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Original Article

Assessment of the risk of obstructive sleep apnoea among patients with type 2 diabetes and its associated factors using the STOP-BANG questionnaire: A cross-sectional study

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الملخص

أهداف البحث: تهدف الدراسة لتقييم مخاطر انقطاع النفس الانسدادي اثناء النوم لدى مرضى السكري من النوع الثاني في جنوب المملكة العربية السعودية وعوامل الخطر المرتبطة به.

طرق البحث: هذه الدراسة عبارة عن دراسة مقطعية أجريت في مستشفى القوات المسلحة بجازان. تم تقييم انتشار انقطاع النفس الانسدادي أثناء النوم من خلال ترجمة عربية مصدقة لاستبانة فحص (ستوب-بانج). تم إجراء عمليات الجدولة المتقاطعة وفقا لمستويات مخاطر انقطاع النفس الانسدادي أثناء النوم المقدرة وتبعها تحليل الانحدار لتقدير احتمالات ارتفاع مخاطر الاصابة وفقا للمتغيرات السريرية والديموغرافية المقاسة.

النتائج: بلغ العدد الإجمالي للمشاركين 306 حيث كان 70٪ فوق سن الخمسين، و 81٪ متزوجين، و 53٪ من الإناث. كانت الدرجة المتوسطة الإجمالية لمستوى مخاطر توقف النفس الانسدادي اثناء النوم التي تم تقييمها بواسطة عناصر استبانة (ستوب-بانج) هي 3 على مقياس من صفر إلى 8 حيث تم تصنيف 63.1٪ من المشاركين في العينة على أنهم معرضون لخطر كبير لحدوث المرض. تم تحديد العديد من الارتباطات ذات الدلالة الإحصائية حيث تم اكتشاف نسب الأرجحية ذات مستوى خطر أعلى من المرض وفقا للعمر والجنس والحالة الاجتماعية ومحيط الخصر والرقبة ومستويات السكري التراكمي ومؤشر كتلة الجسم ومدة مرض السكري والاعتلال المشترك مع ارتفاع ضغط الدم.

الاستنتاجات: يمكن أن يكون الخطر الأكبر للإصابة بانقطاع النفس الانسدادي أثناء النوم الذي تم تحديده في العينات من مرضى السكري مرتبطا بانتشار السمنة، ومحيط العنق، وارتفاع ضغط الدم، وعوامل أخرى مرتبطة بمدة مرض السكري وعلاجه. بالإضافة إلى ذلك، فإن الارتباط بين محيط الخصر، والسكري التراكمي، والمدة منذ تشخيص مرض السكري يشير إلى وجود تأثير تداخلي يتطلب مزيدا من البحث.

الكلمات المفتاحية: السكري التراكمي؛ جازان؛ السعودية؛ انقطاع التنفس الانسدادي النومي؛ داء السكري من النوع 2؛ محيط الخصر

Abstract

Objective: To assess the risk of obstructive sleep apnoea (OSA) and its associated risk factors among patients with type 2 diabetes in southern KSA.

Methods: This was a cross-sectional study conducted at the Armed Forces Hospital in Jazan. The prevalence of OSA was assessed using a validated Arabic translation of the STOP-BANG screening questionnaire. The odds of a higher OSA risk were calculated via regression analysis, according to the measured clinical and demographic variables.

Results: The total number of participants was 306, of which 213 (69.6%) were over the age of 50, 247 (80.7%) were married, and 161 (52.6%) were female. The overall median score of the OSA risk level assessed by the STOP-BANG items was three on a scale of 0–8, of which 193 (63.1%) of the participants in the sample were classified as being at high risk of developing OSA. Several statistically significant associations were identified, where odds ratios (ORs) with a higher OSA risk level were detected

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according to age, sex, marital status, waist and neck circumference, haemoglobin A1c (HbA1c) and body mass index levels, duration of diabetes, and comorbidity with hypertension ($p < 0.05$).

Conclusion: The higher risk of OSA identified in our sample of diabetic patients can be related to a high prevalence of obesity, larger neck circumferences, hypertension, and other factors linked to the duration and treatment of diabetes. Additionally, the association between waist circumference, HbA1c, and duration since the diagnosis of diabetes suggests an interaction effect that requires further investigation.

Keywords: Body mass index; HbA1c; KSA; Obstructive sleep apnoea; Type 2 diabetes; Waist circumference

Introduction

Obstructive sleep apnoea (OSA) is a common, preventable disease characterised by repetitive upper airway obstruction resulting in recurrent agitation and episodic desaturation of haemoglobin oxygen during sleep.[1] OSA is reported to be associated with several comorbidities, such as insulin resistance, obesity, cardiovascular disease, depressed mood, and hypertension.[2–4] In addition, an untreated OSA condition may cause drowsiness and increase the risk of traffic accidents.[5] OSA is primarily diagnosed through polysomnography, but there are multiple questionnaire-based screening tools to identify high-risk individuals.[6]

The reported prevalence of OSA differs according to variations in the population's demographic and clinical characteristics. Senaratna et al.'s systematic review investigated the prevalence of OSA in the general population and identified 24 eligible studies. Reported cases of OSA in the general population varied between 9% and 38%, with the prevalence reported to be higher among males, senior citizens, and those with obesity.[7] Furthermore, patients with type 2 diabetes are the most commonly reported persons with sleep disorders.[8]

KSA has a high prevalence of diabetes. With more than four million people diagnosed, 18.3% of the Saudi population suffers from diabetes.[9] The prevalence of diabetes in the Saudi population is thought to be influenced by limited physical activity and high levels of obesity.[10] Wali et al. utilised a two-step approach to identify individuals at risk of developing OSA by administering a screening questionnaire followed by confirmatory polysomnography testing. Based on 2,652 subjects between the ages of 30 and 60, the study estimated that 8.8% of the general population in KSA suffers from OSA.[11]

The current evidence suggests that patients with diabetes are at a higher risk of developing OSA. Nonetheless, the association between OSA and diabetes remains debatable, as several studies have reported conflicting findings. The pathophysiological aspects of the association between OSA and diabetes remain unclear. Some reports indicate that the association between the two conditions is bidirectional, suggesting that diabetes increases the risk of developing OSA and that OSA influences diabetes management and control.[12–14]

Evidence concerning the prevalence of OSA among patients with diabetes in KSA is currently limited. Furthermore, the association between OSA risk and anthropometric and clinical parameters among patients with diabetes is currently limited and conflicting. This study aims to recruit a sample of patients diagnosed with type 2 diabetes and assess the risk of OSA. Furthermore, this study aims to detect the associations between anthropometric and clinical parameters and OSA risk in a sample of patients with diabetes.

Materials and Methods

Study context and settings

This investigation included a cross-sectional study conducted at the Armed Forces Hospital in Jazan between January and March 2021. The hospital was considered to be a secondary health care setting, and recruitment occurred in affiliated diabetes and family medicine clinics. Patients with type 2 diabetes who were being treated for diabetes and users of family clinics were targeted as subjects.

Data collection

Data were collected at the Armed Forces Hospital in Jazan by interviewing patients who had received a diagnosis of type 2 diabetes from a diabetes or family medicine clinic. Each participant had been diagnosed with type 2 diabetes and was over the age of 18; prospective participants were excluded if they were diagnosed with any other type of diabetes, such as type 1 diabetes or gestational diabetes. The interviews were performed by family medicine physicians, and to ensure consistency in the interview process, a workshop was held to familiarise the interviewers with the study protocol and data collection process.

Patients were selected through systematic sampling while waiting in the reception rooms of diabetes and family medicine clinics. A list of patients (in order of attendance) was used to facilitate systematic sampling, and every third patient, according to the order of attendance on the patient list, was approached. Each interview was performed after explaining the steps involved in and the objectives of the study to the individual patient and securing their consent. The interviews were conducted in private rooms, and each interview lasted between 10 and 15 min. The number of patients required for an adequate sample was estimated using the StatCal function of the Epi Info software. Kalakattawi et al. investigated the risk of OSA among patients with type 2 diabetes using the STOP-BANG questionnaire and found that 42.1% had a moderate to high risk of developing OSA.[15] With a prevalence of 42.1%, a confidence interval (CI) of 90%, and a 5% margin of error, the required sample size for this study was estimated as 264 participants. Participation was voluntary and reliant on the quality of the patients' medical records. Therefore, to avoid a reduction in the sample size due to refusal to participate or exclusion of cases because of missing medical records data, 15% was added to the estimated sample size

of 264 participants. As a result, the final required sample size increased to 304 participants.

Data collection tool

The developed data collection tool consisted of three main components. The first component was collected through interviews and designated to measure patients' demographic variables, namely age, gender, education level, and socioeconomic status. Additionally, the risk of OSA was assessed using a validated Arabic translation of the STOP-BANG screening questionnaire.[16,17] The questionnaire has a reported Cronbach's alpha coefficient of 0.7, with 98% sensitivity for identifying subjects with OSA.[17] The STOP-BANG sleep apnoea screening questionnaire consists of eight questions (see Table 2).

The second component of data collection involved measuring participants' neck and waist circumferences using a measuring tape. The neck circumference was measured at the midline of the neck between the mid-cervical spine and the mid-anterior neck using a calibrated plastic tape. In men, it was measured just below the laryngeal prominence (Adam's apple).[18] Waist circumference was measured according to the World Health Organization (WHO) guidelines, which stipulate that the measurement is to be taken at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest.[19]

The third component of the data collection tool was a data extraction sheet designated to collect participants' HbA1c levels, fasting blood glucose (FBG) levels, and height and weight measurements from their medical records. Body mass index (BMI) was subsequently calculated based on the extracted height and weight data, in accordance with the WHO Global Database on BMI instructions, in which weight in kilograms is divided by height in meters squared (kg/m^2). BMI was categorised into four groups according to the WHO definition: underweight (BMI $<$ 18.50), normal weight (18.50–24.99), overweight (25.00–29.99), and obese (BMI $\geq$ 30.00).[20]

Data analysis

Data were recorded and analysed using the Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corporation, Armonk, NY, USA). Descriptive analyses of the demographic and clinical variables were performed by calculating frequencies and proportions. Several continuous variables, such as age, duration of diabetes since diagnosis, and waist circumference, were grouped together by their estimated means to facilitate comparisons between the study groups. BMI was separated into four groups according to the WHO guidelines. HbA1c and FBG levels were grouped together based on the American Diabetes Association's glycaemic control guidelines.[21] The neck circumference measurements were grouped according to screening criteria that were set to identify subjects at risk of developing OSA.[16]

Each identified item was given a value of one. The sum of each patient's STOP-BANG questionnaire scores resulted in a risk score varying between zero (no risk) and eight (extremely high risk). The OSA scores were then separated into two risk-level groups, with an estimated median of three. Patients scoring less than three were placed in the low-risk group, and patients scoring three or above were placed in the high-risk group. Cross-tabulation was performed according to estimated OSA risk levels. Univariate regression analysis was used to estimate the odds of higher OSA risk, according to the measured clinical and demographic variables. Finally, multivariate regression analysis was performed to assess the potential association between HbA1c, waist circumference, and OSA risk, while controlling for other demographic and clinical variables. To determine statistically significant tests, a p-value of 0.05 was designated.

Results

The study had a total of 306 participants; none of the patients approached rejected the invitation to participate, and the collected data were complete for all participants. All data collection steps were completed for each participant, and demographic and clinical characteristics were recorded (see Table 1). Of the patients recruited for the study, 213 (69.6%) were over the age of 50 (with a mean age of 55 years), 247 (80.7%) were married, and 161 (52.6%) were female. In addition, 155 participants (51.7%) had been

Table 1: Demographic and clinical characteristics of 306 patients with type 2 diabetes in Jazan, KSA.

Variables	n (%)
Age	
≤50 years	93 (30.4)
>50 years	213 (69.6)
Gender	
Male	145 (47.4)
Female	161 (52.6)
Marital status	
Married	247 (80.7)
Divorced	5 (1.60)
Widowed	44 (14.4)
Single	10 (3.30)
Duration of diabetes	
<7 years	151 (49.3)
≥7 years	155 (50.7)
Drug used for DM	
Oral	199 (65.0)
Insulin	19 (6.20)
Both	88 (28.8)
Comorbidity with hypertension	150 (49.?)
Smoking status	
Smoker	22 (7.20)
Non-smoker	284 (92.8)
HbA1c	
<7%	66 (21.6)
7–8%	66 (21.6)
>8%	174 (56.9)
Fasting blood glucose	
<130 mg/dl	74 (24.2)
≥130 mg/dl	232 (75.8)
Waist circumference	
<100 cm	143 (46.7)
≥100 cm	163 (53.3)
Neck circumference	
≤40 cm	225 (73.5)
>40 cm	81 (26.5)
BMI	
Healthy weight (18.5 and 24.9 kg/m^2)	28 (9.2%)
Overweight (25.0 and 29.9 kg/m^2)	107 (35.0%)
Obese (≥30.0 kg/m^2)	170 (55.6%)

Table 2: Findings of the STOP-BANG questionnaire among a sample of 306 patients diagnosed with diabetes in Jazan, KSA.

Variables		**n** (%)
Do you SNORE loudly (louder than talking or loud enough to be heard through closed doors)?	Yes	148 (48.4)
Do you often feel TIRED, fatigued, or sleepy during the daytime?	Yes	142 (46.4)
Has anyone OBSERVED you stop breathing during your sleep?	Yes	42 (13.7)
Do you have or are you being treated for high blood PRESSURE?	Yes	150 (49.0)
BMI more than 35 kg/m^2?	Yes	63 (20.5)
AGE over 50 years old?	Yes	213 (69.6)
NECK circumference >16 inches (40 cm)?	Yes	81 (26.5)
GENDER: Male?	Yes	145 (47.4)

diagnosed with diabetes for seven years or more before the study, 199 (65.0%) patients had been prescribed oral medication for diabetes, and only 22 of the patients reported being smokers at the time of the study (7.20%).

The remaining clinical characteristics (Table 1) indicated limited glycaemic control and a high prevalence of obesity among the participants. The number of patients with an HbA1c level >8 mg/dl was 174 (56.9%), and 75% (232 patients) had an FBG level ≥130 mg/dl. The mean BMI of the recruited patients was 31.3, with less than 10% (28 patients) classified as having a normal BMI. The remaining patients were classified as overweight or obese, and 163 (53.3%) had a waist circumference of 100 cm or more.

The findings of the STOP-BANG questionnaire (see Table 2) illustrate that the most frequently measured risk item was patient age above 50 years. This was followed by treatment for high blood pressure in the past and having issues with loud snoring. The overall median score of the

Table 3: Demographic and clinical characteristics of 306 patients with type 2 diabetes, classified according to OSA risk level in Jazan, KSA.

Variables	n (%)	Category based on SBQ		OR [95% CI]
		Lower OSA risk	Higher OSA risk	
Age				
≤50 years	93 (30.4)	63 (67.7)	30 (32.3)	1
>50 years*	213 (69.6)	50 (23.5)	163 (76.5)	**6.8 [3.9–11.7]**
Gender				
Male	145 (47.4)	42 (29.0)	103 (71.0)	**1.9 [1.2–3.1]***
Female	161 (52.6)	71 (44.1)	90 (55.9)	1
Marital status				
Married	247 (80.7)	91 (36.8)	156 (63.2%)	6.8 [1.4–32.9]
Divorced	5 (1.60)	2 (40.0)	3 (60.0%)	6 [0.5–63.9]
Widowed	44 (14.4)	12 (27.3)	32 (72.7)	**10.6 [1.9–57.5]***
Single	10 (3.30)	8 (80.0)	2 (20.0)	1
Smoking status				
Smoker	22 (7.20)	9 (40.9)	13 (59.1)	1
Non-smoker	284 (92.8)	104 (36.6)	180 (63.4)	1.1 [0.4–2.8]
HbA1c				
<7%	66 (21.6)	29 (43.9)	37 (56.1)	1
7–8%	66 (21.6)	18 (27.3)	48 (72.7)	**2.1 [1.01–4.3]***
>8%	174 (56.9)	66 (37.9)	108 (62.1)	1.2 [0.7–2.2]
Fasting blood glucose				
<130 mg/dl	74 (24.2)	34 (45.9)	40 (54.1)	1
≥130 mg/dl	232 (75.8)	79 (34.1)	153 (65.9)	1.6 [0.9–2.8]
Waist circumference				
<100 cm	143 (46.7)	72 (50.3)	71 (49.7)	1
≥100 cm	163 (53.3)	41 (25.2)	122 (74.8)	**3.01 [1.8–4.8]***
Neck circumference				
≤40 cm	225 (73.5)	108 (48.0)	117 (52.0)	1
>40 cm	81 (26.5)	5 (6.20)	76 (93.8)	**14.03 [5.4–35.9]***
BMI:				
Healthy weight (18.5 and 24.9 kg/m^2)	28 (9.20)	19 (67.9)	9 (32.1)	1
Overweight (25.0 and 29.9 kg/m^2)	107 (35.0)	42 (39.3)	65 (60.7)	**3.2 [1.3–7.9]***
Obese (≥30.0 kg/m^2)	170 (55.6)	51 (30.0)	119 (70.?)	**4.9 [1.1–11.6]***
Duration of diabetes				
<7 years	151 (49.3)	70 (46.4)	81 (53.6)	1
≥7 years	155 (50.7)	43 (27.7)	112 (72.3)	**2.2 [1.3–3.6]***

*$p < 0.05$.

Table 4: Multivariate logistic regression to assess the association between HbA1c, waist circumference, and duration since diabetes diagnosis and OSA risk level among 306 patients with type 2 diabetes in Jazan, KSA.

Variables	n (%)	Category based on SBQ		OR [95% CI]
		Lower OSA risk	Higher OSA risk	
HbA1c				
<7%	66 (21.6)	29 (43.9)	37 (56.1)	1
7–8%	66 (21.6)	18 (27.3)	48 (72.7)	0.911 [0.49–1.6]
>8%	174 (56.9)	66 (37.9)	108 (62.1)	1.77 [0.92–3.41]
Waist circumference				
<100 cm	143 (46.7)	72 (50.3)	71 (49.7)	1
≥100 cm	163 (53.3)	41 (25.2)	122 (74.8)	**3.091 [1.8–5.07]***
Duration of diabetes				
<7 years	151 (49.3)	70 (46.4)	81 (53.6)	1
≥7 years	155 (50.7)	43 (27.7)	112 (72.3)	**2.14 [1.2–3.5]***

*p-values < 0.05.

Table 5: Distribution of OSA risk level among 306 patients with type 2 diabetes, classified according to gender, waist circumference, and neck circumference in Jazan, KSA.

	Gender		Category based on SBQ		Total	p-values
			Lower OSA risk	Higher OSA risk		
Neck circumference	Male	≤40 cm	38 (36.5)	66 (63.5)	104	0.001**
		>40 cm	4 (9.8)	37 (90.2)	41	
	Female	≤40 cm	70 (57.9)	51 (42.1)	121	<0.001**
		>40 cm	1 (2.50)	39 (97.5)	40	
Waist circumference	Male	<100 cm	21 (42.?)	29 (58.?)	50	0.014*
		≥100 cm*	21 (22.1)	74 (77.9)	95	
	Female	<100 cm	51 (54.8)	42 (45.2)	93	0.002*
		≥100 cm*	20 (29.4)	48 (70.6)	68	

*chi-square test, **Fisher's exact text.: p-values <0.05.

OSA risk level as assessed by the STOP-BANG items was three on a scale of 0–8. When the sample was classified according to the median OSA risk level, 193 (63.1%) participants were classified as having a high risk of developing OSA.

As illustrated in Table 3, the distribution of the sample was determined according to OSA risk level, demographics, clinical variables, and estimated odds ratios (ORs). Several statistically significant associations were identified where ORs indicating a higher OSA risk level were detected according to age (OR among patients older than 50 = 6.8), sex (OR among men = 1.9), marital status (OR among married patients = 10.6), waist circumference (OR among patients with a waist circumference of 100 cm or more = 3.01) and neck circumference (OR among patients with a neck circumference of more than 40 cm = 14.03), HbA1c (OR among patients with HbA1c between 7 and 8 = 2.1), BMI (OR among patients with a BMI between 25 and 29.9 = 3.2; OR among patients with a BMI above or equal to 30 = 4.9), duration of diabetes (OR among patients with 7 years or more since diagnosis = 2.2), and comorbidity with hypertension (OR among patients diagnosed with hypertension = 8.8). Additionally, marginal statistical significance was detected concerning the association between a higher risk of OSA and FBG levels ≥130 mg/dl (OR among patients with FBG ≥130 mg/dl = 1.6).

Table 4 displays the findings of a multivariate logistic regression analysis to assess the associations between HbA1c, waist circumference, and duration since diabetes diagnosis and OSA risk level. The findings indicate that the potential association between waist circumference and OSA risk level remained statistically significant (OR among patients with a waist circumference of 100 cm or above = 3.09, $p < 0.001$). Controlling for duration since diabetes diagnosis suggests that the association between HbA1c and OSA risk level is modified by disease duration; after controlling for disease duration, marginal statistical significance was detected, in which patients with HbA1c higher than eight were at a higher risk of OSA (OR = 1.77, $p = 0.08$). Finally, duration since diabetes diagnosis remained statistically significant (OR among patients aged ≥7 years or more since diagnosis = 2.14, $p = 0.003$), suggesting the potential influence of diabetes chronicity on increased OSA risk.

Table 5 illustrates the distribution of OSA risk levels, classified according to neck circumference, waist circumference, and sex. It can be noted that higher OSA risk levels were observed among male and female patients with a neck circumference of more than 40 cm compared with those with a neck circumference of 40 cm or less ($p \leq 0.001$). Similarly, higher OSA risk levels were observed among male and female patients with a waist circumference of 100 cm or more compared with those with a waist circumference of less than 100 cm ($p < 0.05$).

Discussion

This was a cross-sectional study targeting type 2 diabetes patients and followed up at the Armed Forces Hospital in Jazan to assess the risk of OSA based on the STOP-BANG questionnaire. These findings indicate a high prevalence of OSA risk among the recruited patients. The risk was augmented by several demographic and clinical factors, such as a high BMI, a large neck circumference, and comorbidity with hypertension. Greater odds of OSA risk were detected among patients with higher HbA1c and FBG levels, larger waist circumferences, and a longer duration of diabetes.

Our findings can be compared with those of several other local and international investigations. However, studies assessing OSA risk among patients with diabetes in KSA are limited. Kalakattawi et al. used STOP-BANG questionnaires to assess OSA risk among patients with type 2 diabetes in Taif and reported that 42.1% of their participants scored three or more,[15] which is significantly lower than the 63.1% detected in our sample. This can be partially explained by their study participants' youth and the lower frequency of hypertension in the sample. Notably, Kalakattawi et al. did not investigate the association between estimated OSA risk and demographic and clinical variables.

Other studies conducted in KSA measured OSA risk among patients with type 2 diabetes using the Berlin questionnaire. In the city of Buraidah, Algeffari et al. conducted a study involving 201 patients with type 2 diabetes and concluded that 44.3% were at a higher risk of developing OSA.[22] In addition, the study reported that higher BMI and longer durations since diabetes diagnosis contribute to a higher risk of OSA. These findings are similar to ours and indicate the potential impact of high BMI and a longer duration of diabetes on increasing the risk of OSA among patients with type 2 diabetes.

In Al-Ahsaa, Aljabr et al. also utilised the Berlin questionnaire and reported that only 30.6% of the 147 participants with diabetes were at a higher risk of developing OSA.[23] The mean age of the patients was 53 years. More than half of the patients were male, 32% had a BMI > 35, and 76.7% reported having hypertension. It is unclear why the estimated OSA risk in their sample was lower than the estimates derived from our investigation and others; however, methodological differences in Aljabr et al.'s OSA risk assessments could explain the variation, as they did not consider relevant variables such as neck circumference and the duration of diabetes.

The findings of our investigation can be compared with those of similar international investigations. In southwestern Ethiopia, Abdissa conducted a study involving 253 patients with type 2 diabetes. The research was based on the STOP-BANG questionnaire and concluded that 45% of the recruited patients had a higher risk of developing OSA (risk score of three or less).[24] Additionally, the study found statistically significant associations between the risk of developing OSA and higher BMI, neck circumference measured at 40 cm or more, and comorbidity with hypertension. These results are similar to our findings.

Foroughl et al. conducted another largescale study in Iran involving a random sample of 4,021 participants, including 239 patients diagnosed with diabetes.[25] Foroughl et al. utilised the STOP-BANG questionnaire and revealed that 78.6% of the diabetes patients were at high risk of developing OSA; this figure dropped to 35.1% among participants who did not have diabetes. A study assessing the prevalence of high-risk OSA among 1,143 Jordanian patients with type 2 diabetes using the Berlin questionnaire reported that 48.5% of the patients were at a higher risk of OSA,[26] which is relatively lower than the prevalence of high-risk OSA detected in our sample. Furthermore, Fallahi et al. included five studies measuring the prevalence of OSA among a total of 2,360 Iranian patients with diabetes in their systematic review and meta-analysis and reported that the prevalence of OSA was 54.5%, which was higher among females (66.22%) than among males (63.26%).[27] Their findings differ from ours; in our study, a higher prevalence of OSA risk was detected among male patients.

Conflicting findings have been identified in the literature concerning the association between HbA1c levels and OSA risk. Priou et al.'s multicentric study compared the sleep recordings of a sample of 497 treated patients with diabetes including a sample of 265 newly diagnosed patients with diabetes who did not receive any treatment. It was concluded that HbA1c levels were higher among newly diagnosed, untreated diabetes patients with higher OSA severity.[28] Similarly, another study reported that the odds of having an HbA1c $> 6\%$ was larger among patients with an apnoea hypopnoea index of 50 or more compared with other categories.[29] However, Subramanian et al.'s larger retrospective study identified several clinical predictors of OSA among patients with diabetes, including but not limited to foot disease, receipt of insulin, and cardiac disease, although no association with HbA1c categories was detected.[30] Finally, another study suggested the influence of non-Caucasian race on increased OSA risk among patients with diabetes compared with white Europeans.[31] In addition to the potential association between HbA1c and OSA, the current evidence suggests correlations with OSA severity, waist circumference,[32] waist-to-height ratio,[33] and BMI.[34] The findings of our investigation suggest associations between HbA1c level, waist circumference, and OSA risk levels. However, after controlling for the influence of duration since the diagnosis of diabetes, regression analysis revealed a stronger association with waist circumference compared with HbA1c.

Although current evidence concerning the association between HbA1c and OSA is conflicting and inconsistent, a modification of the risk level after controlling for duration since diabetes diagnosis may suggest an interaction effect that requires further investigation. Finally, the detected association between waist circumference and OSA risk level was consistent with the findings of other investigations.[32–34]

Our investigation had multiple strengths and weaknesses. The importance of our investigation stems from targeting high-risk groups with screening tools to identify those who are at a higher risk of developing OSA. Detecting high-risk individuals can have important health implications, such as

early identification, application of relevant preventive and curative measures, and the enhanced well-being of patients with diabetes. For example, one of the findings of the STOP-BANG questionnaire indicated that 46.4% of patients experience considerable fatigue or drowsiness during the day. This could be particularly dangerous when a patient is behind the wheel of a car. Among the study's other strengths were proper calculation of the sample size and measurement of HbA1c. The limitations of this study include the lack of polysomnography, which is the gold standard confirmatory test for OSA diagnosis. However, the high sensitivity and specificity of the STOP-BANG questionnaire make it an excellent screening tool for OSA. Additionally, as the study was cross-sectional, assessment of the impact of OSA risk on diabetes control and outcomes was not addressed. Finally, hypothyroidism, which is a secondary cause of OSA, was not assessed in the recruited sample.

Conclusions

Our investigation identified a high risk of OSA among patients diagnosed with type 2 diabetes. The higher risk of OSA identified in our sample of diabetic patients may be related to the high prevalence of obesity, larger neck circumferences, hypertension, and other factors linked to the duration and treatment of diabetes. Additionally, the association between waist circumference, HbA1c, and duration since diabetes diagnosis suggests an interaction effect that requires further investigation.

Based on the findings of our investigation, it is important to establish screening programs to ensure the early identification of patients at higher risk of developing OSA, especially among patients with longer durations of diabetes and higher waist circumferences.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

Ethical approval to conduct the study was granted through the Jazan Research Ethics Committee (approval number 006–2020, February 9, 2020). Additionally, administrative approval to conduct the study at the Armed Forces Hospital in Jazan was given, and patient participation in the study only occurred after securing informed consent. This study was conducted in accordance with the Declaration of Helsinki.

Authors contributions

JS and AB developed the study concept and design. HD and FH were responsible for the development and testing of the data collection tool as well as for data collection and data entry. IG was responsible for data analysis and also prepared the final draft of the manuscript. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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