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Original Research Paper

Audiology

UNRAVELLING THE NEXUS: INVESTIGATING HEADPHONE USAGE AND HEARING IMPAIRMENT AMONG COLLEGE STUDENTS

Manisha K Shibu*

Clinical Supervisor, Department of Audiology, Marthoma College of Special Education, Institute of Speech and Hearing, Badiadka, Perdala P.O, Kasaragod- 671551, Kerala *Corresponding Author

Mr. Nithin A K

Associate Professor (Audiology), Marthoma College of Special Education, Institute of Speech & Hearing, Badiadka, P.O. Perdala, Kasaragod-671551, Kerala.

ABSTRACT Noise-induced hearing loss (NIHL) is rising among young adults due to unsafe headphone use. Conventional tests may miss early auditory changes, making sensitive measures essential. **Methods:** A descriptive study was conducted among 60 college students aged 18–25 in Kasaragod, Kerala, who regularly used headphones. Data were collected using questionnaire, and audiological evaluations included Pure Tone Audiometry (PTA), Extended High-Frequency Audiometry (EHFA), and high-frequency Distortion Product Otoacoustic Emissions (HF-DPOAE) done. **Results:** PTA revealed normal thresholds in most participants, whereas EHFA detected elevated thresholds in over 50%. DPOAE showed reduced amplitudes in 21.66% at standard and 36.66% at high frequencies. Students listening for more than two hours daily exhibited greater high-frequency threshold shifts. **Conclusion:** Listening duration affected hearing more than volume, emphasizing EHFA and HF-DPOAE for early detection of auditory damage.

KEYWORDS : Headphone use, NIHL, EHFA, DPOAE

INTRODUCTION

Communication has always been central to human society, with hearing serving as a cornerstone for interaction and social development (Podury et al., 2023). Hearing, or auditory perception, is the process of detecting vibrations as pressure changes in the medium (Plack, 2014). Sound waves enter the ear canal, vibrate the eardrum, and are amplified by the ossicles before reaching the cochlea. The basilar membrane differentiates frequencies: high pitches at the base and low pitches toward the apex. Stereocilia movement generates electrical impulses transmitted by the auditory nerve to the brain, where sound is interpreted (U.S. Department of Health and Human Services, 2015). Any disruption in this pathway may result in hearing loss.

Noise-induced hearing loss (NIHL) is a leading preventable cause of auditory dysfunction, with about 500 million individuals globally at risk (Jo & Baek, 2024). Prolonged noise exposure damages sensory hair cells, leading to temporary or permanent threshold shifts (Natarajan et al., 2023). Temporary threshold shift (TTS) may recover within hours to days, while permanent threshold shift (PTS) is irreversible. The extent depends on both noise intensity and duration. Mechanisms include stereocilia damage, oxidative stress, reduced cochlear blood flow, neuroinflammation, and excitotoxicity, which may also cause hidden hearing loss (synaptopathy) undetected in audiograms (Natarajan et al., 2023). Early symptoms include tinnitus, muffled sounds, and difficulty hearing in noisy environments (Clercq et al., 2018).

Recreational noise, particularly from music, is a major NIHL contributor. Music-induced hearing loss (MIHL) develops with prolonged, loud listening, leading to tinnitus, hyperacusis, and pitch distortion (Zhao et al., 2011). The rising popularity of headphones, especially among adolescents, increases this risk (Reddy et al., 2018). The COVID-19 pandemic further aggravated exposure through prolonged online learning, remote work, and gaming, with sudden loud noises in games accelerating auditory damage (Ghoshmoulic & Deshmukh, 2024).

Adolescent NIHL is a growing public health concern. In the U.S., hearing loss among adolescents aged 12–19 increased from 14.9% (1988–1994) to 19.5% (2005–2006) (Shargorodsky et al., 2010). High-volume personal music device use is linked to communication difficulties, depression, reduced self-esteem, and social stigma (Hong et al., 2013). Improper earphone use also contributes to ear infections and cerumen accumulation, especially when devices are shared (Ghoshmoulic & Deshmukh, 2024). While some studies report no direct link between headphone use and NIHL, others found reduced Pure Tone Audiometry thresholds in regular users of personal listening devices (Sulaiman et al., 2013).

Despite the increasing prevalence of headphone use, there is limited evidence from Kerala on its effects. With NIHL risk on the rise, it is essential to assess headphone-related auditory changes among college students in Kasaragod district. This study therefore seeks to explore the relationship between headphone usage and the likelihood of hearing loss in this population, with specific objectives to investigate the impact of headphone use on hearing abilities and to examine how listening duration and volume levels contribute to the risk of hearing loss in young adults.

METHOD

A descriptive study was conducted to assess the impact of headphone use on hearing among college students in Kasaragod, Kerala. Audiological evaluations were performed in the audiology room at Marthoma College of Special Education. 66 individuals aged 18–25 years who regularly used headphones were recruited via stratified sampling from colleges across Kasaragod district. Inclusion criteria included age 18–25 years, headphone use >1 year, ≥1–2 hours/day at ≥50% device volume, and willingness to consent.

Exclusion criteria were history of otalgia, ear discharge, congenital hearing loss, prolonged noise exposure, neurological/psychological disorders, or inability to comply with study procedures.

The study was conducted in three phases. Phase 1 involved questionnaire development and validation by six audiology experts. Phase 2 included online questionnaire administration and participant selection. Phase 3 comprised audiological assessments including otoscopy, tympanometry (MAICO MI 34), Pure Tone Audiometry (0.25–8 kHz), Extended High-Frequency Audiometry (9–18 kHz) using MAICO MA 42, and Distortion Product Otoacoustic Emissions (DPOAEs; f1=65 dB SPL, f2=55 dB SPL, 1.5–12 kHz). Thresholds were classified per WHO guidelines, and DPOAE amplitudes <−10 dB SPL indicated reduced cochlear function.

Participants were divided into groups based on headphone usage duration (1–2 hours/day vs. >2 hours/day) and listening volume (medium vs. loud). Data were analyzed using IBM SPSS v27. Descriptive statistics summarized variables, normality was checked with the Shapiro-Wilk test, and the Mann-Whitney U test compared groups. Informed consent was obtained from all participants. Ethical approval was granted on 28/07/2023, IRB permission was secured, and participant confidentiality was maintained.

RESULT

Investigate The Relationships Between The Duration Of Headphone Usage And The Likelihood Of Developing Hearing Loss In The Young Population.

Effect of Headphone Usage duration (1 to 2 Hours vs. > 2 Hours) in Pure Tone Audiometry, revealed that there was a significant difference between the groups (1 to 2 Hours vs. Greater than 2 Hours) at 4KHz (U = 379.00, p = 0.004) in the right ear. There were no significant differences observed between the groups for the left ear in any of the frequencies (Table 1).

Table 1 Indicates Descriptive Analysis And Mann Whitney U Test Result Of Pure Tone Audiometry Frequencies By Headphone Usage Duration (1-2hours/day vs. > 2 hours/day)

Ear		250 Hz	500 Hz	1 KHz	2 KHz	4 KHz	8 KHz
	N	12	12	12	12	12	12
	Mean	8.7500	10.833	6.2500	5.8333	5.0000	5.4167
1 to 2 Hours	Median	10.000	10.000	5.0000	5.0000	5.0000	5.0000
	SD	6.0771	4.6871	4.3301	5.1492	4.7673	7.5252
	IQR	9	5	5	10	9	10
RT	N	48	48	48	48	48	48
Greater than 2 Hours	Mean	9.2708	10.520	9.1667	9.4792	10.416	9.3750
	Median	10.000	10.000	10.000	10.000	10.000	10.000
	SD	4.8366	5.2834	5.0878	6.3781	6.4274	6.8900
	IQR	5	10	5	5	10	10
	p value	0.829	0.592	0.103	0.073	0.004	0.088
	N	12	12	12	12	12	12
	Mean	7.5000	9.5833	6.6667	9.1667	4.5833	6.2500
1 to 2 Hours	Median	7.5000	10.000	7.5000	10.000	5.0000	5.0000
	SD	3.9886	3.9648	4.9236	4.1742	7.2168	8.5612
	IQR	5	0	9	9	10	9
LT	N	48	48	48	48	48	48
Greater than 2 Hours	Mean	8.6458	9.0625	8.6458	9.5833	9.1667	10.416
	Median	10.000	10.000	10.000	10.000	10.000	10.000
	SD	4.809	4.799	5.624	5.538	7.317	6.087
	IQR	5	5	5	10	10	10
	p value	0.477	0.677	0.333	0.771	0.084	0.051

Effect of Headphone Usage duration (1 to 2 Hours vs. > 2 Hours) in extended high frequency Audiometry, results revealed, there was a significant difference in the threshold between the groups (1 to 2 Hours vs. Greater than 2 Hours) at 9 KHz (U = 404.500, p = 0.029), 10 KHz (U = 398.000, p = 0.039), 16 KHz (U = 424.000, p = 0.012) and 18 KHz (U = 450.000, p = 0.002) in the right ear. In the left ear, at 9KHz (U = 405.500, p = 0.026), 11.2KHz (U = 413.000, p = 0.020), 12.5KHz (U = 461.500, p = 0.001), 14 KHz (U = 435.000, p = 0.006) and 16KHz (U = 418.500, p = 0.015), there was a significant difference observed between both the groups (Table 2).

Table 2 Indicates Descriptive Analysis And Mann Whitney U Test Result Of Extended High Frequency Audiometry By Headphone Usage Duration (1-2hours/day Vs. > 2 Hours/day)

Ear		9KHz	10 KHz	11.2 KHz	12.5 KHz	14 KHz	16 KHz	18 KHz
	N	12	12	12	12	12	12	12
	Mean	4.583	9.166	12.50	13.33	20.00	25.00	14.16
1 to 2 Hours	Median	.0000	10.00	10.00	15.00	20.00	17.50	10.00
	SD	9.159	7.017	7.833	10.29	15.07	19.18	12.40
	IQR	10.00	8.75	12.50	18.75	30.00	23.75	16.25
R T	N	48	48	48	48	48	48	48
	Mean	10.31	15.62	18.54	20.31	12.50	22.50	19.16
Greater than 2 Hours	Median	10.00	15.00	20.00	22.50	25.00	35.00	32.50
	SD	8.715	9.432	11.621	12.60	13.08	16.12	9.999
	IQR	13.75	15.00	20.00	20.00	10.00	23.75	15.00
	p value	0.026	0.039	0.071	0.063	0.185	0.012	0.002
	N	12	12	12	12	12	12	12
	Mean	5.000	6.250	9.166	9.583	12.50	22.50	19.16
1 to 2 Hours	Median	2.500	5.000	7.500	5.000	7.500	20.00	20.00
	SD	8.790	7.423	6.685	8.908	13.39	19.24	14.27
	IQR	10.00	13.75	10.00	10.00	23.75	38.75	27.50
L T	N	48	48	48	48	48	48	48
Greater than 2 Hours	Mean	10.93	12.39	16.97	21.45	25.41	37.18	26.25
	Median	10.00	10.00	20.00	25.00	25.00	35.00	30.00
	SD	8.608	11.060	10.80	11.010	13.20	16.40	9.196
	IQR	10.0	15.00	15.00	15.00	20.00	15.00	10.00
	p value	0.026	0.073	0.020	0.001	0.006	0.015	0.144

Effect of Headphone Usage duration (1 to 2 Hours vs. > 2 Hours) in Distortion Product Otoacoustic Emission (DPOAE), results revealed there were no significant differences (p >0.05) in the results for both the right and left ears in both the groups.

Effect of Headphone Usage duration (1 to 2 Hours vs. > 2 Hours) in high-frequency DPOAEs, results revealed a significant difference between the groups in right ear at 9 KHz (U =147.500, *p* = 0.009), 10 KHz (U =153.00, *p* = 0.013), and 11 KHz (U =177.00, *p* = 0.040). There were no significant differences between the groups (1 to 2 Hours vs. Greater than 2 Hours) in any of the frequencies in the left ear (Table 3).

Table 3 Indicates Descriptive Analysis And Mann Whitney U Test Result Of Distortion Product Otoacoustic Emission (DPOAE) – High Frequency By Headphone Usage Duration (1-2hours/day vs. > 2 hours/day)

Ear		9KHz	10 KHz	11KHz	12 KHz
	N	12	12	12	12
	Mean	4.367	4.192	4.283	0.608
1 to 2 Hours	Median	6.950	5.800	5.400	3.200
	SD	9.0870	7.8234	9.2639	10.0377
	IQR	9.7	7.7	8.8	14.0
RT	N	48	48	48	48
Greater than 2 Hours	Mean	-1.860	-1.579	-.698	-3.123
	Median	1.250	1.250	2.400	-.050
	SD	8.6974	8.3335	9.4104	9.7622
	IQR	9.9	12.0	11.3	17.2
	p value	0.009	0.013	0.040	0.226
	N	48	48	48	48
	Mean	0.875	3.458	3.358	1.950
1 to 2 Hours	Median	3.200	5.100	4.900	3.750
	SD	7.6061	6.5737	8.9852	7.0516
	IQR	4.4	5.3	7.8	6.4
LT	N	48	48	48	48
Greater than 2 Hours	Mean	-2.371	-1.756	-1.202	-1.190
	Median	1.050	2.300	1.950	1.300
	SD	10.1369	9.7432	10.2181	9.8561
	IQR	14.7	13.8	10.8	15.7
	p value	0.360	0.094	0.139	0.346

2.Investigate the relationships between the volume of headphone usage and the likelihood of developing hearing loss in the young population.

Effect of Headphone Usage Volume (Medium vs. Loud) in Pure Tone Audiometry, Extended High Frequency Audiometry, Distortion product otoacoustic emission (DPOAE) – Conventional, Distortion product otoacoustic emission (DPOAE) – High frequency results revealed there were no significant differences (*p* >0.05) in the results for both the right and left ears in both the groups (Medium vs. Loud).

DISCUSSION

The present study examined the impact of headphone use on auditory thresholds among college students, focusing on listening duration and volume. While conventional Pure Tone Audiometry (PTA) largely indicated normal hearing, Extended High-Frequency Audiometry (EHFA) and high-frequency Distortion Product Otoacoustic Emissions (HF-DPOAEs) detected early cochlear alterations. These results suggest that prolonged headphone use may contribute to subclinical auditory damage, particularly affecting high-frequency sensitivity before symptoms or measurable loss appear on standard audiometry.

Participants using headphones for more than two hours daily showed significantly elevated thresholds at 4 kHz in the right ear compared with shorter-duration users. This finding aligns with studies reporting a 4–6 kHz "notch" as an early marker of noise-induced hearing loss (NIHL) (Schmuziger et al., 2006; Suleiman et al., 2015). The basal cochlea, which processes high frequencies, is highly susceptible to noise-induced injury (SCENIHR, 2008). The right-ear predominance may be linked to ear preference during calls or music, anatomical variations such as ear canal size, or headphone placement.

EHFA revealed significant threshold differences between groups, particularly in the 9–18 kHz region, with the >2 hours/day group exhibiting poorer thresholds. Early cochlear changes are typically evident at extended high frequencies before conventional PTA shows abnormalities (Peng et al., 2007; Sulaiman et al., 2013). Over half the participants demonstrated elevated thresholds in at least one ear, with greater deterioration in the right ear. Similar outcomes have been reported by Meyer-Bisch (1996) and Peng et al. (2007), who found elevated EHF thresholds in personal listening device (PLD) users. These results underscore EHFA as a sensitive tool for early NIHL detection among young adults.

Although conventional DPOAEs showed no significant differences, HF-DPOAEs revealed reduced amplitudes at 9–11 kHz in the right ear among participants listening for more than two hours daily. Reduced amplitudes indicate early outer hair cell (OHC) dysfunction. These findings agree with Attias et al. (2001), who showed that OAEs detect cochlear impairment before audiometric thresholds change, and Mazlan et al. (2002), who emphasized their predictive role for future decline. Again, the right-ear effect may reflect ear dominance or asymmetric headphone use.

No significant differences were found between medium- and loud-volume groups across PTA, EHFA, or DPOAEs. The average listening level (~58 dB HL) was below the hazardous threshold of 85 dB HL associated with NIHL (Mazlan et al., 2002). Noise-cancelling technology may further reduce the need for high volume (Sarow, 2024). These findings differ from Catalano and Levin (1985), who reported excessive exposure, but agree with Wong et al. (1990) and Almeida et al. (2020), who observed generally safe listening levels despite auditory complaints.

CONCLUSION

Listening duration emerged as a more critical determinant of early auditory risk than listening volume. Extended High-Frequency Audiometry and HF-DPOAEs proved highly sensitive for detecting subtle cochlear changes before conventional PTA. These findings emphasize the importance of including high-frequency assessments in routine audiological practice and support awareness campaigns that highlight safe listening durations to prevent early-onset NIHL in young populations.

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