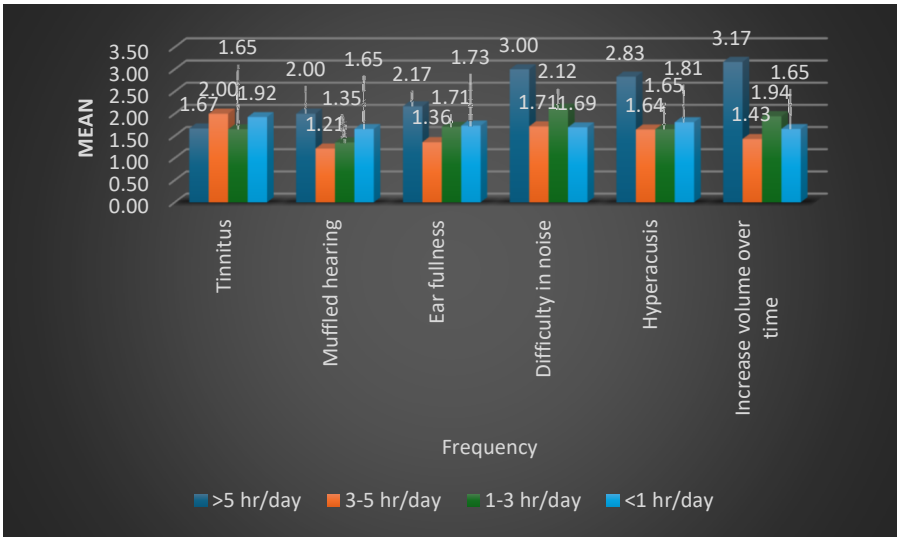

Fig 1: *Showing Mean Frequency of Self-Perceived Auditory Symptoms as a Function of Daily Music Listening Duration.*

Severity of Auditory Symptoms in association with PMD usage

The relationship between PMD and severity of auditory symptoms (Table 3 and Figure 2) revealed that Hyperacusis was the only auditory symptom where severity was significantly associated with listening duration (p = 0.038), with Group 1 reporting the highest mean severity (1.33, SD = 0.816). Other parameters like tinnitus (p = 0.102) and muffled hearing (p = 0.450) were not statistically significant.

Table 3: *Showing Mean Severity of Self-Perceived Auditory Symptoms as a Function of Daily Music Listening Duration.*

		>5 hr/day	3-5 hr/day	1-3 hr/day	<1 hr/day
Severity	Tinnitus	1.00	1.07	0.47	0.58
	Muffled hearing	0.83	0.64	0.35	0.31
	Ear fullness	0.67	0.50	0.71	0.62
	Difficulty in noise	1.00	0.57	0.76	0.46
	Hyperacusis	1.33	0.43	0.47	0.58
	Increase volume over time	0.67	0.50	0.53	0.38

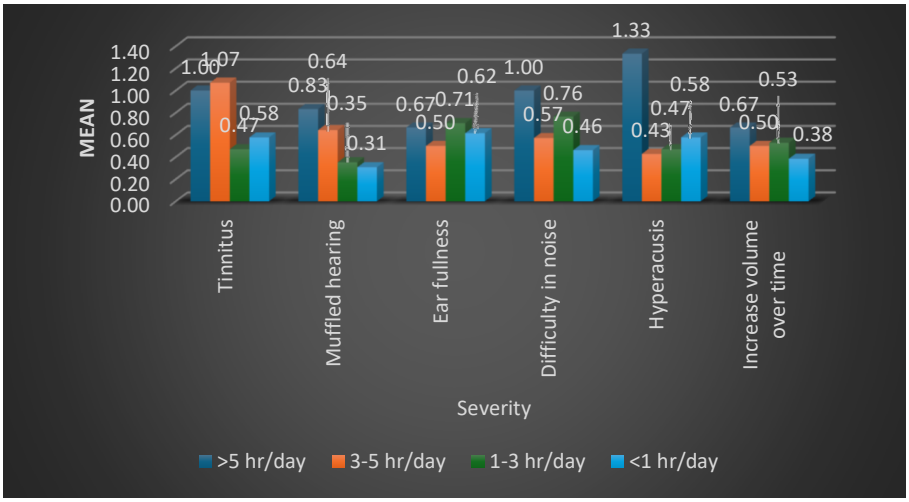

Fig 2: *Showing Mean Severity of Self-Perceived Auditory Symptoms as a Function of Daily Music Listening Duration.*

DISCUSSION

Findings from the present study offer vital information on the role of contemporary music listening habits as precursors to permanent HL. Principal finding was that heavier PMD use on daily basis was significantly associated with greater frequency of auditory symptoms like difficulty hearing in noise, hyperacusis, and the progressive need to increase device volume over time. By examining the correlation between the duration of music listening habits and the perceived auditory symptoms, present study revealed early warning signs that herald the onset of MIHL.

The presence of hyperacusis among the main complaints in both frequency and severity analyses is remarkable as it has recently emerged as one of the earliest signs of NIHL that occurs before a definite threshold shift. The greatest score frequencies were detected in the >5 hr/day group with a mean score of 1.33. This was in line with the findings of Beha et al, (2025) who found the prevalence of various symptoms such as hypersensitivity to sounds among headphone users. The findings were also in line with the work by Sulaiman et al. (2015) who found early high-frequency hearing changes among PMD users who were exposed for longer durations.

Significant association between listening duration and difficulty hearing in noise warrants clinical attention. Difficulty listening in noise is a hallmark early symptom of cochlear synaptopathy—sometimes described as "hidden HL"—in which normal audiometric thresholds coexist with deficits in temporal resolution and speech-in-noise perception. The pronounced frequency scores in Group 1 (mean = 1) and Group 3 (mean = 0.76) suggest a dose-dependent pattern rather than a purely linear one. The intermediate group (3–5 hr/day) reporting lower mean scores than the 1–3 hr/day group may reflect individual variability

in susceptibility, differences in listening patterns beyond gross duration, or the relatively small Group 1 sample size.

Volume escalation that is requirement for increasing device volume over time is a behaviorally measurable indicator of auditory desensitization or threshold shift. This symptom also showed the largest Kruskal-Wallis H value in the frequency domain ($H = 8.900$, $p = 0.031$) and the highest mean in Group 1 (mean = 0.67), which indicated that heavy users are progressively requiring greater volume output, a phenomenon that is consistent with subclinical habituation to loud noises. This phenomenon is also consistent with the observations of Zia et al. (2013), which indicated that post-exposure hearing symptoms were reported by PMD users in a developing country context despite being aware of the risks of NIHL.

Tinnitus, muffled hearing, and ear fullness did not reach statistical significance in either frequency or severity analysis. This is inconsistent with the findings of Hayat et al. (2022) who reported a 73% prevalence of tinnitus among PMD users and Byeon (2021) who found a positive association between earphone use and self-reported tinnitus among adolescents. However, several explanations are possible for the negative finding in our data set, intermittent nature of tinnitus is a key factor because it is a phenomenon that is heavily dependent on context. The use of a 5-point Likert scale may not have been sensitive enough to capture group differences. A second possible explanation is that the group with highest music exposure had least participants (n=6) may have contributed to the negative finding. A study with a greater sample size and a better distribution of heavy use may have been better able to capture group differences for tinnitus.

The fact that this result was not significant for muffled hearing is in line with Balajelini et al. (2021), who found no significant relationship between general mobile phone use and clinical hearing impairment.

Chodankar and Rane (2025) and Beha et al. (2025) have recently highlighted the importance of recreational audio device use as a non-occupational auditory hazard, and these results contribute to this literature supporting screening of young adults with heavy PMD use for early signs of auditory pathology. Gopal et al. (2019) investigation on safe listening behaviors highlighted individual susceptibility and exposure as key determinants of early auditory dysfunction, and these results suggest daily music listening duration as a measurable determinant of early auditory dysfunction in young adults with heavy PMD use.

SUMMARY and CONCLUSION

Present study investigated auditory changes as early signs of HL among PMD users by assessing the frequency and severity of self-reported auditory symptoms in relation to varying listening duration. The results showed that there were associations between the duration of music listening and auditory symptoms, with the highest symptom frequency among PMD users who used PMDs for >5 hours a day. The results were consistent with previous studies conducted by Sulaiman et al. (2015), Hayat et al. (2022) and Gajendran et al. (2025). The study concludes that PMDs usage for long hours can lead to early auditory stress and that auditory symptoms can be early signs of MIHL.

CLINICAL IMPLICATIONS

Results of current study have implications for audiologists and speech-language pathologists in assessing and identifying early signs of recreational noise-induced auditory damage. The auditory symptoms, i.e., difficulty in hearing in noise, hyperacusis, and increasing loudness, should be considered potential early signs of subclinical auditory damage even in the absence of any HL. PMD usage and auditory symptoms in discussion should be a part of routine clinical screening. Additionally, preventive measures should be taken to avoid permanent HL. Speech-in-noise testing, optoacoustic emission, and extended frequency audiometry can be used to assess and identify such early signs of auditory damage.

LIMITATIONS

Current study included 63 participants, although this is not very low, it is still limited and affects the statistical power. Moreover, the number of participants in Group 1 is only 6. This is important because the current study is trying to investigate the group with the heaviest usage. It is important to note that the group with the heaviest usage had the most severe symptoms. Furthermore, the current study relied on self-reporting for all the outcome measures. No objective measure using audiometry was included. It is important to note that the current self-reporting measure is subject to recall bias. Moreover, it is important to note that the current design is cross-sectional. As such, it is not possible to determine if the symptoms resulted from the heavy usage of PMD or if the people with the sensitivity to hearing had different usage habits.

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