



# Effective of musical training in elderly people applying to the use of hearing aids

Efeito do treinamento musical em idosos candidatos ao uso de próteses auditivas

Efecto de la formación musical en ancianos candidatos al uso de audífonos

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## Abstract

**Introduction:** The association between hearing aid fitting and auditory training may improve an individual's communication and reduce functional deficits. **Objective:** To investigate the benefit in quality of life, depressive symptoms, cognitive aspects, temporal resolution, and limitation in daily activities for elderly people with hearing loss, after fitting hearing aids associated or not with musical auditory training. **Methods:** Ten patients distributed into Experimental Group (EG) consisting of five elderly people (aged 64 to 79 years old), and Control Group (CG), consisting of five elderly people (aged 62 to 77 years old), with moderate symmetric sensorineural hearing loss underwent anamnesis, cognitive screening CASI-S, audiological evaluation including Word Recognition Score (WRS), Client-Oriented Scale of Improvement (COSI), temporal resolution (GIN), screening for depressive symptoms (GDS-15), quality of life questionnaires (SF-36) and IOI-HA self-assessment. All were fitted with hearing aids, but only the EG had auditory musical training. The outcomes were performed in three moments: before the fitting of the hearing aids; 11 weeks after, with the EG undergoing musical training for seven weeks; and four months later. **Results:** There was no difference between groups according to age, educational level, and cognitive screening. All had better thresholds in the GIN after the intervention. The GDS-15 and SF-36 scores were not significantly different between groups and assessments. **Conclusion:** The use of hearing aids associated or not with musical training improved temporal resolution, but there was no improvement in the quality of life, depressive symptoms, cognition, and COSI scale.

**Keywords:** Presbycusis; Aging; Hearing Aids; Simulation Training.

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### Authors' contributions:

DTMKO: Study design and outline, methodology and data collection.

MCM: Study design and outline, methodology, critical review and guidance.

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**Received:** 9/10/2020

**Accepted:** 11/23/2020



## Resumo

**Introdução:** Associação entre adaptação de próteses auditivas e treinamento auditivo pode melhorar a comunicação do indivíduo e reduzir os déficits funcionais. **Objetivo:** verificar o benefício na qualidade de vida, sintomas depressivos, aspectos cognitivos, resolução temporal e limitação em atividades de vida em idosos com perda auditiva, após adaptação de próteses auditivas associadas ou não ao treinamento auditivo musical. **Métodos:** Grupo Experimental - GE: cinco idosos (64 a 79 anos) e Grupo Controle - GC: cinco idosos (62 a 77 anos), todos com perda auditiva neurosensorial simétrica de grau moderado. Foram submetidos à anamnese, miniteste de triagem cognitiva CASI-S, avaliação audiológica incluindo Índice Porcentual de Reconhecimento de Fala (IPRF), Client-Oriented Scale of Improvement (COSI), resolução temporal (teste GIN), triagem para sintomas depressivos (EDG-15), questionários de qualidade de vida (SF-36) e de autoavaliação para próteses auditivas (QI-AASI). Todos receberam próteses auditivas, e apenas o GE, o treinamento auditivo musical. Avaliação realizada em três momentos: antes da adaptação das próteses auditivas; 11 semanas após a adaptação das mesmas, sendo o GE submetido ao treinamento musical por sete semanas; e quatro meses depois. **Resultados:** Não houve diferença entre grupos segundo idade, escolaridade e triagem cognitiva. Todos apresentaram melhores limiares no teste de resolução temporal após a intervenção. Os escores dos testes de qualidade de vida e sintomas depressivos não foram significativamente diferentes entre grupos e avaliações. **Conclusão:** O uso efetivo de próteses auditivas, associado ou não ao treinamento musical, melhorou a resolução temporal. Não houve melhora significativa na qualidade de vida, sintomas depressivos, cognição e COSI.

**Palavras-chave:** Presbiacusia; Envelhecimento; Auxiliares de audição; Treinamento por simulação.

## Resumen

**Introducción:** Asociación entre adaptación de prótesis auditivas y entrenamiento auditivo puede mejorar la comunicación del individuo y reducir los déficits funcionales. **Objetivo:** verificar el beneficio en la calidad de vida, síntomas depresivos, aspectos cognitivos, resolución temporal y limitación de la vida de las personas mayores con hipoacusia, tras adaptación de audífonos asociada o no al entrenamiento auditivo musical. **Métodos:** Grupo Experimental – GE: cinco ancianos (64 a 79 años) y Grupo Control - GC: cinco ancianos (62 a 77 años) todos con hipoacusia neurosensorial simétrica moderada. Fueron sometidos a la anamnesis, miniprueba de triaje cognitiva CASI-S, evaluación audiológica incluyendo Índice Porcentual de Reconocimiento de Habla (IPRH), Client-Oriented Scale of Improvement (COSI), resolución temporal (prueba GIN), clasificación para síntomas depresivos (EDG-15), cuestionarios de calidad de vida (SF-36) y autoevaluación de audífonos (QI-AASI). Todos recibieron los audífonos, sólo el GE, el entrenamiento auditivo musical. Evaluación realizada en tres momentos: antes de la adaptación de los audífonos; 11 semanas después de la adaptación de las mismas siendo el GE sometido al entrenamiento musical por siete semanas; y cuatro meses después. **Resultados:** No hubo diferencia entre grupos según edad, escolaridad y triaje cognitivo. Todos presentaron mejores umbrales en la prueba de resolución temporal después de la intervención. Los resultados de las pruebas de calidad de vida y los síntomas depresivos no fueron significativamente diferentes entre grupos y evaluaciones. **Conclusión:** Usar audífonos asociados o no con entrenamiento musical mejoró la resolución temporal. No hubo mejora significativa en la calidad de vida, síntomas depresivos, cognición y COSI.

**Palabras clave:** Presbiacusia; Envejecimiento; Audífonos; Entrenamiento simulado.

## Introduction

Senescence is part of human development and consists of the slow and progressive deterioration of organic functions. According to the World Health Organization, the percentage of people over the age of 60 worldwide will increase from 12% to 22% between 2015 and 2050. The increase in life expectancy requires measures to attenuate the difficulties arising from aging<sup>1</sup>.

Affecting about two thirds of people over 65 years of age, Age-Related Hearing Loss (ARHL) is one of several sensory deficiencies that may arise in aging<sup>2</sup>. This condition<sup>3</sup> has a great impact on social, emotional, physical and psychological well-being, negatively influencing the communication and interpersonal relationships of the hearing impaired.

Speech-language pathology intervention may assist in hearing loss in the elderly with the fitting of hearing aids in order to provide greater access to speech sounds (greater audibility), thus assisting in the processing of information and in the discrimination of sound patterns<sup>4</sup>.

In combination with the fitting of hearing aids, auditory training can be used to work on hearing skills in order to improve the individual's communication and reduce functional deficits<sup>5</sup>. There are significant changes in the morphology of the central nervous system and in auditory performance after the reintroduction of acoustic signals through acoustic stimulation<sup>4</sup>.

Based on the premise that hearing aids help people with hearing loss to have greater access to speech sounds, provide better audibility and that auditory training includes exercises to improve detection and discrimination skills, among others<sup>4,5</sup>, this study decided to investigate the following hypothesis:

If elderly people who are applying for the use of amplification devices, after speech-language pathology intervention through the fitting of hearing aids, will have a better quality of life with less depressive symptoms, less cognitive decline, better temporal resolution and less limitation in activities of daily living and if an auditory musical training would provide more significant improvements.

Therefore, this study aimed to investigate the benefit in quality of life, depressive symptoms, cognitive aspects, temporal resolution and limitation in life activities in elderly people with hearing

loss, after fitting of hearing aids, associated or not with musical auditory training.

## Methods

This study was carried out at the Integrated Center for Hearing Assistance, Research and Teaching (NIAPEA) of the Department of Speech-Language and Hearing Sciences at the Universidade Federal de São Paulo (UNIFESP), a highly complex service focused on Hearing Health in the Brazilian Unified Health System (SUS). Elderly people who were waiting for the delivery of their hearing aids were invited to participate in the study.

This study was approved by the Research Ethics Committee (CEP) of the institution under the opinion no. 2.179.302.

After agreeing to participate in the study, by signing the Free and Informed Consent Form (ICF), patients were submitted to the research protocol prepared for this study. This was a longitudinal intervention study, whose inclusion criteria for sample composition were:

- Aged between 60-79 years;
- Moderate symmetrical bilateral sensorineural hearing loss according to the WHO, considering the average of pure tone hearing thresholds of the frequencies of 500, 1000, 2000 and 4000 Hz between 41 and 60 dB HL<sup>6</sup>;
- Word Recognition Score (WRS) equal to or greater than 60%;
- As reported by Jerger et al, individuals with moderate sensorineural hearing loss reach the minimum score of 60% of correct answers on the WRS test, at the presentation level of 40 dB above the quadrilateral average of the frequencies of 500, 1,000, 2,000 and 4,000Hz<sup>7</sup>;
- Applicants for the use of hearing aids without previous experience with amplification devices.
- Having a score equal to or greater than 20 points on the Cognitive Abilities Screening Instrument - Short Form (CASI-S).

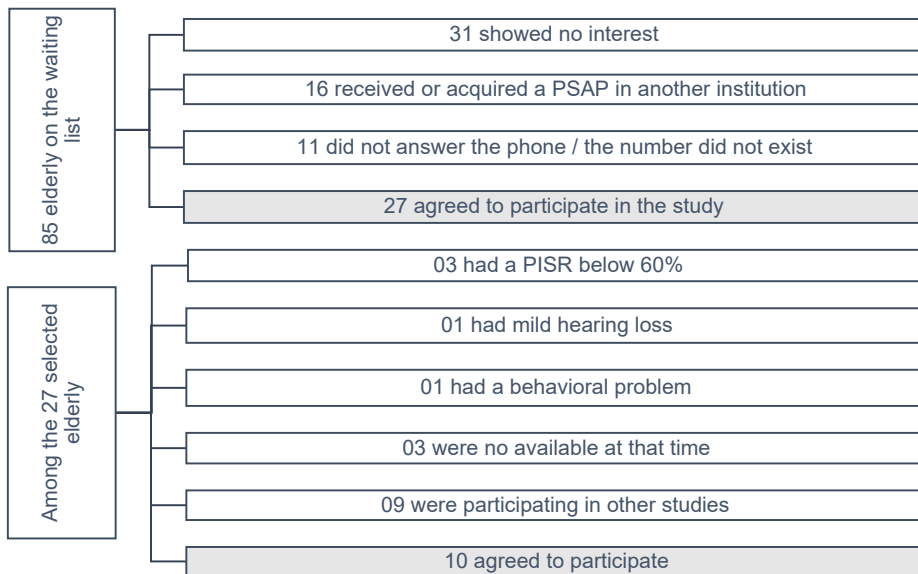
In turn, the exclusion criteria were as follows:

- Having evident neurological and/or psychiatric disorders;
- Patients who were participating in other studies.

Then, 85 elderly people were selected from the survey of the medical records of the elderly on the service waiting list. The researcher contacted

these potential participants by phone and 27 agreed to participate in the research that included the fitting of hearing aids and musical training. Of these 27, 12 were excluded because nine were already participating in another survey and three were not available at that time. The remaining 15 were scheduled for a new audiological evaluation. Five were withdrawn: three had a WRS of less than 60%, one had hearing improvement (mild hearing loss) and the other had behavioral problems that would not allow participating in the research. Finally, 10 elderly people were included in the study and randomly distributed into two groups: one group was submitted only to hearing aid fitting, counsel-

ing and guidance on handling and communication strategies, while the other group received hearing aids with their respective counseling and musical training. Although the two groups were randomly divided, some participants refused to participate in the group that performed the musical training, as it involved follow-up visits for the fitting of hearing aids (approximately four), plus seven weeks of training (each session would last one hour), in addition to the three evaluations during the process, totaling approximately 13 appointments. The transportation and availability of the caregiver were also considered by the patients at the time of allocation to a group.



**Figure 1.** Identification of elderly according to the criteria defined in the research

Paired according to age and gender, the 10 elderly comprised the following groups:

- Control group (CG) – consisting of 05 elderly people aged 62 to 77 years, three females and two males.
- Experimental group (CG) – consisting of 05 elderly people aged 64 to 79 years, two females and three males.

Then, both groups were submitted to the rehabilitation program (fitting of hearing aids and counseling), in addition to musical auditory training performed only by the experimental group, as shown below.

### Procedures

Anamnesis, cognitive screening and Brazilian Economic Classification Criteria.

Initially, the study collected data related to the identification and past history of the complaint, in addition to the application of the CASI-S cognitive screening and the questionnaire for economic evaluation of the Brazilian Market Research Association (ABEP) - Brazilian Economic Classification Criteria.

**Cognitive Screening - Cognitive Abilities Screening Instrument – Short Form (CASI-S)** includes repetition (registration), temporal orienta-

tion, verbal fluency and evocation, with a maximum score of 33 points. For elderly people up to 70 years old, scores from 0 to 23 are suggestive of dementia, while for elderly people over 70 years old, the cutoff score is 20<sup>8,9</sup>.

**Brazilian Economic Classification Criteria - Brazilian Market Research Association (ABEP), changes validated in 2019**, introduces variables as the number of appliances and electronics, housing conditions, educational level of the householder and access to public utility services. Points are assigned to these items to find out which socioeconomic class the family belongs to<sup>10</sup>.

### Study protocol

The study protocol of this research consisted of the application of the following procedures:

#### Basic audiological evaluation

After performing anamnesis and meatoscopy, the elderly in the control group and in the experimental group underwent audiological evaluation<sup>11</sup>, including:

- Pure-tone threshold audiometry by air in the frequencies from 250 to 8000 Hz and by bone in the frequencies from 500 to 4000 Hz.
- Speech recognition threshold (SRT)
- Word Recognition Score (WRS)

Pure-tone threshold audiometry and logaudiometry were performed in an acoustic booth using an Interacoustics AC33 audiometer with TDH 39 headphones.

**Word Recognition Score (WRS)** was performed at 40 dB SL above the average of pure tone auditory thresholds of 500, 1,000 and 2,000 Hz in both ears or at the level of greatest comfort,

as reported by the patient. Patients were asked to repeat a list of twenty-five monosyllabic words<sup>12</sup>. The patient received 4% for each correct answer, thus totaling 100% at the end of the test<sup>13</sup>.

**Assessment of limitations in activities of daily living using the Client Oriented Scale of Improvement (COSI)**<sup>14</sup> applied at the time of the anamnesis. Patients could name up to five specific auditory, emotional or social situations, which they would like to improve after the fitting of the hearing aids. At the end of the rehabilitation process, two questions were asked to each patient about each of the situations identified at the beginning of the process. The first question would be an assessment of the patients on the degree of change in their hearing ability for the situations listed. The degree of change is classified by a series of five descriptors ranging from “worse” to “much better”. The second question would ask patients to evaluate their final ability with the hearing aid for each of the situations identified. This classification ranges from “can hardly hear” in a situation to “can almost always hear” in the same situation. Again, there were five options for the patient. These final ratings of ability have equivalent percentages ranging from 10% for “hardly ever” to 95% for “almost always”. The degree of classification change has no numerical equivalent in the COSI form, but the developers noted that the five descriptors can be classified on a scale of 1 to 5 for analysis purposes, with the number 1 corresponding to “worst” and 5 corresponding to “much better”.

At the end of the first phase of COSI application, the audiologist classifies each situation according to each of the sixteen categories defined by the test authors<sup>14</sup>.

**Chart 1.** Categories of the COSI questionnaire (Client Oriented Scale of Improvement)

Categories of the COSI questionnaire			
Conversation with 1 or 2 in quiet.	Conversation with 1 or 2 in noise.	Conversation with group in quiet.	Conversation with group in noise.
Television/Radio @ normal volume.	Familiar speaker on phone.	Unfamiliar speaker on phone.	Hearing phone ring from another room.
Hear front door bell or knock.	Hear traffic.	Increased social contact.	Feel embarrassed or stupid.
Feeling left out.	Feeling upset or angry.	Church or meeting.	Other.

**Assessment of temporal resolution by the Gaps-In-Noise (GIN) test**<sup>15</sup> assesses temporal resolution based on the measurement of the smallest interstimulus interval (ISI - gap) that the participant is able to perceive. The test consists of the presentation of zero to three episodes of silence with the silence varying from two to 20 milliseconds (ms) in a white noise lasting six seconds. 60 ISIs (gaps) were presented to the patient. The procedure was applied using supra-aural headphones in an acoustic booth, with the stimulus presented at 50 dB SL, based on the average of the thresholds of 500 Hz, 1000 Hz and 2000 Hz or the maximum comfort level, when required. The test was performed on each ear separately, with half of the band on the right ear and half on the left ear, in that order.

Then, the results were analyzed considering:

1. the percentage of correct answers of gaps (60)
2. the gap threshold; that is, the shortest time that the individual was able to identify at least four out of six gaps of the same interval in ms<sup>15</sup>.

**Geriatric Depression Scale (GDS-15)**, which is validated for local use<sup>16</sup>, and consists of a reduced test with 15 negative/affirmative questions for detecting depressive symptoms in the elderly. A score from five points characterizes depression, while results equal to or greater than 11 indicate severe depression.

**Medical Outcomes Study 36 – Item Short-Form Health Survey (SF-36)** is a generic instrument that was translated and validated in Brazil<sup>17</sup> and is used to assess the population's quality of life. Consisting of 11 questions with 36 items divided into 8 domains: physical aspect, functional capacity, mental health, pain, social and emotional aspects, vitality, and general health status. The final score ranges from 0 to 100, in which zero corresponds to the worst health status and 100 to the best.

**Digit span test**<sup>18</sup> was used to assess the capacity of retaining information from working memory by presenting increasing sequences of digits. This test consists of eight series for direct order and seven for reverse order and there is a gradual increase in the number of digits in each series. The direct order is applied first, followed by the reverse order, which is administered regardless of whether the patient fails completely in the direct order. Each item consists of two sequences, both of which are applied. The test ends when the participant misses both sequences with the same number of digits.

The score is calculated by the largest sequence of number of digits correctly remembered.

**International Outcome Inventory for Hearing Aids (IOI-HA)** has a version translated and adapted to Portuguese<sup>19</sup> that was used in this study. This instrument was applied seven months after the hearing aid fitting, in order to report, from the patient's point of view, the daily use, benefit, limitation of basic activities, satisfaction, restriction of participation, impact in relation to other individuals, quality of life and the degree of hearing difficulties experienced by patients without hearing aids.

### *Speech-Language Pathology Intervention*

Hearing aids fitting process performed in CG and EG

Hearing aids, ear molds and/or fitting with a thin tube and olive were selected according to the degree and characteristics of the hearing loss.

Hearing aids were adjusted using the manufacturer's software, available in NOAH v4, according to the prescriptive method DSL v5. In order to adjust the gain and maximum output, the adjustments were made using the Audioscan Verifit1, based on the protocol used in the service<sup>20</sup>. According to the guideline used, the gain should be within +/- 5 dB of the target provided by the DSL v5 rule. The International Speech Test Signal (ISTS) was used at 65 dBNPS as the stimulus to assess the acoustic gain, while the tone burst stimulus was used at 85 dBNPS to verify the Maximum Power Output (MPO).

Once the hearing aids were properly adjusted, the patients were instructed on handling, cleaning, conservation and use strategies, emphasizing the importance of the effective use of the amplification device, to assist in acclimatization. Patients underwent weekly follow-up (an average of four appointments) until they had no doubts and were making effective use of the amplification device - at least eight hours a day. The caregivers were also instructed.

Music Auditory Training Program performed only with the EG

After concluding the process of hearing aid fitting, the elderly in the experimental group (EG) underwent the musical auditory training, as proposed by Freire<sup>21</sup>.

Seven DVDs were used for the Music Auditory Training Program involving the interaction of the auditory and visual system. This training was conducted outside the acoustic booth, using two portable speakers attached to the notebook, and each session lasted approximately one hour. Hearing aids and batteries were checked at the beginning of each session for functionality to ensure the audibility of sounds throughout the session.

The evaluator should explain the purpose of the DVD at the beginning of each session and present a demonstration of the tasks that would be worked, so that the patient could understand the proposal. In all stages, the elderly person performed the actions as directed on the screen and the evaluator handled the computer at the time of the final result of each level of difficulty and in the breaks for reading the

instruction, when necessary. Although the elderly could handle the computer, they were unfamiliar with the equipment and were afraid.

Each track on the DVD was aimed to stimulate the auditory system in an increasing scale of difficulty, according to the objective of each session. Each level had 10 exercises and at the end, the participant was asked to mark the number of correct answers and the evaluator should also mark the result. If the score was from zero to six, the level was repeated; if the score was from seven to 10, the patient would reach the next level.

Frequency ranges of the instrumental sounds from 200 to 4000 Hz were used, in addition to the music as background noise composed of five instruments (guitar, vibraphone, piano, flute and drum).

**Chart 2.** Activities performed on each DVD and their respective auditory mechanisms

DVDs	DVD identification	Activities	Mechanisms
DVD #1	Figure-ground for instrumental sounds	Identification of instrumental sounds overlapping a song	Selective attention (Figure-ground)
DVD #2	Figure-ground for sequential sounds	Identification of a series of instrumental sounds overlapping a song	Selective attention (temporal ordering)
DVD #3	Duration of sounds	Identify and name a series of sounds of different durations.	Temporal processing (temporal ordering)
DVD #4	Frequency of sounds	Identify and name a series of sounds of different frequencies.	Temporal processing (resolution and temporal ordering)
DVD #5	Rhythm and time structure	Identify rhythmic structures through motor reproduction and visual association.	Temporal processing (resolution and temporal ordering)
DVD #6	Auditory closure	Identify incomplete familiar songs.	Selective attention (closure)
DVD #7	Directed listening	Identification of two overlapping sounds with recognition of the sound source of these sounds.	Selective attention (Figure-ground)

The experimental group completed the musical training in seven weeks and the results were recorded in specific protocols.

The exercises proposed in each DVD involved attention, working memory and auditory skills. It should be noted that auditory and visual stimulations were included in all exercises in order to train the integration between these two systems.

### Assessment Periods

The participants were assessed at three different moments:

**First assessment:** was performed in a session before the fitting of the hearing aids and consisted of the following procedures: audiological evaluation, COSI; GIN; SF-36 and GDS-15.

The process of hearing aid fitting was carried out just after of the first assessment, following the protocol adopted in the hearing health service.

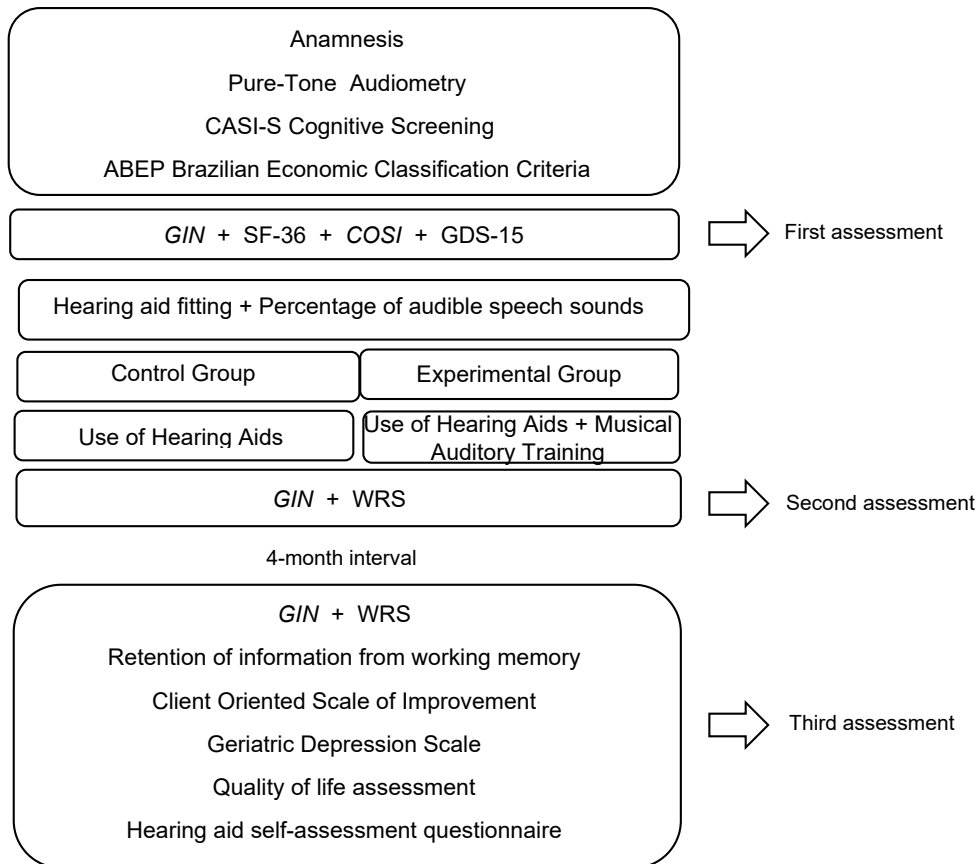
**Second evaluation:** It took approximately four weeks for all patients to adapt to the amplification device. The Experimental Group performed the Musical Training for seven weeks before the second evaluation, thus totaling 11 weeks after the fitting of the hearing aids in which the GIN test was ap-

plied and the WRS was reevaluated. The Control Group used only the amplification device and had no follow-up visit until the second evaluation was scheduled.

**Third evaluation:** Was performed four months after the second evaluation and included the fol-

lowing: COSI, WRS, GIN, Digit span, SF-36, GDS-15 and IOI-HA. The GIN test and the IOI-HA questionnaire were applied by another clinician in order to characterize a double-blind study.

The following flowchart describes all the stages in this study.



**Figure 2.** Flowchart of this study

## Results

This chapter will be divided into two parts to facilitate the presentation of the results:

### Part 1 – Sample characterization

After evaluating the 10 elderly participants, the descriptive statistics were calculated for the variables age, educational level, socioeconomic level, cognitive screening and retention of information

from working memory according to the groups, as shown in Table 1.

### Part 2- Comparative study between the benefit obtained by the participants of the EG and CG.

Table 2 shows the correlation between the GIN and WRS tests according to the groups and the three assessments.



**Table 1.** Descriptive values and comparative analysis of groups in terms of age, educational level, performance in CASI-S and Digit Span and scores in the ABEP Brazilian Criteria

Variable	Group	Mean	SD	Median	Min.	Max.	p-value	ES
Age (years)	EG	71.00	6.36	73.00	64.00	79.00	0.635	0.168
	CG	72.80	6.22	74.00	62.00	77.00		
Educational level (years)	EG	10.80	3.42	9.00	8.00	15.00	0.087	0.570
	CG	5.40	4.22	4.00	0.00	11.00		
CASI-S (score)	EG	31.20	2.05	33.00	28.00	33.00	0.183	0.437
	CG	28.00	4.64	31.00	21.00	33.00		
Direct Digit Span (score)	EG	8.40	0.89	9.00	7.00	9.00	0.508	0.240
	CG	7.60	1.82	7.00	6.00	10.00		
Indirect Digit Span (score)	EG	4.60	1.52	5.00	2.00	6.00	0.278	0.307
	CG	4.00	1.41	4.00	2.00	6.00		
ABEP Brazilian Criteria (score)	EG	30.60	8.35	26.00	24.00	42.00	0.079	0.563
	CG	22.40	9.76	22.00	12.00	38.00		

N=10 subjects

Mann-Whitney U test

Legend: SD: Standard deviation; Min.: Minimum; Max.: Maximum; p≤0.05; ES: Effect size.

**Table 2.** Descriptive values of the parameters of the GIN and WRS tests according to the group and the three evaluations

Assessment	Variable	Group	Mean	SD	Median	Min.	Max.
1	GIN – Correct answers (%)	EG	21.33	9.96	23.33	8.00	35.00
		CG	21.80	11.52	26.60	10.00	36.00
	GIN – Gap detection threshold (ms)	EG	18.00	7.58	15.00	10.00	30.00
		CG	20.00	9.35	15.00	10.00	30.00
	WRS of the best ear (%)	EG	91.20	9.55	96.00	76.00	100.00
		CG	78.40	3.58	76.00	76.00	84.00
2	GIN – Correct answers (%)	EG	28.18	8.30	30.00	16.00	38.30
		CG	31.66	4.86	30.00	26.67	38.33
	GIN – Gap detection threshold (ms)	EG	13.60	3.13	15.00	8.00	15.00
		CG	13.40	4.22	12.00	10.00	20.00
	WRS of the best ear (%)	EG	92.00	8.00	96.00	80.00	100.00
		CG	77.60	6.07	76.00	72.00	84.00
3	GIN – Correct answers (%)	EG	38.27	6.52	40.00	30.00	45.00
		CG	36.66	6.25	35.00	28.30	45.00
	GIN – Gap detection threshold (ms)	EG	11.40	2.19	10.00	10.00	15.00
		CG	11.00	2.24	10.00	10.00	15.00
	WRS of the best ear (%)	EG	91.20	9.55	96.00	76.00	100.00
		CG	77.60	14.31	88.00	60.00	88.00

Mann-Whitney U test

Legend: SD: Standard deviation; Min.: Minimum; Max.: Maximum.

Note: An arbitrary value of 30 ms was adopted for the GIN gap detection thresholds that exceeded 20 ms.

It can be noted that the CG performed better in the second and third assessments (13.40/11.00) for the GIN test threshold than the EG (13.60/11.40). The EG showed better results in the three moments of the WRS assessment, with a significant difference in the second evaluation. The values were

similar in both groups and in the three evaluations of the GIN test percentage.

The comparison between the evaluations according to the group and the groups according to the evaluation are shown in Table 3.

**Table 3.** Comparison of the groups according to the assessment and the assessments according to the group in relation to the parameters of the GIN and WRS tests

Variable	Comparison between groups						Comparison between assessments	
	1st Assessment		2nd Assessment		3rd Assessment		EG	CG
	EG x CG		EG x CG		EG x CG		1 x 2 x 3	1 x 2 x 3
	pa	ES	pa	ES	pa	ES	pb	pb
GIN – Gap detection threshold (ms)	0.976	0.069	0.841	0.106	>0.999	0.163	0.223	0.146
GIN – Correct answers (%)	0.952	0.033	0.571	0.199	0.810	0.100	0.015*	0.036*
WRS of the best ear (%)	0.071	0.615	0.032*	0.700	0.079	0.547	0.867	0.801

Mann-Whitney U test (a) and Friedman test (b).

Legend: \*: Statistically significant value at the 5% level ( $p \leq 0.05$ ); ES: Effect size.

As for the comparison of the groups, the results shown in Table 3 demonstrate that there was a statistically significant difference between the EG and CG according to the WRS from the first assessment to the second assessment, as the EG had a higher WRS value when compared to the CG. In this sense, individuals who underwent musical training had a better performance in the WRS in the second evaluation compared to individuals who did not undergo musical training.

As for the comparison of the assessments of each group, there was a difference between the evaluations for the two groups in relation to the gap detection threshold in the GIN test. The post hoc analysis, carried out by means of the Wilcoxon signed-rank test with Bonferroni correction for multiple comparisons, showed that there was a

difference between assessments 1 and 3 ( $p=0.013$ ,  $r=0.900$ ) for the EG. In turn, there was no difference for any of the three comparisons for the CG between pairs of assessments (1x2:  $p>0.999$ ,  $r=0.150$ ; 1x3:  $p=0.053$ ,  $r=0.750$ ; 2x3:  $p=0.173$ ,  $r=0.600$ ). Thus, individuals who had musical training showed improved performance in the GIN test between assessments 1 and 3, while there was an improvement in individuals who did not have musical training in the same test. However, this effect was not large enough to identify which assessments differed from each other.

Table 4 shows the performance in the SF-36 questionnaire and in the screening for depressive symptoms GDS-15 according to groups and assessments, as well as the comparison of assessments.

**Table 4.** Descriptive values and comparative analysis of assessments in relation to performance in the SF-36 and GDS-15 questionnaires according to the group

Group	Variable	Assessment	Mean	SD	Median	Min.	Max.	p-value	ES
EG	GDS-15 (score)	Pre	2.60	3.44	1.00	0.00	8.00	0.500	0.447
		Post	1.40	2.07	1.00	0.00	5.00		
	SF-36: Functional capacity (score)	Pre	65.00	16.96	65.00	45.00	90.00	>0.999	0.000
		Post	70.00	19.69	65.00	45.00	90.00		
	SF-36: Physical functioning (score)	Pre	85.00	22.36	100.00	50.00	100.00	>0.999	0.141
		Post	90.00	22.36	100.00	50.00	100.00		
	SF-36: Pain (score)	Pre	73.80	17.56	62.00	61.00	100.00	0.250	0.507
		Post	88.40	11.35	84.00	74.00	100.00		
	SF-36: General health status (score)	Pre	63.60	10.74	62.00	52.00	80.00	0.188	0.469
		Post	71.70	3.49	72.00	67.50	77.00		
	SF-36: Vitality (score)	Pre	82.00	13.04	80.00	70.00	100.00	>0.999	0.058
		Post	83.00	11.51	85.00	65.00	95.00		
	SF-36: Social aspects (score)	Pre	82.50	11.18	75.00	75.00	100.00	0.250	0.516
		Post	95.00	11.18	100.00	75.00	100.00		
SF-36: Emotional aspects (score)	Pre	66.64	33.35	66.60	33.30	100.00	0.500	0.344	
	Post	86.66	29.83	100.00	33.30	100.00			
SF-36: Mental health (score)	Pre	82.40	12.84	84.00	68.00	100.00	>0.999	0.000	
	Post	84.00	13.56	84.00	64.00	100.00			
CG	GDS-15 (score)	Pre	5.00	2.45	5.00	3.00	9.00	0.125	0.598
		Post	3.80	3.03	2.00	2.00	9.00		
	SF-36: Functional capacity (score)	Pre	59.00	23.29	55.00	35.00	90.00	0.250	0.507
		Post	48.00	32.71	55.00	15.00	90.00		
	SF-36: Physical functioning (score)	Pre	45.00	37.08	50.00	0.00	100.00	>0.999	0.000
		Post	40.00	45.41	25.00	0.00	100.00		
	SF-36: Pain (score)	Pre	55.60	17.91	51.00	41.00	84.00	>0.999	0.000
		Post	59.20	34.77	72.00	10.00	100.00		
	SF-36: General health status (score)	Pre	65.40	21.34	64.00	42.00	87.00	0.0375	0.408
		Post	46.60	19.89	42.00	25.00	72.00		
	SF-36: Vitality (score)	Pre	62.00	22.25	65.00	35.00	95.00	0.938	0.086
		Post	60.00	11.73	55.00	50.00	80.00		
	SF-36: Social aspects (score)	Pre	67.50	31.37	62.50	37.50	100.00	0.500	0.235
		Post	82.50	27.39	100.00	37.50	100.00		
SF-36: Emotional aspects (score)	Pre	46.63	29.78	66.60	0.00	66.60	>0.999	0.000	
	Post	46.65	38.00	33.33	0.00	100.00			
SF-36: Mental health (score)	Pre	79.20	8.20	80.00	72.00	92.00	0.750	0.258	
	Post	75.20	12.77	72.00	60.00	92.00			

Wilcoxon signed-rank test.

Legend: SD: Standard deviation; Min.: Minimum; Max.: Maximum; ES: Effect size.

Results in Table 4 also show that there was no statistically significant difference in relation to the performance in the GDS-15 and in all categories of the SF-36 for both groups before and after the intervention. Thus, both individuals who received auditory training and individuals who did not re-

ceive it had no changes between the pre and post training moments in relation to these variables.

In turn, Table 5 shows the correlation analysis between the IOI-HA and COSI, SF-36, GDS-15, GIN and WRS in the post-training assessments according to the group.

**Table 5.** Correlation analysis between IOI-HA and COSI, SF-36, GDS-15, GIN and WRS in post-training assessments according to the group

Variable			1	2	3	4	5	6	7	8
EG	IOI-HA	Coef.	0.289	-0.289	0.408	0.323	0.740	0.740	0.667	NA
		p-value	0.638	0.638	0.495	0.596	0.152	0.152	0.219	NA
CG	IOI-HA	Coef.	-0.200	0.103	-0.821	-0.354	-0.474	-0.671	0.335	0.205
		p-value	0.747	0.870	0.089	0.559	0.420	0.215	0.581	0.741

			9	10	11	12	13	14	15	16	17
EG	IOI-HA	Coef.	0.889	0.408	0.304	-0.889	0.866	0.408	0.408	0.289	-0.304
		p-value	0.044*	0.495	0.619	0.044*	0.058	0.495	0.495	0.638	0.619
CG	IOI-HA	Coef.	-0.154	0.410	-0.500	1.000	-0.359	0.447	0.900	0.300	0.783
		p-value	0.805	0.493	0.391	<0.001*	0.553	0.450	0.037*	0.624	0.118

Spearman's rank correlation coefficient

Legend: Coef.: Coefficient; \*: Statistically significant value at the 5% level ( $p \leq 0.05$ ); 1: GIN - Percentage (2nd assessment); 2: GIN - Percentage - (3rd assessment); 3: GIN detection threshold (2nd assessment); 4: GIN detection threshold (3rd assessment); 5: WRS (2nd assessment); 6: WRS (3rd assessment); 7: COSI - Degree; 8: COSI - Final ability; 9: SF-36 - Functional capacity; 10: SF-36 - Physical functioning; 11: SF-36 - Pain; 12: SF-36 - General Health Status; 13: SF-36 - Vitality; 14: SF-36 - Social aspects; 15: SF-36 - Emotional aspects; 16: SF-36 - Mental health; 17: GDS-15.

There was a statistically significant and positive correlation (directly proportional) between the following pairs of variables, indicating that the increase in one of the variables was associated with the increase in the other variable:

- EG: IOI-HA and SF-36 - Functional Capacity;
- CG: IOI-HA and SF-36 - General health status;
- CG: IOI-HA and SF-36 - Emotional aspects.

There was a statistically significant and negative correlation (inversely proportional) between the following pairs of variables, indicating that the increase in one of the variables was associated with the decrease in the other variable:

- EG: IOI-HA and SF-36 - General health status.

There were no statistically significant correlations for the other pairs of variables.

## Discussion

As reported, this study aimed to investigate the benefit in quality of life, depressive symptoms, cognitive aspects, temporal resolution and limitation in life activities in elderly people applicants for the use of hearing aids through the fitting of hearing aids, associated or not with musical auditory training.

The demographic and cognitive variables of the elderly participants in both groups were analyzed at first in order to characterize the sample. The descriptive values and comparative analysis of the groups in relation to age, educational level, cognitive tracking, retention of information from working memory and socioeconomic level found

that there was no statistically significant difference between the groups in relation to age, educational level and score in the CASI-S mini-test, Digit Span and Socio Economical Brazilian Criteria. Although individuals who had auditory training had results similar to individuals who did not have such training (Table 1) in relation to these variables, it is noteworthy that the educational and socioeconomic level of the participants of the EG were better than those of the CG ( $p=0.08$  and  $p=0.07$ , respectively).

In addition, the CG had a higher mean age, lower score in the CASI-S cognitive screening and in the Digit span test. This may have occurred due to the moment of the random allocation of participants in the control and experimental groups, but some participants preferred to remain in the control group, as it required less follow-up visits and less demand for participation in general. It may be suggested whether individuals with more education seek to improve more and more while those less educated prefer to remain in the same situation and not seek challenges and possible changes. This hypothesis could explain the difference between the groups in terms of educational and socioeconomic level.

The elderly in EG who had a higher level of education performed better on the Digit Span test in both the direct and reverse order. These findings agree with the studies of Tripathi et al.<sup>22</sup>.

Andrade et al.<sup>23</sup> reported that individuals with a high educational level may have high professional levels that require excessive use of attention,

memory and other cognitive processes and this demand in information processing could also be reflected in auditory skills, which can be verified by findings of the EG in this study.

As for economic classification<sup>18</sup>, the study reported two elderly (20%) in B1, one (10%) in B2, four (40%) in C1, two (20%) in C2 and one (10%) in DE. These results were similar to those found by Carniel et al<sup>24</sup>, who used the same ABEP criteria and found that most of the participants belonged to the upper classes. Regarding the educational level, an elderly participant (10%) was illiterate, while five (50%) had up to eight years of schooling and four (40%) had eight or more years of study.

The results obtained in the assessments before and after intervention in the two groups submitted to auditory rehabilitation, and only one of them (EG) also submitted to musical auditory training, are discussed below:

The comparative analysis carried out between the results of the GIN and WRS tests in the three assessments according to the groups showed that the CG performed better in the second and third assessments (13.40/11.00) for the GIN test threshold than the EG (13.60/11.40). In turn, the EG had better results in the three moments of the WRS assessment, with a significant difference in the second evaluation, which was performed after auditory training. The values were similar in both groups and in the three evaluations in the percentage of the GIN test.

Educational level, lower average age and better socioeconomic level may have contributed to the better performance of the EG (as shown in Tables 2 and 3). These variables have been discussed in another international study<sup>25</sup>.

The gap detection is a measure of the temporal auditory resolution that assesses the individual's ability to perceive an interval of silence in the midst of a continuous stimulus.<sup>15</sup> A study<sup>26</sup> involving elderly people with hearing loss reported a lower average percentage of gap detection and a higher temporal acuity threshold than those observed in the literature in the elderly. There was an effect of acoustic stimulation by means of hearing aids in the processing of information in the Central Auditory System in this study, as the individuals had an improvement in the auditory ability of temporal resolution. There was also an influence of educational level on temporal resolution tasks.

The comparison of the results obtained in each group in the SF-36 Quality of Life questionnaire and in the screening for depressive symptoms GDS-15 before and after six months of effective use of hearing aids (Table 4) found no statistically significant difference between the assessments for both groups.

The results obtained in the SF-36 quality of life questionnaire showed that the results of all domains evaluated by this questionnaire were better in the EG, after the intervention, although with no statistical significance. In turn, the CG had scores lower than those presented before the fitting of hearing aids in some domains (functional capacity, physical aspects, general health status, vitality and mental health) of the SF-36 questionnaire, but also with no statistical significance. It should be noted that EG already had a better quality of life than the CG group before the interventions, which can be explained by their higher education, better socioeconomic level, younger age and better results in cognitive screening.

However, some of the elderly in the CG, with less education, lower socioeconomic level and older age, refused to participate in the EG, which required a greater number of appointments and more time in the service. This refusal may show resignation and a lack of motivation for change.

Screening scores for the GDS-15 depressive symptoms were better in both groups after intervention, although with no statistical significance. Several authors have conducted studies with the elderly population on the improvement of depressive symptoms<sup>27</sup> and quality of life<sup>28</sup> with the use of hearing aids.

The correlation analysis between the self-assessment questionnaire for hearing aids (IOI-HA) using pairs of variables with COSI, SF-36, GDS-15, GIN and WRS in the post-training musical evaluations and according to the groups showed a statistically significant and positive correlation (directly proportional) between the IOI-HA and SF-36 in the functional capacity for the EG, and in the general health status and emotional aspects for the CG. There was also a statistically significant and negative (inversely proportional) correlation between the pairs of variables IOI-HA and SF-36 in the general health status for the EG. There were no statistically significant correlations for the other pairs of variables (as shown in Table 5).

A study<sup>29</sup> with COSI and IOI-HA found that users of hearing aids had improved quality of life, family relationships and the community in general.

Auditory training can be a facilitating agent for speech recognition as it represents specific auditory experiences that train and seek to improve auditory skills. This behavior may be associated with the greater cognitive capacity showed by the experimental group in this study, who may have opted for auditory training to seek a way to improve their auditory performance in the face of everyday challenges. In this context, studies that aimed to investigate the effectiveness of auditory training in elderly users of hearing aids, found that it improves the performance of attention and speech recognition skills, reduces the restriction of participation of this population and improves the quality of life<sup>30</sup>.

According to the results of this study, all elderly people had better results with statistical significance in the GIN tests for the threshold in ms when comparing the three assessments.

The EG had better WRS in the three assessments when compared to the CG.

However, this study had some limitations, such as the sample size and the difficulty in forming homogeneous groups regarding the variables education, socioeconomic level and even age.

## Conclusion

Based on the proposed objectives, the effective use of hearing aids associated or not with musical training promoted an improvement in temporal resolution - threshold of the GIN test combined with the speech-language pathology intervention.

The group that performed the auditory training had an improvement in the WRS throughout the study. There was no improvement in quality of life, depressive symptoms, cognitive aspects and activities of daily living for the elderly included in the two groups.

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