CoDAS
ISSN 2317-1782 (Online version)

Original Article
Artigo Original

Clinical profile and implications of tinnitus in individuals with and without hearing loss

Perfil clínico e implicações do zumbido em indivíduos com e sem perda auditiva

Jaíse Thainara Mores[1]
Amanda Bozza[1]
Cristiana Magni[1]
Raquel Leme Casali[2]
Maria Isabel Ramos do Amaral[2]

Keywords

Tinnitus
Hearing Loss
Quality of Life
Normal Hearing
Impairment

ABSTRACT

Purpose: To compare clinical characteristics of tinnitus and interference in quality of life in individuals with and without associated hearing loss, as well as to discuss the association of quantitative measurements and qualitative instruments. **Methods:** A quantitative, cross-sectional and comparative study approved by the Research Ethics Committee (No. 973.314/CAEE: 41634815.3.0000.0106) was carried out. The responses of the psychoacoustic assessment of tinnitus (intensity, frequency, minimum masking level and loudness discomfort level for pure tone and speech), as well as the Tinnitus Handicap Inventory (THI) questionnaire, and the visual analogue scale (VAS) were compared between 15 patients with tinnitus and peripheral hearing loss (group I) and 16 adults with normal hearing (group II). **Results:** The mean VAS and THI scores obtained in GI were 5.1 (+1.5) and 42.3 (+18), and in GII, 5.7 (+2.6) and 32.7 (+25), respectively. This result suggests moderate GI annoyance and moderate/mild GII annoyance (p>0.005). There was a positive and moderate correlation between THI and VAS only in GII. In the psychoacoustic evaluation, significant differences were observed between the groups regarding the measurement of loudness (*p=0.013) and the minimum masking level (*p=0.001). **Conclusion:** There was no direct influence of the presence of hearing loss in relation to the impact of tinnitus. The differences found between the groups regarding the psychoacoustics measures can be justified by the presence of cochlear damage. The objective measurement of tinnitus, regardless of the presence or absence of peripheral hearing loss, is an important instrument to be used along with self-evaluation measures.

Descritores

Zumbido
Perda Auditiva
Audição
Qualidade de Vida
Prejuízo

RESUMO

Objetivo: comparar as características clínicas do zumbido e interferência na qualidade de vida em indivíduos com e sem perda auditiva associada, bem como discutir a associação de mensurações quantitativas e instrumentos qualitativos de avaliação. **Método:** estudo quantitativo, descritivo e de corte transversal aprovado pelo Comitê de Ética em pesquisa (nº 973.314/2016 CAEE: 41634815.3.0000.0106). Foram comparadas as respostas da avaliação psicoacústica do zumbido (pesquisa de intensidade, frequência, nível mínimo de mascaramento e limiar de desconforto para tom puro e fala), bem como questionário *Tinnitus Handicap Inventory (THI)* e escala visual analógica (EVA) de 15 sujeitos portadores de zumbido e perda auditiva periférica (grupo GI) e 16 indivíduos normo-ouvintes (grupo GII). **Resultados:** O escore médio na EVA e THI no GI foi, respectivamente, de 5,1(+1,5) e 42,3(+18) e no GII de 5,7(+2.6) e 32,7(+25), sugerindo incômodo moderado no GI e moderado/leve no GII (p>0,005). Verificou-se correlação moderada entre o THI e EVA apenas no GII. Na avaliação psicoacústica, observaram-se diferenças significantes entre os grupos referentes à medida da *loudness* (*p=0,013) e ao nível mínimo de mascaramento (*p=0,001). **Conclusão:** a perda auditiva parece não se constituir em um fator determinante para o maior ou menor impacto do zumbido na qualidade de vida do sujeito. Já as diferenças encontradas entre os grupos, referentes às medidas psicoacústicas, podem ser justificadas pela presença do dano coclear em si. A mensuração objetiva do zumbido, independentemente da presença ou não da perda auditiva periférica, caracteriza-se como um importante instrumento complementar às medidas de auto avaliação.

Correspondence address:
Maria Isabel Ramos do Amaral
Universidade Estadual de Campinas – UNICAMP
Rua Tessália Vieira de Camargo, 126, Cidade Universitária Zeferino Vaz, Campinas (SP), Brasil, CP 6111, CEP: 13083-887.
E-mail: mamaral@fcm.unicamp.br

Received: March 18, 2018.

Accepted: February 25, 2019.

Study conducted at Clínica Escola do Departamento de Fonoaudiologia – CEFONO, Universidade Estadual do Centro-Oeste – Unicentro - Irati (PR), Brasil.

[1] Departamento de Fonoaudiologia, Universidade Estadual do Centro Oeste – Unicentro - Irati, PR, Brasil.

[2] Departamento de Desenvolvimento Humano e Reabilitação, Faculdade de Ciências Médicas – FCM, Universidade Estadual de Campinas – UNICAMP – Campinas (SP), Brasil.

Financial support: nothing to declare.

Conflict of interests: nothing to declare.

INTRODUCTION

Tinnitus is defined as the conscious perception of a sound generated without the presence of an external sound source. Despite being characterized as a prevalent condition in the population, it still remains a clinical and scientific challenge[1]. According to epidemiological studies, it affects between 5 and 30% of the population, with greater incidence in men[1]. Approximately 15% of cases lead to negative interference in daily life, and about 5% are considered disabling[2].

Although there have been advances in the specific literature of tinnitus, its pathophysiology and, consequently, its etiology have not been completely clarified. It is known that its etiology may be multifactorial, being associated with middle ear diseases, neurological, neurodegenerative, cardiovascular, metabolic and psychological disorders or, in the vast majority of cases, sensorineural hearing loss[3]. Although these are often concomitant symptoms, tinnitus is known to be perceived as more harmful by individuals than the negative implications of hearing loss[4].

Though not as frequently, tinnitus can also be reported by individuals with normal hearing in about 5 to 10% of cases[1]. According to the literature, the condition should be considered a relevant symptom in these subjects, because it may be a sign of future hearing loss or of an existing abnormality not yet detected by conventional methods[5]. Some studies have been conducted in this population to elucidate the possible relationship between tinnitus and the functioning of central auditory pathways[6], along with high-frequency audiometry and suppression of otoacoustic emissions[7,8].

Nevertheless, there are few studies comparing subjects with tinnitus, associated or not with sensorineural hearing loss, to understand the differences regarding the symptom's characterization and the implications for quality of life. Sanchez et al. (2005)[9] point out the fact that tinnitus may manifest with some similar clinical characteristics in subjects with and without associated hearing loss, such as time of onset and type, ear and frequency of the condition; on the other hand, negative implications for aspects of daily life, such as concentration and sleep quality, seem to be more evident in the presence of concomitant sensorineural hearing loss.

It is a fact that often, in the case of individuals who complain of tinnitus, there is no standardization regarding the procedures that are effectively included in clinical practice, despite the extensive description of psychoacoustic methods for the objective measurement of the symptom and number of instruments available for identifying complaints and its impact on daily life[1,10]. The difficulty in measuring tinnitus, in addition to limiting a better understanding of this symptom and its relationship with other factors such as hearing loss, for instance, makes it difficult to evaluate the results of drug therapy and other types of treatment.

In addition to the analysis of clinical history, both quantitative (objective) and qualitative instruments can be applied for the clinical assessment of tinnitus. Quantitative ones include psychoacoustic measurements, loudness and pitch measurements being the most widespread. As for the qualitative instruments, Visual Analog Scales (VAS) and self-perception questionnaires stand out. The different methods require more or less participation from the patient, being characterized as complementary clinical instruments.

Given the above, the present study aimed to compare the main clinical characteristics related to the occurrence of tinnitus and to investigate the interference of this symptom on quality of life in two groups of subjects; with and without hearing loss. In addition, it discussed the association of quantitative measures and qualitative instruments in the evaluation of the condition.

METHODS

Study type and location

This is a retrospective and subsequently prospective, cross-sectional, quantitative and descriptive study, approved by the Research Ethics Committee of the institution where it was conducted, under opinion No. 973.314./2016.

Subject selection and sample characterization

Initially, the subjects were selected in a retrospective analysis of the medical records of patients subjected to audiological evaluation at the University Clinic of a public institution between 2012 and 2016. For inclusion in the study, we considered only the medical records that contained all information regarding the result of the basic audiological evaluation and the presence or absence of tinnitus reported at the time of the assessment. Based on the results of the analysis, the patients were contacted by telephone. Those who showed interest were asked to come to the clinic at a scheduled date and time, received explanations about the research and signed the informed consent form. The participants were then divided into two groups, according to the following inclusion criteria:

- *Group I (GI)*: participants aged from 20 to 60 years old who reported tinnitus and had unilateral or bilateral mild to moderate sensorineural hearing loss, according to the criteria of Silmam and Silverman[11]. Those with type A, Ar or Ad tympanogram curve and presence or absence of acoustic reflexes, whether unilaterally or bilaterally, were included. The use of individual hearing aid was not an exclusion criterion.
- *Group II (GII):* participants aged from 20 to 60 years old who reported tinnitus and normal results in the basic audiological evaluation, considering thresholds up to 20dB at the frequencies researched, ranging from 250 to 8000Hz, and type A tympanogram curve with presence of bilateral ipsilateral and contralateral acoustic reflexes[11].

The exclusion criteria considered for both groups included patients who reported pulsatile tinnitus, less prevalent in the population and of possible vascular etiology, and/or neurological or cognitive disorders that compromised the understanding of the procedures to be performed. Subjects with a history of exposure to occupational noise were not excluded due to the high prevalence of the onset of sensorineural hearing loss and tinnitus in this population.

Previous procedures

The following procedures were performed to confirm the inclusion criteria and the permanence of tinnitus as an auditory symptom at the moment of evaluation, even if the subject had been subjected to some kind of medical/otorhinolaryngologic treatment and/or undergone the hearing aid adaptation process between the date of the medical record and the date of the research:

- Audiological anamnesis: information about the occurrence of hearing complaints and symptoms, otological and family history, aspects of general health and occupational history were collected, along with data on the use of hearing aids and performance of otorhinolaryngologic follow-up related to the complaint of tinnitus and/or hearing loss.
- Meatoscopy: performed to rule out any obstruction of the external acoustic meatus.
- Basic audiological evaluation (BAE): performed to confirm the hearing thresholds recorded in the previous examination documented in the medical record, and to ensure normal conditions regarding the functioning of the middle ear at the time of the assessment. It was composed of Pure-Tone Audiometry (PTA) surveyed at frequencies ranging from 250 to 8000Hz in octave intervals, Speech Audiometry and Immitanciometry (Tympanometry and Acoustic Reflex Research). The equipment used were an Interacoustic DA65 audiometer with TDH 49 earphones, and an Interacoustics AT235 immittance meter, duly calibrated according to the ISO 389 and IEC 60645 criteria.

Data collection

After confirming the results of the basic audiological evaluation, participants who met the inclusion and exclusion criteria previously described were subjected to the following data collection procedures:

- Specific tinnitus questionnaire: prepared by the researchers, considering the main aspects to be investigated in the clinical history of tinnitus[12]. The data collected pertained to the symptom's characterization, time of onset, affected ear and type, worsening and improvement factors, other associated symptoms, including headache, irritation, hyperacusis, autophony, and general health problems, such as hypertension and renal diseases, hypo or hyperthyroidism, cervical alterations, among others, in addition to the regularity or lack of practice of physical activity.
- Tinnitus Handicap Inventory (THI) — version validated in Portuguese[13]: applied to quantify the annoyance caused by tinnitus. It consists of 25 questions, divided into three categories: functional, emotional and catastrophic. The analysis of the result considers a scale ranging from zero (0 — tinnitus does not intervene in daily life) to one hundred (100 — degree of severe discomfort).
- Visual Analog Scale (VAS): consists in the application of a visual graph that determines the level of discomfort or annoyance generated by tinnitus on a scale from zero (0 — no discomfort) to ten (10 — maximum discomfort).
- Psychoacoustic assessment of tinnitus: performed according to the criteria described by Branco-Barreiro[12]. The parameters investigated were pitch, loudness, minimum masking level (MML) and loudness discomfort level (LDL), detailed below:

1) *Pitch:* the ear contralateral to the one affected by tinnitus, according to the participant's report, was exposed to a narrowband noise (NBN). In cases of bilateral tinnitus or perception within the head, the ear exposed was the one contralateral to the most affected. The pitch of the exposure was 10dBNS (sensitivity level) at frequencies ranging from 250 to 8000Hz, until the individual could identify which one was closest to the pitch perceived.
2) *Intensity*: the side affected by tinnitus was exposed to a pure tone with an initial intensity 10dB below the hearing threshold at the pitch previously estimated by the participant. The signal was increased dB by dB until the participant could identify the intensity that was equivalent to the one perceived. At the end, the difference between the hearing threshold and the intensity found in the survey was estimated in dBNS.
3) *Minimum masking level (MML):* this measure was performed to determine the effects of masking noise on the perception of tinnitus, which may become more or less intense or even suppressed by its presence. A narrow band noise (NBN), initially below the hearing threshold of the side affected by tinnitus, was used for this purpose. In cases of bilateral tinnitus or perception within the head, the ear with better hearing was the one exposed. The noise was increased 5 by 5dB, and its intensity was estimated in dB in relation to the participant's report regarding some kind of change in the perception of tinnitus.
4) *Loudness Discomfort Level (LDL):* sound tolerance and dynamic range of hearing were measured with pure pulsed tone at frequencies ranging from 250 to 8KHz and speech noise (dBSN). For pure tone, the research was based on the previously researched threshold, and the stimulus was increased 5 by 5dB. For speech, firstly, the signal ("bang bang bang") was presented at the comfort level reported by the subject (approximately 30 to 40dB above the mean level of frequencies ranging from 500 to 2000Hz). Then, the intensity of the stimulus was increased 5 by 5dB in both ears. The discomfort level was determined when the subject reported discomfort for that stimulus (pure tone or speech) and requested the interruption of the test by raising his/her hand.

After data collection, all participants received the results of the evaluations performed and verbal and written guidance on hearing care, factors related to the worsening of symptoms, and the importance of healthy lifestyle habits as well as annual audiological follow-up and monitoring. Those who were already being followed-up received the report of the evaluations performed and a request for a follow-up visit with their doctor. Those who were not being followed-up were referred.

Statistical analysis

The Statistical Package for Social Science — SPSS version 17 was used to compare the groups regarding their performance in the psychoacoustic evaluation of tinnitus and the score obtained in the questionnaires. These data were presented using descriptive statistics (mean and standard deviation) and compared by the ANOVA test. Pearson's correlation was used to verify the relationship between the THI and VAS questionnaires.

The significance level adopted was 0.05 (5%), and all p-values considered statistically significant were marked with (*).

RESULTS

The sample consisted of 31 subjects aged from 20 to 60 years old. In GI (n=15), composed of 8 (53.3%) women and 7 (46.7%) men, age ranged from 40.9 to 60.7 (mean of 57.7+6.0). In GII (n=15), composed of 8 (50%) women and 8 (50%) men, age ranged from 25.1 to 58.2 (mean of 40.3+10.7). In the comparison between groups, it was possible to observe statistically significant differences regarding mean age (*p=<0.001). As for the distribution of the genders, there were no statistically significant differences in the comparison between groups (p=0.853).

Regarding the degree of hearing loss of GI subjects, all participants (n=15) had mild sensorineural hearing loss, 12 (80%) bilateral and 3 (20%) unilateral, and only 2 subjects (13.3%) used hearing aids bilaterally, both for a period of less than 1 year, with no improvement in the perception of tinnitus. All subjects with unilateral hearing loss reported tinnitus on the same side as the side of loss.

Chart 1 presents the demographic data of GI and GII subjects regarding age and gender, in addition to the side and approximate time of onset of the symptom reported by the participant.

Regarding the data obtained in the specific questionnaire applied, in both groups, continuous tinnitus was more prevalent than intermittent tinnitus, without statistical difference (GI=10/66.7% and GII=12/75%; p=0.609), as was single compared to multiple tinnitus (GI=14/93.3% and GII=14/97.5%; p=0.583). In the description of tinnitus regarding hissing or whistling, the type most reported by group 1 was whistling (GI=12/83.6%) compared to hissing in group II (GII=11/73.3%), such difference being statistically significant (p=*0.038).

The results by group regarding the associated health problems are shown in Table 1.

In relation to the report on the moments and factors associated with the worsening of tinnitus, 14 subjects from GI (93.3%) mentioned nighttime/silence as the worst moment and aggravating factor, the same period having been mentioned by only 6 subjects (37.5%) of GII (*p=0.018). Only 1 subject from GI (6.7%) mentioned noise exposure as a worsening factor, while in GII, 5 subjects (31.25%) mentioned it (*p=0.031). The association with food as trigger was mentioned by only 5 subjects in GII (31.25%) (*p<0.001).

Regarding the practice of regular physical activity, only 1 subject from GI (6.7%) reported the habit. As for GII, 6 subjects (37.5%) mentioned physical activity as a healthy habit, this difference between groups being statistically significant (*p=0.040).

Tables 2 and 3 show the results of both groups regarding the characterization of the impact and discomfort caused by tinnitus, according to the classification obtained with the Tinnitus Handicap Inventory (THI) and Visual Analogue Scale (VAS), and the correlation between them, respectively. There were no significant differences in the distribution of performance between groups, considering either THI or VAS. However, a significant moderate correlation between THI and VAS was found only in GII.

Chart 1. Demographic data and characterization of tinnitus for subjects in Group I (n=15) and Group II (n=16)

GI	Age	Sex	Time	Side	GII	Age	Sex	Time	Side
1	59.3	F	5 years	Right	1	37.9	M	7 months	Right
2	58.3	M	5 years	Left	2	36.1	F	2 years	Left
3	59.2	F	6 years	Bilateral	3	37.5	M	6 months	Left
4	60.3	M	12 years	Left	4	58.2	F	2 years	Left
5	59.1	M	7 years	Left	5	55.9	F	5 years	Left
6	55.6	F	8 years	Left	6	26.3	M	3 years	Left
7	57.2	F	9 years	Left	7	38.5	F	15 years	Bilateral
8	56.6	M	10 years	Left	8	30.1	M	2 years	Bilateral
9	60.6	M	4 years	Bilateral	9	36.11	M	11 years	Bilateral
10	49.2	M	6 years	Head	10	30.1	F	2 years	Right
11	60.7	F	6 years	Bilateral	11	51.11	F	3 years	Bilateral
12	60.7	F	24 years	Bilateral	12	35.2	M	6 months	Bilateral/Head
13	52.5	F	3 years	Left	13	25.1	F	9 months	Right
14	40.9	M	2 years	Left	14	43.1	M	11 years	Bilateral/Head
15	45.8	F	10 months	Left	15	49.9	F	2 months	Left
—	—	—	—	—	16	53.8	F	5 years	Left
Mean:	57.7	—	—	—		40.3	—	—	—
SD+:	6	—	—	—		10.7	—	—	—

Caption: SD = Standard Deviation

Finally, the results of the psychoacoustic assessment of tinnitus can be seen in Table 4. The statistically significant differences found were related to the loudness perception measure, higher in GII in relation to GI, and to the lower minimum masking levels in GII compared to GI.

Table 1. Distribution (%) and comparison between groups regarding health problems

Health condition	GI		GII		P-value
	N	%	N	%	
Arthrosis/Hypertension	1	6.70%	0	0.00%	0.464
Diabetes	0	0.00%	1	6.30%	0.143
Diabetes/Hypertension	1	6.70%	0	0.00%	0.464
Hypertension	4	26.70%	3	18.80%	0.464
Hyperthyroidism	1	6.70%	1	6.30%	0.591
Hyperthyroidism/Anxiety	1	6.70%	0	0.00%	0.464
Hypothyroidism	1	6.70%	0	0.00%	0.464
Labyrinthitis	1	6.70%	0	0.00%	0.464

Two-Proportion Equality Test

Table 2. Individuals in Groups I and II according to the score obtained in THI (percentage) and VAS (mean score)

THI Classification	GI		GII		P-value
	N	%	N	%	
Slight	1	6.70%	4	25.00%	0.165
Mild	6	40.00%	7	43.80%	0.833
Moderate	4	26.70%	3	18.80%	0.598
Severe	4	26.70%	2	12.50%	0.318
Mean	42.30%		32.7%		0.235
Standard Deviation (SD)	18.0%		25.20%		
VAS	GI		GII		P-value
	N Mean+SD		N Mean+SD		0.478
	15 5.1+1.5		16 5.7+2.6		

ANOVA – variance analysis

Table 3. Correlation between THI and VAS

THI X VAS	Corr (r)	P-value
GI	-8.10%	0.775
GII	51.80%	*0.04
All	30.90%	0.09

Caption: statistical significance Pearson's Correlation

Table 4. Individuals in Group I and Group II, according to the results of the psychoacoustic assessment of tinnitus

Psychoacoustic Measurements	Group	n	Mean	Standard Deviation	P-value
Pitch (Hz)	GI	15	5900.0	2508.6	0.380
	GII	16	6562.5	1547.8	
Loudness (dBSL)	GI	15	8.6	3.9	*0.013
	GII	16	5.1	3.4	
MML (dB)	GI	15	78.3	12.3	*0.001
	GII	16	57.5	19.2	
LDL (Pure tone — dB)	GI	15	92	9.6	0.377
	GII	16	87.5	17	
LDL (Speech – dBSL)	GI	15	85	10	1.0
	GII	16	85	11.4	

Caption: MML – Minimum Masking Level; LDL – Loudness Disconfort Level Hz=Hertz; dB= decibel; SL = sensation level; dBSL= decibel sensation level; ANOVA – variance analysis

DISCUSSION

Considering the fact that GI subjects had tinnitus-associated hearing loss and the known relationship between hearing loss and age[14], the results of the comparison between groups regarding age showed expected statistical differences, with higher mean in GI (*p<0.001). The prevalence of hearing loss, and consequently of tinnitus, is known to increase with age, regardless of exposure to occupational noise or lack thereof[15].

Although advanced age and sensorineural hearing loss may be considered aggravating factors for the occurrence of tinnitus[16], there is no consensus as to whether these variables are directly related to the degree of severity of the symptom. One hypothesis relates to the degree of hearing loss, since some studies indicate that subjects with mild sensorineural hearing loss may have a lower perception of tinnitus annoyance compared to subjects with more severe hearing loss and advanced age[17,18].

Another important aspect to be considered refers to the influence of hearing loss on the degree of interference of tinnitus in aspects of daily life. It is hypothesized that the association of the symptom with hearing loss could be a "cofactor" of this interference, since the perception and rating attributed to tinnitus annoyance would, in most cases, be influenced by limitations resulting from hearing loss as well. It is often difficult for the patient to dissociate the two aspects[16].

However, considering the results of the application of the THI and VAS instruments, the findings of the present research did not show significant differences between groups regarding the damage caused by tinnitus on a daily basis. Although the differences between groups were not significant, the total mean THI score was higher in GI compared to GII, the values obtained having corresponded to moderate and mild annoyance, respectively. Regarding VAS, both groups showed results that characterize a perception of moderate annoyance. Given these data, it is not possible to conclude that there was a direct influence of the presence of hearing loss on this aspect. A sample with a larger number of participants in both groups would likely show the importance of these findings in a statistically significant way.

In the comparison of THI with VAS, a moderate positive correlation between the instruments was found only for group II (*p=0.04). THI is considered a very complete method for assessing the impact of tinnitus, because its results make it possible to quantify the symptom's impact on the quality of life of patients while considering different spheres related to daily activities, but it is more difficult to be interpreted and answered by the subject when compared to the VAS method, requiring the help of an evaluator in many cases. VAS is characterized as a simpler measure to be assimilated for offering visual support, being more easily understood and answered by the individual without the help of a professional or family member, in addition to its shorter application time. Considering the statistical results obtained in the present sample, it is possible to state that the simultaneous application of both instruments contributed to the gathering of more consistent and representative data from both groups, corroborating researches that describe THI and VAS as distinct but complementary instruments[19].

The association between tinnitus and hearing loss is well described in the literature, since damage or degeneration of the inner ear and the vestibulocochlear nerve can cause the onset of tinnitus. The symptom would therefore result from changes in the neural network along the auditory pathways after the establishment of cochlear damage[20]. Despite the lower frequency of subjects with tinnitus associated with some degree of hearing loss compared to subjects with normal thresholds[5], the presence of the symptom in normal-hearing individuals was found to be an important phenomenon to be studied. The hypothesis[21] that subjects with normal peripheral hearing may show hearing abnormalities frequently above the 8000Hz frequency or central abnormalities seems to justify the occurrence of the symptom in individuals with normal hearing thresholds, in the conventional evaluation.

The results found regarding the factors associated with the worsening of tinnitus reported by the participants showed significant differences between groups, and in GI, nighttime/silence was the aggravating factor that was most frequently mentioned. It is believed that this is related to the fact that noise competition caused by a noisy environment can be considered a relief factor for disturbing the perception of tinnitus, and that hearing aids can often help mitigate the symptom in individuals with hearing loss[22]. In GI, two subjects made use of this resource.

The differences between groups regarding aggravating factors were exacerbated due to the diversity of other aspects mentioned more significantly by GII only: noise as worsening factor (*p=0.031) and food triggers (*p<0.001). These differences between groups strengthen the multifactorial etiology of tinnitus, which suffers interference from various associated factors such as metabolic issues, dizziness and/or headache, pre-existing diseases and regular practice of physical activity, for example, conditions that, in the absence of cochlear damage, may be more evident in individuals with tinnitus and normal hearing thresholds. A recent study showed this specific population's difficulty understanding speech in noisy environments, with worse performance of these individuals in speech perception tasks compared to those without tinnitus[21].

On the other hand, considering factors associated with tinnitus, the assessment of the subjects' health problems and/or comorbidities showed significant differences (*p=0.049), with a higher number of reports of general health problems by participants of GI. It is believed that the older age of the subjects in GI is a determining factor of this finding, as is the practice of regular physical activity, which, in turn, was reported by more participants of GII, a difference that was found to be significant.

Systemic arterial hypertension (SAH), associated or not with other diseases, was the factor that was most often mentioned by both groups. Auditory and vestibular disorders may be secondary to SAH. Abnormalities in the circulatory system and increase in blood viscosity cause a decrease in capillary blood flow and, consequently, oxygen transport, which may damage the organ of Corti and generate tinnitus[23]. Despite this, based on the data presented here, it would not be possible to confirm the direct relationship between these variables, corroborating other findings that did not show this aspect[24]. However, it can be still discussed as an aggravating factor of hearing damage and, consequently, of tinnitus.

Regarding the psychoacoustic measures researched, the data from both groups did not differ and corroborate the greater occurrence of high-pitched tinnitus, as well as the region of hearing loss in the case of GI subjects[21]. Although a recent study demonstrated similar pitch perception results around the 6000Hz frequency[25], the fact that the high frequencies were not included in the present research may justify the fact that the mean value found here, in both groups, is considered lower compared to other works, ranging from 10 to 14000Hz[26].

Regarding the assessment of intensity, expressed as sensitivity level (SL), statistical difference was found between groups (*p=0.013), with greater perception of tinnitus by participants of GI. This result could be partly explained by the occurrence of other factors that are directly related to the characteristics of this group, such as the presence of hearing damage itself, different etiologies of the existing hearing loss, as well as time of the onset of the hearing damage and consequently of tinnitus. In addition, it is possible to hypothesize that the damage and communication barriers resulting from the presence of hearing loss favor the negative reinforcement of the perception of tinnitus, influencing the perception of intensity.

The literature presents several results regarding the intensity of tinnitus and its relationship with the severity and degree of annoyance. Researchers, even in the 1990s, reported little relation between these factors, as well as correlation of loudness with the stress and handicap caused by tinnitus[27]. More recent studies point to the intensity of tinnitus as a possible predictor of perception of the symptom's severity[2,28], as well as moderate correlations between intensity and degree of annoyance[17].

The fact some patients in the present study reported their perception of intensity as ranging from 1 to 2dBNS, with moderate degree of annoyance, is an important fact, since many individuals believe that the intensity of tinnitus is a crucial factor for the symptom's impact on quality of life, and perceive it as much more intense than most environmental sounds. The absence of objective data regarding intensity in an evaluation process may favor the strengthening of the complaint, a factor that promotes the development of psychosocial barriers associated with the symptom. Since there is no consensus that the severity of tinnitus is necessarily associated with its intensity[17,27,28], this information can also be understood as a tool with which to guide patients and plan at least part of treatment. Regardless of whether it is associated with hearing loss or not, the severity of tinnitus may also be related to the degree of discomfort in daily tasks and other functional impairments, which could lead to mental disorders such as difficulty concentrating, sleep disorders, anxiety, mood swings and even social isolation[5,17]. In this scenario, the present study reinforces the fact that the subject's knowledge of the symptom's psychoacoustic characteristics is a therapeutic and awareness/guidance tool that should be used routinely in clinical practice.

In the Loudness Discomfort Level (LDL) test, there were no statistical differences for neither pure tone nor speech, and both groups showed values within the acceptable limits of normality, i.e., variations between 85 and 100dB[29]. This result

did not indicate, therefore, any degree of intolerance to sounds, a finding compatible with the absence of complaints, both in GI and GII, related to hyperacusis, phonophobia or misophonia, based on the specific questionnaire applied.

As for the Minimum Masking Level (MML) test, the findings showed significant differences between groups, with lower mean in GI ($p<0.001$). The measurement of MML has been used along with intensity in clinical research with tinnitus patients, and some authors show evidence that it may be correlated with the degree of perception of the level of stress caused by tinnitus[30]. However, no study was found correlating this measurement in patients with and without hearing loss. Since GI was composed of subjects with sensorineural hearing loss, it is believed that the difference in this finding may be related to existing cochlear damage and loss of outer hair cells, causing a possible alteration/distortion in the perception of the sensation of intensity due to the nonlinearity of the cochlea.

Although MML and loudness provide relevant data to be analyzed, these measures do not take into account the degree of discomfort reported by the subject affected by tinnitus. In a study cited above[30], the authors argue that subjective measures obtained with questionnaires may show better results and higher rates in the pre- and post-treatment comparison of tinnitus subjects than psychoacoustic measures, being more suitable for use in clinical practice. However, considering that MML reflects the ease with which tinnitus can be masked by environmental sounds[28], it is believed that this measure may help evaluate the benefit of using noise masking in the treatment of tinnitus, also being an important parameter for establishing the adjustments needed to adapt these devices to patients with or without associated hearing loss. In addition, specifically for subjects with hearing loss and tinnitus, the risk of discomfort caused by the masking noise is higher, as the intensity required to change these subjects' perception of tinnitus is lower, and therefore should be taken into account when adapting any type of resource, be it hearing aid or tinnitus masking.

Since tinnitus is a multifactorial otological symptom influenced by many factors discussed here, such as psychoacoustic characteristics, subjective perceptions of annoyance and other associated conditions, as well as gender and age, the composition of a representative sample is a challenge and, therefore, the present research still has some limitations. These limitations are related to sample size and to the fact that the participants were selected based on an analysis of the medical records of subjects who had already shown interest in undergoing an audiological evaluation and/or had otological complaints. In addition, some factors were not analyzed and may be considered in future studies on the subject, such as the correlation between psychoacoustic measures and tinnitus annoyance in both groups, in addition to the analysis of the findings in relation to the gender variable.

Finally, it should be noted that the literature about individuals with tinnitus and normal hearing thresholds has not explored the relationship between the symptom's psychoacoustic characteristics and its impact on different spheres of daily life and on quality of life. In addition, since self-perception questionnaires and psychoacoustic tinnitus measures are different assessment approaches, the data resulting from them complement each other. Thus, the possibility of quantification of the symptom based on the results of a psychoacoustic assessment, which is not always performed routinely in patients referred to basic audiological evaluation, makes it an important complementary tool in relation to self-assessment measures of the impact of tinnitus on daily life.

CONCLUSION

The findings of this research allow concluding that the presence of hearing loss itself has not been shown to be a single and determining factor of the greater or lesser impact of tinnitus on quality of life, which is also influenced by other aspects. Thus, it is believed that the association of different clinical instruments allows a better understanding of the factors that may influence the impact of tinnitus on subjects with and without associated hearing loss, also supporting the assessment and planning of the appropriate treatment for each case.

REFERENCES

1. McCormack A, Edmondson-Jones M, Somerset S, Hall D. A systematic review of the reporting of tinnitus prevalence and severity. Hear Res. 2016;337:70-9. http://dx.doi.org/10.1016/j.heares.2016.05.009. PMid:27246985.
2. Flores LS, Teixeira AR, Rosito LPS, Seimetz BM, Dall'Igna C. Pitch and loudness from tinnitus in individuals with noise-induced hearing loss. Int Arch Otorhinolaryngol. 2016;20(3):248-53. http://dx.doi.org/10.1055/s-0035-1562935. PMid:27413408.
3. Manche SK, Madhavi J, Meganadh KR, Jyothy A. Association of tinnitus and hearing loss in otological disorders: a decade-long epidemiological study in a South Indian population. Rev Bras Otorrinolaringol. 2016;82(6):643-9. http://dx.doi.org/10.1016/j.bjorl.2015.11.007. PMid:26923827.
4. Nondahl DM, Cruickshanks KJ, Wiley TL, Klein BEK, Klein R, Chappell R, et al. The ten-year incidence of tinnitus among older adults. Int J Audiol. 2010;49(8):580-5. http://dx.doi.org/10.3109/14992021003753508. PMid:20560859.
5. Sanchez TG, Mak MP, Pedalini MEB, Levy CPD, Bento RF. Tinnitus and hearing evolution in normal hearing patients. Int Arch Otorhinolaryngol. 2005;9(3):220-7.
6. Tugumia D, Samelli AG, Matas CG, Magliaro FC, Rabelo CM. Auditory training program in subjects with tinnitus. CoDAS. 2016;28(1):27-33. http://dx.doi.org/10.1590/2317-1782/20162015113. PMid:27074186.
7. Serra LS, Granjeiro RC, Braga SC, Oliveira CA, Sampaio AL. Association between suppression of otoacoustic emissions and annoyance levels in tinnitus patients with normal hearing. Int Tinnitus J. 2015;19(2):52-8. http://dx.doi.org/10.5935/0946-5448.20150009. PMid:27186933.
8. Vielsmeier V, Lehner A, Strutz J, Steffens T, Kreuzer PM, Schecklmann M, et al. The relevance of the high frequency audiometry in tinnitus patients with normal hearing in conventional pure-tone audiometry. BioMed Res Int. 2015;302515:1-5.
9. Sanchez TG, Medeiros IRT, Levy CPD, Ramalho JRO, Bento RF. Zumbido em pacientes com audiometria normal: caracterização clínica e repercussões. Rev Bras Otorrinolaringol. 2005;71(4):427-31. http://dx.doi.org/10.1016/S1808-8694(15)31194-0.
10. Azevedo AA, Oliveira PM, Siqueira AG, Figueiredo RR. Análise crítica dos métodos de mensuração do zumbido. Rev Bras Otorrinolaringol. 2007;73(3):418-23. http://dx.doi.org/10.1590/S0034-72992007000300019.
11. Silmam S, Silvermam CA. Basic audiologic testing. In: Silmam S, Silvermam CA, editors. Auditory diagnosis: principles and applications. San Diego: Singular Publishing Group; 1997. p 44-52.
12. Branco-Barreiro FCA. Avaliação audiológica básica e psicoacústica do zumbido. In: Samelli AG, organization. Zumbido: avaliação, diagnóstico e reabilitação. 1. edição. São Paulo: Lovise; 2004. p 55-60

13. Schmidt LP, Teixeira VN, Dall'lgna C, Dallagnol D, Smith MM. Adaptação para língua portuguesa do questionário Tinnitus Handicap Inventory: validade e reprodutibilidade. Rev Bras Otorrinolaringol. 2006;72(6):808-10. http://dx.doi.org/10.1016/S1808-8694(15)31048-X. PMid:17308834.

14. Bauer MA, Zanella ÂK, Filho IG, Carli G, Teixeira AR, Bós ÂJ. Profile and prevalence of hearing complaints in the elderly. Braz J Otorhinolaryngol. 2017;83(5):523-9. http://dx.doi.org/10.1016/j.bjorl.2016.06.015. PMid:27569691.

15. Brewster KK, Ciarleglio A, Brown PJ, Chen C, Kim HO, Roose SP, Golub JS, Rutherford BR. Age-related hearing loss and its association with depression in later life. Am J Geriatr Psychiatry. 2018;26(7):788-796.

16. Mondelli MFCG, Rocha AB. Correlação entre os achados audiológicos e incômodo com zumbido. Arq Int Otorrinolaringol. 2011;15(2):172-80. http://dx.doi.org/10.1590/S1809-48722011000200009.

17. Hiller W, Goebel G. Factors influencing Tinnitus loudness and annoyance. Arch Otolaryngol Head Neck Surg. 2006;132(12):1323-30. http://dx.doi.org/10.1001/archotol.132.12.1323. PMid:17178943.

18. Pinto PCL, Sanchez TG, Tomita S. Avaliação da relação entre severidade do zumbido e perda auditiva, sexo e idade do paciente. Rev Bras Otorrinolaringol. 2010;76(1):18-24.

19. Figueiredo RR, Azevedo AAO, Oliveira PM. Análise da correlação entre a escala visual-análoga e o Tinnitus Handicap Inventory na avaliação de pacientes com zumbido. Rev Bras Otorrinolaringol. 2009;75(1):76-9. http://dx.doi.org/10.1016/S1808-8694(15)30835-1.

20. Ryan D, Bauer CA. Neuroscience of Tinnitus. Neuroimaging Clin N Am. 2016;26(2):187-96. http://dx.doi.org/10.1016/j.nic.2015.12.001. PMid:27154602.

21. Buzo BC, Carvallo RM. Psychoacoustic analyses of cochlear mechanisms in tinnitus patients with normal auditory thresholds. Int J Audiol. 2014;53(1):40-7. http://dx.doi.org/10.3109/14992027.2013.840931. PMid:24168288.

22. Jastreboff MM. Sound therapies for tinnitus management. Prog Brain Res. 2007;166:435-40. http://dx.doi.org/10.1016/S0079-6123(07)66042-7. PMid:17956808.

23. Gibrin DCP, Melo JJ, Marchiori MLL. Prevalência de queixa de zumbido e prováveis associações com perda auditiva, diabetes mellitus e hipertensão arterial em pessoas idosas. CoDAS. 2013;25(2):176-80. http://dx.doi.org/10.1590/S2317-17822013000200014. PMid:24408248.

24. Marchiori LLM. Zumbido e hipertensão arterial no processo de envelhecimento. Rev Bra de Hipertens. 2009;16(1):5-8.

25. Nascimento IDP, Almeida AA, Diniz J Jr, Martins ML, Freitas TMMWC, Rosa MRDD. Tinnitus evaluation: relation among pitch matching and loudness, visual analog scale and tinnitus handicap inventory. Braz J Otorhinolaryngol. 2019 [no prelo]:1-6.

26. Suzuki FAB, Suzuki FA, Onishi ET, Penido NO. Psychoacoustic classification of persistent tinnitus. Rev Bras Otorrinolaringol. 2018;84(5):583-90. http://dx.doi.org/10.1016/j.bjorl.2017.07.005. PMid:28826945.

27. Folmer RL, Griest SE, Meikle MB, Martin WH. Tinnitus severity, loudness, and depression. Otolaryngol Head Neck Surg. 1999;121(1):48-51. http://dx.doi.org/10.1016/S0194-5998(99)70123-3. PMid:10388877.

28. Al-Swiahb JN, Hwang ES, Kong JS, Kim WJ, Yeo SW, Park SN. Clinical and audiologic characteristics of patients with sensorineural tinnitus and its association with psychological aspects: an analytic retrospective study. Eur Arch Otorhinolaryngol. 2016;273(12):4161-5. http://dx.doi.org/10.1007/s00405-016-4108-0. PMid:27234666.

29. Katzenell U, Segal S. Hyperacusis: review and clinical guidelines. Otol Neurotol. 2001;22(3):321-6. http://dx.doi.org/10.1097/00129492-200105000-00009. PMid:11347634.

30. Rabau S, Cox T, Punte AK, Waelkens B, Gilles A, Wouters K, et al. Changes over time of psychoacoustic outcome measurements are not a substitute for subjective outcome measurements in acute tinnitus. Eur Arch Otorhinolaryngol. 2015;272(3):573-81. http://dx.doi.org/10.1007/s00405-013-2876-3. PMid:24395086.

Authors' contributions

MIRA participated, as advisor, in the idealization and planning of the study, as well as in the analysis and interpretation of the data. JTM was responsible for data collection. JTM, MIRA, AB and CM participated in the analysis and interpretation of the data. JTM, MIRA and RLC were responsible for writing the manuscript. RLC and MIRA were responsible for the final critical reading of the work. MIRA was responsible for the submission of the manuscript.