

Pitch and Loudness Tinnitus in Individuals with Presbycusis

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Abstract

Introduction Tinnitus is a symptom that is often associated with presbycusis.

Objective This study aims to analyze the existence of association among hearing thresholds, pitch, and loudness of tinnitus in individuals with presbycusis, considering the gender variable.

Methods Cross-sectional, descriptive, and prospective study, whose sample consisted of individuals with tinnitus and diagnosis of presbycusis. For the evaluation, we performed anamnesis along with otoscopy, pure tone audiometry, and acuphenometry to analyze the psychoacoustic characteristics of tinnitus individuals.

Results The sample consisted of 49 subjects, with a mean age of 69.57 ± 6.53 years, who presented unilateral and bilateral tinnitus, therefore, a sample of 80 ears. In analyzing the results, as for acuphenometry, the loudness of tinnitus was more present at 0dB and the pitch was 6HKz and 8HKz. Regarding the analysis of the association between the frequency of greater hearing threshold and tinnitus pitch, no statistical significance ($p = 0.862$) was found. As for the association between the intensity of greater hearing threshold and tinnitus loudness, no statistical significance ($p = 0.115$) was found.

Conclusion There is no significant association between the hearing loss of patients with presbycusis and the pitch and loudness of tinnitus.

Keywords

- ▶ presbycusis
- ▶ tinnitus
- ▶ aging

Introduction

Presbycusis is a word derived from the Greek (*presbus* = elder + *ákousis* = hearing), which means reduced hearing acuity caused by aging.¹ Its etiology is multifactorial and is characterized as bilateral, symmetrical, with slow and progressive evolution, mainly affecting high frequencies. It starts usually

between 20 and 30 years of age, but becomes socially awkward from 40 to 50 years.² Studies show that there is an increase in the prevalence of presbycusis according to age, with a greater loss in high frequencies (from 80–89) and flattening out in individuals aged over 90 years.^{3,4} Presbycusis is a problem associated with senescence, with

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consequences to social and functional activities as well as to the psychological well-being of individuals.^{3,5,6}

Tinnitus is a symptom related to the hearing system, which may be observed in individuals diagnosed with presbycusis.⁷ This is the conscious perception of sound that originates in the ears or head of the patient without the presence of an external source of sound generator,⁸ that is, the sensation of sound in the absence of an external sound stimulus.⁹ Its main origin is in the cochlea, and may be associated with various diseases that may spread to other auditory pathways.⁷

Ear diseases are the leading causes of tinnitus, but diseases that affect the ear secondarily, such as metabolic, cardiovascular, neurological, psychiatric, dental changes and possibly the consumption of drugs, caffeine, nicotine and alcohol may cause etiology.⁸

With respect to age, this is a symptom observed in adults and children,¹⁰ but its incidence increases with increasing age and also with hearing loss, making it a more common complaint in older individuals^{7,10} and more common in men¹¹ than women. It may be unilateral or bilateral, but in some cases patients can't refer to the side that sense, referring to the perception of sound inside the head, or, optionally, on the outside of the head.^{7,10}

Psychoacoustic characteristics of tinnitus, which are frequency (pitch) and intensity (loudness), differ among patients, as well as in location and duration of tinnitus.⁸ The manner in which this symptom disturbs people's quality of life also varies from patient-to-patient, as they present different reactions.¹² If gender is considered, literature data are controversial, since research shows that gender has no influence on the nuisance caused by tinnitus,¹³⁻¹⁵ reporting similarities in how men and women feel the symptom. However, there are studies that demonstrate greater nuisance in males,¹⁶ while others have reported greater discomfort among women.^{17,18} A recent study using functional imaging in patients with tinnitus reported differences in the activity of the orbitofrontal cortex extending to the frontopolar cortex of men and women with this symptom.¹⁵ The orbitofrontal cortex is an important tool for the emotional processing of sounds, justifying possible gender differences in the perception of tinnitus.¹⁵

Previous research have shown a relationship between tinnitus and hearing, which is more common and severe when associated with hearing loss.^{11,19} Another study also reported this relationship, with influence of frequency band and hearing thresholds.²⁰

As an auditory perception or, in other words, a subjective characteristic, the conditions for research on tinnitus are limited.²¹ Nonetheless, given that this is a symptom with great impact in the lives of individuals, all scientific contribution in this area becomes important and necessary.^{8,10}

The assumptions described and the scarce national and international literature on research correlating hearing loss and the results found in the psychoacoustic measurements of tinnitus (pitch and loudness) justify the importance of this research.

The objective of this study is to analyze the existence of an association between hearing thresholds, pitch, and loudness

of tinnitus in individuals with presbycusis, considering the gender variable.

Methods

This is a transversal, descriptive, and prospective study, whose sample consisted of individuals with presbycusis and tinnitus in the Chronic Tinnitus Clinic of the hospital of the institution that hosted this study.

The sample included individuals with tinnitus, whether unilateral or bilateral, diagnosed with presbycusis, and who underwent complete otorhinolaryngologic and audiological evaluation, with audiological exams (otoscopy, pure tone audiometry by air and bone conduction, acoustics, and acuphenometry impedance measures). The study excluded patients with a history of cognitive and / or neurological impairment observed during records analysis.

Initially, all patients were treated by an otorhinolaryngologist for the investigation of otologic and health history, as well as otoscopy.

Afterwards, all patients underwent an audiological evaluation conducted with pure tone audiometry performed in a soundproof booth, with audiometer Siemens, Unity PC model with HDA 200 headphones and bone vibrator B71 for research of the thresholds by air in the frequencies of 250Hz, 500Hz, 1000Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz, and 8000Hz, and also bone conduction thresholds in the frequencies of 500Hz, 1000Hz, 2000Hz, 3000Hz, and 4000Hz.

Subsequently, we performed acuphenometry to analyze the psychoacoustic characteristics of each individual tinnitus, or we observed the sensation of pitch and loudness of the tinnitus. We found that pitch corresponds to the frequency of the symptom (low, medium, or high) and loudness to the intensity of it, which is equivalent to the volume of feeling reported by the pure tone of the patient or narrowband noise.⁸

The acuphenometry was performed using the procedures described by Branco-Barreiro,²² which initially was made to search for pitch. In all frequencies, we selected the ear of the individual threshold, added another 10 dBHL and presented pure tone or noise, according to the patients' description on the characteristics of their tinnitus. We requested that the patient raise his or her hand when realizing that the sound presented was similar to his or her tinnitus. Next, we researched loudness. In the frequency indicated by the patient as similar to their tinnitus, the stimulus was presented (pure tone or noise), with initial intensity 10 dBHL below the patient's threshold. Next, we increased intensity in steps of 2 dBHL, and the patients would raise their hand as soon as they realized that the intensity was similar to the presented tinnitus. This intensity was recorded and subtracted from the individual hearing threshold. This calculation enables the determination level of sensation. After the audiological evaluation, all subjects returned for consultation with the otorhinolaryngologist for the causal diagnosis of hearing loss and tinnitus.

The research had the approval of the institution's Ethics Committee, recorded under number 06026, as well as Informed Consent (IC) of all participating individuals.

For data analysis, the sample was divided into subgroups according to the variable of interest, which were gender, frequency of greater hearing threshold, intensity of greater hearing threshold, pitch, and loudness obtained in acuphenometry. Regarding the frequency of greater hearing threshold and the pitch in acuphenometry, we analyzed the frequency bands analysis according to the following considerations: severe (250Hz and 500Hz), medium (1000Hz, 2000Hz, and 3000Hz), and acute (4000Hz, 6000Hz, and 8000Hz).

Regarding the intensity of greater hearing threshold, subgroups were divided according to individual threshold between 0 and 25 dB HL, 26 and 40 dB HL, 41 and 70 dB HL, 71 and 90 dB HL, and above 90 dB HL. As for loudness in acuphenometry, the group was divided into individuals who had tinnitus between 0 and 4 dBSL, 5 to 9 dBSL, 10 to 14 dBSL, 15 to 19 dBSL, 20 to 24 dBSL, 25 to 30 dBSL, and above 30 dBSL.

We entered the data into a database built in Microsoft Excel. We performed the analysis using SPSS software version 18, with the correlation analysis through the Pearson correlation coefficient, Student's *t*-test for comparison of independent means, and Fisher's Exact Test. We considered a significance level of 5% ($p < 0.05$).

Results

The study sample consisted of 49 subjects, with a mean age of 69.57 ± 6.53 years, minimum age of 53 years and maximum of 85 years. As for gender, the study included 28 female subjects (57.15%) and 21 male (42.85%). Of these, 7 (14.28%) had tinnitus in the right ear (RE), 11 (22.44%) in the left ear (LE), and 31 (63.26%) in both ears (BE). Thus, for data analysis, we considered only the ears that had tinnitus, totalizing 80 ears, 38 RE and 42 LE.

► **Table 1** shows the frequency distribution of the individuals according to the intensity of greater hearing threshold. In analyzing the results, we observed that most of the patients evaluated had their greatest auditory thresholds between 50 and 75 dB HL. The average loudness of tinnitus was 17.9 dB HL. ► **Table 2** shows the frequency distribution of the loudness of tinnitus obtained in acuphenometry. Most of the evaluated ears (80.1%) had tinnitus loudness between 0 dB HL and 19 dB HL.

► **Table 3** shows the comparison between genders with regards to the characteristics of greater hearing threshold (frequency and intensity) and psychoacoustic characteristics of tinnitus (pitch and loudness). We concluded that there is no significant difference between genders comparing the average frequency of greater hearing threshold ($p = 0.889$), intensity of greater hearing threshold ($p = 0.140$), pitch obtained in acuphenometry ($p = 0.144$), and loudness obtained in acuphenometry ($p = 0.139$).

► **Table 4** shows the analysis between gender and two other variables, loudness and frequency range, obtained in acuphenometry. There was no significant association in both comparisons, with $p = 0.603$ and $p = 0.555$, respectively.

In ► **Table 5**, we present the frequency distribution of patients according to frequency of greater hearing threshold

Table 1 Distribution of frequency of ears evaluated according to the intensity of greater hearing threshold

Intensity of greater hearing threshold (dB HL)	N	%
30 - 35	7	8.8
40 - 45	10	12.6
50 - 55	17	21.3
60 - 65	20	25.1
70 - 75	14	17.5
80 - 85	6	7.5
90 - 95	4	5.1
110	2	2.5
Total	80	100.0

Abbreviations: dB HL, decibel hearing level; N, number; %, percentage.

Table 2 Distribution of frequency of ears evaluated according to the loudness of tinnitus obtained in acuphenometry

Acuphenometry - Loudness (dBSL)	N	%
0 - 4	19	23.7
5 - 9	17	21.3
10 - 14	12	15.1
15 - 19	16	20.0
20 - 24	7	8.8
25 - 30	6	7.6
< 30	3	3.8
Total	80	100.0

Abbreviation: (dBSL), decibel sensation level; N, number; %, percentage.

and pitch in acuphenometry. We found low correlation ($r = 0.080$) and no significance ($p = 0.478$).

Regarding the analysis of the frequency range of greater hearing threshold (divided into severe, medium, and high), and pitch obtained in acuphenometry (ranked in the same way), we observed no significant association ($p = 0.081$) (► **Table 6**).

► **Table 7** demonstrates the analysis of the intensity ratings of greater hearing threshold and loudness in acuphenometry, whereby it is possible to conclude that there was no significant association between these variables ($p = 0.115$).

Discussion

The results of this study show that the mean age observed in the sample (69.57 ± 6.53 years) was consistent with other studies investigating tinnitus in the elderly. Previous research found average ages of 69.53 years²³ and 65.5 years.²⁴

As for tinnitus location, some studies corroborate this research, primarily finding bilateral tinnitus, followed by unilateral LE, and, finally, unilateral RE.^{18,25,27}

Table 3 Comparison of the gender characteristics of greater hearing threshold (frequency and intensity) and psychoacoustic characteristics of tinnitus (pitch and loudness)

Variables	Gender	N	Average	Standard deviation	p-value
Often the higher threshold	F	48	6791.7	1878.9	0.889
	M	32	6851.6	1856.6	
Higher threshold intensity	F	48	58.5	17.2	0.140
	M	32	64.4	17.1	
Pitch (acuphenometry)	F	48	3869.8	2597.0	0.144
	M	32	4781.3	2867.2	
Loudness (acuphenometry)	F	48	12.3	10.7	0.139
	M	32	9.1	7.2	

Abbreviations: F, female; M, male; N, number.

Student *t*-test, with significance level of 5% ($p < 0.05$).

Table 4 Analysis of the influence of gender on the acuphenometry loudness and frequency range obtained in acuphenometry

Gender	Acuphenometry											
	Loudness (dB HL)							p-value	Frequency Range			
	0 - 4	5 - 9	10 - 14	15 - 19	20 - 24	25 - 30	< 30		Serious	Medium	Acute	p-value
F (n = 48)	11	8	8	9	4	4	4	0.603	8	14	26	0.555
M (n = 32)	8	9	4	7	3	1	0		3	8	21	
Total	19	17	12	16	7	5	4		11	22	47	

Abbreviations: dB HL, decibel hearing level; F, female; M, male.

Fisher's exact test with a significance level of 5% ($p < 0.05$).

Table 5 Frequency analysis of greater hearing threshold and the pitch in acuphenometry

Frequency	Greater frequency hearing threshold		Pitch in Acuphenometry	
	N	%	N	%
250	1	1.3	3	3.8
500	–	–	8	10.0
1000	1	1.3	7	8.8
2000	1	1.3	10	12.5
3000	4	5.0	5	6.3
4000	4	5.0	12	15.0
6000	19	23.8	18	22.5
8000	50	62.5	17	21.3
Total	80	100.0	80	100.0

Abbreviations: N, number; %, percentage.

Pearson's correlation coefficient (*r*), with a significance level of 5% ($p < 0.05$).

$r = 0.80$.

$p = 0.478$.

Considering gender, we observed that the number of females (57.15%) was higher than men. Previous studies confirm our results, varying between 51% and 64% women

in their samples.^{18,25–29} A possible explanation to be considered is the fact that women are more careful and concerned about their health, seeking further medical care and, thus, show higher prevalence in studies and research.¹² Moreover, given that the sample of this study consisted of elderly people, we must mention the higher proportion of senior females in Brazil as a possible factor in female prevalence.³⁰ Research shows that in 2000, for every 100 elderly women there were 81 elderly men. By 2050, this ratio will be 100 elderly women to 76 elderly men.³¹

We did not find previous literary data to corroborate the findings of this study in terms of psychoacoustic characteristics of tinnitus in patients with presbycusis, comparing gender and pitch and loudness of tinnitus (► **Tables 3 and 4**). However, a study conducted with 607 women and 573 men with chronic tinnitus with an average age of 50 years observed an average pitch in women of 5.7 Hz and 5.4 Hz for right and left ears, respectively.¹⁸ As for men, average pitch was 5.7 Hz for both ears.¹⁸ This is gender indifference in accordance with the present study. More recent research, however, differs from our data, finding higher pitch value in women (average 3963.2 and 3602 Hz for right and left ears, respectively) than in men (3047.6 in RE and 3228 Hz in LE).³² Regarding the loudness of tinnitus, we observed differences between this study and previous studies,^{16,18} where the authors report significantly higher loudness in men

Table 6 Analysis of the frequency range of greater hearing threshold and pitch obtained in acuphenometry, by frequency bands

Frequency range of greater hearing threshold	Acuphenometry - Frequency Range				p-value*
	Serious	Average	Acute	Total	
Serious	–	–	1	1	0.081
Average	1	4	1	6	
Acute	10	18	45	73	
Total	11	22	47	80	

Fisher's exact test with a significance level of 5% ($p < 0.05$).

Table 7 Analysis of the intensity ratings of greater hearing threshold and the loudness in acuphenometry

Greater threshold intensity	Acuphenometry - Loudness (dB HL)							Total	p-value
	0 - 4	5 - 9	10 - 14	15 - 19	20 - 24	25 - 30	< 30		
26 - 40	1	3	–	5	2	1	–	12	0.115
41 - 70	14	9	12	6	5	3	3	52	
71 - 90	3	5	–	3	–	1	1	13	
< 90	1	–	–	2	–	–	–	3	
Total	19	17	12	16	7	5	4	80	

Abbreviation: dB HL, decibel hearing level.

Fisher's exact test with a significance level of 5% ($p < 0.05$).

(42.3 dB for RE and 44.3 dB for LE) compared to women (35.7 dB for RE and 37.3 dB for LE).¹⁸

When analyzing frequency of greater hearing threshold (► **Tables 5** and **6**), we observed higher thresholds at high frequencies. This is in agreement with the audiological profile that characterizes presbycusis, a sensorineural hearing loss with downward audiometric curve. Other studies in elderly patients with tinnitus also reported this audiological pattern.^{3,5,23} Another study performed in the state of Rio Grande do Sul in Brazil involving a sample of 215 elderly also showed that the frequencies with greater hearing thresholds were 6000Hz and 8000Hz.³³

Regarding tinnitus pitch, this study found that most of the evaluated ears had a high pitch, which corroborates previous research.^{26,32,34,35} Despite the fact that frequency of greater hearing threshold and pitch in acuphenometry are located in the range of high frequencies, corroborating the study of Noreña et al.,³⁶ the correlation between these variables is weak. Other studies also report a poor correlation between the pitch of the tinnitus and hearing loss frequencies, or even no correlation,^{25,29,37–40} although number of ears examined may have an influence in this trend. In fact, some authors found a positive correlation between tinnitus pitch and frequency with greater hearing loss.³⁸

The greater the intensity of the auditory threshold was found that in most of the individuals ranged between 40 and 65dBNA, which is also compatible with presbycusis above and is comparable with previous studies.³³ In relation to the loudness of the tinnitus, it was found that the majority of cases varied between 0 and 19 dBSL, corroborated by a recent study where only 8% of the sample had tinnitus loudness equal to or greater than 20 dBSL.³² The average of this feature

(17.9 dBSL) is higher than the value reported in previous research, where the average was 14.1 dB.⁴¹ However, the difference between studies may be due to sample average age (32.1 years) was younger than the sample of the present research.

The analysis of the intensity of greater hearing threshold and the loudness of tinnitus showed no significant association. In the literature, were not found previous studies correlating these variables. However, this finding may have been due to the fact of acuphenometry be a subjective test that depends on the intellectual capacity and concentration of the patient at the time of performing the test,⁴² and thus can restrict the results.¹⁸

Conclusions

This study showed no association between hearing loss, gender, pitch, and loudness of tinnitus in individuals with presbycusis. However, the studied literature still has significantly controversial data on such characteristics, highlighting the importance of further research on the topic.

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