Acoustic trauma inducing 'low frequency' sensorineural hearing loss; A cross-sectional study among medical students using Pure Tone Audiometry

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Abstract

Objectives: This study aimed to ascertain current practices prevalent among medical students using electroacoustic devices. We also aimed to determine pattern and frequency of hearing loss among medical students. Design: Cross-sectional Participants: Students of 3rd year and 4th year MBBS at Jinnah Sindh Medical University, Karachi, Pakistan were included. Data collection dated from December 2019 till February 2020 using convenience sampling technique. Setting: Students were invited to ENT OPD, Jinnah Postgraduate Medical Centre, Karachi. Through a structured proforma, we recorded practices regarding electroacoustic devices. We investigated hearing of medical students by tuning fork tests and Pure Tone Audiometry. Main Outcome Measures: Using SPSS software version 23 we applied Chi square test, Pearson correlation and independent t test at 95% CI and p=<0.05 as significance level. Results: A total of 221 students fulfilled inclusion criteria. 96.4%(n=213) regularly used electroacoustic devices. Students mostly used insert type earphones connected with a smartphone. More than 30% of medical students demonstrated low frequency (0.25-0.5kHz) sensorineural hearing loss (SNHL). Pearson correlation yielded strong positive correlation with hearing loss and years of exposure(p=<0.001). Male students used electroacoustic devices more frequently than female students(p=0.01). However, we did not observe significant difference between their mean thresholds. Conclusion: Acoustic trauma has been conventionally described to affect higher frequencies. We found low frequency SNHL among majority of students. This indicates that specific type of acoustic trauma can affect particular frequencies on audiogram. KEY WORDS: Low frequency hearing loss, medical students, Pure Tone Audiometry, personal listening devices, hearing thresholds, noise induced hearing loss, sensorineural hearing loss

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KEY POINTS:

1. Noise exposure either occupational or recreational is the leading preventable cause of hearing impairment
2. 96.4% of medical students used electroacoustic devices with insert type earphone being the most common connected to a smartphone
3. Low frequency (250-500Hz) sensorineural hearing loss was found among more than 30% of medical students
4. Most of the students having hearing loss at Pure Tone Audiometry were unaware of their hearing loss and did not complain tinnitus
5. Specific bandwidth acoustic trauma can affect audiometric frequencies other than conventionally described hence require management accordingly

INTRODUCTION:

Hearing impairment is the most common sensory disability found among human beings. [1] After aging, noise exposure either occupational or recreational is the leading cause. Noise induced hearing loss (NIHL) once established, is irreversible, only partly manageable though totally preventable. [2] WHO estimated that 1.1 billion young people (12-35 years) are at risk of hearing loss due to recreational noise exposure. [3]

Leisure time noise exposure has become a great concern of public health. Occupational noise hazards have been evidently defined and protective measures are adopted globally. But no such preventive methods are clearly devised for the protection of dreadful effects of recreational noise. [4] Noise induced acoustic trauma has been conventionally described to effect high tone frequencies when assessed by Pure Tone Audiometry (PTA). This high tone frequency loss is graphical representation of response of hair cells in cochlear base. Based on the guidelines of Health and Safety Executive it was proposed that the frequency where notch appears in a pure tone audiogram suggests the specific type of noise to which one was exposed. Intense low frequency noise can cause maximal loss at lower frequencies while intense high frequency sound can predominantly affect higher frequencies. [5]

Hearing difficulty not only hinders the functional capacity of an individual but also affects the intellectual health of a potential mind. A large population-based study discovered that low frequency hearing loss (0.25-0.5kHz) among young and middle age people[6] while generalized hearing loss among elderly population considerably affect mental health and quality of life.[7]

Objectives:

Present study intended to determine the pattern and frequency of hearing loss among medical students using electroacoustic devices. We also aimed to ascertain the current practices followed by medical students regarding use of electroacoustic devices.

METHODS:

Operational Definition: Electroacoustic devices refer to transducers which convert electrical signals into sound signals e.g., handsfree, headphone, Bluetooth handsfree etc.

Design:

Our study had a cross-sectional design. We conducted this study among medical students at Jinnah Sindh Medical University (JSMU), Karachi. Data collection dated from December 2019 till February 2020. Institutional Review Board (IRB) of JSMU approved the study (Ref: JSMU/IRB/2019/-215).

Participants:

Inclusion criteria were students of 3rd year and 4th year MBBS, either male or female, age between 19-24 years and individuals with normal hearing. Whereas, exclusion criteria comprised of students not giving consent, those with prior diagnosis of hearing loss, type I diabetes mellitus, acute upper respiratory tract infections, acute or chronic ear infections, allergic rhinitis, positive history for ototoxic drugs, past medical history of meningitis, enteric fever in childhood, past surgical history for cleft lip or palate, using hearing aid and family history of hearing loss.

Sample size:

We employed non-probability convenience sampling technique. For sample size calculation we used open Epi calculator. A related study reported 84% prevalence of hearing loss among mobile phone users.[(10)] Using this information at 95% CI and error of ±5%, we figured out sample size of 194.

Setting and Hearing Assessment:

We invited students to the Ear, Nose and Throat (ENT) OPD, Jinnah Postgraduate Medical Centre, Karachi (JPMC) for tuning fork tests (TFTs) and PTA. We explained whole procedure to the students and acquired informed consent on individual basis. Using a structured proforma, we collected sociodemographic information, electroacoustic device usage history and relevant medical and surgical history from each participant. Sociodemographic data included age, gender, year of study and residence. We also asked about type of electroacoustic device (insert type earphones, supraural headphones or Bluetooth handsfree), per day duration, source to which these devices were connected and using since when.

Postgraduate trainees of ENT performed Rinne test and Weber test on each participant with a 512 Hz tuning fork. We regarded centralized hearing of the tuning fork as normal while base of tuning fork placed at forehead or upper incisors. For Rinne test we applied loudness comparison technique. In which we kept the base of tuning fork on mastoid process to assess bone conduction (BC). For air conduction (AC) we located prongs of tuning fork lateral to the external auditory canal (EAC). We considered positive (normal) result when air conduction proved better than bone conduction (AC >BC).

Immediate next to TFTs we sent our students for PTA. We instructed them regarding the test procedure. Trained audiometrists performed PTA in a soundproof booth. They assessed each participant first for air conduction (AC) at octave frequencies i.e. 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz. To differentiate the type of hearing loss from conductive to sensorineural, they also investigated bone conduction when AC thresholds were beyond normal range. Significant air-bone gap was considered greater than 15 dB (decibel) between air and bone conduction thresholds. Test frequencies for bone conduction were from 500 Hz to 4000 Hz. They generated the findings of PTA on an audiogram. To classify hearing loss at each frequency we applied WHO grading of hearing impairment. Where normal was 25 dB or less, mild hearing loss from 26-40 dB, moderate from 41-60 dB, severe from 61-80 dB while profound hearing loss including deafness was 81dB or greater.

Main Outcome Measures:

We did data entry and analysis using IBM SPSS Statistics, version 23 (IBM Corp.). We carried out descriptive statistical analysis to obtain the frequencies, mean and standard deviation (S.D). We applied Chi square test and Fischer exact test to find the association of electroacoustic device use with independent variables like gender and year of study. We utilized Pearson correlation to find the association between hearing loss and electroacoustic device usage. We also employed independent t test to compare the means at octave frequencies among male and female students. We kept p value <0.05 and 95% CI as level of statistical significance. We described our findings using STROBE reporting guidelines.

RESULTS:

A total of 246 students participated in the study. However, only 221 satisfied the inclusion criteria. We excluded rest as exclusion criteria. Mean age of students was 21 years (S.D: ±0.927; Range: 20-24). Out of 221, 74.7% (n=165) were females while 25.3% (n=56) were males. Students from 3^{rd} year and 4^{th} year were almost equal (49.3% Vs. 50.7% respectively). Among recruited sample, 96.4% (n=213) were regularly using electroacoustic devices. With insert type earphones being the most common (73.8%; n=163). Followed by Bluetooth handsfree (14%; n=31) and supra-aural headphones (5%; n=11). Students reported smartphone (90%; n=199) as the most frequently used source for listening to these devices, followed by laptop (32.6%; n=72) and tablet (5.9%; n=13).

Listening duration of 44.8% (n=99) medical students stood between one to two hours per 24 hours. Nevertheless, 19.5% (n=43) exceeded three hours per day. In our study, 26.2% (n=58) undergraduates practiced high volume setting for listening. Near half of the users (47.9%; n=106) were experiencing electroacoustic devices beyond five years. Wherein 22.6% (n=24) were enjoying their use for 10 or more years.

We found statistically significant difference among average listening duration between male (165.77 ± 103.39 minutes) and female students (120.09 ± 121.76 minutes) t (219) = 2.516, p =0.013. We did not observe any significant difference for volume setting (p=0.851) and duration since years (p=0.145) with gender. Likewise, no statistically significant difference existed between volume setting preference (p=0.977) and duration since years (p=0.820) with year of study. TABLE I represents the listening habits of our study sample.

Among electroacoustic device users Rinne test was negative (BC >AC) in 3 ears on right side. Weber test was lateralized in 7% (n=15) to right ear and same for the left ear. Almost one third of medical students who were using electroacoustic devices suffered mild sensorineural hearing loss (SNHL) at frequencies 250 Hz (31.9%; n=68) and 500 Hz (31.5%; n=67) in right ear. In left ear, 29.1% (n=62) at frequency of 250 Hz while 23% (n=49) at 500 Hz fall under mild SNHL. In our study only 5.6% (n=12) and 6.6% (n=14) students suffered mild (sensorineural) hearing loss at 4kHz and 8kHz in right ear, respectively. There was no air bone gap in any of the cases. TABLE II summarizes the hearing thresholds of electroacoustic device users at audiometric octave frequencies.

We applied Pearson correlation to find association of hearing loss with per day listening duration and listening years. We did not find any significant correlation with per day duration. However, we noticed statistically significant association between listening years and hearing loss. Positive correlation existed at 500Hz (p=<.001), 1000Hz (p=<.001), 2000Hz (p=<.001) in right ear. In left ear, there was significant positive correlation at 250Hz (p=<.001), 500Hz (p=<.001), 1000Hz (p=0.04) and 2000Hz (p=<.001).

Independent t test carried at 95% CI did not show any significant difference between mean hearing thresholds of male and female students. TABLE III displays the means at octave frequencies among male and female students.

DISCUSSION:

To the best of our information (based on published literature), present study is the largest to be conducted in Pakistan among medical students using PTA for hearing assessment. Our study comprised 221 participants with age group between 20-24 years (Mean±S.D: 21±0.927). Similar range was mentioned in comparable studies. [11,12] Male to female ratio was 1:3. This represents comparative larger number of female students studying in medical colleges of this region.

We found a high prevalence (96.4%) of electroacoustic device usage amongst medical students. Rekha et al.

reported personal listening device (PLD) use by medical students with frequency of 86.1% on daily basis [13]. A study from Hamadan University of Medical Sciences, Iran stated 91.2% prevalence of PLD use.[14] A recent study conducted by Basu et al. narrated 5.4% medical students never used an electroacoustic device.[15] In our study only 3.6% students denied their use of personal listening devices. This high prevalence of electroacoustic device use can be attributed to current educational practices followed by medical students. Such as online lectures and 3D animated content available for vast academic topics.

Participants of our study preferred insert type earphones. The most widely used source was smartphone. Parallel studies observed the similar preferences. [13,14] A study from Jeddah stated that almost all the medical students used a smartphone.[16] Easy availability of smartphones, comfortable portability along with broad range compatibility for wide variety of earphones are the possible attractions making them the first choice among their users.

Our study showed that hearing impairment was strongly correlated with the prolonged exposure to listening devices. Near half of our participants were using electroacoustic devices for more than five years. However, previous studies reported variable results for association between hearing loss and listening duration.[11,12] Volume preferences did not vary considerably from alike studies. [13,14]

We found less prevalence of self-reported hearing symptoms (tinnitus 9.5%, vertigo 2.7%) in comparison with other studies.[8,13,14] Interestingly, we also noted that majority of medical students who displayed hearing loss in PTA were not experiencing tinnitus and even not aware of their hearing impairment. For example, in right ear at 500Hz, 88.4% (n=61) having mild hearing loss did not complain tinnitus.

Upon PTA, around one third of our medical students showed mild sensory hearing loss at lower frequencies (250 Hz and 500 Hz). Similar pattern of low frequency hearing loss was detected in a study conducted among 56 medical students [9]. A study was performed among 136 employees of a Malaysian telecommunication company. This revealed impaired hearing in 21.2% of the personnel. An equal distribution of hearing loss in low, middle, and high frequencies was noticed.[17] The possible explanation to this distinctive pattern of low frequency loss might be due to the intensity of noise to which they were exposed as indicated by McBride et al.[5] The participants of our study were medical students who might be using electroacoustic devices for educational purposes mostly. The staff of telecommunication company used headphones for receiving phone calls which involve conversational frequencies. The intensity, pitch and bandwidth of sound generated in such content differ considerably from that produced in music and occupational noise. In addition, a prolonged exposure up to 8 hours per day over 85dB (Permissible Exposure Limit) is required to produce characteristic pattern of NIHL. [18] None of our study participants reached this limit hence traditional notch at frequency of 4kHz was not found among most of the users.

In our study we found mild hearing loss (26-40dB) in majority of cases. Cochlear apex is responsible for perceiving low frequency sounds. Halpin et al. demonstrated that audiogram inherits some limitations when assessing low frequency SNHL especially when high frequency thresholds are within normal range. This is due to asymmetric spread of stimulus along basilar membrane of cochlea. Healthy hair cells in the middle or base of cochlea get stimulated and generate the response for lower frequencies. The upper limit being 50dB in such cases.[19]

This study has certain unavoidable limitations owing to its cross-sectional study design and non-probability sampling technique. This was a single centre study hence we cannot generalize the findings. This study therefore suggests correlation but cannot confirm causation.

CONCLUSION:

We investigated the hearing thresholds of medical students using PTA. Majority of students demonstrated low frequency SNHL. These findings are contrary to the conventionally described high frequency hearing loss in noise trauma. This indicates that acoustic trauma not only affects high frequencies but can also impact other hearing thresholds as well and needs hearing rehabilitation accordingly. Moreover, protective measures should be taken to avoid this type of hearing loss which is completely preventable.

CONFLICT OF INTREST:

Authors declare no conflict of interest

FUNDING STATEMENT:

Authors have no funding disclosures to declare

DATA AVAILIBILTY STATEMENT:

The data that support the findings of our study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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TABLES:

TABLE I. Listening Habits of the Study Sample

Total study population (N)	221
Characteristics	No. (%)
Mean age (S.D)	21 (±0.927)
Gender	
Male	56 (25.3)
Female	165 (74.7)
Year of study	
3^{rd} year	109 (49.3)
4^{th} year	112 (50.7)
Electroacoustic device use since	
Never	8 (3.6)
1-2 years	35 (15.8)
3-4 years	72 (32.6)
5-6 years	52 (23.5)
>7 years	54 (24.4)
Volume level	
No use	8 (3.6)
Low	10 (4.2)
Medium	145 (65.6)
High	58 (26.2)
Listening time per day	
No use	8 (3.6)
Less than 1 hour	39 (17.6)
1-2 hours	99 (44.8)
2-3 hours	32 (14.5)
>3 hours	43 (19.5)
Other symptoms (if any)	
Tinnitus	21 (9.5)
Vertigo	6 (2.7)
Earache	11 (5)
Headache	39 (17.6)

TABLE II: Hearing Thresholds of Pure Tone Audiometry at Octave Frequencies among Elec-

troacoustic Device Users (n=213)

Test Frequency	Normal (<25dB)	Mild HL11HL= Hearing Loss (26-40dB)	Moderate HL (41-60dB)	Severe HL (61-80dB)
Right ear 250 Hz	139 (65.3)	68 (31.9)	6 (2.8)	-
Right ear 500 Hz	145 (68.1)	67 (31.5)	1 (0.5)	-
Right ear 1000 Hz	198 (93)	15 (7)	-	-
Right ear 2000 Hz	202 (94.8)	10 (4.7)	1 (0.5)	-
Right ear 4000 Hz	200 (93.9)	12 (5.6)	1 (0.5)	-
Right ear 8000 Hz	196 (92)	14 (6.6)	2 (0.9)	1 (0.5)
Left ear 250 Hz	150 (70.4)	62 (29.1)	1 (0.5)	-
Left ear 500 Hz	163 (76.5)	49 (23)	1 (0.5)	-
Left ear 1000 Hz	199 (93.4)	13 (6.1)	1 (0.5)	-
Left ear 2000 Hz	199 (93.4)	12 (5.6)	1 (0.5)	1 (0.5)
Left ear 4000 Hz	198 (93)	13 (6.1)	1 (0.5)	1 (0.5)
Left ear 8000 Hz	194 (91.1)	16 (7.5)	2 (0.9)	1 (0.5)

TABLE III: Mean thresholds at octave frequencies among male and female students

Test frequency	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Right ear	**Right ear**	**Right ear**	**Right ear**	**Right ear**	**Right ear**	**Right ear**
Male	26.66	23.98	22.02	21.0	22.21	22.86
Female	27.10	24.88	22.82	20.58	21.41	22.09
P value	0.63	0.31	0.20	0.56	0.35	0.46
Left ear	**Left ear**	**Left ear**	**Left ear**	**Left ear**	**Left ear**	**Left ear**
Male	24.89	24.34	22.02	21.86	22.86	22.34
Female	26.2	24.38	21.78	20.62	20.88	22.22
P value	0.11	0.96	0.79	0.31	0.09	0.90