



Brazilian Journal of Otorhinolaryngology

ISSN: 1808-8694

revista@aborlccf.org.br

Associação Brasileira de

Otorrinolaringologia e Cirurgia Cérvico-

Facial

Brasil

de Melo Araujo, Tiago; Martinelli Lório, Maria Cecília

Effects of sound amplification in self-perception of tinnitus and hearing loss in the elderly

Brazilian Journal of Otorhinolaryngology, vol. 82, núm. 3, mayo-junio, 2016, pp. 289-296

Associação Brasileira de Otorrinolaringologia e Cirurgia Cérvico-Facial

São Paulo, Brasil

Available in: <http://www.redalyc.org/articulo.oa?id=392445788008>

- How to cite
- Complete issue
- More information about this article
- Journal's homepage in [redalyc.org](http://redalyc.org)

[redalyc.org](http://redalyc.org)

Scientific Information System

Network of Scientific Journals from Latin America, the Caribbean, Spain and Portugal

Non-profit academic project, developed under the open access initiative



ORIGINAL ARTICLE

## Effects of sound amplification in self-perception of tinnitus and hearing loss in the elderly<sup>☆,☆☆</sup>



Tiago de Melo Araujo<sup>a,\*</sup>, Maria Cecília Martinelli Iório<sup>b</sup>

<sup>a</sup> Post-graduate in Human Communication Disorders, Department of Phonoaudiology, Escola Paulista de Medicina, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil

<sup>b</sup> Department of Phonoaudiology, Escola Paulista de Medicina, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil

Received 14 April 2015; accepted 12 May 2015

Available online 16 October 2015

### KEYWORDS

Questionnaires;  
Scales;  
Elderly;  
Tinnitus;  
Hearing aids

### Abstract

**Objective:** To determine the effect of the use of hearing aids in self-perception of tinnitus and hearing loss in the elderly.

**Methods:** A total of 24 elderly patients between 60 and 70 years of age with moderate-grade sensorineural hearing loss were evaluated and divided into two groups according to the presence or absence of tinnitus. All volunteers were fitted with binaural micro-channel hearing aids of the same brand and model and submitted to tests, scales, and questionnaires relevant to this topic. The evaluations were performed before and after one and three months of effective use of these hearing aids.

**Results:** Acoustic stimulation through the effective use of hearing aids caused a reduction in the perception of tinnitus sound intensity (especially in evaluations with the prosthesis on) and in nuisance associated with this symptom and with hearing loss. In addition, all participants were satisfied with the use of hearing aids.

**Conclusion:** The continuous use of hearing aids is beneficial for the treatment of tinnitus and hearing loss, bringing satisfaction to users.

© 2015 Associação Brasileira de Otorrinolaringologia e Cirurgia Cérvico-Facial. Published by Elsevier Editora Ltda. All rights reserved.

<sup>☆</sup> Please cite this article as: Araujo TM, Iório MCM. Effects of sound amplification in self-perception of tinnitus and hearing loss in the elderly. Braz J Otorhinolaryngol. 2016;82:289–96.

<sup>☆☆</sup> Study conducted in the *Núcleo Integrado de Assistência, Pesquisa e Ensino da Audição* (NIAPEA), Department of Phonoaudiology, Escola Paulista de Medicina, Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil.

\* Corresponding author.

E-mail: [tiagoaraujofono@yahoo.com.br](mailto:tiagoaraujofono@yahoo.com.br) (T.M. Araujo).

**PALAVRAS-CHAVE**

Questionários;  
Escalas;  
Idoso;  
Zumbido;  
Auxiliares de audição

**Efeitos da amplificação sonora na autopercepção do zumbido e da perda auditiva em idosos****Resumo**

**Objetivo:** Verificar o efeito do uso de próteses auditivas na autopercepção do zumbido e da perda auditiva em idosos.

**Método:** Foram avaliados 24 idosos com perda auditiva neurosensorial de grau moderado e idades entre 60 e 70 anos divididos em dois grupos conforme a presença ou não de zumbido. Todos os voluntários foram adaptados binauralmente com próteses auditivas micro canais de mesmo fabricante e modelo e submetidos a testes, escalas e questionários pertinentes ao tema. As avaliações ocorreram pré, e após um e três meses de uso efetivo das próteses auditivas.

**Resultados:** A estimulação acústica por meio do uso efetivo de próteses auditivas propiciou redução na autopercepção da intensidade sonora do zumbido (principalmente nas avaliações com as próteses) e no desconforto com este sintoma e com a perda auditiva. Além disso, todos os participantes mostraram-se satisfeitos com o uso dos dispositivos de amplificação.

**Conclusão:** O uso contínuo das próteses auditivas é benéfico ao tratamento do zumbido e da perda auditiva, além de implicar na satisfação dos usuários.

© 2015 Associação Brasileira de Otorrinolaringologia e Cirurgia Cérvico-Facial. Publicado por Elsevier Editora Ltda. Todos os direitos reservados.

**Introduction**

According to the World Health Organization, tinnitus, *i.e.*, sound perception by a person in the absence of an external generating source,<sup>1</sup> is a symptom that affects about 278 million people worldwide, and about 28 million in Brazil.<sup>2</sup> International data indicate that the prevalence of tinnitus in the general population increased from 15% to 25.3% in only 15 years, and these numbers grow with the increasing age of the population.<sup>3</sup>

Approximately 20% of patients with chronic tinnitus (tinnitus present for over three months) experience a significant nuisance effect,<sup>4</sup> and among other complaints describe flaws in reasoning, memory, and concentration; impairment of speech discrimination and ability to maintain selective attention; and decreased pleasure derived from leisure activities, resting, and conviviality in their social environment.<sup>5-7</sup>

A temporary or permanent decrease in auditory stimuli (sensory deficit) increases the sensitivity of subcortical neurons, resulting in the plastic reorganization of the auditory cortex, with subsequent sustained awareness of tinnitus.<sup>8,9</sup>

The literature suggests that feelings of intensity with respect to tinnitus may be related to the nuisance caused by this condition,<sup>10,11</sup> and that there are several tools<sup>12-15</sup> which can be used to assess and monitor the treatment of patients suffering from this symptom, among which the authors emphasize the acuphenometry test, the visual-analogue scale (VAS), and the Tinnitus Handicap Inventory (THI) questionnaire. In patients with tinnitus associated with hearing loss, the IOI-HA (International Outcome Inventory for Hearing Aids) is also of value when rehabilitation is through the use of hearing aids.

Studies of plasticity have suggested that an increase of the auditory stimulus provided by sound amplification through the use of hearing aids can induce secondary

plasticity, helping to decrease the nuisance associated with tinnitus.<sup>16,17</sup>

From this perspective, the hypotheses that guided us to initiate this research were that the use of sound amplification would reduce the sensation of intensity of tinnitus in the elderly with hearing impairment and decrease the nuisance associated with both symptoms (tinnitus and hearing loss), determining the success of patient's adaptation to hearing aids.

Considering that the presence of tinnitus also interferes in health self-perception in the elderly,<sup>18</sup> the present study aimed to verify the effect of the use of hearing aids in self-perception of tinnitus in the elderly with hearing impairment.

**Methods**

This research was conducted in the Integrated Center for Assistance, Research, and Education in Hearing (Núcleo Integrado de Assistência, Pesquisa e Ensino em Audição [NIAPEA]), Department of Phonoaudiology, Escola Paulista de Medicina/Universidade Federal de São Paulo (EPM/UNIFESP) during the years 2013 and 2014, after approval by the Ethics Committee in Research, UNIFESP, under Presentation Certificate for Ethics Assessment (CAAE) No. 09876112.1.0000.5505.

This study consisted of an interventional prospective study and of a non-probabilistic sample, which monitored and evaluated 24 elderly patients aged 60-70 years, divided into two groups according to the presence or absence of tinnitus symptoms. The subjects' participation was voluntary and confirmed by signing the informed consent.

Initially, a survey was conducted with a medical record analysis of all patients who were seen in the service between the years 2010 and 2013 in order to ascertain the occurrence of tinnitus in the population attended to in NIAPEA. There

were 3580 medical records analyzed, with the exclusion of those subjects outside the intended age group of this study, resulting in 658 medical records. Of these, it was found that 512 (78%) patients reported the presence of tinnitus (with or without nuisance) and 146 (22%) reported not having the symptom.

Accordingly, eligibility criteria were defined for the composition of the sample and formation of study (TG – with tinnitus) and control (TGw/o – without tinnitus) groups.

Thus, for both groups, inclusion criteria were presence of moderate-grade bilateral acquired sensorineural hearing loss (mean of pure tone auditory thresholds 41–60 dB HL at 500, 1000, 2000, and 4000 Hz), flat or slightly downward audiometric configuration, speech recognition percentage scores of  $\geq 76\%$ , and type-A tympanometry curves in both ears. Furthermore, Brazilian Portuguese was required to be their mother tongue; finally, subjects needed to be candidates for the use of binaural microchannel hearing aids.

*For the TG:* after this first selection, patients who met these criteria were submitted to the VAS and the THI questionnaire, because only patients with a constant awareness of annoying tinnitus remained in the group, according to the following criteria defined for this study: VAS  $\geq 5$  (at least moderate grade) and THI  $\geq 38$  (at least moderate grade).<sup>19</sup>

*For the TGw/o:* it was required not to have the symptom under study.

Subjects with obvious neurological, articulatory, and/or verbal fluency disorders and those with previous experience with the use of hearing aids also were excluded.

Given the eligibility criteria listed above and after the investigation conducted through analysis of medical records and telephone and/or face-to-face contact, the final sample consisted of 24 subjects (18 females and six males) distributed in two groups: TG = 12 and TGw/o = 12.

## Procedures

TG seniors who met eligibility criteria were submitted to an acuphenometry test (perception of frequency and sound intensity level of tinnitus measurements), VAS (subjective degree of nuisance caused by hearing loss and tinnitus), THI (subjective degree of nuisance caused by tinnitus), and IQ-ISAD (success of the patient's adaptation to hearing aids) questionnaires. TGw/o seniors were submitted to VAS (subjective degree of nuisance caused by hearing loss) and IQ-ISAD.

In this study, effective use of hearing aids mandated that the subject used the device for at least eight hours/day. All seniors were fitted with microchannel hearing aids of the same brand and model, whose frequency range described in the technical sheet ranges from 150 to 7000 Hz.

The acuphenometry test, used to measure data, such as perception of frequency and intensity of tinnitus, is quite useful in assessing and monitoring treatment of patients with this symptom,<sup>14</sup> and was implemented at three points in time: before the fitting of hearing aids (T1), after one month (T2), and after three months of effective use (T3). In T2 and T3, the tests were applied with and without the device, utilizing a Grason-Stadler GSI 61 audiometer with supra-aural TDH 50P phones.

The VAS is an easy-to-use scale that is most commonly used in studies on this subject,<sup>14</sup> and provides self-assigned scores between 0 and 10 reflecting the nuisance associated with the assessed symptom (tinnitus or hearing loss) in a simple and objective way.

The THI questionnaire, developed<sup>20</sup> in 1996 and adapted<sup>12</sup> and validated<sup>21</sup> for Brazilian Portuguese, assesses emotional, functional, and catastrophic aspects of tinnitus patients.

The IQ-ISAD questionnaire, proposed<sup>22</sup> in 2002 and also translated and adapted into Portuguese,<sup>15</sup> reflects the success of the patient's adaptation to hearing aids, by evaluating each of the following areas: use, benefit, limitation of activities, satisfaction, participation restriction, impact of hearing loss in contact with other people, and quality of life. These domains are only evaluated in patients with hearing aids, after experience with the use of amplification.

## Statistics

In the statistical analysis, SPSS v. 17, Minitab v. 16, and Excel 2010 software were used. Wilcoxon (evolution of the individuals within the group) and Mann-Whitney (comparison between groups) tests also were used. This study adopted the 0.05 significance level (5%) for statistical analysis. In the tables, the statistically significant values were marked with an asterisk [\*]; however, those values that, due to their proximity to the acceptance limit, tended to be significant (up to 5% above the value of  $\alpha$  adopted), were marked with a hash character (#).

## Results

This study evaluated 24 elderly patients: 12 women aged 61–70 years (mean 66.9) in the TG, and six men and six women aged 61–69 years (mean 64.5) in the TGw/o.

The range, in years, of education for the TG was 5–10 years and for the TGw/o was 6–10 years.

The duration of time from the onset of hearing loss until the intervention with hearing aids for both groups exhibited a variation of 2–30 years of hearing deprivation, with an average of 8.7 years for the TG and 8.2 years for the TGw/o.

The length of time from the onset of tinnitus until the adaptation of hearing aids averaged 10.5 years for the TG, ranging from four to 30 years.

Comparing the type of tinnitus reported by the patient and the measure of the perception of pitch frequency of this symptom (acuphenometry), 100% ‘‘pure tone’’ tinnitus was observed, with descriptions such as whistle, cricket, bell, hissing, and buzzer, at frequencies of sensation around 2000 and 8000 Hz, with a mean of 5300 Hz for the right ear and 5100 Hz for the left ear.

The sensation of sound intensity caused by tinnitus (acuphenometry) in the TG demonstrated a significant reduction for both ears over the evaluations (Tables 1 and 2).

The mean scores for the nuisance associated with hearing loss, as measured by VAS, decreased over time in both groups, with statistically significant difference in T3, at which time the TGw/o experienced less nuisance than the TG (Table 3).

**Table 1** Descriptive statistics and comparative study among time points of evaluation for the feeling of sound intensity (dB SL) of tinnitus in the right ear (TG).

Measures	T1	T2w/o	T3w/o	T2	T3
Mean	6.66	6	5.28	4.47	3.78
Median	6.3	5.8	5	4.5	3.2
Standard deviation	1.3	1.23	0.99	1.24	1.18
Q1	5.7	5	4.8	3.5	3
Q3	7.7	6.8	6.2	5	5
<i>n</i>	12	12	12	12	12
CI	0.74	0.7	0.56	0.7	0.67

*n*, number of subjects; Q1, first quartile; Q3, third quartile; CI, confidence interval; TG, tinnitus group; T1, first evaluation; T2w/o, second evaluation without prosthesis; T2, second evaluation with prosthesis; T3w/o, third evaluation without prosthesis; T3, third evaluation with prosthesis.

Statistical test used: Wilcoxon.

*p*-Values obtained in the comparison between time points: T2w/o × T1: 0.022\*; T3w/o × T1: 0.002\*; T2 × T1: 0.002\*; T3 × T1: 0.002\*.

**Table 2** Descriptive statistics and comparative study among time points of evaluation for the perception of sound intensity (dB SL) of tinnitus in the left ear (TG).

Measures	T1	T2w/o	T3w/o	T2	T3
Mean	6.66	6.19	5.47	4.61	3.61
Median	6.3	5.8	5.3	4.7	3.5
Standard deviation	1.38	1.29	1.17	1.59	1.06
Q1	6	5.5	5	4.1	3.2
Q3	7.6	7	6.2	5.1	4
<i>n</i>	12	12	12	12	12
CI	0.78	0.73	0.66	0.9	0.6

*n*, number of subjects; Q1, first quartile; Q3, third quartile; CI, confidence interval; TG, tinnitus group; T1, first evaluation; T2w/o, second evaluation without prosthesis; T2, second evaluation with prosthesis; T3w/o, third evaluation without prosthesis; T3, third evaluation with prosthesis.

Statistical test used: Wilcoxon.

*p*-Values obtained in the comparison between time points: T2w/o × T1: 0.022\*; T3w/o × T1: 0.002\*; T2 × T1: 0.002\*; T3 × T1: 0.002\*.

The nuisance from tinnitus, as measured by VAS, showed a significant reduction in the perception of intensity from tinnitus in the TG at time points T2 and T3 relative to T1 (Table 4).

For the total score of THI across evaluations, a significant reduction in nuisance complaints related to tinnitus was observed. At T1, the nuisance was moderate, at T2, it became light, and at T3, it was negligible (Table 5).

Regarding the IQ-ISAD questionnaire, the groups were homogeneous in comparisons between T2 and T3 vs. T1,

both by total score and by question (without statistical significance) (Table 6).

## Discussion

Because the aging process brings organic and physiological changes to the auditory system, we chose to study elderly patients in a restricted age group.<sup>23</sup> Thus, this study avoided comparing the performance of elderly patients with very

**Table 3** Descriptive statistics and comparative study among groups, by time point, for VAS (uncomfortable with hearing loss).

Times/groups	Mean	Median	Standard deviation	Q1	Q3	<i>n</i>	CI	<i>p</i> -Value
T1 TG	7	7	1.21	6.8	8	12	0.68	0.295
T1 TGw/o	7.67	7.5	1.5	7	8.3	12	0.85	
T2 TG	4.33	4.5	1.3	4	5	12	0.74	0.370
T2 TGw/o	4.75	5	1.29	4	6	12	0.73	
T3 TG	3.08	3	1.08	2.8	4	12	0.61	0.040
T3 TGw/o	2.08	2	1.31	1	3	12	0.74	

VAS, visual analogue scale; *n*, number of subjects; Q1, first quartile; Q3, third quartile; CI, confidence interval; TG, tinnitus group; TGw/o, group without tinnitus; T1, first evaluation (unaided); T2, second evaluation (with prosthesis); T3, third evaluation (with prosthesis).

Statistical test used: Mann-Whitney.

**Table 4** Descriptive statistics and comparative study among evaluation time points for VAS (uncomfortable with tinnitus) (TG).

Measures	T1	T2	T3
Mean	8.75	4.67	2.25
Median	9.5	4	2
Standard deviation	1.48	1.3	1.14
Q1	7.8	4	2
Q3	10	5.3	3
<i>n</i>	12	12	12
CI	0.84	0.74	0.64

VAS, visual analogue scale; *n*, number of subjects; Q1, first quartile; Q3, third quartile; CI, confidence interval; TG, tinnitus group; TGw/o, group without tinnitus; T1, first evaluation (unaided); T2, second evaluation (with prosthesis); T3, third evaluation (with prosthesis).

Statistical test used: Mann-Whitney.

*p*-Values obtained in the comparison between time points: T2 × T1: 0.002\*; T3 × T1: 0.002\*.

different ages. The occurrence of tinnitus in people aged 55–75 years is substantial.<sup>24</sup>

A higher proportion of female elderly patients were observed in this study (18 women; 12 in the TG). There is a greater occurrence of symptoms in females<sup>24,25</sup>; however, it is notable that women have always shown more concern about the deterioration of hearing, as well as with their general health.<sup>26</sup>

Studies of plasticity have suggested that an increase in the auditory stimulus provided by the hearing aid can induce secondary plasticity,<sup>16,17</sup> also diminishing the nuisance and the change of attentional focus with respect to tinnitus, because decreased hyperactivity would occur in regions of the auditory pathway and also in non-auditory pathways, such as those associated with perception, attention, memory, and emotional reactions.<sup>27</sup>

In line with this study, a higher incidence of “pure tone” tinnitus was observed (66%), but with frequencies around 6000 and 8000 Hz.<sup>28</sup> In the current survey, the mean value

**Table 5** Descriptive statistics and comparative study among evaluation time points for total score of THI questionnaire (TG).

Measures	T1	T2	T3
Mean	45	21.33	9.17
Median	41	20	8
Standard deviation	7.36	8.24	2.89
Q1	39.5	16	7.5
Q3	51	25	10.5
<i>n</i>	12	12	12
CI	4.16	4.66	1.63

THI, Tinnitus Handicap Inventory; *n*, number of subjects; Q1, first quartile; Q3, third quartile; CI, confidence interval; TG, tinnitus group; T1, first evaluation (unaided); T2, second evaluation (with prosthesis); T3, third evaluation (with prosthesis). Statistical test used: Wilcoxon.

*p*-Values obtained in the comparison between time points: T2 × T1: 0.002\*; T3 × T1: 0.002\*.

found for perception of tinnitus frequency falls within the range of amplification frequencies of hearing aids, which could explain the good prognosis for a decrease in the nuisance associated with the symptom. Another study found a similar mean (5333 Hz) and mentioned the importance of the choice of the hearing aid according to its frequency band.<sup>29</sup> A different study found a significant decrease of sound intensity of tinnitus in subjects whose frequency of the symptom was below 6000 Hz, and concluded that the frequency of tinnitus should be considered as an important factor in the success of amplification.<sup>30</sup>

A significant decrease in the perception of sound intensity caused by tinnitus was observed throughout the evaluations for both ears (Tables 1 and 2). It is noteworthy that in the assessments with hearing aids this perception of intensity was lower, when compared to the assessments carried out without these devices. This fact demonstrated the beneficial effect of a sustained acoustic stimulation on the perception of tinnitus by the patient. Similarly to the described results, perception of intensity of tinnitus levels was observed between 5 and 10 dB SL.<sup>31</sup>

Other authors<sup>32</sup> found no effect with the use of hearing aids in the perception of tinnitus sound intensity in any of the groups they studied; thus, those authors concluded that one month of treatment was not sufficient to demonstrate the effects of amplification in brain plasticity. However, they also did not report the time of effective use of hearing aids by the subjects they studied, and in the present study, positive results were observed from the first month of use.

Regarding the nuisance caused by hearing loss as measured by VAS, a significant reduction was observed from the evaluations in both groups (Table 3), with statistical difference only at T3, when the TGw/o reported less nuisance compared to the TG. The literature<sup>25</sup> states that the nuisance caused by tinnitus is added to that from the hearing loss; thus, it can be a difficult task for the patient to isolate symptoms, in order to define the quantification of nuisance.

Again, comparing the TG results for the nuisance due to hearing loss and to tinnitus (Table 4), a greater nuisance associated with tinnitus vs. hearing loss in T1 could be perceived. At T3, the mean that expresses the nuisance with tinnitus was lower than the mean that reflects the nuisance due to hearing loss, *i.e.*, the symptom that bothered the most exhibited the greatest improvement. In the specialized literature,<sup>33,34</sup> the nuisance associated with tinnitus can cease immediately with the use of hearing aids, but this does not occur with hearing loss with respect to perception and understanding of speech.

Where hearing loss and tinnitus occur together, an investigation into which of these symptoms causes the greater nuisance is warranted,<sup>35</sup> in order to target the therapeutic approach. In this study, TG showed greater nuisance from tinnitus; thus, in addition to the use of amplification, it was necessary for the participants to understand the pathophysiology of the symptom and the role of rehabilitation, helping them to reduce anxiety and control their expectations.

The findings of this study corroborate results<sup>36</sup> in which a reduction in nuisance due to hearing loss was observed in 96% of participants following fitting of hearing aids. The authors also emphasized the positive plastic changes in the central nervous system with the continuous use of the devices.

**Table 6** Descriptive statistics and comparative study among groups, by time point, for total score and by the IQ-ISAD tool.

Times/groups		Mean	Median	Standard deviation	Q1	Q3	n	CI	p-Value	
Total	T2	TG	31.42	31.5	1.16	31	32	12	0.66	0.788
		TGw/o	31.58	31	1.83	30.8	32.5	12	1.04	
	T3	TG	34.25	34.5	0.87	33.8	35	12	0.49	0.780
		TGw/o	34.17	34	0.83	33.8	35	12	0.47	
(Qu1)	T2	TG	4.92	5	0.29	5	5	12	0.16	0.546
		TGw/o	4.83	5	0.39	5	5	12	0.22	
	T3	TG	5	5	0	5	5	12	-	1.000
		TGw/o	5	5	0	5	5	12	-	
(Qu2)	T2	TG	4.08	4	0.67	4	4.3	12	0.38	0.527
		TGw/o	4.25	4	0.75	4	5	12	0.43	
	T3	TG	4.83	5	0.39	5	5	12	0.22	1.000
		TGw/o	4.83	5	0.39	5	5	12	0.22	
(Qu3)	T2	TG	3.92	4	0.79	3	4.3	12	0.45	0.975
		TGw/o	3.92	4	0.67	3.8	4	12	0.38	
	T3	TG	4.67	5	0.49	4	5	12	0.28	0.660
		TGw/o	4.75	5	0.45	4.8	5	12	0.26	
(Qu4)	T2	TG	4.42	4	0.51	4	5	12	0.29	0.527
		TGw/o	4.25	4	0.62	4	5	12	0.35	
	T3	TG	5	5	0	5	5	12	-	0.070
		TGw/o	4.75	5	0.45	4.8	5	12	0.26	
(Qu5)	T2	TG	4.67	5	0.49	4	5	12	0.28	0.660
		TGw/o	4.75	5	0.45	4.8	5	12	0.26	
	T3	TG	4.92	5	0.29	5	5	12	0.16	1.000
		TGw/o	4.92	5	0.29	5	5	12	0.16	
(Qu6)	T2	TG	4.92	5	0.29	5	5	12	0.16	0.284
		TGw/o	4.75	5	0.45	4.8	5	12	0.26	
	T3	TG	5	5	0	5	5	12	-	0.148
		TGw/o	4.83	5	0.39	5	5	12	0.22	
(Qu7)	T2	TG	4.50	4.5	0.52	4	5	12	0.30	0.090
		TGw/o	4.83	5	0.39	5	5	12	0.22	
	T3	TG	4.83	5	0.39	5	5	12	0.22	0.148
		TGw/o	5	5	0	5	5	12	-	

IQ-ISAD, International Questionnaire – Individual Sound Amplification Device; n, number of subjects; Q1, first quartile, Q3, third quartile; CI, confidence interval; TG, tinnitus group; TGw/o, group without tinnitus; T2, second evaluation; T3, third evaluation; Qu1, question 1; Qu2, question 2; Qu3, question 3; Qu4, question 4; Qu5, question 5; Qu6, question 6; Qu7, question 7.  
Statistical test used: Mann-Whitney.

In the present study, all volunteers suffered sensorineural hearing loss, *i.e.*, the nuisance from tinnitus could result from the permanent decrease in auditory stimuli with increased sensitivity of neurons in the subcortical centers, and the treatment with hearing aids decreases the peripheral deficit, causing the acoustic signal to be better expressed in the central auditory nervous system (CANS).<sup>37</sup>

Current research also showed that the mechanisms underlying plasticity also function during old age; therefore clinicians should not avoid therapeutic interventions in the elderly.

Still, with respect to the nuisance caused by tinnitus, the THI questionnaire results (Table 6) demonstrate that, during the evaluations, a significant decrease in nuisance complaints related to tinnitus occurred, either by total score or by the use of the scale. At T1, the nuisance was moderate; at T2, it became light; and at T3, negligible.

There is a direct relationship between the score of this questionnaire and the nuisance associated with tinnitus,<sup>38,39</sup> that is, it is clear that there was a reduction in nuisance over time.

As to the result of applying the IQ-ISAD (Table 6), the groups were homogeneous in comparisons between T2 and T3 vs. T1, both by total score and by question; there was no statistical significance. One study<sup>40</sup> mentioned that the reduction of tinnitus with the use of hearing aids can influence the users' satisfaction with the amplification device. In the current study, it was found that both groups already had high scores at T2, reaching 34 points at T3 – positive results also found in other studies.<sup>41,42</sup>

In the TG, whose participants reported a decrease in the perception of and nuisance associated with tinnitus, the level of satisfaction with the use of hearing aids is understandable. In some cases, patients with tinnitus are more concerned with relieving that symptom than actually reducing their hearing difficulties with the use of hearing aids, and use the device only if it produces tinnitus masking.<sup>40</sup>

With the IQ-ISAD, we found<sup>43</sup> no correlation among the variables gender, age, degree, hearing loss time, side of adaptation of hearing aids, time for adaptation, and amplification device category with the degree of user satisfaction.

Thus, these variables would not interfere with the results obtained from the questionnaire.

The results of this study revealed a significant reduction in self-perception of tinnitus in terms of sound intensity, and in the discomfort caused by this symptom and by the hearing loss. It is important to emphasize that the performance of the TG volunteers in acuphenometry test revaluations was even better when these subjects were evaluated with the devices on, which reinforces the importance of patient education regarding the continued use of hearing aids.

## Conclusion

From the data obtained, it was concluded that, during the evaluations in both groups, a decrease in nuisance caused by hearing loss was observed, and also that the perception of sound intensity and the nuisance caused by tinnitus were reduced after intervention with acoustic stimulation through sound amplification. There was no difference between groups with respect to success of adapting to hearing aids.

## Funding

This study was funded by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

## Conflicts of interest

The authors declare no conflicts of interest.

## References

- Sanchez TG, Ferrari GMS. O que é zumbido? In: Samelli AG, Org. *Zumbido: avaliação, diagnóstico e reabilitação*. São Paulo: Lovise; 2004. p. 17–22.
- Sanchez TG, Knobel KA, Ferrari GMS, Batezati SC, Bento RF. Grupo de apoio a pessoas com zumbido (GAPZ): metodologia, resultados e propostas futuras. *Arq Otorrinolaringol*. 2002;6:278–84.
- Shargorodsky J, Curhan GC, Farwell WR. Prevalence and characteristics of tinnitus among US adults. *Am J Med*. 2010;123:711–8.
- Pinto PCL, Sanchez TG, Tomita S. The impact of gender, age and hearing loss on tinnitus severity. *Braz J Otorhinolaryngol*. 2010;76:18–24.
- Han BI, Lee WH, Kim YT, Lim SJ, Shin KS. Tinnitus: characteristics, causes, mechanisms, and treatments. *J Clin Neurol*. 2009;5:11–9.
- Hennig TR, Costa MJ, Urnau D, Becker KT, Schuster LC. Recognition of speech of normal-hearing individuals with tinnitus and hyperacusis. *Int Arch Otorhinolaryngol*. 2011;15:21–8.
- Mondelli MFCG, Rocha AB. Correlação entre os achados audiológicos e incômodo com o zumbido. *Arq Int Otorrinolaringol*. 2011;15:172–80.
- Davis A, Rafeia EA. Epidemiology of tinnitus. In: Tyler RS, editor. *Tinnitus handbook*. San Diego (CA): Singular Publishing Group; 2000. p. 1–23.
- Eggermont JJ, Roberts LE. The neuroscience of tinnitus. *Trends Neurosci*. 2004;27:672–82.
- Newman CW, Wharton JA, Shivapuja BG, Jacobson GP. Relationships among psychoacoustic judgments, speech understanding ability and self-perceived handicap in tinnitus subjects. *Audiology*. 1994;33:47–60.
- Branco FCA [dissertação] Zumbido em adultos ouvintes normais – um estudo sobre o processamento auditivo central e o handicap. São Paulo: Pontifícia Universidade Católica de São Paulo; 1998.
- Ferreira PEA, Cunha F, Onishi ET, Branco-Barreiro FCA, Ganança FF. Tinnitus Handicap Inventory: adaptação cultural para o português brasileiro. *Pro Fono*. 2005;17:303–10.
- Bahmad FM Jr, Venosa AR, Oliveira CA. Benzodiazepines and GABAergic in treating severe disabling tinnitus of predominantly cochlear origin. *Int Tinnitus J*. 2006;12:140–4.
- Azevedo AA, Oliveira PM, Siqueira AG, Figueiredo RR. Análise crítica dos métodos de mensuração do zumbido. *Rev Bras Otorrinolaringol*. 2007;73:418–23.
- Bevilacqua MC, Henriques JPS. Questionário Internacional – Aparelho de Amplificação Sonora Individual (QI-AASI). Copenhagen: BC Decker Inc.; 2002.
- Amorim RMC, Almeida K. Estudo do benefício e da aclimatização em novos usuários de próteses auditivas. *Pro Fono*. 2007;19:39–48.
- Gatehouse S. The time course and magnitude of perceptual acclimatization to frequency responses: evidence from monoaural fitting of hearing aids. *J Acoust Soc Am*. 1992;92:1258–68.
- Araujo TM, Iorio MCM. Perfil populacional de idosos encaminhados à seleção de próteses auditivas em hospital público. *Audiol Commun Res*. 2014;19:45–51.
- McCombe A, Baguley D, Coles R, McKenna L, McKinney C, Windle-Taylor P. Guidelines for the grading of tinnitus severity: the results of a working group commissioned by the British Association of Otolaryngologists, Head and Neck Surgeons, 1999. *Clin Otolaryngol Allied Sci*. 2001;26:388–93.
- Newman CW, Jacobson GP, Spitzer JB. Development of the tinnitus handicap inventory. *Arch Otolaryngol Head Neck Surg*. 1996;122:143–8.
- Schmidt LP, Teixeira VN, Dalligna C, Dallagnol D, Smith MM. Brazilian Portuguese Language version of ‘‘Tinnitus Handicap Inventory’’: validity and reproducibility. *Braz J Otorhinolaryngol*. 2006;72:808–10.
- Cox RM, Alexander GC. The International Outcome Inventory for Hearing Aids (IOI-HA): psychometric properties of the English version. *Int J Audiol*. 2002;41:30–5.
- Strouse A, Ashmead DH, Ohde RN, Grantham DW. Temporal processing in the aging auditory system. *J Acoust Soc Am*. 1998;104:2385–99.
- Santos TMM, Branco FCA, Rodrigues PF, Bohlsen YA, Santos NI. Study of the occurrence and the characteristics of tinnitus in a Brazilian audiological clinic. In: Proceedings of the sixth international seminar. 1999. p. 543–5.
- Ferreira LMBM, Ramos Junior AN, Mendes EP. Caracterização do zumbido em idosos e de possíveis transtornos relacionados. *Braz J Otorhinolaryngol*. 2009;75:249–55.
- Espmark AK, Rosenhall U, Erlandsson S, Steen B. The two faces of presbycusis: hearing impairment and psychosocial consequences. *Int J Audiol*. 2002;41:125–35.
- Langguth B, Kreuzer PM, Kleinjung T, De Ridder D. Tinnitus: causes and clinical management. *Lancet Neurol*. 2013;12:920–30.
- Mor R [dissertação] Emissões otoacústicas e audiometria de altas frequências: estudo em pacientes com zumbido sem perda auditiva. São Paulo: Universidade Federal de São Paulo; 2003.
- Santos GM [tese] A influência do gerador de som associado à amplificação convencional para o controle do zumbido: ensaio clínico cego randomizado. Universidade de São Paulo; 2013.
- Schaette R, König O, Hornig D, Gross M, Kempter R. Acoustic stimulation treatments against tinnitus could be most effective when tinnitus pitch is within the stimulated frequency range. *Hear Res*. 2010;269:95–101.



31. Ribeiro PJ, Iorio MCM, Fukuda Y. Tipos de zumbido e sua influência na vida do paciente: estudo em uma população ambulatorial. *Acta AWHO*. 2000;19:125–35.
32. Moffat G, Adjout K, Gallego S, Thai-Van H, Collet L, Norena AJ. Effects of hearing aid fitting on the perceptual characteristics of tinnitus. *Hear Res*. 2009;254:82–91.
33. Folmer RL, Stevenson EA, Tran A. Factors associated with long-term improvements in tinnitus severity. In: *Proceedings of the VII international tinnitus seminar*. 2002. p. 115–23.
34. Silva RCF, Bandini HHM, Soares IA. Aparelho de amplificação sonora individual: melhora a sensação do zumbido? *Rev CEFAC*. 2002;4:81–6.
35. Esteves CC, Brandão FN, Siqueira CGA, Carvalho SAS. Audição, zumbido e qualidade de vida: um estudo piloto. *Rev CEFAC*. 2012;14:836–43.
36. Ferrari GMS, Sanchez TG, Pedalini MEB. A eficácia do molde aberto para o controle do zumbido. *Rev Bras Otorrinolaringol*. 2007;73:370–7.
37. Buss LH, Rossi AG, Buss CH, Oliveira RC. Desempenho nas habilidades auditivas de atenção seletiva e memória auditiva em um grupo de idosos protetizados: influência de perda auditiva, idade e gênero. *Rev CEFAC*. 2013;15:1065–72.
38. Huang CY, Lee HH, Chung KC, Chen HC, Shen YJ, Wu JL. Relationships among speech perception, self-rated tinnitus loudness and disability in tinnitus patients with normal pure-tone thresholds of hearing. *ORL*. 2007;69:25–9.
39. Acrani IO, Pereira LD. Resolução temporal e atenção seletiva de indivíduos com zumbido. *Pro Fono*. 2010;22:233–8.
40. Siqueira KL, Assencio-Ferreira VJ. O uso do aparelho de amplificação sonora individual (AASI) no alívio do sintoma zumbido. *Rev CEFAC*. 2002;4:81–6.
41. Prates LPCS, Iorio MCM. Aclimatização: estudo do reconhecimento de fala em usuários de próteses auditivas. *Pro Fono*. 2006;18:259–66.
42. Teixeira CF, Augusto LGS, Caldas Neto SS. Prótese auditiva: satisfação do usuário com sua prótese e com seu meio ambiente. *Rev CEFAC*. 2008;10:245–53.
43. Moda I, Mantello EB, Reis ACMB, Isaac ML, Oliveira AA, Hippolito MA. Avaliação da satisfação do usuário de aparelho de amplificação sonora. *Rev CEFAC*. 2013;15:778–85.