https://doi.org/10.23925/2176-2724.2022v34i3e55322

Auditory and cognitive aspects in adults with type 2 Diabetes *Mellitus*

Aspectos audiológicos e cognitivos em adultos com Diabetes *Mellitus* tipo 2

Aspectos auditivos y cognitivos en adultos con Diabetes *Mellitus* tipo 2

Pablo Jordão Alcântara Cruz[*]
Évora Gaia Carvalho Lima[*]
Josilene Luciene Duarte[*]
Nathália Monteiro Santos[*]
Kelly da Silva[*]
Grace Anne Azevedo Dória[*]
Raphaela Barroso Guedes-Granzotti[*]

Abstract

Introduction: Diabetes *Mellitus* (DM) is a metabolic disorder caused by the absence or reduction of insulin secretion or by changes in the functioning of this hormone in the body, which may involve physical and cognitive changes. **Objective:** To analyze the audiological and cognitive aspects of type 2 Diabetes *Mellitus* in adults. **Method:** Cross-sectional study carried out in people aged between 18 and 59 years, of both genders. Participants were divided into two groups: Study Group (SG) - people diagnosed with Diabetes *Mellitus* and the Control Group (CG) - people without Diabetes. All underwent glycemic, cognitive and auditory assessment. *Mann-Whitney's test* was used for statistical analysis, with a significance level of 0.05. **Results:** 32 individuals participated in the study, 19 (59.4%) in the EG and 13 (40.6%) in the CG. The mean age of the participants was 46.8 ± 8.3 years, with a mean education of 6.8 ± 6 years, with 25 (78.1%) females and 7 (21.9%) males. A statistically significant difference was observed

Universidade Federal de Sergipe – UFS, Sergipe, Brazil.

Authors'contributions:
PJAC: Collection, Methodology, analysis of results, writing and e text revision
EGCL: Collection, Methodology, analysis of results, writing and text revision
JLD: Collection, analysis of results and text revision
NMS: Text revision
KS: Methodology, analysis of results and text revision
GAAD: Text revision
RBGG: Methodology, analysis of results and text revision

E-mail for correspondence: Kelly da Silva – kelly.fonoufs@gmail.com
Received: 06/05/2021
Accepted: 20/06/2022

between the groups for the score related to attention and calculation, recall and total Mini-Mental State Examination (MMSE) score, with worse performance in the EG. There was no statistically significant difference between the groups regarding the audiological aspects evaluated. **Conclusion:** Individuals with type 2 Diabetes Mellitus did not present risks for audiological alterations, however they presented a high risk for cognitive alterations. the findings demonstrate that constant speech therapy monitoring is essential to identify changes early.

Keywords: Diabetes Mellitus; Speech, Language and Hearing Sciences; Cognition; Hearing; Audiology.

Resumo

Introdução: A Diabetes *Mellitus* (DM) é um distúrbio metabólico causado pela ausência ou diminuição da secreção de insulina ou por alterações do funcionamento deste hormônio no organismo, podendo envolver alterações físicas e cognitivas. **Objetivo:** Analisar os aspectos audiológicos e cognitivos de adultos com Diabetes *Mellitus* tipo 2. **M**étodo**:** Estudo transversal realizado em pessoas com idade entre 18 e 59 anos, de ambos os gêneros. Os participantes foram divididos em dois grupos: Grupo Estudo (GE) - pessoas com diagnóstico de Diabetes *Mellitus* e o Grupo Controle (GC) - pessoas sem Diabetes. Todos foram submetidos à avaliação glicêmica, cognitiva e audiológica. Para análise estatística foi utilizado o teste de *Mann-Whitney*, sendo estipulado o nível de significância de 0,05. **Resultados:** Participaram do estudo 32 indivíduos sendo 19 (59,4%) no GE e 13 (40,6%) no GC. A média de idade dos participantes foi de 46,8 ± 8,3 anos, com escolaridade média de 6,8 ± 6 anos, sendo 25 (78,1%) do gênero feminino e 7 (21,9%) do masculino. Foi observada diferença estatisticamente significativa entre os grupos para a pontuação referente à atenção e cálculo, recordação e escore total do MEEM, com pior desempenho no GE. Não foi observada diferença estatisticamente significante entre os grupos nos aspectos audiológicos avaliados. **Conclusão:** Indivíduos com Diabetes *Mellitus* tipo 2 não apresentaram riscos para alterações audiológicas com os instrumentos utilizados, entretanto apresentaram um alto risco para alterações cognitivas. Os achados demonstram que o acompanhamento fonoaudiológico constante é essencial para identificar as alterações precocemente.

Palavras-chave: Diabetes Mellitus; Fonoaudiologia; Cognição; Audição; Audiologia.

Resumen

Introducción: La Diabetes *Mellitus* (DM) es un trastorno metabólico causado por la ausencia o reducción de la secreción de insulina o por alteraciones en el funcionamiento de esta hormona en el organismo que puede implicar alteraciones físicas y cognitivas. **Objetivo:** Analizar los aspectos audiológicos y cognitivos de adultos con Diabetes *Mellitus* tipo 2. **M**étodo**:** Estudio transversal realizado en personas de entre 18 y 59 años, de ambos sexos. Los participantes se dividieron en dos grupos: Grupo de Estudio (GE) - personas diagnosticadas con diabetes *mellitus* y Grupo Control (GC) - personas sin Diabetes. Todos se sometieron a evaluación glucémica, cognitiva y audiológica. Para el análisis estadístico se utilizó la prueba de *Mann-Whitney*, con un nivel de significancia de 0.05. **Resultados:** Treinta y dos individuos participaron en el estudio, 19 (59,4%) en el GE y 13 (40,6%) en el GC. La edad media de los participantes fue de 46,8 ± 8,3 años, con una educación media de 6,8 ± 6 años, con 25 (78,1%) mujeres y 7 (21,9%) hombres. Se observó diferencia estadísticamente significativa entre los grupos para la puntuación relacionada con atención y cálculo, recuerdo y puntuación total del MEEM, con peor desempeño en el GE. No hubo diferencia estadísticamente significativa entre los grupos en los aspectos audiológicos evaluados. **Conclusión:** Los individuos con Diabetes Mellitus tipo 2 no presentaban riesgo de alteraciones audiológicas, sin embargo presentaban un alto riesgo de alteraciones cognitivas. Los resultados demuestran que el monitoreo constante de la terapia del habla es esencial para identificar cambios temprano.

Palabras clave: Diabetes Mellitus; Fonoaudiologia; Cognición; Audición; Audiología.

Introduction

Diabetes Mellitus (DM) condition refers to a metabolic syndrome with a strong genetic component, which causes physical, social, and psychological damage[1]. It can be subdivided into two large groups: Type 1 Diabetes Mellitus (T1DM), characterized by a deficiency in insulin production due to the destruction of pancreatic β-cells[2], and Type 2 Diabetes Mellitus (T2DM), defined by disorders of action or secretion of insulin, in which one of the situations may predominate, but usually both are present[3]. Furthermore, there is also Gestational Diabetes Mellitus, which refers to an increase in insulin production and insulin resistance initiated during pregnancy, as well as other forms of Diabetes Mellitus that are multiple and depend on the underlying change related in each case[2].

When untreated, DM can cause chronic and acute complications, such as nephropathy, retinopathy, diabetic foot, cardiovascular disease, neuropathy and secondary cognitive changes to vascular compromise, the formation of neurofibril plaques, and the influence of changes in glucose metabolism[4]. Therefore, DM presents a strong risk factor for the development of cognitive impairment, since factors such as energy dysregulation, inflammation, decreased perfusion, increased oxidative stress, and protein deposition can affect the brain of these individuals[5]. As a result, research has linked T2DM with reduced cognitive function and a higher decline in verbal memory, verbal fluency, and processing speed, suggesting an unexpected impact before old age on cognitive reserve[5,6].

Cognition is considered a set of highly motivated processes, such as attention, memory, planning, and execution[7] with which it is possible to act in a multisemiotic world, acquiring knowledge and making decisions[8]. For communication to occur, human language uses elements that connect interlocutors, a unique ability to symbolize simple, complex, concrete, and abstract thoughts[9] that is decisive for cognitive development and human sociability[8].

Thus, cognition and communication can be seen as inseparable and linked by language[10], and hearing as an important element for the full development of oral communication[11]. The processing of sound stimuli consists of a series of neuroanatomical connections that occur from the neurons of the cochlea to the cerebral auditory cortex, where it enables the individual to generate emotional, cognitive, and linguistic responses[12]. Therefore, any change in the auditory system and/or cognitive abilities can have consequences for the individual's communication[13].

Although the results found in the literature are still inconsistent with each other regarding the association between DM and hearing loss, the most accepted hypothesis is that the inner ear can be affected by microvascular lesions, such as diffuse thickening of the basement membrane and vascular endothelium, or by the involvement of the eighth cranial nerve, both due to diabetic angiopathy[14,15,16].

There are still few studies that address the relationship between Diabetes Mellitus and cognition and hearing quality, even though these are notoriously important for communication and directly affect one's life. So, to improve knowledge about these changes and consequently advance its approach and intervention, this study aimed to analyze the audiological and cognitive aspects of adults with type 2 Diabetes Mellitus.

Methodology

Study design

This is a cross-sectional, comparative study carried out at the clinical school of Speech, Language and Hearing Sciences at the Federal University of Sergipe, on the Lagarto campus, with a convenience sample. The survey included adults aged between 18 and 59 years, of both genders, residents of the city of Lagarto/SE and surroundings, divided into a group with Type 2 diabetes and a group without diabetes, observing their level of education. Individuals who presented some type of cognitive or structural alteration that made it impossible to perform the auditory assessment or to respond to the protocols were excluded, and they were referred to the appropriate treatment specialties.

Ethical aspects

The present research was approved by the Research Ethics Committee of the Federal University of Sergipe (CAAE 06958519.9.0000.5546), according to resolution 466/2012, and all participants signed the Free and Informed Consent Form.

Procedures

For cognitive screening, the described and adapted version of the Mini-Mental State Examination (MMSE)[17] was used, which covers temporal and spatial orientation, attention, memory, calculation, naming, repetition, reading, and writing, totaling a score of 30 points. For people with no literacy, the cut-off point of 20 points was used. For those with one to four years of study, 25 points; for those who had five to eight years of study, 26; for those who had nine to 11 years of schooling, 28; and for those with more than 11 years of study, 29 points.

For the audiological evaluation, a specific anamnesis was initially carried out, by the institution's audiology department, to investigate complaints related to the auditory system (previous history and evolution of hearing complaints, family history of disease, exposure to noise, and general health). Subsequently, an otoscopy was performed, with a Mikatos otoscope, to verify the conditions of the external acoustic meatus for the hearing exams.

Tonal Threshold Audiometry (TTA) was performed in a soundproof studio, using a two-channel audiometer, Interacoustics AD229b, via supra-aural headphones model TDH-39, calibrated to the ANSI-69 standard. Pure tone thresholds were investigated at frequencies from 0.25 to 8 kHz by air conduction and from 0.5 to 4 kHz by bone conduction only when hearing thresholds worse than 25 dBHL were obtained by air conduction. Normal hearing was considered a hearing threshold up to 25 dBHL and hearing loss as tonal thresholds above 25 dBHL, according to the World Health Organization (WHO)[18]. Logoaudiometry was performed with a sound stimulus sensation level of 30 dBNS above the tritone average of the 500, 1000 and 2000 Hz auditory thresholds of the audiogram, using a phonetically balanced list of two-syllable words with descending technique in 10 dBHL increments, to the minimum audible intensity, and rising in increments of 5 dBHL, to verify the Speech Recognition Threshold (SRT), and 25 monosyllabic words in the intensity of 30 dBNS to verify the Speech Perception Index (SPI).

Acoustic immittance measurements were performed using an automatic equipment model AT235 from Interaucoustics. The first stage consisted of tympanometry, obtained with a 226 Hz probe tone. To obtain the tympanogram, a pressure of 200 – 400 daPa was applied, at a rate of 200 daPa per second, at an intensity of 75 dBSPL. The elements analyzed were the maximum admittance peak and the volume at the maximum admittance peak. Then, research was carried out on the thresholds of acoustic reflexes at frequencies of 500, 1000, 2000 and 4000 Hz, at the maximum admittance pressure peak obtained in tympanometry. To investigate the acoustic reflex threshold, an ascending technique was used, starting at the minimum intensity allowed by the equipment, 50 dBHL of stimulus presentation level, not exceeding 90 dBNS, considering that all individuals had normal hearing according to the WHO analysis criteria[18]. The acoustic reflex threshold was defined as the lowest intensity in which an admittance change of 0.02 mmho was detected. The last intensity at which the reflex was determined at each tested frequency was repeated to confirm the response. The modalities in the acoustic reflex were by ipsi and contralateral stimulation to the reference ear.

Statistical analysis

For the descriptive analysis of the results, measures of tendency and central dispersion were used, in addition to the absolute and relative frequency of the results. For statistical analysis, the Mann-Whitney test was used, with a significance level of 5%.

Results

Thirty-two individuals participated in the study, divided into two groups: Study Group (SG) with 19 (59.4%) individuals with type 2 Diabetes Mellitus and Control Group (CG) with 13 (40.6%) individuals without diabetes. The average age of the participants was 46.8 ± 8.3 years old, with average schooling of 6.8 ± 6 years, 25 (78.1%) of them were female and 7 (21.9%) were male.

Table 1 presents the characterization of the participants, by group, in terms of age, gender, schooling, glycemic index, presence of Systemic Arterial Hypertension (SAH), physical activity at least once a week, smoking, and alcohol use.

Table 1. Characterization of research participants by study group

		SG	CG
		N (%)	N (%)
Gênero	Feminino	15 (78,9)	10 (76,9)
	Masculino	4 (21,1)	3 (23,1)
Idade (média±DP)		49,6±6,6	42,8±9,1
Índice Glicêmico		240,5±103,2	103,6±6,4
Presença de HAS		9 (47,37)	4 (30,77)
Realiza atividades físicas		11 (57,89)	4 (30,77)
Tabagismo		1 (5,26)	2 (15,38)
Uso de bebidas alcoólicas		4 (21,05)	9 (69,23)

Legend: SG- individuals with Diabetes Mellitus e CG- individuals without Diabetes Mellitus.

Table 2 presents the results of the cognitive screening. A statistically significant difference was observed between the groups studied for the score referring to attention and calculation, recall, and total MMSE score, with worse performance in the SG.

Table 2. Comparison of performance on the Mini-Mental State Examination in people with and without Diabetes *Mellitus*

	SG			CG			P-value
	Mean ± SD	Median	Min-Max	Mean ± SD	Median	Min-Max	
Temporal and Spatial Orientation	9.63±0.83	10	7-10	10±0	10	10-10	0.3
Record	3±0	3	3-3	3±0	3	3-3	1.0
Attention and Calculation	2.53±1.65	3	0-5	4.15±1.28	5	1-5	<0.01*
Remembrance	2.21±0.63	2	1-3	2.77±0.44	3	2-3	0.02*
Language	7.79-1.13	8	6-9	8.08±1.04	8	6-9	0.5
Total Score	25.16±2.99	26	20-29	28±2.12	28	23-30	<0.01*

Legend: SG- individuals with Diabetes Mellitus and CG- individuals without Diabetes Mellitus.
P-value according to the Mann-Whitney test

Table 3 shows the average of the auditory thresholds obtained in the pure tone audiometry by air, in the frequencies of 250 to 8kHz. Although the SG presented better thresholds at frequencies of 3kHz, 4kHz, 6kHz and 8kHz in the right ear, and at 4kHz and 6kHz in the left ear, compared to the CG, this finding should not be considered, since in both groups, most individuals had hearing thresholds within the normal range and, as this difference was less than 15 dB, it does not characterize as an asymmetry between ears.

Table 3. Mean and standard deviation of thresholds (dB) obtained in Pure Tone Audiometry for the groups studied

	SG	CG	p-value	SG	CG	p-value
	RE	RE		LE	LE	
0.25 kHz	18.2±6.9	18.1±11.5	1.0	18.4±7.1	14.2±9.5	0.3
0.5 kHz	18.2±6.1	15.4±10.5	0.3	17.4±4.8	13.9±7.1	0.2
1 kHz	15.5±7.4	14.2±8.9	0.6	14.7±5.4	11.1±8.9	0.4
2 kHz	16.3±4.4	13.5±8.0	0.08	14.7±5.4	10.4±5.6	0.06
3 kHz	14.5±7.2	15.8±4.9	0.6	15.3±7.7	11.9±4.8	0.1
4 kHz	15.3±11.1	19.6±12.7	0.3	16.1±9.7	17.3±6.6	0.8
6 kHz	17.1±9.3	22.3±12.7	0.3	17.6±8.9	18.5±6.6	0.6
8 kHz	18.2±12.7	22.7±15.6	0.5	15.8±10.3	15.8±8.6	0.9

Legend: SG- individuals with Diabetes Mellitus and CG - individuals without Diabetes Mellitus.
P-value according to the Mann-Whitney test.

Table 4 presents the results of the acoustic reflex thresholds of the contralateral stapedius muscle of the studied groups. All subjects presented acoustic reflex and type A tympanometric curves in both groups.

Table 4. Mean and standard deviation of contralateral acoustic reflex thresholds (in decibels) between groups

	SG	CG	p-value	SG	CG	p-value
	RE	RE		LE	LE	
0.5 kHz	74.2±17.3	84.2±10.4	0.1	83.2±11.2	86.5±9.4	0.6
1 kHz	82.1±10.6	84.6±8.6	0.6	83.3±9.4	85.4±9.9	0.9
2 kHz	83.9±10.2	84.6±11.1	0.1	85.3±10.6	81.8±24.9	0.7
4 kHz	85.3±12.5	81.1±10.2	0.3	84.1±12.3	84.6±14.2	1.0

Legend: SG- individuals with Diabetes Mellitus and CG- individuals without Diabetes Mellitus.
P-value according to the Mann-Whitney test. .

Discussion

The research aimed to analyze the findings of conventional audiological assessment associated with the results of cognitive assessment in a group of adults with type 2 Diabetes Mellitus compared to their peers without diabetes. The participants were people aged between 29 and 58 years. We kept the sample among patients aged less than 60 years to isolate the auditory and cognitive alterations characteristic of senescence itself. According to the data obtained in anamnesis, 57.89% of the individuals in the SG practice physical exercises, and only 30.77% of the CG have the same habit. This data can be justified by the fact that physical exercise is one of the non-pharmacological methods used to control DM. The literature provides evidence of improvement in blood glucose levels, heart rate, and Body Mass Index (BMI) in people with Diabetes Mellitus who practice aerobic or resistance exercise[19,20,21].

Another relevant result was the comparison of the MMSE results between the groups, in which the control group performed better than the group with diabetic individuals in all tests (orientation, recording, attention and calculation, recall, and language). Researchers showed similar results in a study carried out with individuals between 50 and 65 years old. In it, the Mini-Mental State Examination was applied to assess cognitive function, obtaining a median of 26 points in the group of patients with DM and 28 points in the control group[22], just like the present study. The results found in this research are also in agreement with review studies that affirm evidence of cognitive deficit under the influence of DM due to hypoglycemia, hyperglycemia, intrace-

rebral β-amyloid accumulation, abnormalities in insulin signaling, or other factors[5,23].

Also regarding MMSE results, it was observed that individuals with hypertension in addition to diabetes had lower results than individuals with DM alone. A longitudinal study comparing both groups also found greater cognitive decline among people with diabetes and hypertension compared to people with non-hypertensive diabetes, besides a higher incidence rate of dementia and a higher prevalence of stroke[24].

It wasn't possible to observe a statistically significant difference between the results of the conventional audiological assessment in the studied population. The analysis of pure tone audiometry revealed sensorineural hearing loss in two individuals, one in the SG with a moderate degree, and the other in the CG with a mild degree, using WHO's classification (2014). The rest of the sample presented auditory thresholds within the normal range. These results are contradictory to several studies that evaluated the audiometry of diabetic individuals, which revealed a predominance of bilateral sensorineural hearing loss in individuals with Diabetes *Mellitus*[14,15,22,26,27,28]. Our results can be justified by the good general health status and glycemic control presented by the individuals participating in the SG, associated with the duration of the disease.

Regarding the configuration of the audiometric curve, most of the individuals in the SG had a flat curve, slightly descending from frequencies of 3 kHz. This shows that, despite the majority having auditory thresholds and normal hearing classification, according to the WHO criteria (2014), there is already a tendency for auditory impairment in high frequencies. A study also observed that, in the specific analysis of the tested frequencies, certain high frequencies are more affected in these patients. However, they do so in the form of a descending audiometric curve, where low frequencies are more preserved than high frequencies[22]. Other evidence in the literature[3,22,25] demonstrates the same results, bringing this configuration as a characteristic of hearing loss due to DM.

The priority of this study was to demonstrate the use of conventional audiological assessment procedures associated with basic cognition tests in the care of patients with Diabetes Mellitus. Some of the limitations are related to the small sample. New studies need to be carried out with a larger sample and with a longitudinal follow-up that allows the detection of subtle alterations in cognitive and auditory performance by using tests and standard evaluation procedures, to demonstrate its sensitivity to detect resulting functional alterations of this health condition. We know that the use of electroacoustic tests, such as otoacoustic emissions, and electrophysiological tests, like Auditory Evoked Potentials, have high sensitivity to detect physiological changes in the cochlea and auditory pathways, respectively. In addition, they can still have their results associated with cognitive tests. However, access to these evaluation procedures is not a reality in all centers where these individuals are assessed. Thus, it's recommended that the audiological and cognitive assessment findings of individuals with type 2 Diabetes Mellitus be carefully evaluated, with the aim of frequent monitoring to detect auditory and cognitive alterations early, for rehabilitation and improvement in the quality of life of these individuals.

Conclusion

This research has shown that individuals with type 2 Diabetes Mellitus did not present risks for audiometric alterations. However, they presented a high risk for cognitive alterations. It shows that constant speech therapy monitoring is essential to identify changes early, minimizing damage to communication and, consequently, to the quality of life of these people.

Support: FAPITEC/SE

References

1. Lopes RMF, Nascimento RFL, Wendi GW, Argimon IIL. A diabetes mellitus causa deterioração cognitivo em idosos? Um estudo de revisão. Av. Psicol. Latinoam. 2013; 31(1): 131–9.

2. Lyra R et al. Sociedade Brasileira de Diabetes. [s.l: s.n.]. v. 5. 2020.

3. Alvarenga KF, Duarte JL, Silva DPC, Agostinho-Pesse RS, Negrato CA, Costa OA. Potencial cognitivo P300 em indivíduos com diabetes mellitus. Rev. bras. otorrinol. 2005; 71(2): 202–7. https://doi.org/10.1590/S0034-72992005000200014

4. Almeida-Pititto B, Almada Filho CM, Cendoroglo MS. Déficit cognitivo: mais uma complicação do diabetes melito? Arq. bras. Endocrinol. Metabol. 2008; 52(7): 1076–83. https://doi.org/10.1590/S0004-27302008000700003

5. Lopes CM, Junior JCSM, Pessoa IA, Wan-Meyl FS, Burbano RMR. Diabetes Mellitus e a Doença de Alzheimer. Arquivos Catarineneses de Medicina. 2018; 47(1): 159–68.

6. Callisaya ML, Beare R, Moran C, Phan T, Wang W, Srikanth VK. Type 2 diabetes mellitus, brain atrophy and cognitive decline in older people: a longitudinal study. Diabetologia. 2019; 62(3): 448–58. doi: 10.1007/s00125-018-4778-9.

7. Pucci P. Disfagia e Cognição. [s.l: s.n.] 2019.

8. Morato E M. Das Relações Entre Linguagem, Cognição E Interação - Algumas Implicações Para O Campo Da Saúde. Linguagem em (Dis)curso. 2016; 16(3): 575–90. https://doi.org/10.1590/1982-4017-160304-0516D

9. Lent R. Cem Bilhões de Neurônios? 2a ed. [s.l.] Atheneu; 2010.

10. Cavalcante S, Abrantes AM, Souza AL. Linguagem, discurso e cognição: desafios e perspectivas. Scripta. 2014; 18(34): 11-20.

11. Costa SS. Audição, comunicação e linguagem: um convite à reflexão. Rev. HCPA & Fac. Med. Univ. Fed. Rio Gd. do Sul. 1999; 19(2): 147–66.

12. Boéchat EM. et al. Tratado de Audiologia. 2a ed. [s.l.] Guanabara Koogan; 2015.

13. Borges MGS, Labanca L, Couto EAB, Guarisco LPC. Correlações entre a avaliação audiológica e a triagem cognitiva em idosos. Rev. CEFAC. 2016; 18(6): 1285–93. https://doi.org/10.1590/1982-021620161865616

14. Diniz TH, Guida HL. Hearing loss in patients with diabetes mellitus TT - Perdas auditivas em pacientes portadores de diabetes melito. Braz. J. Otorhinolaryngol. 2009; 75(4): 573–78. https://doi.org/10.1590/S1808-86942009000400017

15. Ferreira JM, Sampaio FMO, Coelho JMS, Almeida NMGS. Perfil audiológico de pacientes com diabetes mellitus tipo II. Rev. Soc. Bras. Fonoaudiol. 2007; 12(4): 292–7. https://doi.org/10.1590/S1516-80342007000400007

16. Maia CAS, Campos CAH. Diabetes Mellitus como causa de perda auditiva. Rev. Bras. Otorrinolaringol. 2005; 71(2): 208–14. https://doi.org/10.1590/S0034-72992005000200015

17. Brucki SMD, Nitrini R, Caramelli P, Bertolucci PHF, Okamoto IH. Sugestões para o uso do mini-exame do estado mental no Brasil [Internet]. Arquivos de Neuro-Psiquiatria. 2003 ; 61(3-B): 777-81. https://doi.org/10.1590/S0004-282X2003000500014

18. World Health Organization. Prevention of blindness and deafness: Grades of hearing impairment, 2014. Available at: http://www.who.int/pbd/deafness/hearing_impairment_grades/en/. Acessed mar 10, 2020.

19. Arsa G, Lima L, Almeida SS, Moreira SR, Campbell CSG, Simões HG. Diabetes mellitus tipo 2: Aspectos fisiológicos, genéticos e formas de exercício físico para seu controle. Rev. Bras. Cineantropom. Desempenho Hum. 2009; 11(1): 103–11.

20. Santos GO, Santos LL, Silva DN, Silva SL. Exercícios Físicos E Diabetes Mellitus: Revisão / Physical Exercises and Diabetes Mellitus: Review. Brazilian Journal of Development. 2021; 7(1): 8837–47. DOI:10.34117/bjdv7n1-599

21. Silva CA, Lima WC. Efeito Benéfico do Exercício Físico no Controle Metabólico do Diabetes Mellitus Tipo 2 à Curto Prazo. Arq. bras. endocrinol. metab. 2002; 46(5): 550–6. https://doi.org/10.1590/S0004-27302002000500009

22. Ferreira JM, Sampaio FMO, Coelho JMS, Almeida NMGS. Perfil audiológico de pacientes com diabetes mellitus tipo II. Rev. Soc. Bras. Fonoaudiol. 2007; 12(4): 292–7. https://doi.org/10.1590/S1516-80342007000400007

23. Bavaresco DV, Ferreira NC, Ceretta LB, Tuon L, Simões PW, Gomes KM et al. Prejuízos cognitivos em Diabetes Mellitus: revisão da literatura. Inova Saúde. 2016; 5(1): 30. https://doi.org/10.18616/is.v5i1.2336

24. Hassing LB, Hofer SM, Nilsson SE, Berg S, Pedersen NL, McClearn G et al. Comorbid type 2 diabetes mellitus and hypertension exacerbates cognitive decline: Evidence from a longitudinal study. Age Ageing. 2004; 33(4): 355–61. doi: 10.1093/ageing/afh100.

25. León-Morales LVD, Jáuregui-Renaud K, Garay-Sevilla ME, Hernández-Prado J, Malacara-Hernández JM. Auditory impairment in patients with type 2 diabetes mellitus. Arch. Med. Res. 2005; 36(5): 507–10. doi: 10.1016/j.arcmed.2005.02.002.

26. Ferreira JM, Câmara MFS, Almeida PC, Neto JB, Silva CAB. Alterações auditivas associadas a complicações e comorbidades no diabetes mellitus tipo 2. Audiology - Communication Research, 2013; 18(4): 250–9.

27. Ferreira JM, Câmara MFS, Almeida PC, Neto JB, Silva CAB. Características audiológicas de pacientes com diabetes mellitus Tipo 2. Rev. CEFAC, 2016; 18(5): 1050–9. doi: 10.1590/1982-0216201618522415

28. Mozaffari M, Tajik A, Ariaei N, Ali-Ehyaii F, Behnam H. Diabetes mellitus and sensorineural hearing loss among non-elderly people. East. Mediterr. Health J. 2010; 16(9): 947–52.