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Original Article

Hearing Loss Related with Type 2 Diabetes in an Elderly Population

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OBJECTIVE: Considering that both hearing loss and Type 2 diabetes (DM2) are significant health issues, it is worthwhile to examine the relationship between the two. After evaluating the existing literature, it was evident that there have not been sufficient prospective studies about hearing loss and DM2 that include elderly participants. Therefore, the aim of this study was to focus on and evaluate the interaction between DM2 and hearing loss in an elderly population.

MATERIALS and METHODS: The current study included 93 DM2 subjects, 65-89 years of age, as well as a control Group of 90 non-diabetic subjects, aged 65-85 years of aged, who were matched to the DM2 subjects by age and sex.

RESULTS: The current investigation produced five major findings. The diabetics had higher thresholds for all frequencies, except 0.25 kHz, compared to the controls. Although there were significant differences at low frequencies, such as 0.5 and 1 kHz, the differences were most pronounced at 2, 4, and 8 kHz. The thresholds for speech reception were significantly higher in the diabetics than in the controls. Also, there were no side differences between the right and left ears in the diabetics or the controls, and the diabetics had lower speech discrimination scores than the controls.

CONCLUSION: Diabetes is a complex, systemic disease that can affect multiple organs and physiological functions, on molecular and biochemical levels. The current investigation showed that elderly DM2 subjects had poorer hearing levels when compared with age and sex matched non-DM2 subjects.

KEY WORDS: Age-related hearing loss, presbycusis, Type 2 diabetes, geriatric, audiometric measurements

INTRODUCTION

In recent decades, there has been a rapid progression in population aging, and with advancing age, chronic diseases and functional impairments become more common. One of these is age-related hearing loss (presbycusis), the most common sensory deficit, and a significant chronic medical condition in the elderly [1-3].

It is well known that presbycusis is a result of various types of physiological degeneration due to aging, plus the accumulated effects of noise exposure, smoking, medical disorders and their treatment, and hereditary susceptibility [4]. It is characterized by bilateral, symmetrical, and slowly progressive reduced hearing sensitivity and speech understanding in noisy environments, slowed central processing of acoustic information, and impaired localization of sound sources [5].

Type 2 diabetes mellitus (DM2), another common chronic disease that occurs with advancing age, is a metabolic disorder that affects up to 7% of the population worldwide [6, 7]. It is characterized by high blood glucose in the context of insulin resistance and relative insulin deficiency. Previous studies have shown the destructive neurodegenerative results of diabetes, such as oxidative damage, increased apoptosis, and intracellular calcium toxicity. These pathological changes, at the cellular level, cause major side effects of hyperglycemia, such as retinopathy, nephropathy, neuropathy, and coronary arterial and peripheral vascular diseases. In addition, histopathological studies demonstrate that the nerves and vessels of the inner ear in subjects with DM2 are damaged by the sustained hyperglycemia [7-9], possibly leading to neuronal degeneration within the auditory system [10]. However, in spite of these pathological findings in the inner ear, an evaluation of the existing literature showed that the relationship between diabetes and hearing loss is still controversial. While some studies revealed an increased risk of hearing loss in diabetes patients, other studies did not find any differences in hearing loss between controls and diabetes patients [6,10-20].

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Considering that both hearing loss and DM2 are significant health issues, it is worthwhile to examine the relationship between the two. Although the association between diabetes and hearing loss has previously been studied, there have not been sufficient prospective studies of hearing loss and DM2 that included elderly participants [18]. Therefore, the aim of this study was to focus on and evaluate the interaction between DM2 and hearing loss in an elderly population.

MATERIALS and METHODS

This study was conducted at the otorhinolaryngology clinic of Amasya University Training and Research Hospital. All investigations were performed in accordance with the Declaration of Helsinki on biomedical studies involving human subjects, and informed consent was obtained from all participating subjects. This study was approved by the Clinical Research Ethics Committee of Ankara Numune Training and Research Hospital.

Volunteers were recruited for participation in a study of hearing loss. Individuals with a history of noise damage, middle ear hearing loss, and history of cognitive function disability were excluded. Also excluded were those who had been treated with ototoxic medications, exhibited serious medical health problems or neurological medical conditions, were diagnosed with Meniere's disease or labyrinthitis, or smoked.

The current study included DM2 subjects 65-89 years of age who met the above inclusion/exclusion criteria above, as well as a control Group of 90 non-diabetic subjects, 65-85 years of age, who were matched to the DM2 subjects by age and sex. Participants with diabetes had been followed up for at least 10 years due to this disease.

Pure tone audiometry was measured at 0.25, 0.5, 1, 2, 4, and 8 kHz to detect the hearing threshold at each given frequency using an AC40 clinical audiometer (Interacoustics, Assens, Denmark) in a sound-isolated room, standardized according to the manufacturer's instructions. Air-conduction thresholds between 0.25 and 8 kHz were measured using TDH-39 earphones and an MX41/AR cover. Bone-conduction thresholds between 0.5 and 4 kHz were measured using an Oticon 60273 vibrator (Oticon, Sm'rum, Denmark). Pure tone average (PTA) was determined, based on the air-conduction average threshold levels in each ear at 0.5, 1, 2, and 4 kHz.

Speech reception threshold (SRT) indicates the acuity with which a subject correctly perceives two-syllable words of equal stress (Spondees). In a quiet setting, this measure primarily taps the peripheral auditory system and indicates the lowest intensity level at which an individual is able to process words (threshold is defined as the 50% point on the psychometric function). SRT, which correlates highly with the pure tone average of 0.5, 1.0, and 2.0 kHz, also serves as a validating criterion for pure tone absolute threshold measurements. Speech discrimination, as opposed to speech sensitivity, is the person's ability not only to hear words but also to identify them. The procedure includes a presentation of 25 selected monosyllabic words at an easily detectable intensity level. The speech discrimination score (SDS) is the percentage of words correctly identified. Pathology of the inner ear, auditory nerve, and/or central auditory pathways can affect this score. The ability of an individual to discriminate speech is not well predicted by the pure-tone audiogram. An individual might hear a sound well enough, but the neural signals could be altered to the extent that the sound is unintelligible.

Tympanometric measurements were performed, after swallowing, on both ears of the 93 patients in the study Group and the 90 patients in the control Group, for a total of 366 ears, using an Impedance Audiometer AZ 7 (Interacoustics, Assens, Denmark).

Bone conduction audiometry and tympanometry were used to rule out the presence of middle ear diseases that would have precluded obtaining valid measures.

Statistical Analysis

Data analysis was performed with SPSS 21.0 (Statistical Package for Social Sciences; SPSS Inc., Chicago, IL). The normal distribution of considered variables was first evaluated using the Shapiro-*Wilk test. Data were shown as mean±standard deviation for continuous variables, and number of cases was used for categorical ones. The differences between the diabetic and control Groups in terms of age and audiologic measurements were compared with a t test. A chi-square test was used for the comparison of categorical variables. The level of significance was set at 0.05.

RESULTS

The study included 183 subjects with a mean age of 71±4.8 years (range, 65-89 years). The participants were divided into two Groups according to the presence of diabetes disease: diabetic and control Groups. There were no statistical difference between the Groups in terms of age and gender (Table 1).

When these Groups were compared to each other, significant differences were found between the diabetic and control Groups in terms of several auditory measurements of both the right and left ears. For all frequencies except 250 Hz, the diabetics demonstrated elevated thresholds when compared to the non-diabetic subjects (Figures 1 and 2). In the right ear, the mean PTA was 32.8±11.7 decibels Hearing Level (dB HL) in the diabetic and 25.4±12.5 dB HL in the control Groups. In the left ear, the mean PTA was 32±11.9 dB HL in the diabetic and 24±12.7 dB in the control Groups. The mean differences in PTA between the Groups were 7.4 dB in the right ear and 8 dB in the left ear. The differences were most pronounced at frequencies of 2, 4, and 8 kHz. Difference in SRT between the two Groups were also significant both the right and left ear. Although the control Group had better SDS than the diabetic Group, the differences were not significant for either the right or left ears (Tables 2 and 3). No differences in auditory measurements between the right and left ears were found in the diabetic or control Groups.

DISCUSSION

The current investigation, conducted on elderly participants, produced five major findings: (1) the diabetics had higher thresholds for

Table 1. Characteristics of the study Groups

	Diabetics	Control group	p value
Age	71.5±4.9	70.2±4.2	0.07
Male (%)	42 (45%)	39 (43%)	0.88
Female (%)	51 (55%)	51 (57%)	0.86

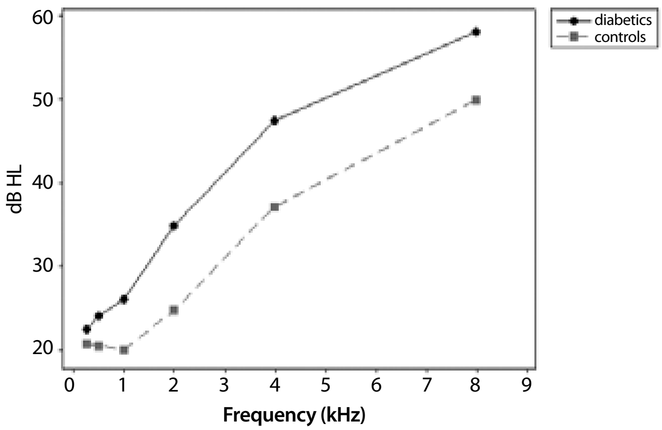

Figure 1. Mean pure tone thresholds for the right ear obtained from two Groups

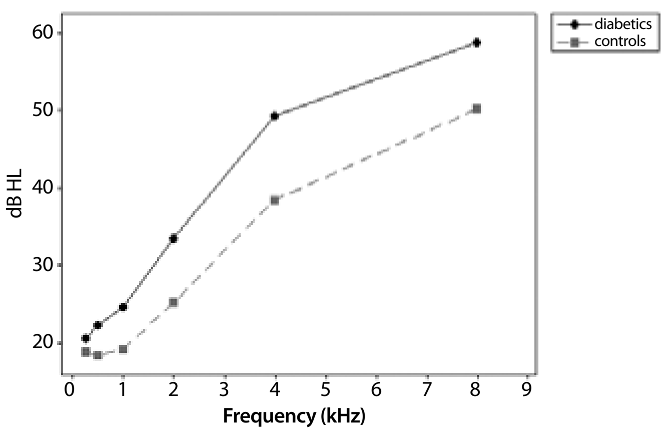

Figure 2. Mean pure tone thresholds for the left ear obtained from two Groups

Table 2. The results of audiologic measurements for the right ear obtained from two Groups

Audiologic measurements	Diabetics	Control group	p value
250 Hz	22.5±11.7	20.7±14	0.3
500 Hz	24±11.3	20.5±13.7	0.05
1000 Hz	26±12.3	20±12.8	0.005
2000 Hz	34.9±16.4	24.7±13.4	<0.001
4000 Hz	47.5±18	37.2±19.2	<0.001
8000 Hz	58.2±18.8	50±22.9	0.01
PTA	32.8±11.7	25.4±12.5	<0.001
SRT	32.6±10.6	23.3±9	0.01
SDS (%)	66.9±11.9	73.6±18	0.056

PTA: Pure tone averagE; SRT: speech reception threshold; SDS: speech discrimination score

all frequencies, except 0.25 kHz, when compared to the controls; (2) although there were significant differences at low frequencies, such as 0.5 and 1 kHz, the differences were most pronounced at 2, 4, and 8 kHz; (3) speech reception thresholds were significantly higher in the diabetics than in the controls; (4) there were no side differences between the right and left ears in either the diabetic or the control

Table 3. The results of audiologic measurements for the left ear obtained from two Groups

Audiologic measurements	Diabetics	Control group	p value
250 Hz	20.6±10.7	18.8±9.6	0.2
500 Hz	22.3±11.4	18.4±9.5	0.01
1000 Hz	24.6±12.8	19.2±10	0.002
2000 Hz	33.5±15.4	25.2±16.2	0.001
4000 Hz	49.3±17.5	38.5±19.9	<0.001
8000 Hz	58.8±18.7	50.2±20	0.01
PTA	32±11.9	24±12.7	<0.001
SRT	31.8±8.1	23.6±11.3	0.02
SDS (%)	66.7±14.1	74.1±17.7	0.051

PTA: Pure tone averagE; SRT: speech reception threshold ; SDS: speech discrimination score

Groups; and (5) the diabetics had lower speech discrimination scores than the controls.

Previous studies have reported conflicting findings regarding the degree of hearing loss in diabetics. Some studies have reported high-frequency loss, others have reported low-frequency loss, and still others have reported hearing loss across frequencies. A cross-sectional study that included 94 participants with DM2 and 94 controls found that high-frequency hearing loss was significantly and positively associated with duration of the disease and age of the participant. The mean age was 50 years, the mean duration of the disease was 7.2 years, and patients with noise exposure were excluded [13].

In a recent study of 50 individuals with DM2 and 50 control participants, the mean age of participants with diabetes was 40.8 years and the mean duration of disease was 7 years. The researchers attempted to control for confounders by excluding those with neurological conditions, noise-induced hearing loss and middle-ear pathology, serious health problems, treatment with ototoxic medications, and history of diseases of the inner ear; smokers; regular consumers of alcohol, and those who failed cognitive screening. The researchers identified increased high-frequency hearing loss among the diabetic participants. As they were younger patients, the last finding was not likely to be due to high-frequency hearing loss associated with aging [19].

Another study, a cross-sectional analysis of adult military veterans (667 males and 27 females), including 342 diabetics and 352 non-diabetics, found that individuals under 60 years of age with diabetes experienced more high-frequency hearing loss than those without diabetes. The study did not specify diagnosis of Type 1 or Type 2 diabetes, but the average duration of the disease was 12.5 years [14].

However, in a study of 30 adults aged 59-92 years that examined hearing loss in older individuals with DM2 compared to controls, Frisina et al. [6] found greater hearing loss at low frequencies in the Group with diabetes, and hearing was worse in the right ear than in the left.

In our study, we found that DM2 had a negative effect on auditory function in aged Type 2 diabetic subjects. The speech discrimination test that measures both the peripheral and central auditory systems also showed a decline in diabetics. Although the differences in SDS between the diabetics and controls were not significant, these results might be dependent on the study design, which excluded participants with serious health problems or neurological conditions due to diabetic complications. These results were consistent with another study conducted with a limited number of participants [6].

Although this study convincingly attributed the negative effects of DM2 on hearing loss in aged subjects, the lack of auditory brainstem-evoked responses and otoacoustic emissions might be a limitation of the current investigation. However, those tests could not be conducted, due to a lack of resources.

In conclusion, diabetes is a complex, systemic disease that can affect multiple organs and physiological functions, on the molecular and biochemical levels. The current investigation showed that elderly DM2 subjects had poorer hearing levels when compared with age -and sex-matched non-DM2 subjects.

Ethics Committe Approval: Ethics committee approval was received for this study from the ethics committee of Ankara Numune Training and Research Hospital. (24.10.2013/20796219-724.01)

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

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