eISSN:2708-888X
http://journals.khalijedental.com.ly/index.php/ojs/index

Original article

Evaluating the Correlation of Fasting Blood Sugar, Glycated Hemoglobin with the Hearing Loss

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ABSTRACT

Background and objectives: *Hearing loss is one of the most prevalent disabilities. Factors that can be controlled are linked to hearing loss. Diabetes, which can potentially lead to hearing loss during cases of high blood sugar levels, appears to be a contributing factor to hearing loss. This study aimed to determine the relationship between fasting blood sugar (FBS) and glycated hemoglobin (HbA1c) with hearing loss.* ***Method***: *This was a cross-sectional study conducted on two groups: the study sample consisting of patients with both diabetes and hearing loss, and the control sample comprising non-diabetic individuals with hearing loss. The study was carried out at the Sabratha Residential Clinic, Surman Clinic Al-Kubra, and Surman General Hospital between April 12, 2022, and October 25, 2023. During this period, a questionnaire was prepared, and a "Pure Tone Audiometry" hearing test was performed in the planning room to assess the hearing status of participants in both the study and control groups.* ***Results:*** *The study involved 80 participants, of whom 44 (55%) were male and 36 (45%) were female, aged 25-65 years. Compared to the control group, the study group had significantly higher fasting blood sugar (FBS: 202.13 ± 48.13 vs. 81.38 ± 9.50, p<0.001) and glycated hemoglobin (HbA1c: 9.48 ± 2.1 vs. 4.25 ± 0.59, p<0.001) levels, The study group exhibited greater hearing impairment in the left ear (56.90 ± 22.94 vs. 44.40 ± 28.13, p=0.031), but the difference in right ear hearing loss was not statistically significant (53.33 ± 24.47 vs. 44.025 ± 28.41, p=0.121). HbA1c (r=0.239, p=0.027) and FBS (r=0.216, p=0.033) both showed significant positive correlations with hearing loss.* ***Conclusion***: *This study found that type 2 diabetes mellitus adversely affects hearing, with sensorineural hearing loss positively correlating with HbA1c and FBS levels. These findings indicate that poor glycemic control is associated with an increased risk of hearing impairment in this patient population.*

Keywords: Hearing loss, FBS, HbA1c, diabetes, Pure Tone Audiometry, Libya

Citation: Hwisa S, Alnaeli G, Faraj M, Elmessawi N, Salem G, Soliman N, et al. Evaluating the Correlation of Fasting Blood Sugar, Glycated Hemoglobin with the Hearing Loss. Khalij-Libya J Dent Med Res. 2023;8(2):148–154.
https://doi.org/10.47705/kjdmr.248201
Received: 03/05/24; **accepted**: 24/06/24; **published**: 02/07/24

الخلفية والأهداف: فقدان السمع هو أحد أكثر الإعاقات انتشارًا. ترتبط العوامل التي يمكن التحكم فيها بفقدان السمع. يبدو أن مرض السكري، الذي يمكن أن يؤدي إلى فقدان السمع أثناء حالات ارتفاع مستويات السكر في الدم، هو عامل مساهم في فقدان السمع. هدفت هذه الدراسة إلى تحديد العلاقة بين سكر الدم الصائم (FBS) والهيموجلوبين السكري (HbA1c) وفقدان السمع. **الطريقة**: كانت هذه دراسة مقطعية أجريت على مجموعتين: عينة الدراسة المكونة من مرضى مصابين بمرض السكري وفقدان السمع، وعينة التحكم المكونة من أفراد غير مصابين بالسكري يعانون من فقدان السمع. أجريت الدراسة في عيادة صبراتة السكنية، وعيادة صرمان الكبرى، ومستشفى صرمان العام بين 12 أبريل 2022 و25 أكتوبر 2023. خلال هذه الفترة، تم إعداد استبيان، وتم إجراء اختبار السمع "Pure Tone Audiometry" في غرفة التخطيط لتقييم حالة السمع للمشاركين في كل من مجموعتي الدراسة والتحكم. **النتائج**: شملت الدراسة 80 مشاركًا، منهم 44 (55%) من الذكور و36 (45%) من الإناث، تتراوح أعمارهم بين 25 و65 عامًا. وبالمقارنة مع مجموعة التحكم، كان لدى مجموعة الدراسة مستويات أعلى بكثير من سكر الدم الصائم (FBS: 202.13 ± 48.13 مقابل 81.38 ± 9.50، p <0.001) والهيموجلوبين السكري (HbA1c: 9.48 ± 2.1 مقابل 4.25 ± 0.59، p <0.001)، وأظهرت مجموعة الدراسة ضعف سمع أكبر في الأذن اليسرى (56.90 ± 22.94 مقابل 44.40 ± 28.13، p = 0.031)، ولكن الفرق في فقدان السمع في الأذن اليمنى لم يكن ذا دلالة إحصائية (53.33 ± 24.47 مقابل 44.025 ± 28.41، p = 0.121). أظهر كل من HbA1c (r=0.239, p=0.027) و FBS (r=0.216, p=0.033) ارتباطات إيجابية كبيرة مع فقدان السمع. **الاستنتاج**: وجدت هذه الدراسة أن مرض السكري من النوع 2 يؤثر سلبًا على السمع، حيث يرتبط فقدان السمع العصبي الحسي بشكل إيجابي بمستويات HbA1c و FBS. تشير هذه النتائج إلى أن ضعف التحكم في نسبة السكر في الدم يرتبط بزيادة خطر ضعف السمع في هذه الفئة من المرض.

eISSN:2708-888X
http://journals.khalijedental.com.ly/index.php/ojs/index

INTRODUCTION

Hearing impairment is one of the most prevalent disabilities globally, affecting over 16% of adults and two-thirds of the population aged 70 and above [1]. Hearing impairment is associated with both controllable factors, such as ototoxic medications, exposure to loud sounds and noise, as well as uncontrollable factors, including age, gender, and genetics [2]. Recently, the role of chronic diseases in the etiology of hearing disorders has become an intriguing research topic [2]. Research indicates that diabetes is linked to hearing impairment, and two-thirds of adults with diabetes experience hearing impairment, which hampers their ability to communicate effectively with others [5.4.3].

The auditory pathway has high metabolic activity, making it a target for the effects of hyperglycemia and diabetes [6]. Hyperglycemia leads to various metabolic disorders that can impair the auditory system both physiologically and anatomically [7]. Diabetic complications, such as coronary artery disease and nephropathy, have been associated with hearing loss. On the other hand, some studies have suggested that factors like high levels of low-density lipoprotein, low levels of high-density lipoprotein, hypertension, smoking, central obesity, alcohol consumption, high triglycerides, blood sugar, and aging may also contribute to hearing loss in individuals with diabetes [3, 8, 9].

Diabetes mellitus is a chronic, multisystem condition characterized by high levels of insulin resistance in the blood and urine, as well as inadequate production or utilization of insulin. The estimated global prevalence of diabetes (both type 1 and type 2) is currently 6.4%, with a projected increase to 7.7% by 2030 [10]. Type 1 diabetes (DM1), also known as autoimmune diabetes, is characterized by insulin deficiency due to the loss of pancreatic beta cells and accounts for less than 10% of cases. In contrast, type 2 diabetes (DM2) results from the progressive loss of insulin-secreting beta cells and inadequate response to insulin secretion, comprising approximately 90-95% of diabetes cases [11]. Diabetes is a leading cause of death and is associated with numerous comorbidities.

Diabetes can lead to changes in the vascular system, basal ganglia, and cochlear hair cells. This is because the cochlea contains a large number of microvascular plexuses that are vulnerable to microvascular plexopathy during periods of hyperglycemia [12]. Additionally, hyperglycemia induces oxidative stress, which in turn causes neuronal damage and microglial activation. These changes result in the degeneration of the microvascular plexuses that supply the cochlear nerve responsible for hearing and balance [2, 13].

Research has demonstrated that several factors are significantly associated with hearing impairment, including alcohol consumption, smoking, chronic renal failure, and high triglyceride levels [3]. Furthermore, studies have found that the prevalence of hearing impairment is substantially higher in adults with diabetes (46.9%) compared to the control group (15.6%) [14].

Given that the auditory pathway is vulnerable to metabolic changes caused by hyperglycemia, it is important to diagnose hearing loss in diabetic patients. Consequently, evaluating the prevalence of hearing loss among individuals with type 2 diabetes can help identify effective ways to mitigate hearing loss in this population. Therefore, the objective of this study is to assess the degree of hearing loss experienced by patients with type 2 diabetes. This study aimed to determine the relationship between hearing loss and diabetes.

METHODS

Study Design

This was a cross-sectional study, as this research approach aligned with the objectives of the current investigation. The study was conducted among the study population and a control group to assess the prevalence and patterns of hearing loss.

Sample and Setting

This study was conducted on patients diagnosed with hearing loss. The participants were divided into two

groups: the study group consisted of patients with hearing loss associated with diabetes, while the control group comprised patients with hearing loss but without a diabetes diagnosis. The study sites included Surman General Hospital, Sabratha Shelter, and Surman Grand Sanatorium.

Study population

The study sample was randomly selected, and consisted of all patients diagnosed with type 2 diabetes and concurrent hearing loss. In addition, a control sample of healthy individuals who did not suffer from diabetes or hearing problems was selected from

Study Sample

The study sample consisted of 80 participants, randomly selected from among both patients and healthy individuals during the period from April 12, 2022 to October 25, 2023.

Description of the Study Sample

The current study sample can be described based on the distribution of the measured variables, which are presented in a relative frequency table.

Study Instrument

Given the absence of a readily available tool to measure the achievement of the current study's objectives, the supervisor and researchers collaboratively developed an instrument to assess the relationship between diabetes and hearing loss. This was accomplished by building upon the scales and tools employed in previous studies. The study instrument comprised questions that captured personal information (e.g., age, gender, height, weight) as well as medical history (e.g., type of diabetes, type of ear disease, laterality of ear injury, type of hearing loss).

Medical Laboratory Tests

Blood samples were collected from the participating patients in the morning to conduct the necessary tests, including measurements of fasting blood sugar (FBS) levels and glycated hemoglobin (HbA1c).

Audiogram Test

A pure tone audiometry (PTA) was performed on the participating patients to assess the degree of hearing loss in their right and left ears.

Statistical Analysis

The study data was analyzed using SPSS software version 25. Descriptive statistics, including mean, frequencies, percentages, and standard deviations (SD), were calculated. Additionally, inferential analyses were conducted, utilizing the Pearson correlation coefficient and independent samples t-test. A significance level of $p < 0.05$ was set for all statistical tests.

RESULTS

A total of 80 cases were 40 cases in the control group and 40 cases in the study group included in this study. male and female were 44 (55%) were male and 36 (45%) were females. The age of the subjects ranged from 25-65 years. (Table 1).

Table 1. Demographic and Clinical Characteristics of Participant in Both Groups.

Items		Study group	Control group
		Frequency (%)	Frequency (%)
Male		22 (55)	22 (55)
Female		18 (45)	18 (45)
Age (yr)	**30 >**	12 (41)	12 (41)
	31- 40	3 (7.7)	3 (7.7)
	41-50	13 (33.3)	13 (33.3)
	51 – 60	3 (7.7)	3 (7.7)
	61 <	4 (10.3)	4 (10.3)
Length (m)	**1.50 – 1.40**	5 (12.5)	5 (12.5)
	1.60 – 1.51	7 (17.5)	7 (17.5)
	1.70 – 1.61	12 (30)	12 (30)
	1.80 – 1.71	9 (22.5)	9 (22.5)
	1.90 – 1.81	7 (17.5)	7 (17.5)
Weight (Kg)	**50 - 30**	4 (10)	4 (10)
	70 – 51	15 (73.5)	15 (73.5)
	90 – 71	17 (42.5)	17 (42.5)
	91 <	4 (10)	4 (10)

The data in Table 2 reveals that 82.5% of the study group participants exhibited some degree of right ear hearing impairment, compared to 77.5% in the control group, suggesting a higher burden of right ear hearing loss among the study cohort. The left ear hearing status showed an even more pronounced disparity, with 85% of the study group experiencing hearing loss, versus only 65% in the control group, indicating that the study group had a considerably greater proportion of individuals with left ear hearing impairment.

Table 2. Hearing Acuity Distribution in the Right and Left Ears in Both Groups

Items	Study group	Control group
	Frequency (%)	Frequency (%)
Right Ear		
No hearing loss	7 (17.5)	9 (22.5)
With hearing loss	33 (82.5)	31 (77.5)
Left Ear		
No hearing loss	6 (15)	14 (35)
With hearing loss	34 (85)	26 (65)

Table 3 presents a comparative analysis of fasting blood sugar (FBS), hemoglobin A1c (HbA1c), and hearing loss in the right and left ears between the study group and control group. The results show that the study group had significantly higher FBS (202.13 ± 48.13 vs. 81.38 ± 9.50, p<0.001) and HbA1c (9.48 ± 2.1 vs. 4.25 ± 0.59, p<0.001) levels compared to the control group. Regarding hearing loss, the study group exhibited greater impairment in the left ear (56.90 ± 22.94 vs. 44.40 ± 28.13, p=0.031), while the difference in right ear hearing loss between the two groups was not statistically significant (53.33 ± 24.47 vs. 44.025 ± 28.41, p=0.121).

Table 3. Comparative of FBS, HbA1c, and Hearing Loss in Right and Left Ears among both groups

Items		Study group	Control group	p-value
FBS		202.13 ± 48.13	81.38 ± 9.50	0.00*
HbA1c		9.48 ± 2.1	4.25 ± 0.59	0.00*
Hearing loss	Right Ear	53.33 ± 24.47	44.025 ± 28.41	0.121
	Left Ear	56.90 ± 22.94	44.40 ± 28.13	0.031*

Table 4 presents the distribution of hearing loss severity between the study group and control group. In the study group, the majority of participants (52.5%) exhibited moderate hearing loss with thresholds between (41-55 dB), followed by severe hearing loss (30%) in the (71-90 dB) range, and slight hearing loss (17.5%) in the (26-40 dB) range. In contrast, the control group had a higher proportion of participants (50%) with slight hearing loss, followed by moderate hearing loss (35%), and severe hearing loss (15%). These findings suggest that the study group had a greater prevalence of more severe degrees of hearing impairment compared to the control group.

Table 4. Distribution of Hearing Loss Severity between Study and Control Groups

Items	Study group	Control group
	Frequency (%)	Frequency (%)
Slight hearing loss (26-40 dB)	7 (17.5)	20 (50)
Moderate hearing loss (41-55 dB)	21 (52.5)	14 (36)
Severe hearing loss (71-90 dB)	12 (30)	6 (15)

The correlation analysis presented in Table 5 reveals a significant positive relationship between hemoglobin A1c (HbA1c), fasting blood sugar (FBS), and hearing loss. Specifically, HbA1c exhibited a statistically significant positive correlation with hearing loss (r=0.239, p=0.027), indicating that higher HbA1c levels were associated with greater degrees of hearing impairment. Similarly, FBS also showed a significant positive correlation with hearing loss (r=0.216, p=0.033), suggesting that increased blood glucose levels were linked to more severe hearing difficulties. These findings underscore the potential clinical implications of the relationship between diabetes-related parameters and the development or progression of hearing loss among the study participants.

Table 5. Correlations between HbA1c, FBS and hearing loss

Items	Hearing Loss (r)	p-value
HbA1c	0.239*	0.027
FBS	0.216*	0.033

**Correlation is significant at the P<0.05 level.*

DISSCUSION

The current cross-sectional study explores the relationship between diabetes mellitus and hearing loss, which remains a subject of ongoing debate, largely due to the incomplete understanding of the underlying pathogenic mechanisms; however, a substantial body of published literature examining hearing loss in individuals with diabetes mellitus has consistently reported a positive association between the two conditions [15], suggesting that the most probable mechanisms contributing to this relationship may include microangiopathy of the inner ear [16, 17], neuropathy of the cochlear nerve, or a combination of both factors, which appear to render the inner ear components more vulnerable to the deleterious effects of diabetes [15].

This study provides valuable insights into the distribution of hearing acuity in the right and left ears among the diabetic patient group and healthy control group. The results indicate that in the control group, a higher percentage of individuals (77.5%) exhibited hearing loss in the right ear. In contrast, a greater proportion of participants (85%) in the diabetic group experienced hearing loss in the left ear compared to the right, which aligns with the findings reported in previous related studies [18,19,20].

Regarding the level of hearing impairment in both ears, the findings reveal distinct patterns between the control group and the diabetic study group. In the right ear, the control group had a lower mean hearing threshold of 44.025 ± 28.41 dB, while the diabetic study group exhibited a higher mean threshold of 53.3 ± 24.47 dB. Furthermore, the left ear hearing threshold was significantly higher in the diabetic study group, with a mean of 56.90 ± 22.94 dB. These results, which indicate higher hearing thresholds in both the right and left ears of the diabetic group, are consistent with the findings reported in previous relevant studies [18, 19], suggesting that the presence of diabetes is associated with an overall increase in hearing impairment, with a more pronounced effect in the left ear.

The findings of this study highlighted the differences in hearing loss severity between the diabetic study group and the non-diabetic control group. Specifically, the study group exhibited a higher prevalence of moderate and severe hearing loss compared to the control group. These findings are in accordance with previous research [16, 19, 21, 22, 23, 24], which has proposed potential mechanisms to explain this relationship, such as the cumulative effects of advanced glycation end products on the inner ear structures in individuals with diabetes, as well as the significant alterations in high-frequency hearing thresholds observed among diabetic patients due to high blood sugar levels [25].

The findings of the current study align with previous reported research, demonstrating a correlation between diabetes and hearing loss [26]. Notably, the present investigation revealed a strong positive correlation ($r = 0.239$) between glycated hemoglobin (HbA1c) levels, a marker of long-term glycemic control, and the degree of hearing impairment, which was statistically significant ($p < 0.05$). This result suggests that diabetes had a significant adverse effect on the participants' auditory function, consistent with the associations reported in prior studies on this topic [27,28]. These findings further corroborate the link between poor glycemic management and an increased risk of developing hearing deficits, underscoring the importance of comprehensive management of diabetes to mitigate the potential impact on hearing health.

The present study has few limitations resulting from the sample size. Despite these constraints, the study provides valuable insights into the distribution of hearing acuity within the study and control groups.

CONCLUSION

The findings of this investigation demonstrate a strong positive correlation between hearing loss and HbA1c levels, which serve as a marker of long-term glucose control. Higher HbA1c values, indicative of poorer glycemic management, were progressively associated with an increased risk of hearing impairment. Similarly, FBS levels also exhibited a significant positive correlation with hearing loss.

The data indicates that diabetes mellitus type 2 is associated with a heightened prevalence of severe degrees of hearing impairment, particularly at high frequencies. These results provide compelling prospective evidence that hearing loss may be a potential consequence of diabetes mellitus, and suggest that individuals with diabetes have a moderately elevated risk of developing future hearing deficits.

Conflict of Interest

The authors declare no detectable conflicts of interest.

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