

# Audiometric Characteristics of Presbycusis: A Hospital-Based Study

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## ABSTRACT

**Background:** Presbycusis is related to degenerative changes of aging resulting from deficient cochlear microcirculation. It is characterized by bilateral, symmetrical, sensorineural hearing loss (SNHL) in which recruitment and speech discrimination is affected in the absence of noise exposure. The objective of this study was to analyze the pure tone audiogram characteristics in Presbycusis.

**Methods:** This descriptive study recruited n=192 cases of presbycusis of both genders, aged 50 to 80 years with convenience sampling technique. The study was conducted at Yusra General Hospital and the National Institute of Rehabilitation Medicine, Islamabad from 1st July 2017 to 30th September 2017. Pure tone audiometry was used to collect audiometric data. SPSS-24 was used for data analysis. Chi-square and Pearson's correlation were used to determine association between variables with  $p < 0.05$  taken as significant.

**Results:** Pure tone audiometry revealed 58 (30.2%) right and 65 (33.9%) left ears with high frequency gently sloping audiogram, while the second commonest configuration being high frequency steeply sloping curve in 51(26.6%) right and 52(27.1%) left ears. There was a significant correlation between the configuration of the audiogram and age with  $p=0.000$ , while no significant correlation with gender ( $p=0.71$ ). The majority, 77 (40.10%) right and 71(36.98%) of left ears had moderately severe hearing loss, while severe hearing loss was second commonest with 60(31.25%) right and 70(36.46%) left ears affected. The severity of hearing loss had a significant ( $P=0.000$ ) positive correlation with age but no significant relationship with gender.

**Conclusion:** High frequency gently sloping audiogram was the commonest configuration followed by high frequency steeply sloping curve. Moderately severe hearing loss was most commonly seen followed by severe hearing loss.

**Key Words:** Audiogram, Aging, Hearing loss, Presbycusis.

### Authors' Contribution:

<sup>3</sup>Conception; <sup>1</sup>Literature research; manuscript design and drafting; <sup>3</sup>Critical analysis and manuscript review; <sup>2</sup>Data analysis; Manuscript Editing.

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## Introduction

Presbycusis is the general term applied to age related hearing loss. It is characterized by reduced hearing sensitivity, little understanding of speech in noisy environments, delayed central processing of acoustic information and impaired localization of sound sources. The risk factors are noise exposure,

hypertension, family history, smoking and medication among many others. Hearing thresholds over 25 dB in both ears is said to be hearing loss and can be classified as mild, moderate, severe, or profound.<sup>1</sup> It is related to degenerative changes of aging occurring in the cochlear hair cells and central

auditory connections resulting from deficient cochlear microcirculation.<sup>2</sup> It is characterized by bilateral, symmetrical, sensorineural hearing loss (SNHL) in which recruitment and speech discrimination is affected in the absence of noise exposure. With presbycusis, the chances of hearing loss (HL) increase by 9% with each year of advancing age.<sup>3</sup> Though etiology is a simple degenerative process of cochlear aging, however, environmental factors may also contribute to it. Presbycusis weakens communication which affects quality of life in many ways, causing personal frustration, relationship problems, anxiety, depression and other negative emotions.<sup>4</sup> Presbycusis is also related to lack of physical activity, certain nutrients, exposure to noise, genetic predisposition and other comorbidities.<sup>5</sup>

Presbycusis is divided into four main types with specific characteristic audiometric curves including Sensory (high frequency steeply sloping curve), Neural (moderate down sloping curve towards high frequency with severely reduced speech discrimination), Strial or metabolic (flat curve) & Cochlear Conductive or mechanical (high frequency gently sloping).<sup>6</sup> Downward sloping audiogram is associated with degenerative changes involving hair cells, spiral ganglion and stria vascularis.<sup>7</sup>

Presbycusis affects the individuals' quality of life in daily social and communicational interactions being prevalent in the aging population.<sup>8</sup> Hussain B et al in a local study noted that with already high prevalence of presbycusis and increase in ageing population in coming decades, it is expected to rise significantly and can become a critical issue for the elderly community.<sup>9</sup> With a dearth of research on presbycusis in Pakistan and an increasing population with longevity as a universal trend along with a lack of organized screening, preventive and management options for the aging population, it might become a burden for the economy by increasing the less productive and partially disabled population.

Hence, this study was conducted with the objective to analyze the pure tone characteristics of presbycusis and may act as a local reference and foundation for further research to plan rehabilitative strategies.

## Material & Methods

This was a descriptive cross-sectional study employing 192 cases of presbycusis using convenience sampling technique. The study was conducted at Audiology clinics of Yusra General Hospital and National Institute of Rehabilitation Medicine, Islamabad, Pakistan over three months from 1st July 2017 to 30th September 2017. A sample size of 196 was calculated taking a population proportion (p) of 0.15<sup>10</sup> and effect size (DEFF) of 1 with 5% absolute precision (d) and the two-sided level of significance (α) of 95% using the formula:

$$N = \frac{z_{\alpha/2}^2 * p * (1 - p) * DEFF}{d^2}$$

Cases with incomplete data were excluded from the study leaving behind a valid sample population of 192 cases. The sample included both genders aged 50 to 80 years and excluded those with infective and obstructive pathologies of the outer and middle ear, tympanosclerosis, otosclerosis, ototoxicity, Meniere's disease and acoustic neuroma. Pure tone audiometry (PTA) was done for data collection. A medical history sheet and otoscope were used to rule out outer and middle ear pathologies. The study was conducted after obtaining approval of the IRB of Isra Institute of Rehabilitation Sciences, Isra University with registration number 1502-M Phil HS-002 dated 18th April 2017 and informed consent from the patients.

PTA was performed using pure tone audiometer model "MAICO MA 51" and both ears were tested with headphones by giving continuous pure tone signals to determine air conduction through the

descending to ascending order. Also, Bone PTA was performed using pure tone audiometer model "MAICO MA 51" and both ears were tested with headphones by giving continuous pure tone signals to determine air conduction through the descending to ascending order. Also, Bone conduction procedure was performed using a bone conductor. These tests were performed in a sound proof room by single audiologist to avoid any impact of noise and any inter-examiner difference. SPSS 24 was used for data analysis. Age was presented by mean and standard deviation while categorical variables were presented by frequencies and percentages. Pearson's correlation and chi-square test were used to determine the association between different variables and a P-value of <0.05 taken as statistically significant.

## Results

The current study sample (n=192) comprised a predominantly male population of 129(67.19%) and 63(32.81%) females with male to female ratio of 2.05:1 and a mean age of 65.85 ± 7.36 years. The pattern of hearing loss among the subjects is shown with high frequency gently sloping curve

(mechanical, cochlear conductive) on an audiogram in 58 (30.2%) and 65 (33.9%) right and left ears respectively. The second commonest configuration was a high frequency steeply sloping curve (sensory) in 51(26.6%) and 52(27.1%) right and left ears respectively. (Table I)

A statistically significant difference (p<0.001) was present between age group and configuration of audiogram with high frequency gently sloping audiogram predominantly seen at age group 56-60 and 61-65 in the right ear and 56-60, 61-65 & 66-70 in the left ear, while high frequency steeply sloping audiogram predominantly seen at age group 66-70 and 71-75 in the right ear and 71-75 years age group for the left ear. Pearson's R correlation was positive.

There was dominance of male gender in the pattern of high frequency gently sloping hearing loss, possibly due to predominance of male population in the sample, however, the difference was not statistically significant (p=0.716) with a negative Pearson R Correlations among gender and configuration of hearing loss.

Ear	Age Group (Years) & Gender	Configuration Of Hearing Loss Curve (Puretone)					Total (N, %)	Correlations	
		Flat	High Frequency Steeply Sloping (Metabolic, Strial)	High Frequency Gently Sloping (Mechanical, Cochlear Conductive)	Precipitous	Fragmentary		Chi-Square	Pearson's R
Right	50 To 55	4	4	6	4	0	18 (9.37%)	Value: 49.233 P-Value: 0.000	Value: 0.080
	56 To 60	4	6	18	6	0	34 (17.71%)		
	61 To 65	9	11	13	7	0	40 (20.83%)		
	66 To 70	12	14	13	8	2	49 (25.52%)		
	71 To 75	5	10	5	4	8	32 (16.67%)		
	76 To 80	4	6	3	0	6	19 (9.90%)		
	Total N (%)	38 (19.8)	51 (26.6)	58 (30.2)	29 (15.1)	16 (8.3)	192 (100%)		

Left	50 To 55	6	4	5	3	0	18 (9.37%)	Value: 59.195 P-Value: 0.000	Value: 0.092
	56 To 60	4	6	22	2	0	34 (17.71%)		
	61 To 65	9	11	12	8	0	40 (20.83%)		
	66 To 70	12	14	16	6	1	49 (25.53%)		
	71 To 75	4	11	6	2	9	32 (16.67%)		
	76 To 80	5	6	4	0	4	19 (9.89%)		
	Total N (%)	40 (20.8)	52 (27.1)	65 (33.9)	21 (10.9)	14 (7.3)	192/ 100%		
Right	M	23	37	37	21	11	129 (67.19)	Value: 2.110 P-Value: 0.716	Value: - .040
	F	15	14	21	8	5	63 (32.81)		
	Total N (%)	38 (19.8)	51 (26.6)	58 (30.2)	29 (15.1)	16 (8.33)	192 (100)		
Left	M	23	39	42	15	10	129 (67.19)	Value: 3.623 P-Value: 0.459	Value: - .056
	F	17	13	23	6	4	63 (32.81)		
	Total N (%)	40 (20.8)	52 (27.1)	65 (33.8)	21(10.9)	14 (7.29)	192 (100)		

As far as the severity of hearing loss is concerned (Table II), the majority, 77 (40.10%) and 71 (36.98%) of right and left ears respectively had moderately severe HL, while severe HL was second commonest

with 60 (31.25%) and 70(36.46%) of right and left ears affected respectively. Profound HL was interestingly uncommon with 14(7.29%) and 15(7.81%) of right and left ears affected.

Table II: Age Group & Gender * Degree/ Severity of Hearing Loss: Cross Tabulation (n=192)									
Ear	Age Group (Years) & Gender	Degree/ Severity of Hearing Loss					Total N (%)	Correlations	
		Mild	Moderate	Moderately Severe	Severe	Profound		Chi-Square	Pearson's R
Right	50 To 55	2	8	7	1	0	18(9.37)	Value: 145.36 P-Value: 0.000	Value: 0.699
	56 To 60	1	21	11	1	0	34(17.71)		
	61 To 65	0	7	25	8	0	40(20.83)		
	66 To 70	0	1	27	19	2	49(25.52)		
	71 To 75	0	1	5	21	5	32(16.67)		
	76 To 80	0	0	2	10	7	19(9.89)		
	Total N (%)	3 (1.56)	38 (19.79)	77 (40.10)	60 (31.25)	14 (7.29)	192 (100)		
Left	50 To 55	2	9	5	2	0	18(9.37)	Value: 146.483 P-Value: 0.000	Value: 0.670
	56 To 60	0	17	13	4	0	34(17.71)		
	61 To 65	0	4	26	10	0	40(20.83)		
	66 To 70	0	3	22	23	1	49(25.52)		
	71 To 75	0	1	3	22	6	32(16.67)		
	76 To 80	0	0	2	9	8	19(9.89)		
	Total N (%)	2 (1.04)	34 (17.71)	71 (36.98)	70 (36.46)	15 (7.81)	192(100)		

Right	M	2	23	58	37	9	129(67.19)	Value: 3.961	Value: 0.019
	F	1	15	19	23	5	63(32.81)	Value: 0.411	
	Total N (%)	3 (1.56)	38 (19.79)	77 (40.10)	60 (31.25)	14 (7.29)	192 (100)		
Left	M	2	23	51	42	11	129(67.19)	Value: 3.572	Value: 0.058
	F	0	11	20	28	4	63(32.81)	P-Value: 0.467	
	Total N (%)	2 (1.04)	34 (17.70)	71 (36.98)	70 (36.46)	15 (7.81)	192(100)		

There was increase in HL with advancing age. The relationship was significant with a p-value of <0.001 with a positive relationship on Pearson's R correlation among age and severity of hearing loss in both ears. Along with male predominance, there was also a predominance of a moderately severe degree in both genders with 58 and 51 males having a moderately severe degree of HL in right and left ears respectively. On the other hand, there were 19

and 20 females with a moderately severe degree of hearing loss in right and left ears respectively. However, the difference was not statistically significant with a p-value of 0.411 and 0.467 in right and left ear respectively with a positive Pearson's R correlation among gender and severity of hearing loss in both ears. Figure 1 shows a positive linear relationship between age and frequency of HL.

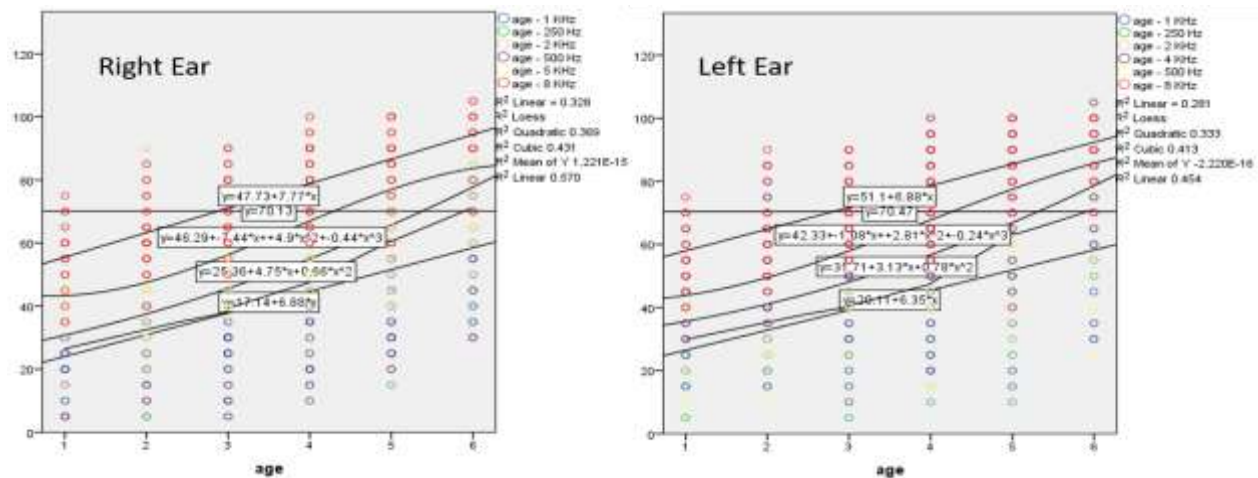


Figure 1: Scatter Plot showing linear positive relationship between age and hearing threshold (n=192)

## Discussion

In this study, with 67.19% males and 32.81% female population and a mean age of  $65.85 \pm 7.0$ , high frequency gently sloping curve (mechanical, cochlear conductive) was the commonest presentation, while the second commonest configuration was high frequency steeply sloping curve (sensory). Literature search revealed varying audiometric configurations like Sarafraz M et al

revealed predominance (64.29%) of the sensory pattern on audiogram followed by neural (16.25%), conductive (9.54%), metabolic (2.68%) and sensory-neural (7.16%) in decreasing order of frequency which is in contrast to this study.<sup>11</sup> Wang & Puel noted sharply sloping curve in high frequency in males compared to gradual slope in females.<sup>12</sup> A study by Wasana K et al reported slow age-related decline with an audiogram showing deterioration at

1, 2 and 4 kHz with a typical moderately sloping curve (mechanical cochlear conductive)<sup>13</sup> which was the most predominant curve in this study as well. In a Nigerian study published in 2013, Sogebi OA et al reported a predominance of serial pattern with a flat loss involving both speech and higher frequencies.<sup>14</sup> Moreover, Demeester K et al in a Belgian study in 2009 reported a predominance of the flat curve (37%) followed by high frequency, gently sloping curve (35%) and high frequency steeply sloping curve (27%). Also, low frequency ascending curve, mid-frequency U-shape and reverse U-shape curves were seen in less than 1% of the subjects.<sup>15</sup>

As far as the severity of HL is concerned, the present study revealed that the majority of right and left ears suffered moderately severe HL, while severe HL was second commonest and profound HL was interestingly uncommon. This finding may be due to the fact that our sample population had a mean age of  $65.85 \pm 7.36$  years being a hospital-based study and very old adults in which severe and profound presbycusis could have been noted, were not included. A somewhat similar pattern was noted in a study by Fei J which revealed normal hearing in 29.5%, mild to moderately severe HL in 59.5% and severe & profound HL in 11% with conductive element noted in 5.45%.<sup>16</sup>

In the current study, a statistically significant difference was noted between age and configuration of the audiogram (p-value of 0.000) with a positive correlation for both ears, due to progress of HL in aging population due to presbycusis. While the predominance of male gender was observed in the pattern of high frequency gently sloping hearing loss, however, the difference was not statistically significant ( $P=0.716$ ). In contrast to our results, a study by Demeester K et al found that in females, a flat curve was significantly more common, while in males, high frequency steeply sloping curves were more frequently encountered and noise and solvent exposure did not affect this pattern.<sup>15</sup> Wu PZ et al noted that though level of HL is quite predictable from hair cell amount

degenerated, however as stria tissue is lost, cell death becomes intense and audiogram slope is not diagnostic for stria degeneration.<sup>17</sup>

As far as the severity of HL is concerned, in the present study, increase in age revealed an increase in the severity of HL, the difference being statistically significant ( $P=0.000$ ) with positive correlation. This difference is due to the degenerative changes occurring in the organ of Corti with increasing age.<sup>1</sup> Similarly, in a study by Rigtters SC et al., an increase in HL of 0.29 to 1.35 dB per year for low and high frequencies respectively was reported in aging population.<sup>18</sup>

With regard to severity/ degree of hearing loss in the current study, gender-wise, the difference was not statistically significant with a p-value of 0.411 and 0.467 in right and left ears respectively with a positive correlation among gender and severity of hearing loss in both ears. In contrast, study by Demeester K et al revealed more hearing loss in females compared to males, with a flat curve of the audiogram,<sup>15</sup> while Wasano K et al did not report any significant gender difference in youngest and oldest age groups.<sup>13</sup> Audiogram findings are critical in predicting inner ear degeneration and hence current study is of significant importance.<sup>17</sup>

## Conclusion

High frequency gently sloping audiogram was the commonest configuration followed by high frequency steeply sloping curve. Severity wise moderately severe hearing loss was the commonest followed by severe hearing loss.

### Disclaimer

This research is part of the main research of M Phil (Speech-language pathology) thesis project.

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