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Original Article

Artigo Original

Effect of sound amplification in speech perception in elderly with and without tinnitus

Efeitos da amplificação sonora na percepção da fala em idosos com e sem zumbido

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Keywords

Hearing
Speech Perception
Aged
Tinnitus
Hearing Aids

ABSTRACT

Purpose: To verify the effect of the use of auditory prostheses on speech perception tests in elderly individuals with and without tinnitus having hearing impairment. **Methods:** We evaluated 24 elderly patients with moderate sensorineural hearing loss, aged between 60 and 70 years, distributed into two groups according to the presence or absence of tinnitus. All of them were fitted with micro-canal auditory prostheses from the same manufacturer and model, and underwent speech perception tests. The assessments were performed with and without the amplification devices after 1 and 3 months of effective use. For data analysis, Mann–Whitney test was used. **Results:** Elderly people from the tinnitus group presented lower performance in speech perception tests than those from the group without tinnitus. In the evaluations with the devices, the performance of both groups was better than when they were evaluated without hearing aids. **Conclusion:** The acoustic stimulation through the effective use of hearing aids produced better speech perception, regardless of the presence of tinnitus.

Descritores

Audição
Percepção da Fala
Idoso
Zumbido
Auxiliares de Audição

RESUMO

Objetivo: Verificar o efeito do uso de próteses auditivas em testes de percepção da fala em idosos deficientes auditivos com e sem zumbido. **Métodos:** Foram avaliados 24 idosos com perda auditiva neurossensorial de grau moderado e idades entre 60 e 70 anos, distribuídos em dois grupos conforme a presença ou não de zumbido. Todos foram adaptados com próteses auditivas microcanais de mesmo fabricante e modelo, e submetidos a testes de percepção da fala. As avaliações ocorreram com e sem os dispositivos de amplificação após um e três meses de uso efetivo. Para análise dos dados foi utilizado o teste de Mann-Whitney. **Resultados:** Os idosos do grupo com zumbido apresentaram, nos testes de percepção da fala, desempenho inferior aos do grupo sem zumbido. Nas avaliações com os dispositivos, o desempenho de ambos os grupos foi melhor do que quando avaliados sem as próteses auditivas. **Conclusão:** A estimulação acústica por meio do uso efetivo de próteses auditivas propiciou melhor percepção da fala, independentemente da presença do zumbido.

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INTRODUCTION

Tinnitus, a sound perception by an individual in the absence of an external generating source[1], is a symptom that is usually associated with complaints such as hearing loss, dizziness, and hyperacusis.

The World Health Organization showed that 278 million people have tinnitus worldwide, and an estimated 28 million people suffer from it in Brazil[2]. International data showed that the prevalence of tinnitus in the general population rose from 15% to 25.3% in just 15 years and that those figures grow with age[3].

The literature indicates that about 20% patients that mention chronic tinnitus present significant discomfort[4] and complaints, such as flaws in reasoning, memory, and concentration; in the speech discrimination; and in the maintenance of selective attention[5-7].

The temporary or permanent reduction of auditory stimuli (sensory deficit) can increase the sensitivity of subcortical neurons, resulting in a plastic reorganization of the auditory cortex, that is, the neural activity throughout the central auditory pathway modifies itself to compensate for the deficit in the peripheral entrance. This leads to a permanent reorganization of the auditory cortex, resulting in a constant perception of tinnitus[8,9].

The studies about imaging techniques and electrophysiological tests provided better understanding of the physiopathology of tinnitus, enabling us to reflect on these facts[10].

However, studies about plasticity have suggested that increased auditory stimulus caused by the sound amplification can induce secondary plasticity, contributing to reduce discomfort with tinnitus and to improve speech recognition over time (acclimatization)[11,12].

In this perspective, the assumptions that supported this research were the elderly individual with hearing loss as an auditory system with low intrinsic redundancy, compromising his or her performance on speech perception tests. In the concomitant presence of chronic tinnitus, this performance would be even worse than the performance of elderly people without the symptom. In addition, the effective use of auditory prostheses could improve the performance of elderly individuals with and without tinnitus having hearing impairment in speech perception tests.

Thus, this study aimed at verifying the effect of the use of auditory prostheses on speech perception tests in elderly people with and without tinnitus having hearing impairment.

METHODS

This research was carried out in the Integrated Center for Hearing Assistance, Research and Teaching (NIAPEA), at the Speech Language Pathology and Audiology Department of the Paulista School of Medicine, Universidade Federal de São Paulo (UNIFESP), during 2013 and 2014, after the approval by the Research Ethics Committee at UNIFESP, with the Certificate of Presentation for Ethics Analysis (CAAE) no. 09876112.1.0000.5505.

This was a study with prospective intervention and non-probabilistic sample that evaluated and compared the performance of 24 elderly individuals aged between 60 and 70 years, divided into two groups, according to the presence or absence of the tinnitus symptom. The participation of the individuals was voluntary and confirmed by signing the informed consent.

Initially, a survey was conducted with the analysis of medical records of all the patients that entered the service between 2010 and 2013 to verify the occurrence of the tinnitus symptom in the population cared for in NIAPEA.

We analyzed 3,580 medical records, discarding 797 (22%) that did not contain any information about tinnitus. Of the remaining 2,783, 2,018 (57%) contained the information that the patient had reported the tinnitus symptom, and 765 (21%) contained the information that the patient had not reported this symptom.

From then on, within the age group determined for this study, we verified that there were 512 (78%) patients informing the occurrence of tinnitus and 146 (22%) patients informing that they did not have the symptom.

In this perspective, the eligibility criteria for the composition of the sample and the formation of the study group (TG, tinnitus group) and of the control group (NTG, no tinnitus group) were defined: presence of acquired, bilateral sensorineural and moderate hearing loss (with mean auditory thresholds of 41–60 dB HL at 500, 1,000, 2,000, and 4,000 Hz), flat or slightly descending audiometric configuration, percentage index of speech recognition higher or equal to 76% in both ears, and type A tympanometric curves.

Also, they should have Brazilian Portuguese as their native language, fluent reading regardless of educational level, right handedness, be candidates for use of micro-canal auditory prostheses, and present the tinnitus symptom in both ears, with perception of constancy and discomfort (TG), considering the scores of the visual analog scale (higher or equal to 5, from the moderate level) and the Tinnitus Handicap Inventory (higher or equal to 38, from the moderate level)[13], or to not have it at all (NTG).

Individuals with difficulty to understand the required tasks, evident neurological, articulation, and/or verbal fluency alterations, and those with previous experience using hearing aids were excluded.

After an investigation through analysis of medical records, contact by telephone and/or in person, in view of the eligibility criteria listed above, the initial sample comprised 19 elderly individuals. However, by the end of 2013, five more patients were included in the study.

In conclusion, the final sample consisted of 24 participants, with 18 females and 6 males, divided into two groups of 12 each for TG and NTG.

Procedures

The elderly individuals that met the eligibility criteria were tested twice for measurement of the speech perception: List of Sentences in Portuguese (LSP) test and Dichotic Sentence Identification (DSI) test, which analyzed, respectively, the

auditory skills of closure and figure-ground, both inherent to the physiological mechanism of selective attention.

The tests were applied to both groups at three moments: before the fitting of the auditory prostheses (T1), with 1 month (T2) and 3 months (T3) of effective use. In T2 and T3, the tests were applied with and without the devices.

In this study, we considered an effective use of auditory prostheses, in T2 and T3, when the recorded usage time indicated, at least, 8 h/day. The duration of each session was, on average, 30 minutes. All the participants were fitted with micro-channel auditory prostheses, of the same manufacturer and model, with the frequency range described in the technical details between 150 and 7,000 Hz.

The LSP test, used for the investigation of signal-to-noise (S/N) ratio, consists of a list of 25 sentences in Portuguese[14] (1A list) and 7 lists with 10 sentences each and a competing speech-spectrum-shaped noise. The use of this material was supported by an ascending–descending strategy, which allows us to determine the sentence recognition threshold in noise (SRTN) at which the individual is able to correctly recognize 50% of the presented sentences. The S/N ratio is the difference between the mean level of sentences and the level of the competing noise. Whenever this value is a negative number, it is understood that the individual was able to recognize the speech in a lower level than the level of the noise.

A Brazilian Portuguese version[16] of the DSI test, which was designed to evaluate the central auditory function in individuals with hearing loss[15], was created. This consisted of 30 pairs of sentences presented dichotically at a 50 dB sensation level or the hearing level more comfortable for the patient. The evaluated individual must identify in a printed list the sentences presented aurally and, for each correct answer, a value of 10% is assigned. The test consists of the training steps, binaural integration, and hearing directed to the right and to the left.

In both tests, we used an audiometer (GSI 61 model; Grason-Stadler), with TDH 50P supra-aural headphones, and a CD player (D-152K model; Sony) coupled to the mentioned audiometer.

Statistical method

In the statistical analysis, we used the software programs SPSS version 17, Minitab 16, and Excel Office 2010 and the statistical Mann–Whitney test (comparison between groups). In this study, we adopted the 0.05 significance level (5%) for the statistical analysis. The statistically significant values were marked with an asterisk (*), as those that, by being close to the acceptance threshold, with a tendency to be significant (up to 5% points above the adopted alpha value), were marked with two asterisks (**).

RESULTS

We evaluated 24 elderly individuals, 12 women aged 61–70 years (mean 66.9 years) in TG, and 6 men and 6 women aged 61–69 years (mean 64.5 years) in NTG.

As for the educational level, a variation of 5–10 years for TG and 6–10 years for NTG was observed. However, for this study, elderly people with fluent reading were accepted, regardless of the educational level.

About the time elapsed from the onset of the hearing loss to the intervention through hearing aids, both groups showed variation between 2 and 30 years of auditory deprivation, with a mean of 8.7 years for TG and 8.2 years for NTG.

As for the time elapsed from the onset of the tinnitus symptom to the fitting of the auditory prostheses, TG had a mean of 10.5 years, ranging between 4 and 30 years.

For the LSP test, the comparative study between the S/N ratios obtained in TG and NTG, for the right and left ears, respectively, showed that TG had higher S/N ratios before and after the Speech Language Pathology and Audiology intervention, through the fitting of the hearing aids, and at the T2 moment, in the left ear, without the use of the devices. A progressive improvement of the S/N ratio was observed in both groups over time (Tables 1 and 2).

For the DSI test, the comparative study between the percentages obtained in the binaural integration stage, in TG and NTG, for the right and left ears, respectively, showed better performance of NTG, being significant only in the T2 and T3 moments, with auditory prostheses in the right ear. For the left ear, the difference between groups was higher, not showing a significant difference only in T3, without the use of auditory prostheses (Tables 3 and 4).

Still regarding the DSI test, the comparative study between the percentages obtained in the stages of hearing directed to

Table 1. Descriptive statistics and comparative study between groups, by moment, for the values of the signal-to-noise ratio in the right ear (n=12)

Moments Groups	Mean (SD)	Median	Q1	Q3	CI	p-value
T1						
TG	10.27 (2.32)	10.5	8.1	11.8	1.31	0.003*
NTG	7.62 (1.74)	7.1	6.4	8	0.99	
T2 without						
TG	9.18 (2.23)	8.9	7.6	10.8	1.26	0.005*
NTG	6.82 (1.24)	6.5	6	7	0.7	
T3 without						
TG	7.2 (1.32)	7.1	6.4	8	0.74	0.063**
NTG	6.23 (1.36)	6	5	7.2	0.77	
T2 with						
TG	7.08 (1.29)	7	6.4	7.7	0.73	0.052**
NTG	6.08 (1.02)	5.7	5.3	6.5	0.57	
T3 with						
TG	5.51 (0.89)	5.5	4.9	6	0.5	0.620
NTG	5.31 (0.95)	5.3	4.6	6.1	0.54	

*Significant values; **Values with tendency to be significant – Mann-Whitney test
Caption: Q1 = first quartile; Q3 = third quartile; N = number of participants; CI = confidence interval; TG = tinnitus group; NTG = no tinnitus group; T1 = first evaluation; T2 without = second evaluation without prosthesis; T2 with = second evaluation with prosthesis; T3 without = third evaluation without prosthesis; T3 with = third evaluation with prosthesis

Table 2. Descriptive statistics and comparative study between groups, by moment, for the values of the signal-to-noise ratio in the left ear (n=12)

Moments Groups	Mean (SD)	Median	Q1	Q3	CI	p-value
T1						
TG	9.78 (1.77)	10.3	8.3	10.7	1	0.008*
NTG	7.57 (1.72)	7.9	6	8.3	0.97	
T2 without						
TG	8.24 (1.21)	8.1	7.1	9.1	0.69	0.148
NTG	7.36 (1.59)	7.1	6.6	7.9	0.9	
T3 without						
TG	7.11 (1.29)	7.4	5.9	8	0.73	0.062**
NTG	6.13 (0.96)	6.5	5.5	7	0.54	
T2 with						
TG	7.04 (1.3)	7.1	6.2	7.6	0.74	0.057**
NTG	6.18 (1.03)	6.5	5	7	0.59	
T3 with						
TG	5.74 (0.96)	5.8	5	6.3	0.54	0.188
NTG	5.27 (0.78)	5.3	5	5.6	0.44	

*Significant values; **Values with tendency to be significant – Mann-Whitney test
Caption: Q1 = first quartile; Q3 = third quartile; CI = confidence interval; TG = tinnitus group; NGT = no tinnitus group; T1 = first evaluation; T2 without = second evaluation without prosthesis; T2 with = second evaluation with prosthesis; T3 without = third evaluation without prosthesis; T3 with = third evaluation with prosthesis

Table 4. Descriptive statistics and comparative study between groups, by moment, for the percentages obtained in the binaural integration stage in the left ear (n=12)

Moments Groups	Mean (SD) (%)	Median (%)	Q1 (%)	Q3 (%)	CI (%)	p-value
T1						
TG	57.5 (6.2)	60	50	60	3.5	0.004*
NTG	66.7 (6.5)	70	60	70	3.7	
T2 without						
TG	67.5 (6.2)	70	70	70	3.5	0.001*
NTG	77.5 (6.2)	80	70	80	3.5	
T3 without						
TG	83.3 (6.5)	80	80	90	3.7	0.343
NTG	85.8 (5.1)	90	80	90	2.9	
T2 with						
TG	76.7 (6.5)	80	78	80	3.7	0.017*
NTG	82.5 (4.5)	80	80	83	2.6	
T3 with						
TG	87.5 (7.5)	90	88	90	4.3	0.038*
NTG	93.3 (4.9)	90	90	100	2.8	

*Significant values – Mann-Whitney test
Caption: Q1 = first quartile; Q3 = third quartile; CI = confidence interval; TG = tinnitus group; NGT = no tinnitus group; T1 = first evaluation; T2 without = second evaluation without prosthesis; T2 with = second evaluation with prosthesis; T3 without = third evaluation without prosthesis; T3 with = third evaluation with prosthesis

Table 3. Descriptive statistics and comparative study between groups, by moment, for the percentages obtained in the binaural integration phase in the right ear (n=12)

Moments Groups	Mean (SD) (%)	Median (%)	Q1 (%)	Q3 (%)	CI (%)	p-value
T1						
TG	66.7 (10.7)	70	60	73	6.1	0.325
NTG	70.8 (5.1)	70	70	70	2.9	
T2 without						
TG	72.5 (6.2)	70	70	80	3.5	0.527
NTG	74.2 (5.1)	70	70	80	2.9	
T3 without						
TG	81.7 (7.2)	80	80	90	4.1	0.140
NTG	85.8 (5.1)	90	80	90	2.9	
T2 with						
TG	77.5 (4.5)	80	78	80	2.6	0.016*
NTG	82.5 (4.5)	80	80	83	2.6	
T3 with						
TG	86.7 (6.5)	90	80	90	3.7	0.047*
NTG	90.8 (2.9)	90	90	90	1.6	

*Significant values – Mann-Whitney test
Caption: Q1 = first quartile; Q3 = third quartile; CI = confidence interval; TG = tinnitus group; NGT = no tinnitus group; T1 = first evaluation; T2 without = second evaluation without prosthesis; T2 with = second evaluation with prosthesis; T3 without = third evaluation without prosthesis; T3 with = third evaluation with prosthesis

the right and to the left, in TG and NTG, respectively, did not show significant difference between the groups, for the stage of hearing directed to the right ear. In the stage of hearing directed to the left ear, it was observed that, in T1, no difference was observed between the groups, however, differences between them were noted in later evaluations, with NTG being significantly better than TG (Figures 1 and 2).

DISCUSSION

We chose to study the elderly in a limited age group, bearing in mind that the aging process causes organic and physiological changes in the auditory system. With this measure, we avoided comparing the performance of elderly individuals with very different ages.

Tinnitus is common in individuals aged 55–75 years[17], as this otorhinolaryngological complaint is frequent among the elderly.

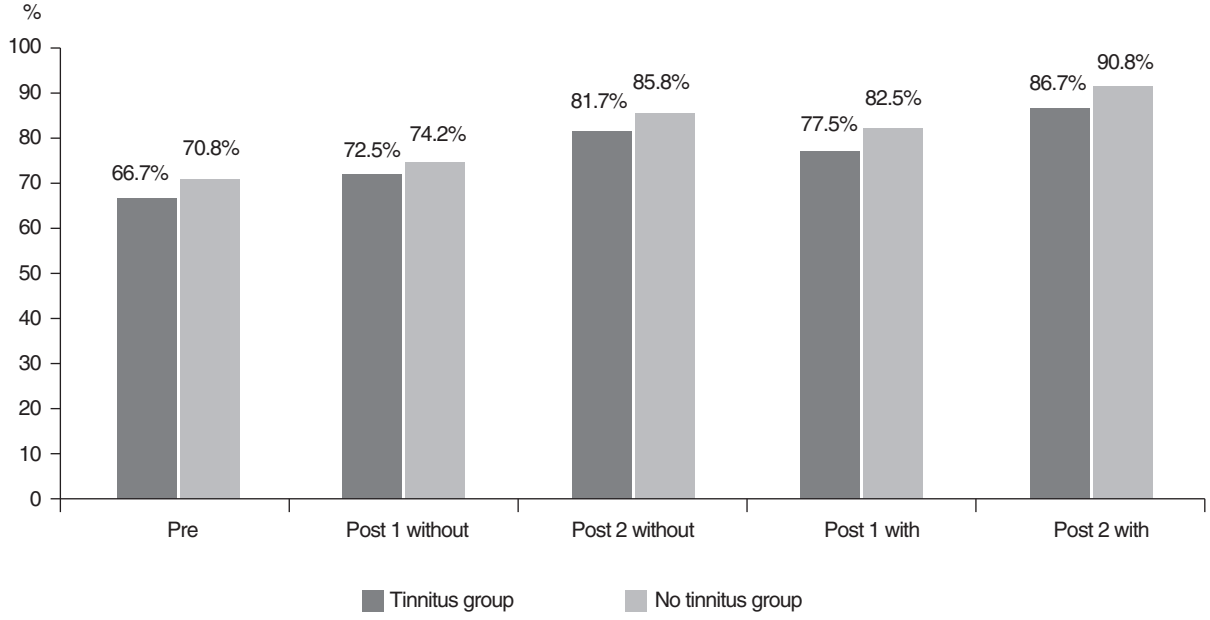
One can note a higher proportion of female elderly participants in this study (18 women, 12 in TG). There is an increased occurrence of the symptoms in females[4,18]; however, it is important to state that women have always shown more concern about the deterioration of hearing, as well as general health[19].

The temporary or permanent reduction of auditory stimuli (sensory deficit) can increase the sensitivity of subcortical neurons, resulting in a plastic reorganization of the auditory cortex, that is, the neural activity throughout the central

auditory pathway modifies itself to compensate for the deficit in the peripheral entrance. This leads to a permanent reorganization of the auditory cortex, resulting in a constant perception of tinnitus[8-10].

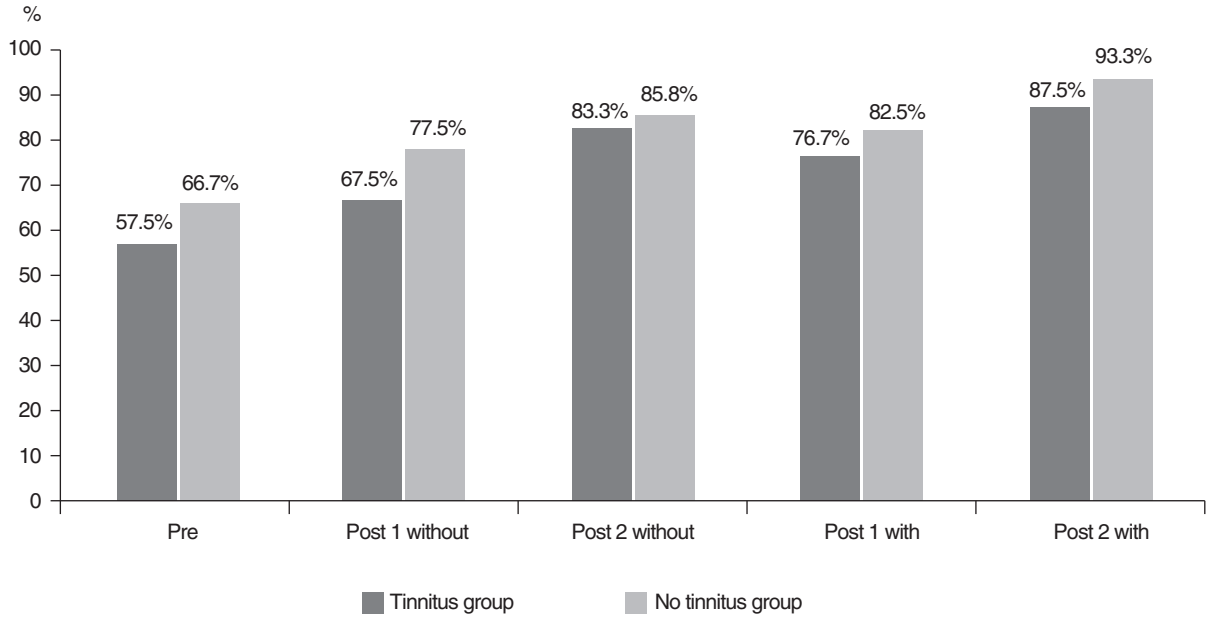
Studies about plasticity have suggested that the increased auditory stimulus caused by the hearing amplification can induce secondary plasticity, contributing to improve speech recognition over time (acclimatization)[12-14].

The effective use of auditory prostheses would promote, also, the reduction of discomfort and the change of the attentional focus on tinnitus. This would benefit the performance of the individuals regarding the speech perception[20] because there would be a reduction in hyperactivity in regions of the auditory pathway and in nonauditory pathways, such as those associated with perception, attention, memory, and emotional reactions[21].



Mann-Whitney test

Figure 1. Comparative study between the tinnitus and no tinnitus groups, by moment, for the percentages obtained in the hearing stage directed to the right ear. The volunteers were evaluated at the following moments: pre (T1), post 1 without (T2 without the use of the auditory prosthesis), post 2 without (T3 without the use of the auditory prosthesis), post 1 with (T2 with the use of the auditory prosthesis), and post 2 with (T3 with the use of the auditory prosthesis)



Mann-Whitney test

Figure 2. Comparative study between tinnitus and no tinnitus groups, by moment, for the percentages obtained in the hearing stage directed to the left ear. The volunteers were evaluated at the following moments: pre (T1), post 1 without (T2 without the use of the auditory prosthesis), post 2 without (T3 without the use of the auditory prosthesis), post 1 with (T2 with the use of the auditory prosthesis), and post 2 with (T3 with the use of the auditory prosthesis)

Individuals with tinnitus and hearing loss would have more difficulty understanding the speech than individuals without tinnitus and hearing loss, even with equal auditory thresholds, because the tinnitus increases the level of difficulty in activities that require understanding of sentences in the presence of noise[22]. The findings of this research agree with what was explained earlier because, since the initial assessment (T1), TG had a worse performance than NTG for the speech perception tests (Tables 1 to 4, Figures 1 and 2).

The comparative study between the S/N ratios obtained in TG and NTG, for the right and left ears, showed that TG had higher S/N ratios before and after the Speech Language Pathology and Audiology intervention, through the fitting of hearing aids. Both groups evolved during the treatment, and at the T3 moment, it was observed that the mean S/N ratio of the groups was closer, that is, the acoustic stimulation allowed, in addition to an improved S/N ratio, a more homogeneous performance among them, which did not occur in T1 (Tables 1 and 2).

A research found that, in tests that evaluate the physiological mechanism of selective attention, individuals with tinnitus and hearing thresholds within normal standards showed lower performance than those without tinnitus and with normal results in the audiometry[23].

The specialized literature[24] pointed out that the results obtained through the use of positron emission tomography indicated that the sensation of tinnitus is associated with activity points in the cortical areas functionally related to attention, emotion, and memory (prefrontal cortex and temporal cortex). In addition, the clinically significant tinnitus would be associated with an improper orientation of the attention, which would maintain a state of sustained alert.

In a study[6] that also used the LSP test to assess the speech recognition in normal-hearing individuals with and without tinnitus and hyperacusis complaints, a lower performance for the SRTN was discovered (with a significant difference for the S/N ratio). The authors inferred that a probable alteration in the functioning of the efferent fibers of the medial olivocochlear system, critical for maintaining selective attention in noisy environments, could affect this performance. These findings corroborate the ones discovered in this research.

Another study[25] assessed the effect of acclimatization in new users of auditory prostheses, which were evaluated without them. The participants were between 28 and 78 years old and had moderate-to-severe sensorineural hearing loss. The assessments took place in three moments: before the fitting, with 14 days of use, and after 3 months of use. They applied the LSP test and obtained as results significant improvements when comparing the moments one and two and one and three, both for the sentence recognition threshold in silence and the SRTN. They concluded that the participants improved their performance over time, even when being evaluated without the hearing aids, and that this improvement may be linked to the effect of acclimatization.

This research found good results, as in the study mentioned earlier. However, although an improved performance without auditory prostheses (after 1 and 3 months of effective use) has been found, the performance achieved in the assessments with the devices was superior. This shows that the auditory system needs continuous acoustic stimulation.

The acoustic stimulation through auditory prostheses was also beneficial to the hearing skills of temporal processing[26] in a group of elderly people. The assessments were made before the fitting and after 3 months of use of the devices to analyze the effects of acclimatization. The authors also commented that there is no consensus in the specialized literature whether only the use of auditory prostheses provides the improvement in hearing skills or whether it is necessary to have auditory training to change the auditory behavior. As in this study, the only adopted treatment was the auditory prosthesis. Nevertheless, auditory training should not be discarded because it helps activating the auditory system, reinforcing beneficial alterations in the auditory behavior and in the central nervous system.

Regarding the test used to analyze the auditory skill of figure-ground (DSI), for both groups, in both ears, a significantly higher percentage was observed, in both ears, in T2 and T3 moments, compared to the T1 moment.

Still, in the comparison between groups for the percentages of the DSI, binaural integration stage (Tables 3 and 4), a better performance was observed in NTG, being significant only in the T2 and T3 moments with auditory prostheses in the right ear. In the left ear, the difference between groups was higher, showing no significant difference only in T3, without the use of auditory prostheses.

The DSI test had its version in Portuguese standardized[16] in individuals with auditory thresholds within normal limits. When applied to 200 individuals, of both genders, divided into four groups according to age groups 13–19 years, 20–29 years, 30–39 years, and 40–49 years, the minimum values of reference were determined, considering the period of testing and the ear: 70% of correct answers on the right and 60% on the left for the binaural integration stage, and 72% of correct answers bilaterally in the directed hearing stage. In conclusion, with increasing age, the percentage of correct answers decreases.

The findings of this study are in agreement with those reported in the literature[27], both for the percentage values and for a better performance in the right ear, in both groups. The right ear advantage in right-handed individuals is expected in the application of a dichotic hearing test, and may be related to the strong connection with the left brain, which, in turn, is the dominant hemisphere for speech stimuli and processing of language information in binaural integration tasks[28].

As for the comparison between groups, in the stages of hearing directed to the right and left (Figures 1 and 2), no significant difference was observed between TG and NTG only for the right ear. NTG performed better in T1, T2, and T3 for both ears.

The literature mentions that there are performance differences between the stages of binaural integration and directed hearing in dichotic hearing tests, with worse results for binaural integration[29], as this step is a more complex task, which requires the recognition and storage of the both auditory information, coming from the right and left ears. For the directed hearing stage, the requested task becomes simpler as a result

of the fact that only one information is to be selected, ignoring the message received in the other ear[30].

The results of this study showed that the group of elderly participants with chronic tinnitus had an inferior performance compared to the group without tinnitus regarding speech perception (auditory skills of closure and figure-ground). However, both groups had improved performance after 1 and 3 months of effective use of auditory prostheses. It is important to point out that the performance of these volunteers was even better when they were evaluated using the devices, which reinforces the importance of orienting the patient regarding the continued use of the auditory prostheses.

CONCLUSION

From the data obtained, it was possible to conclude that the closure and figure-ground skills for verbal sounds are better in the elderly individuals that do not have tinnitus complaints. Nevertheless, both groups showed improvement in the speech perception after an intervention with acoustic stimulation through auditory prostheses.

**TMA was responsible for the elaboration of the research and schedule, literature review, data collection and analysis, writing the article, and submission and procedures for the article; MCMI was responsible for the elaboration of the research and schedule, correcting the article, and approving the final version.*

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