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Evaluation Of Hearing Functions of Children with Type 1 Diabetes: A 2-Year Retrospective Study

Tip 1 Diyabetli Çocukların İşitme Fonksiyonlarının Değerlendirilmesi: 2 Yıllık Retrospektif Çalışma

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ABSTRACT

Objective: *Our study aims to investigate the differences in pure tone audiometry and tympanograms in terms of gender, disease duration, and right-left ear in children with Type 1 diabetes mellitus (Type 1 DM).*

Material and Method: *For our study, a total of 109 patients between the ages of 0-18 who were diagnosed with Type 1 DM between 2016-2017 were identified. Among these, 26 children, 52 ears, aged between 2-18, who applied to the Ear Nose Throat outpatient clinic for different reasons and had anamnesis and examination information, were included. Then, hearing thresholds and middle ear functions were evaluated by looking at pure-tone audiometers and tympanograms. Whether the patients met the study criteria was retrospectively determined by using the patient registration forms filled out by the pediatric endocrinology.*

Results: *In the measurements made for the right and left ears, the conduction threshold values at a frequency of 4000 and 8000 Hz were found to be statistically significantly higher values in the Type 1 DM patient group for 5 years and longer than the control group with Type 1 DM for less than 5 years ($p<0.05$). Both right and left ear bone canal threshold values of the patient group with diabetes for 5 years or longer were found to be statistically significantly higher at a frequency of 4000 Hz ($p<0.05$). A statistically significant and negative moderate correlation was found between the threshold values of speech discrimination (SD) in the right and left ears and the duration of the disease.*

Conclusion: *As a result of our study, individuals with Type 1 DM were found to have a higher risk of developing hearing loss. For this reason, it is recommended to examine hearing in detail and to establish a clinical examination protocol in this patient group.*

ÖZET

Amaç: *Çalışmamızın amacı; Tip 1 diabetus mellitus (Tip 1 DM) çocuklarda, saf ses odyometrileri ve timpanogramlarının; cinsiyet, hastalık süresi ve sağ-sol kulak yönünden farklılıklarının araştırılmasıdır.*

Gereç ve Yöntem: *Çalışmamız için 2016-2017 yıllarında Tip 1 DM tanısı alan yaşları 0-18 arasında değişen toplam 109 hasta belirlenmiştir. Bunların içerisinden, kulak burun boğaz (KBB) polikliniğine farklı sebeplerden başvuran, anamnez ve muayene bilgileri olan yaşları 2-18 arasında değişen, 26 çocuk 52 kulak dâhil edilmiştir. Ardından saf ses odyometrileri ve timpanogramlarına bakılarak işitme eşikleri ve orta kulak fonksiyonları değerlendirilmiştir. Hastaların çalışma kriterlerine uygun olup olmadığı ise pediatrik endokrinoloji tarafından doldurulan hasta kayıt formlarından geriye dönülerek belirlenmiştir.*

Bulgular: *Sağ ve sol kulak için yapılan ölçümlerde 4000 ve 8000 Hz frekansta hava yolu eşik değerlerinin 5 yıl ve daha uzun süre Tip 1 DM'li hasta grubunda, 5 yıldan daha az süre Tip 1 DM'li kontrol grubuna oranla istatistiksel olarak anlamlı bir şekilde daha yüksek değerlerde olduğu bulundu ($p<0,05$). 5 yıl ve daha uzun süre diyabetli olan hasta grubunun hem sağ, hem de sol kulak kemik yolu eşik değerlerinin 4000 Hz frekansta istatistiksel olarak anlamlı bir şekilde daha yüksek değerlerde bulundu ($p<0,05$). Sağ ve sol kulak konuşmayı ayırt etme eşik (SD) değerleri ile hastalık süresi değerleri arasında ise istatistiksel olarak anlamlı ve negatif yönlü orta düzeyde ilişki saptandı.*

Sonuç: *Çalışmamızın sonucunda; Tip 1 DM tanısı olan bireylerde işitme kaybı gelişme riskinin daha fazla olduğu bulunmuştur. Bu sebeple, bu hasta grubunda işitmenin ayrıntılı olarak incelenmesi ve klinik muayene protokolü oluşturulması tavsiye edilmektedir.*

Keywords:
Type 1 diabetes
Hearing loss
Pure-tone audiometry

Anahtar Kelimeler:
Tip 1 diyabet
İşitme kaybı
Saf ses odyometri

INTRODUCTION

Diabetes Mellitus is a genetically defined chronic metabolic disorder characterized by hyperglycemia resulting from autoimmune destruction of beta-cells of the pancreas (1,2). It is caused by reduced tissue responses to insulin in the absence or lack of secretion of the insulin hormone released from beta cells in pancreatic islets (3-6). It also causes vascular and neuropathic complications due to its metabolic effects (5).

Type 1 DM was also called 'insulin-dependent diabetes', 'juvenile diabetes', or 'childhood-onset diabetes' in the past. In type 1 diabetes mellitus, pancreatic beta cells are

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mostly seen in cases of absolute insulin deficiency due to autoimmune damage. Genetic predisposition and many environmental factors that have not been clearly revealed are thought to play a role in the development of type 1 DM (7).

In patients with DM, the mechanism of hearing impairment (as in retinal and kidney dysfunction) is largely unclear because it cannot be evaluated by intravital examination. However, there are many different hypotheses about how DM affects hearing. DM is characterized by the presence of insulin and beta-cell autoantibodies resulting from the autoimmune destruction of insulin-producing beta cells (8). Cochlear hypoxia due to diabetic microangiopathy, neuropathy due to vascular/metabolic events in the cochlear nerves, and changes in cochlear glucose levels are thought to cause auditory pathologies (9-12).

Glucose metabolism significantly affects the physiology of the inner ear, which is metabolically very active. The energy of the inner ear is not stored, so small changes in glucose in the blood affect the function of the inner ear and cause balance disorders. As a result of this mechanism, vertigo, tinnitus, hypoacusis, and ear fullness can occur (13).

Therefore, our study aims to investigate the differences in pure-tone audiometry and tympanograms in terms of gender, disease duration, and right-left ear in children with type 1 DM.

MATERIALS AND METHODS

This study was carried out in Başkent University, Department of Otorhinolaryngology, Audiology Clinic. Written informed consent was obtained from each patient for the tests to be performed in the audiology clinic. It has been declared by the Ethics Committee of Başkent University that there is no harm in conducting the study with the decision dated 24.01.2018 and numbered 3227.

In this study, among 109 patients aged 0-18 who were followed up and treated with a diagnosis of type 1 DM in Başkent University Hospital Pediatric Endocrinology Outpatient Clinic in 2016-2017, 26 patients and 52 ears with anamnesis and examination information, aged between 2-18, who applied to the Ear Nose Throat outpatient clinic for different reasons were included.

Whether the patients met the study criteria was determined by using the patient registration forms filled out by the Endocrinology. The glucose and Hemoglobin A1c (HbA1c) results of the patients were taken into account. With these results, the duration of the disease and the treatment adopted were used as study parameters.

Madsen Orbiter 922-2 Clinical Audiometry (Denmark) device was used for pure voice and speech audiometry. TDH-39 standard earphones were used for conduction hearing thresholds and speech tests, and a radioear B-71 vibrator was used for bone conduction hearing thresholds. Frequencies of 125-8000 Hz for conduction thresholds and 500-4000 Hz frequencies for bone conduction thresholds were evaluated. Conduction and bone conduction thresholds of 500-1000-2000 Hz as mean pure-tone (SSO) were calculated separately for both ears (14). The speaking threshold (SRT) test was performed with a three-syllable word list and speech discrimination (SD) test with a live voice using the monosyllabic phonetic balanced word list (FD-300). Only tympanograms of patients under 2 years of age were evaluated.

Statistical Analysis

The research data were evaluated using the SPSS 22.0 statistical package program. Descriptive statistics are presented as mean (±) standard deviation, median (minimum-maximum), frequency distribution, and percentage. The compliance of continuous variables to normal distribution was evaluated using visual (histogram and probability charts) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). For categorical variables, whether there was a difference between groups in terms of frequency was compared using Chi-square tests. Patients with type 1 DM were divided into two groups (<5 years and ≥ 5 years) as the type 1 DM patient group for 5 years or longer, and the control group with type 1 DM for less than 5 years.

RESULTS

52 ears of 26 patients (10 females, 16 males) diagnosed with type 1 DM were included in the study. The mean age of the patients was 12.5±3.8. The mean disease duration of the patients was 5.4±4.9 (1-16) years, and the mean HbA1c (%) value was 6.6±2.1 (4.7-12.4). When the groups were examined according to the duration of the disease, there were 15 patients (57.7%) with an illness of fewer than 5 years and 11 patients (43.3%) with 5 years or more.

Type A tympanogram was obtained in 21 (80.8%) of the patients and type B tympanogram in 5 (19.2%). SNHL (sensorineural hearing loss) was not detected in 20 (80%) of the patients. Hearing loss in the right and left ears was graded according to SSO (pure tone average); 19 (76.0%) patients and 20 (80%) patients had normal hearing in the right ears and left ears. 5 (20.0%) patients and 4 (16%) patients had mild hearing loss in the right ears and left ears, respectively. 1 (4%) patient had severe hearing loss in the right ear and 1 (4%) patient had severe hearing loss in the left ear.

Table 1 presents the comparison of pure-tone audiometry conduction and bone conduction threshold values of the research groups. In the measurements made for the right and left ears, conduction threshold values at a frequency of 4000 and 8000 Hz were found to be statistically significantly higher in the patient group with DM for 5 years or longer ($p<0.05$). Conduction threshold values at other frequencies were found to be similar in both groups. Besides, in the evaluation made for the bone conduction, it was found that the bone conduction threshold values of both the right ear and left ear at a frequency of 4000 Hz were statistically significantly higher in the patient group with DM for 5 years or longer ($p<0.05$). For both ears between groups, pure-tone threshold mean values and disturbing loudness levels were similar.

Speaking threshold and speech discrimination score values of the participants were compared. In the right and left ear evaluations, speech acquisition threshold values were found to be similar in the group with DM for less than 5 years and the patient with type 1 DM for 5 years or longer. In the right and left ear evaluations, the speech discrimination score % values had statistically significantly lower values in the patient group with type 1 DM for 5 years or longer ($p<0.05$).

Table 1: Comparison of pure-tone audiometry and conduction and bone ducts hearing threshold values of the study groups participating in the study.

		Children with Type 1 DM diagnosis <5 years (n=15)				Children with Type 1 DM diagnosis ≥5 years (n=11)				
	Frequencies	Mean±sd	median	minimum	maximum	Mean±sd	median	minimum	maximum	p
Right ear conduction	500 Hz (dB)	13.5±12.0	10.0	0	35.0	19.1±25.0	10.0	5.0	95.0	0.955
	1000 Hz(dB)	12.1±10.1	10.0	0	30.0	20.5±29.0	10.0	5.0	105.0	0.473
	4000 Hz(dB)	13.6±11.8	10.0	5.0	35.0	27.7±24.0	25.0	10.0	95.0	0.026
	8000 Hz(dB)	12.1±7.8	10.0	0	25.0	30.9±24.2	20.0	18.0	85.0	0.006
Left ear conduction	500 Hz(dB)	12.1±9.9	10.0	5.0	30.0	21.36±23.8	15.0	5.0	90.0	0.083
	1000 Hz(dB)	10.4±8.8	7.5	0	25.0	20.0±27.4	10.0	5.0	100.0	0.185
	4000 Hz(dB)	12.5±9.8	10.0	5.0	30.0	28.2±29.0	15.0	10.0	110.0	0.008
	8000 Hz(dB)	13.6±8.6	10.0	5.0	30.0	35.5±29.6	25.0	5.0	110.0	0.010
Right ear bone	1000 Hz(dB)	4.3±2.7	5.0	0	10.0	10.9±19.9	5.0	0	65.0	0.336
	4000 Hz(dB)	6.1±3.5	5.0	0	10.0	17.3±21.6	10.0	5.0	80.0	0.028
Left ear bone	1000 Hz(dB)	3.6±3.6	5.0	0	10.0	10.0±20.5	5.0	0	70.0	0.518
	4000 Hz(dB)	5.0±3.4	5.0	0	10.0	17.7±21.4	10.0	5.0	80.0	0.003
Pure-tone threshold mean value (dB)	Right ear	13.1±10.5	10.0	3.0	32.0	20.0±26.1	10.0	5.0	96.0	0.415
	Left ear	12.1±10.1	10.0	2.0	30.0	21.6±28.3	13.0	5.0	105.0	0.085
Uncomfortable sound level(dB)	Right ear	107.9±4.3	110.0	100.0	110.0	106.0±5.2	110.0	100.0	110.0	0.334
	Left ear	107.9±4.3	110.0	100.0	110.0	106.0±5.2	110.0	100.0	110.0	0.334

Hz: Hertz, dB: Decibel.

The relationship between disease duration, age, and HbA1c values of the participants in the study with pure-tone audiometric threshold values, speech acquisition threshold, and speech discrimination scores were examined (Table 2). No relationship was found between HbA1c and pure-tone audiometric threshold values, speech reception threshold, and speech discrimination scores. A statistically significant and positive moderate relationship was found between the threshold values of conduction measurements at 4000 and 8000 Hz in both the right and left ears of type 1 DM patients participating in the study and the duration of the disease. It was found that patients with high disease duration values had a high right and left ear conduction threshold values in both frequencies. A statistically significant and positive moderate correlation was found between the right and left ear bone conduction thresholds at a frequency of 4000 Hz and the duration of the disease. Both right and left ear bone conduction threshold values at 4000 Hz frequency were also high in patients with high disease duration values. There was no statistically significant relationship between the measurements at other frequencies and the duration of the disease. There was no statistically significant relationship between right and left ear SRT values and disease duration values. A statistically significant and negative moderate correlation was found between the right and left ear SD values and the duration of the disease ($p>0.05$). SD values of those with high disease duration values were found to be low in the study. A statistically significant and positive moderate correlation was found between the age values of the participants and the left ear bone canal threshold values at a frequency of 4000 Hz; no significant relationship was found between pure-tone audiometric threshold values, speech reception threshold, and speech discrimination scores at all other frequencies.

DISCUSSION

The relationship between hearing loss and type 1 DM started to be discussed by Jordao about 150 years ago after the report of hearing loss and sudden diabetic coma (15-17). Some studies have shown that patients with high blood glucose levels in type 1 DM follow-up have severe hearing loss, and bilateral sensorineural hearing loss may

Table 2: The relationship between the disease duration, age, and HbA1c values of the study participants with pure-tone audiometric threshold values, speech acquisition threshold, and speech discrimination scores.

Spearman's correlation coefficients n=26	Right ear conduction			Left ear conduction			Right ear bone		Left ear bone		Right Ear		Left Ear	
	1000 Hz(dB)	4000 Hz(dB)	8000 Hz(dB)	1000 Hz(dB)	4000 Hz(dB)	8000 Hz(dB)	1000 Hz(dB)	4000 Hz(dB)	1000 Hz(dB)	4000 Hz(dB)	SRT (dB)	SD (%)	SRT (dB)	SD (%)
Duration of Illness, years r(p)	0.128 (0.541)	0.430 (0.032)	0.487 (0.014)	0.218 (0.296)	0.493 (0.012)	0.479 (0.015)	0.192 (0.359)	0.567 (0.003)	0.182 (0.384)	0.681 (0.001)	-0.085 (0.692)	-0.429 (0.037)	-0.136 (0.525)	-0.411 (0.046)
Age r(p)	0.049 (0.815)	0.238 (0.253)	0.209 (0.317)	0.235 (0.259)	0.269 (0.194)	0.242 (0.244)	0.104 (0.619)	0.386 (0.057)	0.182 (0.384)	0.487 (0.014)	-0.179 (0.404)	-0.059 (0.783)	-0.203 (0.342)	-0.060 (0.780)
HgA1c r(p)	-0.118 (0.575)	0.129 (0.540)	0.078 (0.713)	0.018 (0.933)	0.066 (0.753)	0.215 (0.302)	-0.097 (0.646)	0.269 (0.194)	0.152 (0.467)	0.274 (0.185)	-0.135 (0.529)	-0.121 (0.573)	-0.018 (0.933)	0.044 (0.840)

Hz: Hertz, dB: Decibel, HgA1c: Hemoglobin A1c, SRT: Speech Reception Threshold, SD: Speech Discrimination

occur in middle frequencies (18-21).

Damage to the inner ear usually begins after the age of 40 and is noticed later when speaking frequencies (500 Hz, 1000 Hz, and 2000 Hz) remain intact. Nonetheless, it can occur at an earlier age in people exposed to noise and those with vascular and metabolic diseases. DM is responsible for overall metabolic sensorineural hearing loss (22). In this case, it is possible to notice the symptoms of hearing loss earlier in individuals with DM.

Although hearing loss has been observed for a long time in patients with type 1 DM, the cause-effect relationship has not been proven. The pathophysiology of otological findings in type 1 DM is not fully known, but it is thought that the auditory impairment is caused by damage to the inner ear cells or retrocochlear auditory pathways. There are also studies showing that there may be a relationship between glycemic control and hearing loss (24). In animal modeling by Timothy Smith et al., type 1 DM was created by applying streptozocin to mice. Subsequently, it was observed that mice developed cochlear microangiopathy. Thus, cochlear dysfunction occurred and hearing thresholds were affected (25). Based on all these studies, it is seen that DM can affect almost all components of hearing and cause different degrees of hearing loss (23).

In the study conducted on children with type 1 DM between the ages of 5-18 hearing threshold values of type 1 DM patients were higher than the control group. Besides, the auditory thresholds of the patients were positively correlated with the HbA1C concentration at frequencies of 250, 500, 1000, and 4000 Hz (17). In our study, a statistically significant and positive moderate correlation was found between the right and left conduction threshold values at 4000 Hz and 8000 Hz, and the right ear bone canal threshold value at 4000 Hz frequency and the duration of the disease.

In our study, HbA1c values and pure-tone audiometry thresholds were compared to support the negative effect of complications of diabetes on hearing. The relationship of disease duration, age, and HbA1c values with pure-tone audiometric threshold values, speech acquisition threshold, and speech discrimination scores were evaluated.

The significant correlation between HbA1c concentration and auditory thresholds in patient groups in the studies of Elamin et al. (19) and Pessin et al. (20) shows that, if glycemic control is insufficient, it may be an important factor in the development of hearing impairment in patients with type 1 DM. In our study, no relationship was found between HbA1c and pure-tone audiometric threshold values, speech acquisition threshold, and speech discrimination scores. This may be due to the small number of patients and their short duration of illness.

In a study conducted by Trevino-Gonzalez et al. on 84 children and adolescents with type 1 DM, it was observed that there was a prevalence of 14.3% (12 of 84 patients) sensorineural hearing loss. The most affected frequency is 8000 kHz (26). In our study, a statistically significant and positive moderate relationship was found between the threshold values of conduction measurements at 4000 and 8000 Hz in both the right and left ears and the duration of the disease.

In a study conducted by Silva et al. on the speech perception performance of patients with type 1 DM, it was found that pure tone threshold values were significantly higher at high frequencies and medium frequencies compared to partially healthy individuals. It was determined that there is a significant difference for all participants (n = 80 ears) between the thresholds of receiving speech in silence and speaking in the noise of the group with type 1 DM and the control group (27). In our study, the right and left ear speech discrimination score % values were statistically significantly lower in the patient group with DM for 5 years or longer.

Based on the studies in the literature, although high-frequency audiometry was not performed in our study, the audiometric results of individuals with type 1 DM between 0.125 and 8 kHz were evaluated, and significant results were obtained. Possibly because patients with type 1 DM had a short disease duration and the patients were young, DM complications such as nephropathy or retinopathy were not observed in the present study. Therefore, the relationship between diabetic end-organ complications and hearing loss could not be evaluated.

CONCLUSION

In the light of current knowledge, there is evidence that DM can cause hearing loss, but we cannot fully state the cause-effect relationship. Considering the fact that hearing dysfunctions of patients with type 1 DM may be asymptomatic, care should be taken to question patients diagnosed with type 1 DM in terms of hearing. In addition to cardiological and neurological evaluations, it should not be ignored that progressive hearing loss can be prevented in line with the results obtained after a routine ear, nose and throat examination.

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REFERENCES

1. Dąbrowski M, Mielnik-Niedzielska G, Nowakowski A. Involvement of the auditory organ in type 1 diabetes mellitus. Endokrynologia Polska. 2011;62(2):138-44.
2. Fowler MJ. Microvascular and macrovascular complications of diabetes. Clinical diabetes. 2008;26(2):77-82.
3. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes care. 2010;33:S62-S9.
4. Türkiye Endokrinoloji ve Metabolizma Derneği, Diabetes Mellitus ve Komplikasyonlarının Tanı, Tedavi ve İzlem Kılavuzu 6. Baskı, Miki Matbaacılık San ve Tic Ltd Şti Ankara. 2013:16-7.
5. Maia CAS, de Campos CAH. Diabetes mellitus as etiological factor of hearing loss. Brazilian journal of otorhinolaryngology. 2005;71(2):208-14.
6. Mellitus D. Diagnosis and classification of diabetes mellitus. Diabetes care. 2005;28(S37):S5-S10.

7. Bakanlığı Sağlık, Kurumu HS. Türkiye Diyabet Programı 2015-2020. Türkiye Halk Sağlığı Kurumu, Yayın. 2014(816):13.
8. American Diabetes Association. Standards of medical care in diabetes--2014. Diabetes care. 2014;37:S14.
9. Teng ZP, Tian R, Xing FL, Tang H, Xu JJ, Zhang BW, et al. An association of type 1 diabetes mellitus with auditory dysfunction: A systematic review and meta-analysis. The Laryngoscope. 2017;127(7):1689-97.
10. Xipeng L, Ruiyu L, Meng L, Yanzhuo Z, Kaosan G, Liping W. Effects of diabetes on hearing and cochlear structures. Journal of Otology. 2013;8(2):82-7.
11. Malucelli DA, Malucelli FJ, Fonseca VR, Zeigeboim B, Ribas A, de Trotta F, et al. Hearing loss prevalence in patients with diabetes mellitus type 1. Brazilian journal of otorhinolaryngology. 2012;78(3):105-15.
12. Diniz TH, Guida HL. Hearing loss in patients with diabetes mellitus. Brazilian journal of otorhinolaryngology. 2009;75(4):573-8.
13. Klagenberg KF, Zeigelboim BS, Jurkiewicz AL, Martins-Bassetto J. Vestibulocochlear manifestations in patients with type I diabetes mellitus. Brazilian journal of otorhinolaryngology. 2007;73(3):353-8.
14. Belgin E. Periferik iĢitme sisteminin anatomi ve fizyolojisi (Bölüm 3). TemelOdyoloji,(Belgin E, ed), Ankara, Güneş Tıp Kitabevi. 2015;30.
15. Di Nardo W, Ghirlanda G, Paludetti G, Cercone S, Saponara C, Del Ninno M, et al. Distortion-product otoacoustic emissions and selective sensorineural loss in IDDM. Diabetes care. 1998;21(8):1317-21.
16. Golemanov V, Todorova S. High-frequency tonal threshold hearing changes in diabetes mellitus. Vutreshni Bolesti. 1983;22(4):59-62.
17. Okhovat SA, Moaddab MH, Okhovat SH, Al-Azab AAA, Saleh FAA, Oshaghi S, et al. Evaluation of hearing loss in juvenile insulin dependent patients with diabetes mellitus. Journal of Research in Medical Sciences: The Official Journal of Isfahan University of Medical Sciences. 2011;16(2):179.
18. Cullen J, Cinnamond MJ. Hearing loss in diabetics. The Journal of Laryngology & Otology. 1993;107(3):179-82.
19. Elamin A, Fadlallah M, Tuevmo T. Hearing loss in children with type 1 diabetes. Indian Pediatr. 2005;42(1):15-21.
20. Pessin ABB, Martins RHG, de Paula Pimenta W, Simões ACP, Marsiglia A, Amaral AV. Auditory evaluation in patients with type 1 diabetes. Annals of Otology, Rhinology & Laryngology. 2008;117(5):366-70.
21. Wackym PA, Linthicum Jr FH. Diabetes mellitus and hearing loss: clinical and histopathologic relationships. The American journal of otology. 1986;7(3):176-82.
22. Bakır S. KBB notları. Ankara: Derman Tıbbi Yayıncılık. 2015.
23. Kocyigit M, Bezgin SU, Cakabay T, Ortekin SG, Yıldız M, Ozkaya G, et al. An Investigation of Hearing (250-20,000 Hz) in Children with Endocrine Diseases and Evaluation of Tinnitus and Vertigo Symptoms. International archives of otorhinolaryngology. 2020;24(2):204-11.
24. Guillausseau P-J, Massin P, Dubois-LaForgue D, Timsit J, Virally M, Gin H, et al. Maternally inherited diabetes and deafness: a multicenter study. Annals of internal medicine. 2001;134:721-8.
25. Smith TL, Raynor E, Prazma J, Buenting JE, Pillsbury HC. Insulin-dependent diabetic microangiopathy in the inner ear. The Laryngoscope. 1995;105(3):236-40.
26. Treviño-González JL, Campuzano-Bustamante D, Flores-Caloca O, Santos-Lartigue R, Villegas-González Jr M. Prevalence of sensorineural hearing loss in children and adolescents with diabetes mellitus. Medicina universitaria. 2015;17(68):133-7.
27. Silva BCS, Mantello EB, Freitas MCF, Foss MC, de Lima Isaac M, Anastasio ART. Speech perception performance of subjects with type I diabetes mellitus in noise. Brazilian journal of otorhinolaryngology. 2017;83(5):574-9.