ARTICLES

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Hearing Training: Tinnitus and Hearing Skills on Elderly People with Hearing Loss

Treinamento auditivo: zumbido e habilidades auditivas em idosos com perda auditiva

Entrenamiento auditivo: zumbido y habilidad auditiva en ancianos con pérdida auditiva

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Abstract

Introduction: Tinnitus is a harmful acoustic stimulation that can cause disorganization in the Central Auditory Nervous System. Subjects with hearing loss are susceptible to Auditory Processing Disorder, as by sensory deprivation also disorganize the Central Auditory Nervous System. Auditory Training can help in reducing the annoyance with tinnitus, by objectifying synchrony in the auditory pathway. Objective: To estimate the effects of Computerized Auditory Training on the reduction of annoyance with tinnitus and changes in auditory abilities in elderly people with hearing loss and hearing aids users. Material and Method: A quantitative and qualitative cross-sectional study in which five elderly people with tinnitus were rehabilitated with difficulty at least in one auditory ability and hearing loss. Evaluations Pre and Post-Auditory Training were performed, such as: anamnesis and basic audiological evaluation, application of the Tinnitus Handicap Inventory, behavioral auditory processing tests and electrophysiological evaluation. The treatment was performed with Escuta Ativa software, in 16 sessions with approximately 30 minutes each one. Results: There was a statistically significant difference in relation to the pre and post treatment values in the Tinnitus Handicap questionnaire and Behavioral auditory processing tests. There were no pre and post treatment electrophysiological changes. Conclusion: It was possible to evaluate the effects of the Computerized Auditory Training in the reduction of annoyance with tinnitus, through the chosen questionnaire applied pre and post-intervention. Furthermore, some behavioral auditory abilities also

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improved with this intervention. It was not possible to observe electrophysiological changes in the Long-latency auditory evoked potential.

Keywords: Tinnitus; Acoustic stimulation; Hearing; Hearing Loss; Auditory Perceptual Disorders.

Resumo

Introdução: O zumbido juntamente com a perda auditiva, é uma percepção acústica anormal que pode levar a uma desorganização no Sistema Nervoso Auditivo Central. Por isso sujeitos portadores são suscetíveis ao Transtorno do Processamento Auditivo Central. O Treinamento Auditivo, baseado nos conceitos de neuroplasticidade pode auxiliar na redução do incômodo com o zumbido, por objetivar sincronia na via auditiva. **Objetivo:** Estimar os efeitos do Treinamento Auditivo Acusticamente Controlado Computadorizado na redução do incômodo com o zumbido e nas alterações das habilidades auditivas em idosos com perda auditiva usuários de próteses auditivas. **Material e Método:** Estudo transversal quantitativo e qualitativo, no qual foram reabilitados cinco idosos com zumbido, alteração em pelo menos uma habilidade auditiva e perda auditiva. Foram realizadas avaliações pré e pós intervenção, sendo elas: anamnese e avaliação audiológica básica, aplicação do questionário *Tinnitus Handicap Inventory*, testes comportamentais do processamento auditivo e avaliação eletrofisiológica. Realizou-se o tratamento com o software Escuta Ativa, em 16 sessões de em média 30 minutos cada. **Resultados:** Houve diferença estatisticamente significante em relação aos valores pré e pós tratamento no questionário *Tinnitus Handicap Inventory* e nos testes comportamentais. Não houve mudanças eletrofisiológicas pré e pós tratamento. **Conclusão:** Foi possível avaliar os efeitos do Treinamento Auditivo Acusticamente Controlado Computadorizado na redução do incômodo com o zumbido, por meio do questionário escolhido aplicado pré e pós intervenção. Além disso, algumas habilidades auditivas comportamentais também melhoraram com a referida intervenção. Apenas não foi possível observar mudanças eletrofisiológicas no Potencial Evocado Auditivo Longa Latência.

Palavras-chave: Zumbido; Estimulação Acústica; Audição; Perda auditiva; Transtornos da Percepção Auditiva.

Resumen

Introducción: El zumbido junto con la pérdida auditiva, es una percepción acústica anormal que puede conducir a una desorganización en el Sistema Nervioso Auditivo Central. Por eso sujetos portadores son susceptibles al Trastorno del Procesamiento Auditivo Central. El Entrenamiento Auditivo, basado en los conceptos de neuroplasticidad puede auxiliar en la reducción de la incomodidad con el zumbido, por objetivar la sincronía en la vía auditiva. Objetivo: Estimar los efectos del Entrenamiento Auditivo Acústicamente Controlado Ordenado en la reducción de la incomodidad con el zumbido y los cambios de las habilidades auditivas en ancianos con pérdida auditiva usuarios de prótesis auditivas. Material y método: Estudio transversal cuantitativo y cualitativo, en el cual fueron rehabilitados cinco ancianos con zumbido, alteración en por lo menos una habilidad auditiva y pérdida auditiva. Se realizaron evaluaciones pre y post intervención, siendo ellas: anamnesis y evaluación audiológica básica, aplicación del cuestionario Tinnitus Handicap Inventory, pruebas conductuales del procesamiento auditivo y evaluación electrofisiológica. Se realizó el tratamiento con el software Escucha Activa, en 16 sesiones de en promedio 30 minutos cada una. Resultados: Hubo diferencia estadísticamente significativa en relación a los valores pre y post tratamiento en el cuestionario Tinnitus Handicap Inventory y en las pruebas de comportamiento. No hubo cambios electrofisiológicos pre y post tratamiento. Conclusión: Fue posible evaluar los efectos del Entrenamiento Auditivo Acusticamente Controlado Computadorizado en la reducción de la incomodidad con el zumbido, por medio del cuestionario escogido aplicado pre y post-intervención. Además, algunas habilidades auditivas de comportamiento también mejoraron con dicha intervención. Sólo no fue posible observar cambios electrofisiológicos en el Potencial Evocado Auditivo Larga Latencia.

Palabras claves: Acúfeno; Estimulación Acústica; Audición; Pérdida auditiva; Trastornos de la percepción auditiva.

Introduction

Tinnitus is not a disease, but a symptom resulting from some complication in some part of the auditory pathway[1]. Extra-auditory factors and cases of sensorineural hearing loss can also be related to the perception of tinnitus[2-4].

A classic theory on the cause of tinnitus is that it would be related to the abnormal activation of some center in the Central Nervous System, including auditory and extra-auditory pathways, such as the Limbic System and the Autonomic Nervous System[1].

In addition to what has been previously said, it is known that the Central Auditory Nervous System (CANS) is reorganized according to the presence or absence of sensorial stimulation. Hence, plasticity can occur in positive or negative terms, as there is the presence or absence of stimulus. The negative plasticity would be the likely generator of tinnitus, being directly associated with sensorial deprivation, i.e., hearing loss[5]. Thus, tinnitus would be the consequence of an abnormal spontaneous activity in some of the parts of the auditory pathway or in all of it, causing a negative plastic reorganization of the CANS[6].

Attention is called to the importance of patients with hearing loss using hearing aids, especially in the cases with complaint of tinnitus. It is believed that the hearing aids make sound stimulation possible by means of acoustic enrichment of the auditory pathway and, consequently, minimize sensorial deprivation, complaints of communication difficulties, in addition to the perception of tinnitus, as they act upon the neuroplasticity of the CANS[6-10].

The picture described above is even more striking in the elderly population, as, for this age group, the hearing physiological weakening, known as presbycusis, is made evident, as a result of the aging process. Such loss is characterized by a slow progressive worsening of hearing sensibility, especially for high-frequency sounds, and difficulty in understanding speech[11]. Tinnitus is a symptom which, in most elderly, accompanies hearing loss[12]. A decline in the central auditory function (auditory processing) is also observed, which is manifested in the increased difficulty in the abilities of binaural fusion, figure-ground, selective attention, judgement of acoustic patterns, and a reduced speed of auditory closure and synthesis[11-15].

Regarding complaint of tinnitus in the elderly, constant in the aging process, as previously mentioned, it is pointed out that it is not only related to auditory issues, but also to the elderly's general health, which in its turn presents functional decline[6,16].

Concerning the treatment options available, Auditory Training (AT), based on the concepts of brain neuroplasticity, is an intervention means in rehabilitation of Auditory Processing Disorders (APD)[16]. Hence, it has been indicated to patients with hearing loss, who present complaint of understanding speech even after hearing aids have been selected and fitted[17,18]. The purpose of AT is to beneficially activate the CANS and associated systems, with directed activities, so that positive alterations may take place in behavioral and physiologic aspects. Such modifications can be observed and measured through behavioral and electrophysiological assessments of the auditory processing[19].

Based on such presuppositions, it is known that AT reestablishes the neural circuits related to sound perceptual processing, due to the increase in number of neurons involved, to changes in time of neural synchronicity, and to the broadening of synaptic connections. Thus, the AT can improve the function of the auditory system in the resolution of acoustic signals. Based on the assumptions exposed above, authors came to the hypothesis that the use of this rehabilitation method could diminish the perception of tinnitus[2,6,20-22]. It should be noted that there is no papers, in the examined literature, that use the Computerized Controlled Acoustic Auditory Training (C-CAAT), with focus on auditory abilities, in the treatment of patients with tinnitus.

As the hypothesis of this study, it is believed that the use of a specific mode of AT, the C-CAAT, as a means of intervention in elderly with hearing loss, tinnitus and APD, would cause positive modifications in behavioral and electrophysiological aspects, especially the decrease in nuisance caused by tinnitus, as a results of the possible neuroplasticity. Such supposition was measured through specific auditory processing behavioral assessments, record and analysis of long latency auditory evoked potentials (LLAEP), and the use of a questionnaire to verify the decrease of tinnitus discomfort.

Thus, this study aimed at estimating the effects of the C-CAAT on reducing tinnitus discomfort and on the alterations of auditory skills in elderly with hearing loss who use hearing aids.

Methods

This was a quantitative and qualitative, longitudinal study, involving the execution of an auditory training model for the rehabilitation of APD and investigation of changes in tinnitus self-perception.

The project was approved by the Ethics Committee of a federal teaching institution, under the registry number 55688416.6.0000.5346. The participating subjects signed an Informed Consent Form (ICF). It's important to point out that this study complied with the norms and regulating guidelines for research with human beings, as expressed in the Resolution 466/12 of the Conselho Nacional de Saúde, which makes regulations regarding data confidentiality, ensuring the subjects as to secrecy and privacy by the researchers' signing of the Confidentiality Agreement.

The setting for gathering subjects and executing the procedures was an auditory health laboratory. The elderly were invited by the researcher and previously contacted by phone.

The sample was composed of elderly subjects with complaint of tinnitus who agreed to participate in the research, and who met the eligibility criteria. The sample was defined after auditory processing behavioral and electrophysiological assessment, and indication for therapy to rehabilitate the altered auditory skills.

The inclusion criteria were defined as: 1) subjects over 60 years old; 2) subjects with complaint of tinnitus for at least six months (either unilateral or bilateral); 3) subjects with sensorineural hearing loss with degree up to moderate, and with speech recognition percentage index (SRPI) greater than 72%[23]; 4) subjects with alteration in at least one auditory skill, assessed through behavioral and auditory processing tests; and, 5) subjects who had been using, for at least six months, behind-the-ear hearing aids classified as category B by the SUS regulatory law no. 793/GM and 835/GM. This hearing aid model was chosen for being the category with the greatest number of indications following the mentioned SUS regulatory law.

As for the exclusion criteria, these were the ones adopted in this study: 1) subjects with alterations in the middle ear; 2) subjects with uncontrolled metabolic alterations, such as diabetes, thyroid alterations and arterial hypertension, hormonal (hypothyroidism, menopause, and late-onset hypogonadism in males), cardiovascular, dental, and head and neck muscle alterations; 3) self-reported history of neurological and/or psychiatric alterations; and, 4) bilingual subjects and/or musicians.

The battery of procedures for initial composition of the sample consisted of:

1) Basic audiological assessment and anamnesis.
2) Application of the Tinnitus Handicap Inventory (THI) adapted to Portuguese - *Questionário de Gravidade do Zumbido* (QGZ): based on a score, the degree of interference and discomfort on the subject's life due to tinnitus is identified. It is composed of 25 questions divided into scales: functional (measures the discomfort caused by tinnitus), emotional (measures affective responses to tinnitus), and catastrophic (quantifies the despair and the incapacity caused by the symptom). Three are the answer options: "yes" (four points), "sometimes" (two points), and "no" (no points). The sum of the points is categorized in five groups or degrees of seriousness: slight (0 – 16), mild (18 – 36), moderate (38 – 56), severe (58 – 76), and catastrophic (78 – 100) [25].
3) Auditory processing behavioral screening: evaluation of the physiological mechanisms of selective attention and temporal processing.
   - Random Gap Detection Test (RGDT)[26]: has the purpose of assess the temporal resolution through the random presentation of pure tones with intervals of 0 to 40 ms. As the interval detection threshold is the one in which the patient was able to consistently perceive the presence of two intervals in the smallest difference presented. The patient names the number of stimuli, one or two and the number of intervals. For individuals without alterations in temporal resolution skill, it was expected that they would respond with silent interval perception of up to 15 ms. The level of presentation of the stimuli on the RGDT was of 50 dBSL above the average of 500, 1000 and 2000 Hz and/or maximum comfort level. The subject being assessed responded by naming the number of intervals.
4) Speech by white noise test: it assesses the auditory closure ability. The task is monotic, presented at 50 dBSL above the average of 500, 1000 and 2000 Hz and/or level of greater comfort referred by the elderly, and S/N ratio of +20. The list of 25 monosyllables was presented without noise, and another list, with 25

monosyllables, with noise, on the same ear. The criteria of normality adopted were of: ≥70% of correct answers, and difference between the lists with and without noise < 20%[27].

5) Dichotic Digits Test (DDT): it is used to assess the figure-ground ability for verbal sounds in sustained attention and selective attention process. It is composed of 20 sequences with four numbers (two pairs of competing numbers) presented simultaneously on each ear in a presentation level of 50 dB SL above the average of 500, 1000 and 2000 Hz and/or maximum comfort level. It is important to highlight that the subject was assessed through the test in the stages of directed hearing and binaural integration. The subject was instructed to identify the numbers presented on the right ear (10 sequences), and then on the left ear (10 sequences); at another moment, the subject was instructed to repeat the four numbers. The criterion of normality for elderly with hearing loss considered was of RE and LE > 60%[27].

The basic audiological exams and the AP behavioral screening were conducted without use of the hearing aids, in sound booth with two-channel clinical audiometer, of the Fonix Hearing Evaluator brand, model FA 12 type I, and earphones type TDH-39P, Telephonics brand.

6) Auditory processing electrophysiological test:

The LLAEP was performed with Intelligent Hearing System (IHS) two-channel equipment. The elderly were instructed not to make any tiring mental or physical activities, and not to have any stimulating food or drink, such as tea, coffee or chocolate, for at least four hours prior to the exam. The elderly was seated on a comfortable chair and instructed about the procedures of the exam. The assessments were performed with insert earphones and the disposable electrodes positioned at A1 (left mastoid), A2 (right mastoid), Cz (vertex) and the ground (Fpz) on the forehead. The impedance value of the electrodes was inferior to 3 kOhms. The LLAEP assessment was performed with verbal stimulus with the pairs /ba/ and /di/ presented binaurally at an intensity of 80 dBnHL. The number of stimuli used was of 300 (240 frequent and 60 rare), thus respecting the oddball paradigm. The patient was instructed to mark on a paper a line indicating the presence of a different (rare) stimulus among the frequent stimuli. The stimuli chosen were /ba/ as frequent and /di/ as rare. The duration of the stimulus was of 100 µs, with phase-alternated and polarity rarefaction. The filters were of 100 to 3000 Hz, and, for wave visualization, there was a gain of 100,000 in a window of 512ms; no artifacts in number 10% greater than the number of stimuli presented were accepted.

The tracings were not replicated, as the replication could turn the rare stimulus into frequent for the patient, causing fatigue, which would compromise the result of the assessment, as it depends on attention.

Concerning the marking of the P300 wave, only the rare stimuli tracing was taken into account. The highest peak and greatest amplitude wave after the complex P1-N1-P2-N2 was marked. As for the complex P1-N1-P2-N2, it was marked in the frequent stimuli tracing. As an identification parameter for these components, the classic reference data in the area was used[29].

The absolute latency was identified for the components P1, N1, P2, N2 and P3, in milliseconds (ms), and the amplitude of P1-N1, P2-N2 and P3, in microvolts (µV), considering the amplitude from the peak to the following valley, as instructed on the IHS equipment manual.

Regarding the sample composition, a total of 190 elderly were contacted. Of these, 18 attended on the previously scheduled date for the assessments to be conducted as proposed in this study. After the analysis of the eligibility criteria and the performing of the initial sample composition procedures, the sample was composed of 12 elderly of both genders, who had complaints of tinnitus, diagnosed with alteration in one of the auditory skills researched and with bilateral hearing loss. However, only five elderly adhered to the intervention program until the end. Therefore, the final sample was composed of two women and three men, with mean age of 73.6 (minimum = 67; maximum = 84); three of these subjects had moderate degree hearing loss (S2, S3 and S4), S1 presented hearing loss in the frequencies beginning at 2 kz, and S5 had mild degree. The time of sensorial deprivation varied greatly, with average of six years (minimum = three; maximum = 10). As for the time of fitting, the average was of three years (minimum = two; maximum = four).

The rehabilitation of altered auditory skills of the five elderly in the sample took place through the Computerized Controlled Acoustic Auditory Training (C-CAAT) with the *Escuta Ativa* software[28]. This one was chosen for being software that aims at training auditory skills, having already been indicated for adult and elderly patients who used hearing aids[17]; nevertheless, no national or international paper was found which used the Computerized Controlled Acoustic Auditory Training (C-CAAT) in treatment of patients with tinnitus. Hence, its use is an innovation in this study.

Sixteen 30-minute individual sessions were conducted, twice weekly. Supra-aural earphones were used, Sony brand, model MDR-ZX310AP, for the training to be performed. The patients did not use the hearing aids during auditory training.

The activities present in the *Escuta Ativa* software aimed at stimulating the auditory figure-ground skills, binaural integration and separation, temporal resolution, temporal patterning, and auditory discrimination. Through self-perception in pure tones and words, it was made possible for the software to calibrate for each case, thus enabling the configuration of the automatic stimuli presentation level for the activities to be conducted. The 12 activities were described in detail in a study recently published[30].

All the activities had four levels of difficulty: easy, medium, hard, and insane. On the last level, there is the presence of competing noise; however, such noise can be added to any of the levels, according to the elderly's or the therapist's choice. In this study, though, no background noise was added to the other levels. Furthermore, not all levels were performed for all elderly, as the degree of difficulty varied according to their performance, measured by the software itself.

It is important to highlight that these 16 activities were conducted one in each session. Moreover, four sessions consisted of those activities in which the subjects had had their worst performance. The therapist was the same for all the elderly, in order to ensure the same procedure throughout the whole treatment.

After the C-CAAT, reassessment was conducted with the same battery of the assessment, with at least 20 days having passed from the end of the proposed intervention, and 30 days at the most. The reassessments, as well as the assessments, were conducted by a speech-language-hearing therapist not involved with this research; i.e., who did not perform the CAAT. This collaborator inserted the results in a databank, keeping them under secrecy. Such procedure pre- and post-intervention characterized the blind analysis of this research. Lastly, all the results were turned in to the researcher in order to begin the analysis and the verification of the data.

For the statistical analysis of this paper, the level of significance of 0.05 (5%) was used. The confidence intervals were built on 95% statistical confidence. For the comparisons pre- and post-C-CAAT, the Wilcoxon test was used.

Results

On the first table, there are presented the descriptive analysis and the statistical study of the performance of the group of elderly on the THI test pre- and post-C-CAAT (Table 1)

Table 1. Comparison of the performance on the Tinnitus Handicap Inventory test, before and after Computerized Controlled Acoustic Auditory Training in elderly users of hearing aids (n=5)

THI	Pre C-CAAT	Post C-CAAT
Mean	44.4	12.8
Median	40	16
Minimum value	20	2
Maximum value	76	24
Standard deviation	20.4	10.3
N	5	5
CI	17.9	9.0
P-value	0.043*	

Legend: THI: Tinnitus Handicap Inventory; C-CAAT: Computerized Controlled Acoustic Auditory Training; N: Number of subjects; CI: Confidence Interval; *: P-value with statistically significant difference.
Wilcoxon Test

Regarding the degrees of discomfort with tinnitus, measured through the THI, it was noted that before the C-CAAT, the elderly presented more acute degrees of discomfort: S1 presented severe degree on the pre-AT assessment and mild degree post-AT; S2, moderate degree, and after, slight; S3, mild degree on the assessment and slight degree post-AT; S4 and S5, moderate degree and mild degree post-AT.

After that, the measuring of the effect of the proposed therapeutic intervention was studied by means of the analysis of the pre- and post-C-CAAT score on the auditory processing assessment behavioral tests, which were the speech by white noise test, and the Dichotic Digits Test (Table 2). It is important to emphasize that there were no statistically significant difference between the ears; therefore, it was decided to use only the data from one of them to present the results.

Table 2. Performance on the processing assessment behavioral tests before and after the intervention proposed in a group of elderly users of hearing aids (n=5)

		Mean	Median	Standard Deviation	N	CI	P-Value
Speech by Noise	Pre	60.8	60	3.3	5	2.9	0.043*
	Post	85.6	88	10.4	5	9.1	
Dichotic Digits Test	Pre	55.8	60	13.6	5	11.9	0.043*
	Post	71.6	75	10.6	5	9.3	

Legend: N= Number of subjects, SD=Standard Deviation, CI= Confidence Interval; *= P-value with statistically significant difference
Wilcoxon Test

All the patients on the pre-intervention assessment, on the speech by noise test, presented altered score for their age, except for S2 on the LE, having presented normality. On the DDT test, pre-intervention, only one subject (S1) presented change from altered to normal. As for S2, the result remained altered, despite the score having improved, since such improvement was not sufficient to reach normality. The remaining patients were normal at the moment of pre-intervention.

The Random Gap Detection Test (RGDT) data were not presented, as all elderly obtained results within normality since the time prior to intervention.

Concerning the findings of the LLAEP with verbal stimuli performed also in two moments, pre- and post-C-CAAT, it was analyzed at first the difference of the latency of the components in milliseconds on both ears on the assessment and reassessment of the groups of elderly studied (Table 3). Similarly, the modifications on the amplitude of the components P1-N1, P2-N2 and P3 in microvolts (μV) was studied (Table 4).

It is important to highlight that on the P3 wave pre-C-CAAT, the sample N decreases for four elderly; whereas the P3 wave on both ears on the pre-C-CAAT period was absent in one (1) subject, though appearing on the post-C-CAAT period.

Table 3. Comparison between the latencies, in milliseconds, of the long latency auditory evoked potentials, before and after Computerized Controlled Acoustic Auditory Training in elderly users of hearing aids (n=5)

Latency		Mean	Median	Standard Deviation	N	CI	P-value
P1	Pre	63.8	63	7.2	5	6.3	0.138
	Post	68.8	69	7.8	5	6.8	
N1	Pre	109.0	107	5.7	5	5.0	0.225
	Post	113.4	112	5.6	5	4.9	
P2	Pre	194.8	189	19.0	5	16.7	0.285
	Post	192.4	183	24.7	5	21.7	
N2	Pre	256.6	237	46.2	5	40.5	0.080
	Post	270.8	254	54.0	5	47.3	
P3	Pre	357.8	341	40.5	4	39.7	0.715
	Post	355.5	355.5	35.2	5	34.5	

Legend: C-CAAT: Computerized Controlled Acoustic Auditory Training; SD: Standard Deviation; *: P-value with statistically significant difference
Wilcoxon Test

Table 4. Comparison between the amplitudes, in microvolt, of the LLAEP before and after C-CAAT in elderly users of hearing aids (n=5)

Amplitude		Mean	Median	Standard Deviation	N	CI	P-value
P1-N1	Pre	5.64	5.90	1.30	5	1.14	0.068
	Post	7.31	7.15	1.25	5	1.09	
P2-N2	Pre	3.13	2.56	2.38	5	2.09	0.043*
	Post	5.61	4.57	3.90	5	3.42	
P3	Pre	5.78	5.91	4.22	4	4.13	0.109
	Post	7.57	6.50	3.90	5	3.83	

Legenda: TAACC: Treinamento Auditivo Acusticamente Controlado Computadorizado DP: Desvio Padrão *: Valor de P com diferença estatisticamente significante
Teste de Wilcoxon

Discussion

Regarding the discomfort with tinnitus, a statistically significant difference became evident on the score of the THI questionnaire before and after therapeutic intervention in the group of elderly submitted to the cited APD rehabilitation program (Table 1). Such questionnaire has already been used in other current scientific studies as a means of measuring the effect of the different types of AT in the self-perception of tinnitus[20-22]. In two of these papers, the data do not reinforce the findings of this research, once they do not observe statistically significant difference in the discomfort with tinnitus in their respective samples, considering the score on the THI[21,22]. An AT proposal[21] was the development of six interactive computerized games, which did not necessarily stimulate only auditory skills, in 60 adult subjects with complaint of tinnitus. Another study[22] suggested a formal AT program, one conducted in sound booth, with 12 adults with hearing loss. It is supposed that one of the possible justifications for the different outcomes of the studies be related to the sample differences, as in both studies[21,22] the subjects present more severe degree of discomfort with tinnitus than those of this study. Moreover, neither of these studies[21,22] mentions the acoustic stimulation provided by the hearing aids, advocated by other researchers[7-10,13] and visualized in this study. It's further added that the type of intervention was distinct, and probably such choice has stimulated different neural centers of the CANS.

Just as the data made evident throughout this paper, in a research[20] statistically significant difference on THI was found pre- and post-intervention. These authors conducted AT in sound booth only on the auditory skill of discrimination in 20 patients aged form 20 to 60 years. Possibly, that study[20] and this one found the same results, for both did not rehabilitate subjects with incapacitating tinnitus. It is also pointed out that, despite the sample presenting divergent age ranges, both therapeutic proposals have shown minimizing effects on the discomfort with tinnitus.

In the literature examined, another questionnaire was also used to measure the effect of the AT on the self-perception of tinnitus. Authors[2] used the Tinnitus Handicap Questionnaire (THQ) when conducting frequency discrimination AT in sound booth with 70 subjects, from 27 to 85 years old, both with normal hearing and with hearing loss. The authors did not observe effects of this modality of AT on the discomfort with tinnitus, differently from this study. A possible justification for such divergence is that that study[2] had a heterogeneous sample group, and the intervention was based on the rehabilitation of just one auditory skill, regardless of a previous CAP assessment.

Other authors[10] aimed at the acoustic stimulation by means of the use of hearing aids and sound generators as a form of intervention in patients with and without hearing loss, who presented tinnitus, without AT intervention. They observed improvement in the discomfort with tinnitus using the THI to measure this complaint, in both groups after this intervention. Such data, once again, demonstrate the importance of using hearing aids in subjects with hearing loss, as in addition to the sound stimulation, a reduction in discomfort with tinnitus is noted[6-10], as with the data evidenced in this study.

Regardless of the statistical results of the previously cited papers, some authors believe that AT provides a beneficial acoustic stimulation as a means of treatment for subjects with tinnitus and hearing loss[2,6,20-22]. Furthermore, they point out that the motivation brought about by the treatment also provides benefits to these subjects' quality of life[21].

Concerning the degree of discomfort with tinnitus, an improvement is observed in the change in the degree of discomfort with tinnitus, for, after the C-CAAT, all the elderly changed at least one degree on the THI scale. This change was equally observed by other researchers[20-22].

It is known that patients with hearing loss are susceptible to CAPD, as previously mentioned[11,14-17]. The behavioral tests presented in Table 2, used to measure the effect of the C-CAAT, have shown the effect of the treatment proposed in this study on elderly with APD, hearing loss and tinnitus. Different authors consider that the AT is effective as a way of treatment in patients with hearing loss and that make us of hearing aids[14,17,18] in the geriatric population.

When analyzing the performance on the behavioral tests pre-and post-AT (Table 2), it is believed an important and frequently impaired ability in the elderly population with hearing loss is that of binaural interference[14,17], due to lagging on the fibers of the corpus callosum This ability was assessed by the Dichotic Digits Test in this study, with alterations being observed previous to the intervention, similarly to what is presented in the literature.

The speech by noise test presents competing stimulus, simulating daily life situations, being that studies show alteration in this ability[13,14] in the population studied, which agrees with the findings from this research, previously to the proposed AT.

A positive effect of the C-CAAT on the abovementioned auditory skills is pointed out at the moment pre-C-CAAT, since, on the reassessment of the subjects of the sample, most of them presented normality on the DDT and speech by noise tests. This data has already been referred to in the literature[7,11], indicating that even being elderly, this population benefits from this form of auditory rehabilitation.

Differently from what is indicated in the literature[13,14], the elderly in the sample did not present alteration in the auditory skill of temporal resolution, visualized in the data within the standards of normality of the RGDT.

A recent research[14] used the same auditory processing assessment behavioral tests of this study in 11 fitted elderly. When performing and auditory training in five sessions, the authors noted positive changes on these tests score pre-and post-intervention, as in this manuscript. Furthermore, they pointed to a weak adherence to the Auditory Rehabilitation Program proposed, which was equally noticed in this research[14]. It is important to highlight that the study referred to was also conducted at an Auditory Health Service accredited by SUS. The weak adherence is emphasized on the Methodology section, where this study's sample composition was presented. These data may be justified by the lack of knowledge regarding the importance of the auditory training.

It is also believed that the AT can cause physiological changes on the central auditory pathway; in this regard, the LLAEP is widely used to measure these modifications occasioned by the AT, as previously mentioned[19,22]. Concerning Tables 3 and 4, though, no neurophysiological modifications were observed after the intervention proposed on most of the components assessed. In agreement with a study whose methodology was similar to this one's, the modifications may have not occurred due to the intensity of the stimulation furnished[22]. It is suggested that possibly the number of sessions was not enough to provide modifications on central level. Moreover, the sample of this study is composed of elderly, and the neural plasticity in this population is known to decrease. However, it is important to emphasize that, even though there was no statistically significant difference pre- and post-intervention on the component P300 of the LLAEP, its latency data were close to the reference values classic in the litearture[29] for the age group of 50 to 70 years (350 - 470 ms). No references were found in the examined literature regarding the LLAEP amplitude findings, pre- and post-AT, in elderly with tinnitus. There are no studies yet proving a consistent statistical correlation between CAP behavioral assessment and electrophysiological assessment, for in many cases the subject presents behavioral alterations not visualized through the records of the auditory evoked potentials.

Through the findings of this study, the initial hypothesis was partially confirmed, once the use of the C-CAAT as a means of intervention in elderly with hearing loss, tinnitus and APD brought about a relevant decrease of discomfort with tinnitus, and caused positive modifications related to the behavioral auditory skills. Such benefit was not evidenced on the electrophysiological assessment as it had been expected.

Not having a control group may be one of the limitations of this study. Nevertheless, since the adherence to the proposed rehabilitation program was low, the option was to rehabilitate all the elderly for ethical reasons.

Conclusion

It was possible to assess the effects of the Computerized Controlled Acoustic Auditory Training on reducing discomfort with tinnitus, since statistically significant differences were observed on the score of the THI pre- and post-intervention. In addition, the auditory skills also improved with the cited intervention. Only electrophysiological changes were not possible to be observed on the LLAEP in elderly with hearing loss, users of hearing aids and with tinnitus, after the modality of training adopted in this study.

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