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An exploration of lifestyle induced hearing loss risk and hearing acquity among normal hearing individuals

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Abstract
The present study aimed to investigate the relationship between auditory thresholds and Lifestyle Induced Hearing Loss Risk Questionnaire (LIHLRQ). In this study 60 participants in the age range of 19 to 27 years (mean age = 21.59 years, SD = 1.50) with normal hearing sensitivity were categorized in three hearing loss risk groups (no risk, mild risk and moderate risk) based on LIHLRQ scores. The auditory profile at low frequency pure-tone average (LFPTA) and extended high frequency pure-tone average (EHFPTA) of the participants in the three risk groups were compared with respective LIHLRQ scores. Kruskal-Wallis test findings indicated that there were significant differences across the three groups based on LIHLRQ scores. One way ANOVA test revealed that the LFPTA- Right ear was lowest for the participant categorized under 'no risk group. Further, the thresholds were highest for the group of participants with moderate risk. Similar trend was also noted for Low frequency PTA-Left ear. No significant differences were seen with respect to extended high frequency PTA among the three groups. The present study shows that there is a significant difference in LIHLRQ scores among participants with no risk, mild risk and moderate risk for hearing loss. It also shows that there exist a significant difference in Low frequency pure tone average of individuals with no risk for hearing loss and individuals with risk for hearing loss. Hence it can be concluded that LIHLRQ scores provide early indications of changes in hearing thresholds.

Keywords: Lifestyle induced hearing loss risk, low frequency PTA, extended high frequency PTA

Introduction
Adequate hearing sensitivity is an important prerequisite for effective verbal communication. Presence of any degree or type of hearing loss, not only affects one's ability to communicate efficiently but it also impacts the quality of life adversely. As per WHO, the reported global prevalence of hearing loss was 466 Million in the year 2018 [1]. Of this 432 million were adults with hearing loss. This prevalence figure is predicted to rise in future and become 630 million by 2030 and 900 million by 2050 [1].

Evidence from research studies indicate that 17% of teens may have lost some of their hearing probably due to noise exposure and are not aware of it [2]. In a survey study it is also reported that exposure to noise, inappropriate auditory lifestyle / health belief and significant ear related medical history are the crucial domains which increases the risk of hearing loss at a younger age [3].

As conventional audiometry is the foremost audiological procedure to rule out the presence of hearing loss at speech frequencies. Also, extended high frequency audiometry is reportedly an effective measure to probe the presence of hearing loss at an early stage following ototoxicity and Noise exposure. Hence, in the present study it undertaken to find the relationship between the LIHLRQS and subjective measure of hearing threshold.

Aims of the study
The aims of the study include
a) To compare the EHFPTA across LIHLRQ categories
b) To compare LIHRQ score across LIHLRQ categories
c) To compare the LFPTA across LIHLRQ categories
d) To find the correlation between LFPTA and LIHLRQ score across categories.

e) To find the correlation between EHFPTA and LIHLRQ score across categories

Method: The objective of this study was to explore the correlation between LFPTA / EHFPTA and LIHRQ score among individuals with normal hearing with or without risk for hearing loss.

Participants: Present study included 60 university students (17 males and 43 females) in the age range of 19 to 27 years (mean age = 21.59 years, SD = 1.50). Inclusion criteria for participants in the study was hearing within normal limits. Their hearing thresholds in both ears were <25dB HL (WHO) at octave intervals between 250 Hz and 8 kHz. Participants with no complaints or history of any neurological and psychological deficit were included in the study. All the participants were having good socio-economic status with minimum qualification of senior secondary level and proficiency in English language.

Instruments and Test Material: A calibrated single channel Pure tone audiometer (AD629,Interacoustics) with HDA 300 headphones and B-71 bone vibrator and was used to perform the conventional Pure tone audiometry test at frequencies 0.5kHz, 1kHz, 2kHz, 4kHz and to perform extended high frequency pure tone audiometry at 10kHz, 12.5kHz,14kHz and 16kHz frequencies. A questionnaire on LIHLRQ (developed by Dass A, Sanju H, Kumar, A 2018) was used to categorize the participants into different hearing loss risk categories. The LIHLR questionnaire has 28 questions categorized into three sections i.e. Noise Exposure (NE), Lifestyle and Auditory Health Belief (LAHB) and Ear Related Medical History (ERMH). NE section had nine questions related to noise exposure and use of hearing protection device. All questions of NE section were having three forced choice responses i.e. yes, no and sometimes. LAHB section was having 11 questions, related to lifestyle and auditory health belief. Similar to NE section, LAHB section also had three forced choice responses i.e. yes, no and sometimes except two questions. ERMH section consisted 8 questions with two forced choice responses i.e. yes and no.

Test Environment: All of the assessments were conducted in an air-conditioned sound treated double room.

Procedure: The study was conducted in three stages
Stage 1: Administration of LIHLRQ among participants.
Stage 2: Selection of participants under different groups based on LIHLRQ score categories; Group A: No risk for Hearing loss with total LIHLRQ score in the range of 0-6, Group B: Mild risk for hearing loss with total LIHRLQ score in the range of 7-16, Group C: Moderate risk for hearing loss with total LIHLRQ score in the range of 17-26 and Group D: High risk for Hearing loss with total LIHLRQ score >26. There were 14 participants in Group A, 32 participants in Group B, 14 participants in Group C and zero in Group D

Stage 3: Conventional audiometry and extended high frequency audiometry test was performed on each of the participant in all the groups.

Analyses: The data were analyzed using Statistical Package for the Social Sciences (SPSS) version 21 software. Descriptive and inferential analyses were conducted to study the differences across groups in LIHLRQ scores, LFPTA and HFPTA. Shapiro-Wilk's test was administered to see whether the data followed normal distribution. It was noted conducted. However, HFPTA, 'noise exposure', 'lifestyle and auditory health belief' and 'ear related medical history' scores that LIHLRQ scores and LFPTA followed normal distribution and hence one-way ANOVA was did not follow normal distribution. Hence, non-parametric statistics were conducted. Further, the correlation was also analyzed between LFPTA as well as HFPTA and LIHLRQ scores.

Results
The results are provided under the following sub-sections:
a) Comparison of the LIHLRQ Score across three groups,
b) Comparison of 'noise exposure', 'lifestyle and auditory health belief' and 'ear related medical history' scores across the three groups
c) Comparison of LFPTA of right and left ears across the three groups
d) Correlation of LFPTA of right and left ears with LIHLRQ scores
e) Comparison of EHFPTA of right and left ears across the three groups
f) Correlation of EHFPTA of right and left ears with LIHLRQ scores.

Comparison of LIHLRQ score across three groups

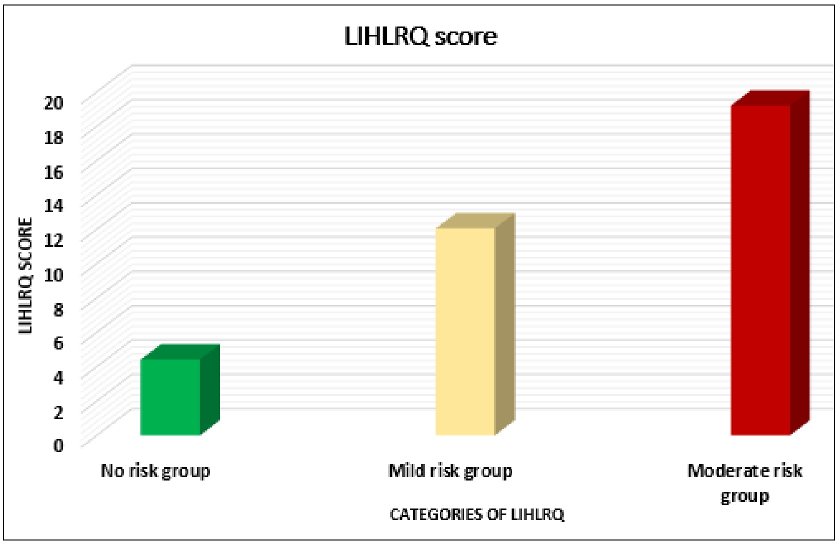


Fig 1: *LIHLRQ score across three groups.*

Mean, median, SD and percentile scores on LIHLRQ for Groups A, B, and C are depicted in Table 1. It was noted that there were differences in all the three groups. The participants with no risk (Group A) had least scores and those with moderate risk scored maximum in LIHLRQ.
Further, to compare these LIHLRQ scores across the three groups statistically, one-way ANOVA test was carried. The results indicated that there was a significant main effect of associated risk factor [$F(2, 57) = 136.52$, $p< 0.01$] on the mean LIHLRQ scores across the 3 groups. Further, a pair-wise comparison with Bonferroni correction was conducted. The results are provided in the Table 1. It was indicated that there were significant differences between all the three groups.

Table 1: Comparison of LIHLRQ scores for three groups of participants

Group	N	Mean (SD)	Median (Q1-Q3)	*p*
No risk	14	4.42 (2-6)	5 (3-6)	< 0.001*
Mild risk	32	12.06 (7-16)	12 (10.25-14)	
Mild risk	32	12.06 (7-16)	12 (10.25-14)	< 0.001*
Moderate risk	14	19.21 (17-26)	18.50 (17-19.50)	
No risk	14	4.42 (2-6)	5 (3-6)	< 0.001*
Moderate risk	14	19.21 (17-26)	18.50 (17-19.50)	

Note: *=Significant with $p<0.05$; SD=Standard deviation; Q1=25th percentile; Q3=75th percentile

Comparison of ‘noise exposure’, ‘lifestyle and auditory health belief’ and ‘ear related medical history’ across groups

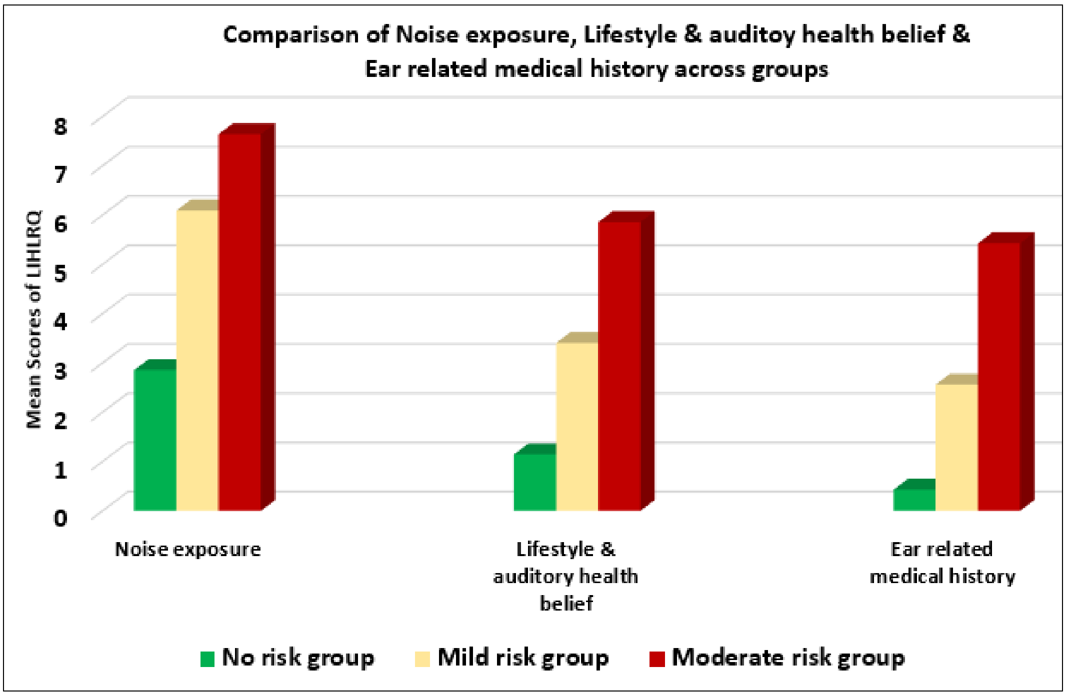


Fig 2: Comparison of Noise exposure, Lifestyle & auditory health belief & Ear related medical history across groups

Table 2, depicts the mean, SD, median, and percentile values for each of the groups. Graphical representation of the mean scores and SD values for the NE, LAHB and ERMH are shown in Figure 2. The median scores were noted to be different between all the three groups for ‘noise exposure’, ‘lifestyle and auditory health belief’, as well as ‘ear related medical history’. It was noted that ‘noise exposure’, ‘lifestyle and auditory health belief’ and ‘ear related medical history’ scores were minimum for participants with no risk. Additionally, these scores were maximum for the participants with moderate risk.
To analyze whether the differences were statistically significant, Kruskal-Wallis tests were conducted. The results indicated that there were significant differences across the three groups in scores on ‘noise exposure’ [$H(2) = 29.66$; $p<0.01$], ‘lifestyle and auditory health belief’ [$H(2) = 30.82$; $p<0.01$], and also ‘ear related medical history’ [$H(2) = 27.95$; $p< 0.01$]. Thus, Mann-Whitney U test was conducted to see the differences between all the three groups. The results revealed that there were statistically significant differences between the three groups for all the three categories that is NE, LAHB and ERHM (Table 2).

Table 2: Comparison of 'noise exposure', 'lifestyle and auditory health belief' and 'ear related medical history' between the three groups

	Group	Mean	SD	Median	Q1-Q3	U	p
Noise Exposure	No risk	2.86	0.77	3	2-3.25	26.50	<0.001*
	Mild risk	6.09	1.87	6	5-7		
	Mild risk	6.09	1.87	6	5-7	125.00	0.005*
	Moderate risk	7.64	2.20	8	6-9		
	No risk	2.86	0.77	3	2-3.25	6.00	<0.001*
	Moderate risk	7.64	2.20	8	6-9		
Lifestyle and auditory health belief	No risk	1.14	1.09	1	0-2	60.50	<0.001*
	Mild risk	3.41	1.72	3	2-4.75		
	Mild risk	3.41	1.72	3	2-4.75	71.00	<0.001*
	Moderate risk	5.86	1.74	6	4.75-7		
	No risk	1.14	1.09	1	0-2	2.00	<0.001*
	Moderate risk	5.86	1.74	6	4.75-7		
Ear related medical history	No risk	0.43	0.85	0	0-0.50	87.50	<0.001*
	Mild risk	2.56	2.23	2	0.50-4		
	Mild risk	2.56	2.23	2	0.50-4	78.50	<0.001*
	Moderate risk	5.42	1.99	6	4-6.5		
	No risk	0.43	0.85	0	0-0.50	3.00	<0.001*
	Moderate risk	5.42	1.99	6	4-6.5		

Note: *=Significant with $p<0.0167$; SD=Standard deviation; Q1=25th percentile; Q3=75th percentile

Comparison of LFPTA for right and left ears across the three groups

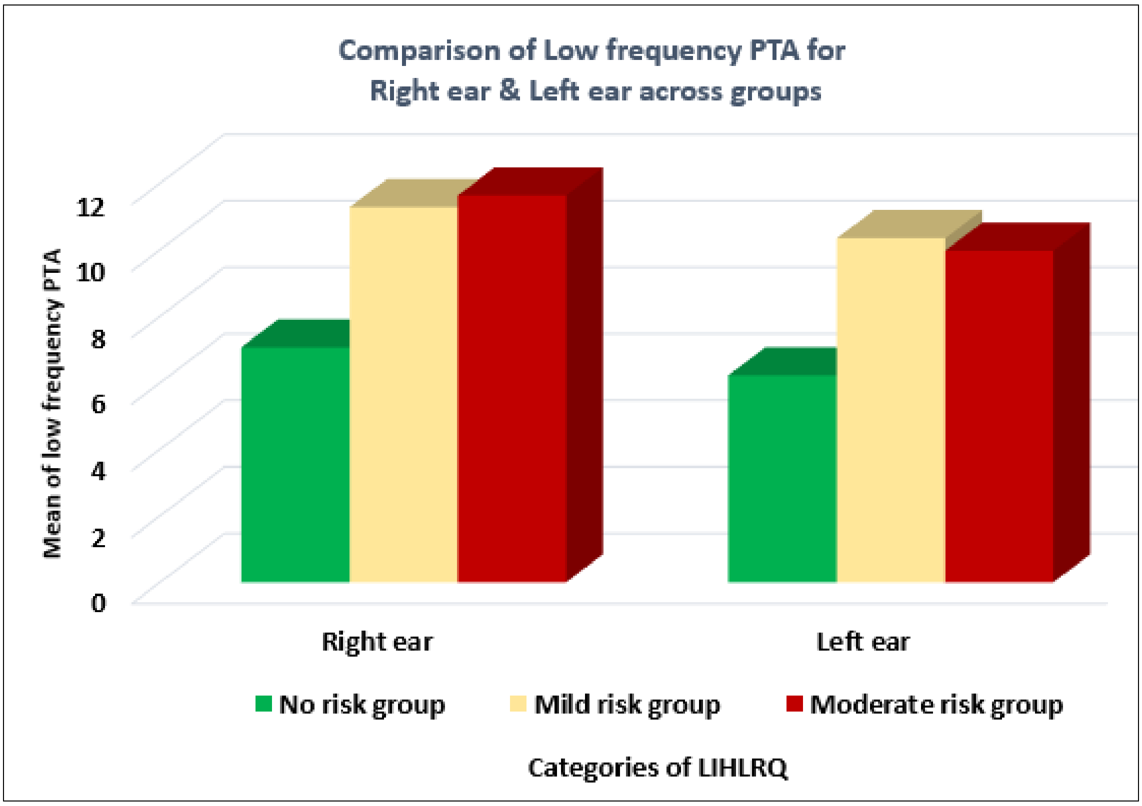


Fig 3: Comparison of Low frequency PTA across groups

Mean, SD, median, and percentiles of LFPTA for right ear and left ear are provided in table 3 for all the three groups of participants. The differences were noted between participants with 'no risk', 'mild risk', and 'moderate risk' for both LFPTA-Right ear as well as LFPTA-Left ear. The LFPTA-Right ear was lowest for those with 'no risk'. Further, the thresholds were highest for the group of participants with moderate risk. Similar trend was also noted for LFPTA-Left ear.

These differences were compared using one-way ANOVA and it was noted that there was a significant main effect of risk factor on LFPTA for right ear [$F(2, 57) = 6.59$; $p = 0.003$] an also for left ear [$F(2, 57) = 6.90$; $p = 0.002$]. Thus, the pair-wise comparisons were done and the results are depicted in table 3 with Bonferroni correction for multiple group comparison. As shown in the table, it was noted that there were significant differences between group with 'no risk' and 'mild risk' and also 'no risk' and moderate risk. However, there was no significant difference between group with 'mild risk' and 'moderate risk'.

Table 3: Comparison of LFPTA of right ear and left ear within the three groups.

	N	LFPTA-Right ear			LFPTA-Left ear		
		Mean (SD)	Median (Q1-Q3)	*p*	Mean (SD)	Median (Q1-Q3)	*p*
No risk	14	7.07 (3.96)	6.60 (4.57-10.40)	0.004*	6.22 (4.31)	6.60 (2.87-8.72)	0.002*
Mild risk	32	11.27 (4.23)	10.80 (8.30-15)		10.35 (3.58)	10 (8.30-12.89)	
Mild risk	32	11.27 (4.23)	10.80 (8.30-15)	1.0	10.35 (3.58)	10 (8.30-12.89)	1.0
Moderate risk	14	11.63 (2.92)	11.60 (9.57-13.72)		9.97 (2.45)	10 (7.89-12.07)	
No risk	14	7.07 (3.96)	6.60 (4.57-10.40)	0.009*	6.22 (4.31)	6.60 (2.87-8.72)	0.021*
Moderate risk	14	11.63 (2.92)	11.60 (9.57-13.72)		9.97 (2.45)	10 (7.89-12.07)	

Correlation of LFPTA of right and left ears with LIHLRQ scores

Scatter plot for correlation of LFPTA of right and left ears are depicted in figure 4. However, the data did not show any specific trend. Further, Pearson correlation of LFPTA of right ear with LIHLRQ also revealed that there was significant but a weak correlation between the two [$r_p(60) = 0.28$; $p = 0.03$]. Additionally, Pearson correlation of LFPTA of left ear with LIHLRQ scores also revealed weak correlation [$r_p(60) = 0.34$; $p = 0.007$].

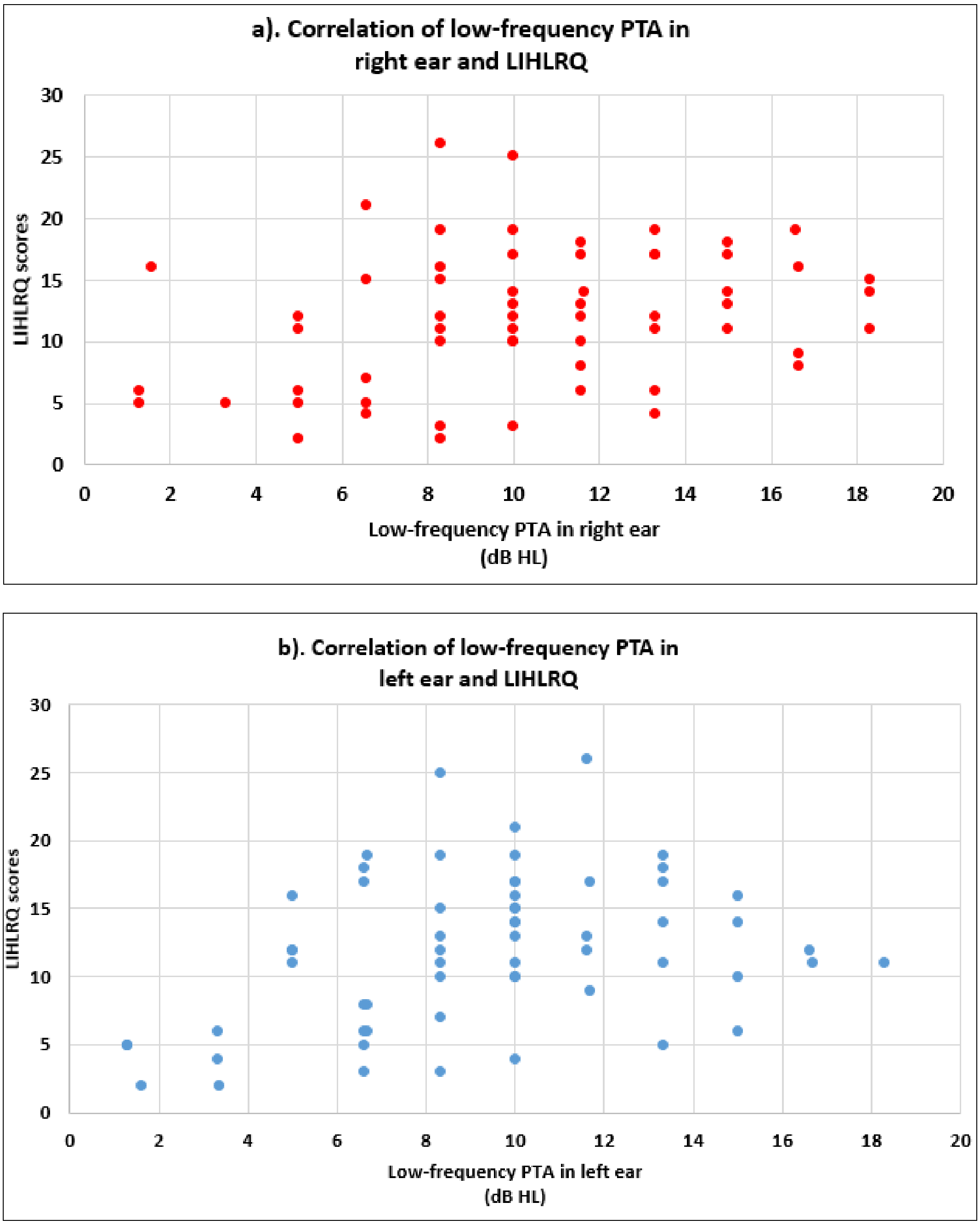


Fig 4: Correlation of low frequency PTA LFPTA in a). right ear and b). left ear with LIHLRQ

Comparison of EHFPTA of right and left ears across the three groups

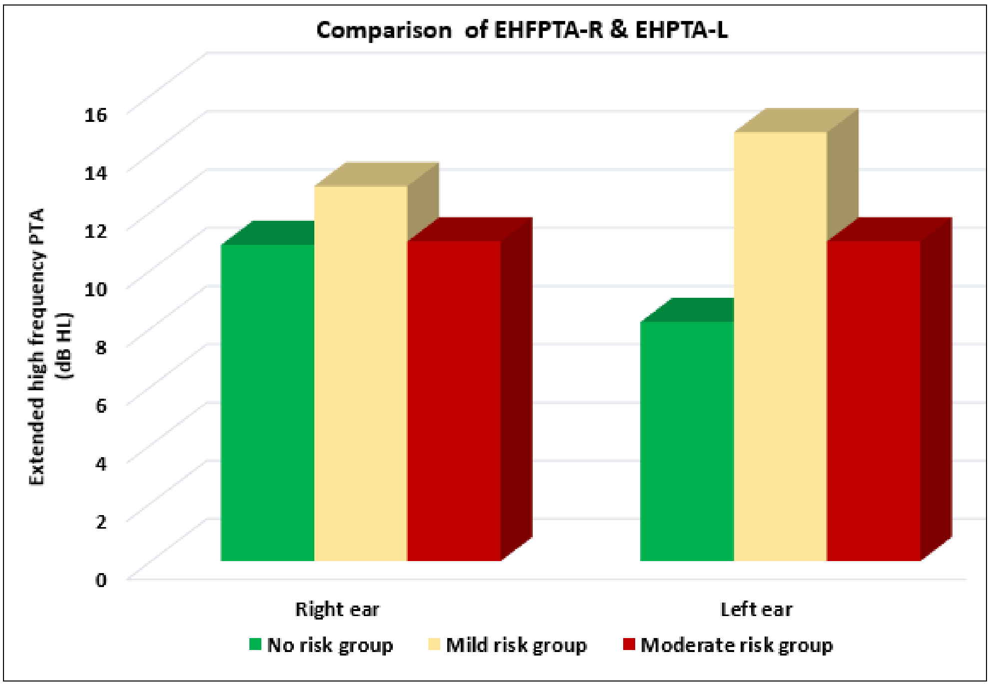


Fig 5: *Comparison of EHFPTA in right and left ear across groups*

Marginal differences were obtained in the median scores of extended high frequency pure-tone average across the three categories for both right ear and left ear. Mean, standard deviation, median and 25th and 75th percentile are provided in Table 4. It was noted that group of participants with no risk had the lowest average.

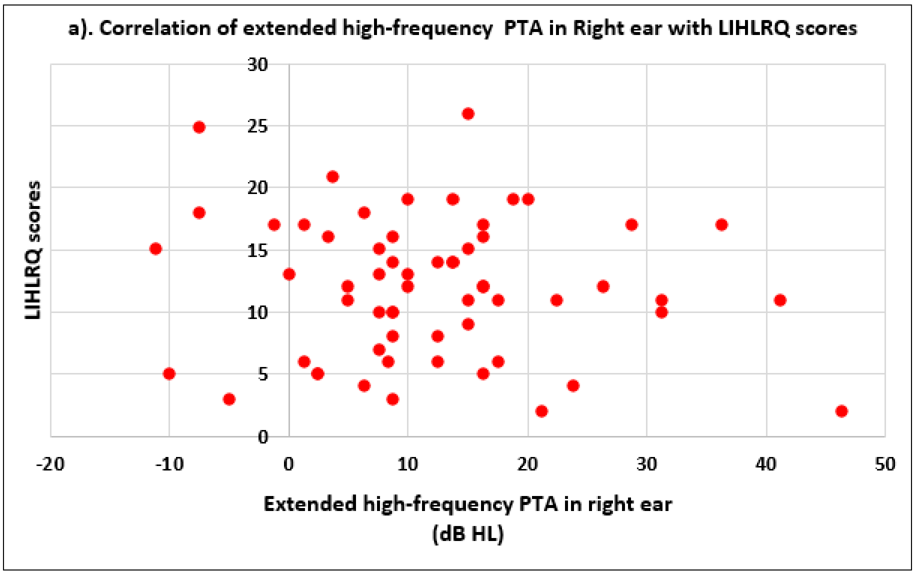
Further, to confirm if these differences were statistically significant Kruskal-Wallis tests were conducted separately for both the ears. It was noted that there no significant difference across the three groups for right ear [$H(2) = 0.69$; $p = 0.71$] as well as left ear [$H(2) = 1.94$; $p = 0.38$].

Table 4: Comparison of EHFPTA of right ear and left ear across the three groups.

Groups		EHFPTA-Right ear		EHFPTA-Left ear	
	N	Mean (SD)	Median (Q1-Q3)	Mean (SD)	Median (Q1-Q3)
No risk	14	10.86 (14.01)	8.52 (2.19-18.44)	8.21 (10.79)	8.75 (4.06-11.87)
Mild risk	32	12.88 (9.84)	11.25 (7.5-16.25)	14.72 (14.52)	11.87 (4.37-23.44)
Moderate risk	14	10.98 (12.86)	11.87 (0.62-19.06)	10.98 (12.13)	9.37 (2.19-16.56)

Correlation of EHFPTA of right and left ears with LIHLRQ scores

For correlating EHFPTA with LIHLRQ scores the scatter plot is depicted in Figure 6. The data did not show any specific trend between the two for either right or left ear. Further, Spearman's correlation was conducted and it was noted that there was a weak correlation between the two for right ear [$r_s(60) = -0.05$; $p = 0.70$]. Similarly, for the left ear also there was a weak correlation between the two [$r_s(60) = 0.09$; $p = 0.47$].



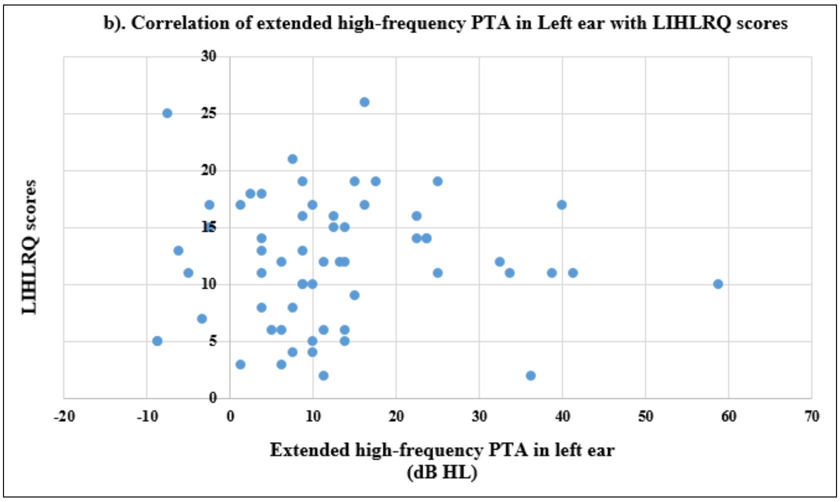


Fig 6: Correlation of EHFPTA in a). Right ear and b). Left ear with LIHLRQ

Discussion

The outcome of the study showed significant difference across the three groups on the basis of LIHLRQ. This is in accordance to the study by Dass *et al.* [3] which was carried out on 412 college going students who showed difference in risk for developing hearing loss based on their lifestyle and were divided among four categories (p<0.05).

The scores of individual domains were compared across the three groups obtained and the results indicated that there were significant differences across the three groups in scores on 'noise exposure' (p< 0.01), 'lifestyle and auditory health belief' (p< 0.01), and also 'ear related medical history' (p< 0.01). Similar findings were reported in the study by Dass *et al.* [3] for difference on comparison of mild risk group and moderate risk group and of no risk group with moderate risk group in scores on 'noise exposure' (p<0.01) 'lifestyle and auditory health belief' (p<0.01) and 'ear related medical history' (p< 0.01). However, on comparing the no risk and mild risk group although there were a difference across NE and LAHB, there was no difference obtained in the score for ERHM.

Both the LFPTA-Right and Left was lowest for those with 'no risk' and highest for those with 'moderate risk'. There were significant differences between group with 'no risk' and 'mild risk' and also 'no risk' and moderate risk, though there was no significant difference between group with 'mild risk' and 'moderate risk'. These findings are corroborated with study by Majumder *et al.* [4] which shows that PTA has a bigger role in understanding the early indication of hearing loss in terms of exposure to noise.

Pearson correlation of LFPTA of right ear and left ear with LIHLRQ respectively revealed that there was a weak correlation between the two. This suggests that LFPTA alone is not a good predictor of hearing loss in early stages and a battery of relevant audiological tests should be administered for the same. Individual thresholds at extended higher frequencies should also be taken into consideration to have better indication of susceptibility of hearing loss as reported in a study by Majumder *et al.* [4]. which estimated that the risk of hearing impairment using models excluding higher frequencies is less sensitive to noise and exposure damage. Another systemic review study showed that initial abnormal or low-level emission for OAEs could predict future hearing loss when carried out along with pure tone audiometry but at the cost of low specificity [5].

The EHFPTA- Right and Left showed marginal differences across the three categories with no significant difference. The participants in the 'no risk' group had the lowest average. This could happen because high frequency thresholds show variability even in individuals with normal hearing. This is in accordance with the study of Carvallo *et al.* [6]. in which 74 individuals aged 18-30 years without any auditory complaints were studied who confirmed the tendency of worsening thresholds with increasing frequency. The study further pointed out no significant difference between the hearing thresholds across the frequencies which is in corroboration to the present study. The variability in EHF can also be due to problems in calibration in the EHF range as well as individual differences in ear canal anatomy which affect standing wave interference pattern.

Although there was a weak correlation obtained between the EHFPTA and LIHLRQ scores for both the ears, studies suggest that EHF thresholds may be sensitive to noise exposure and EHF threshold elevation may occur before any effects in the standard clinical range, although findings are mixed [7]. Another study by Prendergast *et al.* [8] mentioned that the correlations are not strong even for neighboring frequencies as those in fixed level frequency threshold estimation. There are weak correlations across PTA thresholds for test frequencies above 8000Hz which highlights that hearing across the cohort of listeners would be dependent on which PTA frequency is used [9].

Conclusion

The present study shows that there is a significant difference in LIHLRQ scores among participants with no risk, mild risk and moderate risk for hearing loss. It also shows that there exist a significant difference in Low frequency pure tone average of individuals with no risk for hearing loss and individuals with risk for hearing loss. Hence it can be concluded that LIHLRQ scores provide early indications of changes in hearing thresholds.

Future considerations

As EHFPTA alone is not giving the clear picture of audiological profile of individuals at risk for hearing loss. Frequency specific analysis of extended high frequencies in different LIHLRQ categories can be explored further.

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