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Tinnitus disorder: implication in different cognitive abilities of young adults

Transtorno do zumbido: implicação em diferentes habilidades cognitivas de adultos jovens

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ABSTRACT

Purpose: To investigate the cognitive aspects related to temporal-spatial orientation, concentrated auditory attention, visual perception, memory, mathematical skills, language, praxis and executive functions, in young adults with tinnitus disorder. **Methods:** Analytical cohort study, quantitative and transversal, approved by the Research Ethics Committee, under number 56038322100005346. The study included 39 individuals, divided into two groups: participants with tinnitus disorder (G1) and participants without the symptom (G2). All underwent anamnesis, visual inspection of the External Acoustic Meatus, Threshold Tonal Audiometry, Logoaudiometry, Acoustic Immittance Measurements, behavioral assessment of Central Auditory Processing, Self-Perception Scale of Central Auditory Processing Abilities (EAPAC) and Cognitive Assessment (NEUPSILIN). The comparison analysis was performed between the groups, by the total score, cognitive abilities and later by tasks, using the Mann-Whitney U Test. **Results:** There was a statistically significant difference between the groups when analyzing the total score, observing a worse performance in the cognitive aspects of individuals with tinnitus. Still, there was a significant difference between the groups in the praxis skill, in the immediate evocation task and in the constructive one, being worse in the participants with tinnitus. **Conclusion:** Individuals with subjective chronic tinnitus had a lower cognitive performance than subjects without the perception of the symptom.

Keywords: Tinnitus; Cognition; Adults young; Hearing; Neuropsychological tests

RESUMO

Objetivo: investigar os aspectos cognitivos relacionados à orientação temporoespacial, atenção concentrada auditiva, percepção visual, memória, habilidades aritméticas, linguagem, praxias e funções executivas em indivíduos jovens adultos com transtorno do zumbido. **Métodos:** estudo analítico de coorte, quantitativo e transversal. Participaram 39 indivíduos, distribuídos em dois grupos: grupo com transtorno do zumbido (G1) e grupo sem o sintoma (G2). Todos foram submetidos à anamnese, inspeção visual do meato acústico externo, audiometria tonal liminar, logoaudiometria, medidas de imitância acústica, avaliação comportamental do processamento auditivo central, Escala de Autopercepção de Habilidades do Processamento Auditivo Central e Instrumento de Avaliação Neuropsicológica Breve . A análise de comparação foi realizada entre os grupos pelo escore total, habilidades cognitivas e, posteriormente, por tarefas, utilizando o Teste U de Mann-Whitney. **Resultados:** houve diferença estatisticamente significativa entre os grupos quando realizada a análise pelo escore total, observando-se pior desempenho nos aspectos cognitivos dos indivíduos com zumbido. Ainda, houve diferença significativa entre os grupos na habilidade de praxia, na tarefa de evocação imediata e na construtiva, sendo pior nos participantes com zumbido. **Conclusão:** os indivíduos com zumbido crônico subjetivo apresentaram desempenho cognitivo inferior aos participantes sem a percepção do sintoma.

Palavras-chave: Zumbido; Cognição; Adulto jovem; Audição; Testes neuropsicológicos

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INTRODUCTION

Tinnitus is a prevalent otological symptom, related to the conscious perception of an auditory sensation in the absence of external acoustic stimulation[1]. It becomes a disorder when associated with emotional suffering and cognitive dysfunction, bringing behavioral alterations and functional disability to the sufferer[2]. Therefore, its presence creates great challenges for audiologists and otorhinolaryngologists in clinical management, since it is a symptom with complex and multifactorial pathophysiology[1,3,4].

Studies emphasize that tinnitus is often associated with hearing loss, metabolic factors and inadequate habits, in addition to being capable of causing and/or potentiating major physical and emotional disorders[3-6]. Its prevalence has been increasing steadily and, with it, the negative impacts on the living conditions of these individuals, causing restrictions in social and professional relationships[7], such as lack of concentration, anguish, depression, anxiety and other deficits, depending on the severity of the symptom[8,9]. According to the above, it is essential to categorize and classify tinnitus, so that it is possible to understand the particularities and consequences caused in the lives of individuals, thus ensuring personalized and effective individual intervention.

Therefore, it is essential to make a cautious interpretation of tinnitus, taking into account the influence of age, the time of onset of the symptom, as well as the auditory system (peripheral and central) and cognition, considering that recent studies suggest the need to investigate cognitive functions in individuals with tinnitus disorder[10,11]. A study found that patients with tinnitus have a specific deficit in descending executive control of attention[12]. Confirming this study, a systematic review on the impact of tinnitus on cognitive function showed an association between tinnitus and aspects of cognitive function, specifically executive control of attention[13].

Authors conducted a study that aimed to describe and analyze the behavioral evidence of the effect of tinnitus on cognitive performance (working memory and attention). It was found that there is mixed support that tinnitus impairs working memory, executive attention, and selective attention[14].

Therefore, it is extremely important to investigate cognitive abilities in young adults, since most published studies emphasize neuropsychological aspects only in the aging process[2,15].

Given the lack of research on cognition in the tinnitus population, this study focused on evaluating in detail the cognitive abilities in this population. In this sense, the objective of the present study was to investigate the cognitive aspects in young adults with tinnitus disorder.

METHODS

Study design

Quantitative and cross-sectional cohort analytical study, approved by the Research Ethics Committee of the institution where it was carried out, under number 56038322100005346. This research complied with all guidelines for research involving human beings, in accordance with Resolution 466/12 of the Brazilian National Health Council. All study participants signed the Free and Informed Consent Form (FICF), understanding the risks and benefits of their participation. Furthermore, they subsequently received support focused on the symptoms and treatment, for anyone who was interested.

Participants

Were included in this is study individuals of both genders, aged between 18 and 35 years, literate, native Brazilian Portuguese speakers, right-hand preference, hearing thresholds within normal standards, middle ear integrity and contralateral stapedial acoustic reflexes, being necessary to present normality in the minimum central auditory processing battery applied[16,17]. Furthermore, participants with tinnitus should have had at least three months of symptom perception, i.e. chronic subjective tinnitus and a Visual Analogue Scale (VAS) score higher than 4. It is important to note that to participate in this study, individuals should have presented discomfort in their quality of life, that is, in addition to the time of perception of the symptom, it should be characterized as a disorder[2].

The following exclusion criteria were adopted: individuals who were undergoing treatment for tinnitus or had objective tinnitus; hearing loss and/or dizziness; bilingual; with self-reported, diagnosed and/or evident psychological, neurological and/or psychiatric impairment; using psychoactive substances for less than six months; history of alcohol abuse; continuous exposure to noise. These criteria were measured through the application of semi-structured anamnesis, as they are characteristics that can influence the results of the assessments.

In total, 77 patients were treated at the audiology outpatient clinic of a teaching clinic, during the period from July 2021 to May 2022. Of these, 38 were excluded for not meeting the eligibility criteria, due to alterations in one or more auditory skills, characterized as central auditory processing disorder (CAPD). Thus, the final sample consisted of 39 individuals, 27 female and 12 male, aged between 19 and 35 years (average 24.28 years) and between 12 and 19 years of education (average 15.92 years).

Participants were divided into two groups:

- Group 1 (G1) - composed of 20 individuals with tinnitus disorder (seven men and 13 women) aged between 19 and 35 years (average of 24 years) and between 12 and 19 years of education (average of 15.85 years), that is, above the third level (attending higher education, or having already completed it);
- Group 2 (G2) - composed of 19 individuals without tinnitus (five men and 14 women) aged between 20 and 34 years (average of 23 years) and between 12 and 17 years of education (average of 15.5 years), that is, also above the third level.

The groups were matched according to age and education, with no statistically significant difference between them.

Methodological design

The procedures were divided into procedures for sample composition and procedures for research, in order to better understand the method.

Assessment procedures

Regarding the procedures for sample composition, all individuals underwent anamnesis, visual inspection of the external auditory canal, pure tone audiometry (PTA), speech audiometry, acoustic immittance measurements, minimum central auditory processing battery[16,17] and the Scale of Self-Perception of Central Auditory Processing Skills (SPCAPS) [18]. For patients with tinnitus, the Visual Analogue Scale (VAS) and the Tinnitus Handicap Inventory (THI) questionnaire were applied, with the aim of assessing the impact of tinnitus on the individual's quality of life.

Initially, a detailed anamnesis was carried out on auditory and cognitive aspects, as well as general health. For participants with tinnitus, the anamnesis was based on the Investigation Protocol for Speech-Language Pathology Counseling[19]. Therefore, they were asked about the onset of the symptom, type, perception and location of the tinnitus, as well as about intensity, frequency and whether there was any factor that reduced or worsened the tinnitus.

Additionally, participants with tinnitus were asked if they had other symptoms, such as dizziness, headache, temporomandibular joint problems, neck pain, lower back pain or chest pain. Questions were also raised regarding medical treatment (whether they were undergoing treatment and using medication), excessive eating habits, behavioral factors, highlighting sleep and physical activities, emotional factors, metabolic factors, intestinal flow and, finally, perception of memory and organization.

To perform the PTA and speech audiometry, the AD229e audiometer from Interacoustics and TDH-39 headphones were used in an acoustically treated booth. Hearing thresholds were considered within normal standards when they were equal to or lower than 19 dBHL[20]. In speech audiometry, the Speech Recognition Percentage Index (SRPI) was determined based on the repetition of 25 monosyllabic words, researched live. The result was considered normal when a percentage of correct answers equal to or greater than 92% was obtained[20].

Acoustic immittance measurements were performed using AT235 equipment, from Interacoustics, and TDH-39 headphones. To classify the tympanometric curves, a previously proposed criterion was used[20] and, for the stapedial reflexes, criteria also previously indicated[20].

Research procedure

As a focus instrument for the assessment of cognition, the Brief Neuropsychological Assessment Instrument (NEUPSILIN)[21] was used. This is a neuropsychological test, consisting of 32 tasks (Chart 1) that aim to characterize a brief cognitive profile,

Chart 1. Organization of functions, components and cognitive tasks assessed

Orientation	Temporal
	Spatial
Attention	Reverse count
	Digit repetition
Perception	Checking for Equality and Difference of Rows
	Visual hemineglect
	Face perception
	Face recognition
Working Memory	Digit span
	Word span
Episodic-Semantic Verbal Memory	Immediate evocation
	Late evocation
	Recognition
Long-Term Semantic Memory	Two questions
Visual Short-Term Memory	Three figures
Prospective Memory	One task
Oral Language	Naming
	Repetition
	Automatic language
	Oral comprehension
	Inference processing
Written language	Reading aloud
	Written comprehension
	Spontaneous writing
	Copied writing
	Dictated writing
Arithmetic Skills	Four arithmetic calculations
Praxis	Ideomotor
	Constructive
	Reflexive
Executive Function	Problem solving
	Verbal fluency

through eight main cognitive functions: 1) temporal-spatial orientation (time and space); 2) auditory focused attention (counting backwards and repeating sequences of digits); 3) visual perception (equality and difference between lines, visual hemineglect, face perception and face recognition); 4) working memory (ascending ordering of digits and auditory span of words in sentences), episodic verbal memory (immediate, delayed and recognition), semantic memory (long term), visual memory (short term), prospective memory; 5) arithmetic skills; 6) oral language (naming, repetition, oral comprehension, automatic language and inference processing), written language (reading aloud, reading comprehension, spontaneous writing, copied writing and dictated writing); 7) praxis (ideomotor, constructive and reflexive); 8) executive functions (problem solving and verbal fluency). The instrument is indicated in the literature with evidence of validity, as it was designed with methodological rigor and exposed to psychometric studies[21-23].

The cognitive test was applied individually, in a single day, with one evaluator for each participant, in a time of approximately 40 minutes, in a silent room. The researchers who authored the present study applied the instrument to both groups blindly and, initially, carried out training.

To analyze the data, an analysis was first performed with the total raw score (sum of the scores of all test tasks), followed by an analysis of the cognitive skills assessed and, then, an analysis of each task of the respective skill, aiming to clarify the cognitive aspects in detail. The success rate was calculated in points, that is, each participant's correct answer corresponded to 1 point. Therefore, the higher the final score, the better the cognitive performance.

Data analysis

In the statistical analysis, an analysis was performed regarding the normality of the variables, using the Shapiro-Wilk test, identifying a non-normal sample. Then, based on the results, the nonparametric Mann-Whitney U test from the SPSS statistical program was selected to perform the comparative analysis. A p-value less than or equal to 0.05 (5%) was considered as the level of significance.

RESULTS

Figure 1 shows the comparison of the total score of the NEUPSILIN raw score, that is, the sum of all test tasks, between the groups, in which a significant difference can be observed (p=0.034).

Table 1 shows the comparison data between groups G1 and G2, taking into account the raw value of each skill. In this case, a significant difference was observed only in the praxis ability, with better performance in the group without tinnitus (G2).

In Table 2, it is possible to verify the comparison between the groups, by tasks, noting a statistically significant difference in the immediate recall tasks (episodic-semantic verbal memory ability) and constructive recall tasks (praxis ability), in addition to a tendency towards significance in the recall task.

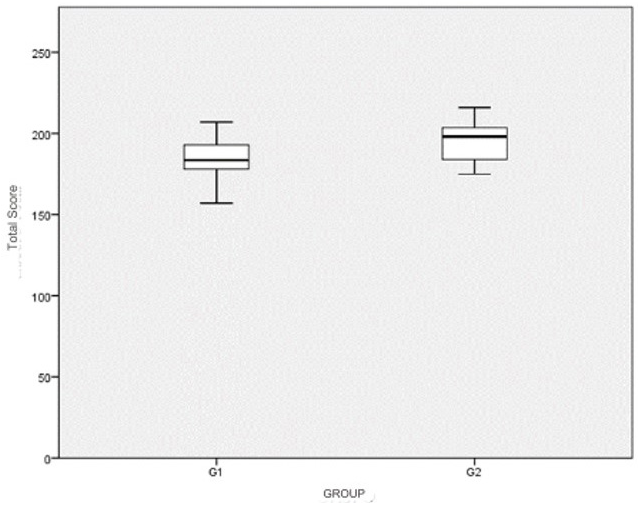

Figure 1. Comparison of the total raw score of the NEUPSILIN test battery (sum of all tasks), between Group 1 and Group 2. Significant difference: p value = p=0.034
Subtitle: G1 = Group with tinnitus; G2 = Group without tinnitus

DISCUSSION

The present research is in full agreement with the specialized literature, since recent studies have already demonstrated the cognitive impacts resulting from the perception of tinnitus disorder[24]. Thus, aiming to understand the anatomical and physiological mechanisms of such deficits, cognitive neuroscience focuses on load theory(25), which takes into account the underlying mechanisms of selective attention, as well as its full interdependence with the role played by perceptive processes, which are defined as the amount of information involved in the processing of task or specific cognitive stimuli, related to target selection and attention. Thus, this processing may be altered as a result of the perception of the symptom and, therefore, may harm the cognitive performance of these individuals. In this sense, the findings of the present study are justified, since worse total scores were identified in participants with tinnitus, demonstrating that the perception of the symptom impacts cognitive aspects (Figure 1).

The main focus of studies has been the investigation of memory and attention skills in individuals with tinnitus disorder[10,12,14,25]. However, this study proposed to investigate beyond these aspects, aiming to understand and clarify separately the subtasks responsible for cognitive performance, considering the importance and the aforementioned consequences arising from the perception of the symptom.

In the comparison by tasks, participants with tinnitus had worse cognitive performance in the immediate recall task (episodic-semantic verbal memory), that is, memory that enables the consolidation and retention of knowledge in a lasting way, as well as in the constructive task (praxis skill), responsible for planning and carrying out the movements necessary to organize tasks. These findings are justified by the involvement of the prefrontal cortex, supplementary motor area, occipital and somatosensory cortex in the perception of tinnitus, considering that these structures correspond to the performance of the neurocognitive tasks evaluated[24,26].

Table 1. Data from the comparison by skill between Group 1 and Group 2

Cognitive Skills	Groups	N	Mean	SD	Min	Max	p-value
Temporospatial Orientation	G1	20	7.85	0.366	7	8	0.083
	G2	19	8.00	0.000	8	8	
Attention	G1	20	24.25	2.425	20	27	0.271
	G2	19	25.05	2.094	21	27	
Perception	G1	20	10.85	1.089	8	12	0.255
	G2	19	11.26	0.733	10	12	
Memory	G1	20	56.25	9.442	39	74	0.118
	G2	19	61.84	9.737	49	79	
Arithmetic Skills	G1	20	7.05	1.356	4	8	0.187
	G2	19	7.58	0.838	6	8	
Language	G1	20	52.05	1.050	49	53	0.449
	G2	19	52.16	1.259	49	53	
Praxis	G1	20	18.55	2.438	13	22	**0.003***
	G2	19	20.47	0.964	18	22	
Problem Solving	G1	20	1.80	0.410	1	2	0.174
	G2	19	1.95	0.229	1	2	
Verbal Fluency	G1	20	6.00	1.414	4	9	0.195
	G2	19	6.63	1.640	3	10	

*Statistically significative

Subtitle: G1 = Group with tinnitus; G2 = Group without tinnitus; n = Total number of individuals; SD = Standard deviation; Min = Minimum values; Max = Maximum values

Table 2. Comparison by tasks between Group 1 and Group 2

Tarefas	Group	N	Mean	SD	Min	Max	p value
Temporal Orientation	G1	20	3.85	0.366	3	4	0.083
	G2	19	4	0.000	4	4	
Spatial Orientation	G1	20	4.00	0.000	4	4	1.000
	G2	19	4.00	0.000	4	4	
Reverse Count	G1	20	19.80	0.523	18	20	0.310
	G2	19	19.95	0.229	19	20	
Repetition of Digit Sequence	G1	20	4.45	2.438	0	7	0.391
	G2	19	5.11	1.997	2	7	
Checking for Equality and Difference of Rows	G1	20	5.60	0.754	3	6	0.733
	G2	19	5.74	0.452	5	6	
Visual Hemineglect	G1	20	1.00	0.000	1	1	1.000
	G2	19	1.00	0.000	1	1	
Face Perception	G1	20	2.35	0.671	1	3	0.457
	G2	19	2.53	0.513	2	3	
Face Recognition	G1	20	1.90	0.308	1	2	0.162
	G2	19	2.00	0.000	2	2	
Ascending Digit Ordering	G1	20	8.20	1.609	6	10	0.943
	G2	19	8.32	1.057	7	10	
Auditory Span of Words in Sentences	G1	20	18.20	5.569	9	28	0.143
	G2	19	20.63	4.991	12	28	
Working Memory	G1	20	26.40	6.676	15	38	0.176
	G2	19	28.95	5.126	21	36	
Immediate Summoning	G1	20	4.60	1.273	2	7	**0.022***
	G2	19	5.84	1.740	3	9	
Late Evocation	G1	20	2.30	1.418	0	4	**0.057***
	G2	19	3.84	2.363	0	8	
Recognition	G1	20	13.20	2.331	8	17	0.831
	G2	19	13.42	2.589	9	18	
Episodic-Semantic Verbal Memory	G1	20	20.10	3.508	14	27	0.108
	G2	19	23.11	5.685	16	34	
Long-Term Semantic Memory	G1	20	4.80	0.523	3	5	0.310
	G2	19	4.95	0.229	4	5	
Visual Short-Term Memory	G1	20	2.95	0.224	2	3	0.523
	G2	19	2.89	0.315	2	3	
Prospective Memory	G1	20	1.95	0.224	1	2	0.523
	G2	19	1.89	0.315	1	2	
Arithmetic Skills	G1	20	7.05	1.356	4	8	0.187
	G2	19	7.58	0.838	6	8	

*Statistically significative

Subtitle: G1 = Group with tinnitus; G2 = Group without tinnitus; n = Total number of individuals; SD = Standard deviation; Min = Minimum values; Max = Maximum values

Table 2. Continued...

Tarefas	Group	N	Mean	SD	Min	Max	p value
Naming	G1	20	4.00	0.000	4	4	1.000
	G2	19	4.00	0.000	4	4	
Repetition	G1	20	9.95	0.224	9	10	0.504
	G2	19	9.84	0.501	8	10	
Automatic Language	G1	20	2.00	0.000	2	2	1.000
	G2	19	2.00	0.000	2	2	
Understanding	G1	20	2.90	0.308	2	3	0.162
	G2	19	3.00	0.000	3	3	
Inference Processing	G1	20	2.95	0.224	2	3	0.251
	G2	19	2.68	0.820	0	3	
Oral Language	G1	20	21.75	0.444	21	22	1.000
	G2	19	21.53	1.073	18	22	
Reading Aloud	G1	20	11.95	0.224	11	12	0.971
	G2	19	11.95	0.229	11	12	
Written Comprehension	G1	20	2.85	0.366	2	3	0.083
	G2	19	3.00	0.000	3	3	
Spontaneous Writing	G1	20	1.90	0.308	1	2	0.162
	G2	19	2.00	0.000	2	2	
Copied Writing	G1	20	2.00	0.000	2	2	1.000
	G2	19	2.00	0.000	2	2	
Dictated Writing	G1	20	11.55	0.686	10	12	0.532
	G2	19	11.68	0.582	10	12	
Written language	G1	20	30.25	0.910	28	31	0.174
	G2	19	30.63	0.597	29	31	
Ideomotor	G1	20	3.00	0.000	3	3	1.000
	G2	19	3.00	0.000	3	3	
Constructive	G1	20	12.90	2.075	9	16	**0.003***
	G2	19	14.58	0.769	13	16	
Reflexive	G1	20	2.65	0.875	0	3	0.310
	G2	19	2.89	0.459	1	3	
Problem Solving	G1	20	1.80	0.410	1	2	0.174
	G2	19	1.95	0.229	1	2	
Verbal Fluency	G1	20	6.00	1.414	4	9	0.195
	G2	19	6.63	1.640	3	10	

*Statistically significative

Subtitle: G1 = Group with tinnitus; G2 = Group without tinnitus; n = Total number of individuals; SD = Standard deviation; Min = Minimum values; Max = Maximum values

In one study, the authors used magnetic resonance imaging to identify neuroanatomical correlates of tinnitus and identified that people with tinnitus disorder have reduced gray matter in the ventromedial prefrontal cortex, for the reception and integration of information and responses[27]. In this sense, such alterations cause difficulties in decision-making, understanding, memorization, inhibition of actions, concentration of attention, organization of complex information and putting it into practice and working memory, justifying the findings of the present research.

Furthermore, authors conducted a comprehensive systematic review and meta-analysis, in which they found an association between tinnitus and worse performance in a variety of broad cognitive domains, such as semantic memory, long-term memory retrieval, executive functions, short-term memory and processing speed[10]. Another study aimed to investigate semantic memory in individuals with tinnitus and found that tinnitus disorder can also affect this cognitive ability[28].

The aforementioned specialized literature demonstrates the association between cognitive aspects and symptom perception. Thus, the present research confirms these findings, since lower cognitive performance was found in young adults with high levels of education and tinnitus disorder. Other studies highlight the importance of knowledge of neuropsychological aspects in the evaluation of patients with tinnitus, as this allows us to understand the specific origin of the cognitive deficit, thus contributing to clinical management[10,29].

According to the findings of the present study, it is evident that young individuals with tinnitus disorder presented alterations in neuropsychological function, when observing the total score. It is noteworthy that in other tasks, such as auditory span of words in sentences, working memory and episodic-semantic verbal memory, it was observed that the group with tinnitus had a lower performance than the group without tinnitus, however, without statistical significance.

Thus, the theory of tinnitus disorder encompasses the real condition faced by these individuals, in whom greater cognitive dysfunctions are observed, which consequently cause emotional harm, leading to behavioral changes and functional disabilities, a fact that must be considered for management in this population, with the aim of minimizing the negative impacts arising from the perception of the symptom[2].

Therefore, careful investigation of cognitive abilities becomes increasingly important in clinical practice, since young, educated patients with tinnitus report difficulties during their daily activities, especially regarding attention, concentration and memory. Substantiating scientific evidence on this topic was the main objective of this study, a milestone for new research in adults.

Therefore, the present research contributes to the specialized literature by highlighting that cognitive aspects in this population must be taken into consideration and investigated, since young individuals with high levels of education have already presented

alterations compared to their peers. Therefore, the findings may infer that, by observing the cognitive aspects of young adults with tinnitus disorder, greater cognitive decline and cognitive effort, which are enhanced with advancing age, can be avoided.

Study limitations

It is important to highlight the need to carry out further studies on the theme covered in this research, with a larger and more representative sample size for the population studied, aiming to ratify the results shown, investigating these aspects in individuals with different levels of education (different cognitive functioning), as well as in individuals with different impacts on their daily lives, arising from the perception of the symptom.

Furthermore, a limitation of the study is the fact that no recordings were made regarding the application of the Brief Neuropsychological Assessment Instrument (NEUPSILIN).

CONCLUSION

Individuals, young adults with tinnitus disorder, presented inferior cognitive performance in tasks of praxis and episodic-semantic verbal memory, when compared to participants without tinnitus.

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