

A Study of Structure And Quality of Sleep on Control and Complications of Type 2 Diabetes Mellitus-A Cross Sectional Study

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ABSTRACT:

Background: Type 2 Diabetes Mellitus (T2DM) is a major global health concern linked to significant complications. Obstructive Sleep Apnea (OSA) is increasingly recognized for its impact on glycemic control, insulin resistance, and cardiovascular risk in T2DM patients. This study explores the effects of sleep disturbances, particularly OSA, on glycemic control and their association with sociodemographic factors.

Methods: This cross-sectional study included 100 participants diagnosed with T2DM. Data on demographic, clinical, and biochemical parameters such as BMI, blood pressure, FBS, HbA1c, and lipid profile were collected. Sleep quality was assessed using standardized questionnaires, and patients with suspected OSA underwent portable polysomnography for diagnosis using the Apnea-Hypopnea Index (AHI).

Results: The study revealed a high prevalence of OSA among T2DM patients, with 33% having mild OSA and 25% having moderate OSA. Significant associations were found between OSA and factors like BMI, dyslipidemia, excessive daytime sleepiness, HbA1c levels, and diabetic retinopathy. The OSA group had significantly higher fasting blood sugar and HbA1c levels, indicating poorer glycemic control. BMI >25 kg/m², high HbA1c, and excessive daytime sleepiness were strongly associated with OSA ($p < 0.0001$). Furthermore, OSA was linked to elevated systolic blood pressure ($p = 0.03$).

Conclusion: This study highlights the high prevalence of OSA in T2DM patients and its significant impact on glycemic control. Routine screening for OSA in T2DM patients, particularly those

with higher BMI and poor glycemic control, may improve both sleep apnea and diabetes management, thereby reducing associated cardiovascular and metabolic risks.

Keywords: Glycemic Control, HbA1c, Obstructive Sleep Apnea, Type 2 Diabetes Mellitus

INTRODUCTION

Diabetes Mellitus is a disorder characterized by high blood glucose levels resulting from defects in the body's ability to produce and/or use insulin.¹ Type 2 Diabetes Mellitus (T2DM), the most common form of diabetes, continues to be a global health concern, affecting an estimated 451 million people worldwide in 2017, according to the International Diabetes Federation.¹ The prevalence of T2DM is expected to rise by 5% annually, with the majority of individuals living in low- and middle-income countries.² T2DM is associated with significant morbidity and mortality, leading to complications such as microvascular and macrovascular damage, as well as an increased susceptibility to other comorbid conditions.³

In addition to these well-established complications, recent studies have highlighted a growing concern regarding the sleep disturbances in individuals with T2DM.¹³⁰⁹⁻¹³¹⁶ Approximately 56.8% of T2DM patients experience altered sleep patterns, including difficulty falling asleep, poor sleep quality, and excessive daytime drowsiness.⁷ These sleep disturbances are often under-recognized, despite their significant impact on overall health and disease management. Among the sleep disorders observed in T2DM patients are Obstructive Sleep Apnea (OSA), Restless Leg Syndrome, neuropathic pain, and nocturia. OSA, in particular, has gained attention due to its association with upper airway obstruction during sleep, leading to oxygen desaturation and disrupted sleep, which can exacerbate metabolic dysfunction.^{8,9}

The link between OSA and insulin resistance has become increasingly evident, with OSA contributing to the severity of T2DM. Studies show that treatment for OSA, such as Continuous Positive Airway Pressure (CPAP) therapy, can improve glycemic control and

reduce insulin resistance in individuals with T2DM. These findings emphasize the importance of addressing sleep disorders, particularly OSA, as part of comprehensive T2DM management to optimize metabolic outcomes.^{6,1309-1316}

This study aims to investigate the effect of sleep disturbances, particularly OSA, on glycemic control in T2DM patients and to examine the relationship between sociodemographic factors and sleep disturbances in individuals with Type 2 Diabetes Mellitus.

Objectives of the Study

1. To assess the prevalence of sleep disorders, particularly OSA, among individuals with T2DM.
2. To find the association between the socio-demographic details and sleep quality among type 2 diabetes mellitus patients.
3. To determine the relationship between sleep quality and glycemic control in T2DM patients.

MATERIALS AND METHODS

Study Design:	Cross-sectional
Study Setting:	JSS Hospital, Mysuru
Study Duration:	18 months
Sample Size:	100

Based on the prevalence of Type 2 Diabetes Mellitus (T2DM) in adults in India, which is approximately 7.1%², the sample size was calculated using the formula:

Where:

- n = sample size
- p = prevalence of T2DM (0.07)
- $q = 1-p$ (0.93)
- z = standard deviation (1.96 for 95% confidence)

- d = margin of error (0.05)

Thus, by substituting in the formula, the total sample size obtained was 100.

Sampling technique: Purposive sampling

Study Population:
Adults diagnosed with Type 2 Diabetes Mellitus.

Inclusion Criteria:

- Adults aged 40 years and above diagnosed with Type 2 DM.

Exclusion Criteria:

- Type 1 Diabetes Mellitus
- Pregnancy
- Critical illness
- Alcohol dependency
- Patients using sleep medications, anti-epileptics, or antipsychotic drugs.

Study Setting and Method of Data Collection:

All subjects who met the inclusion criteria were enrolled after obtaining informed written consent. Demographic details, including age, gender, ethnicity, and associated comorbidities, were collected for each participant. A total of 100 patients with Type 2 DM were enrolled from both the In-patient and Out-patient departments of JSSH, Mysuru. The clinical data collected included the duration of the disease, therapeutic interventions, and any other comorbid conditions.

The following clinical parameters were recorded:

- **BMI (Body Mass Index):** Calculated using weight (kg) / height (m²). Weight was measured on a calibrated digital weighing scale, and height was measured using a non-stretchable tape with the participant standing barefoot.
- **Blood Pressure:** Measured after at least 5 minutes of rest, in both arms, in either a sitting or supine position using a mercury sphygmomanometer. The average of the readings was recorded.
- **Waist Circumference:** Measured at the midpoint between the inferior margin of the ribs

and the superior margin of the iliac crest using a non-stretchable tape.

- **Hip Circumference:** Measured at the level of the greater trochanters.

- **Blood Samples:** 1309-1316 mL samples were drawn after 12 hours of overnight fasting for analysis of lipid profile, fasting plasma glucose, and HbA1c using High-Performance Liquid Chromatography (HPLC).

A detailed history was obtained to assess sleep disturbances, and sleep quality was evaluated using the Berlin Questionnaire for sleep apnea and the Pittsburgh Sleep Quality Index. Patients were also screened for Obstructive Sleep Apnea (OSA) symptoms such as snoring, witnessed apneas, and excessive daytime sleepiness. The Epworth Sleepiness Scale (ESS) was used to measure daytime sleepiness.

Polysomnography:

Patients with symptoms suggestive of OSA and an ESS score of more than 10 underwent a limited portable polysomnography with three channels (nasal airflow, chest movement, and pulse oximetry).

Diagnosis of OSA:

The Apnea-Hypopnea Index (AHI) was calculated, and OSA was diagnosed if the AHI was greater than 5 per hour. The severity of OSA was graded as:¹⁴

- **Mild OSA:** AHI 1309-1316 per hour
- **Moderate OSA:** AHI 1309-1316 per hour
- **Severe OSA:** AHI greater than 30 per hour

Statistical analysis was performed using SPSS software, and the data were entered and analyzed accordingly. Descriptive statistics, including mean and standard deviation, were used to summarize the data. Correlation analysis was conducted to examine relationships between variables, while One-Way ANOVA was applied to compare group differences. Additionally, Student's t-test and Independent Samples Test were used to assess significant differences between variables across different groups.

RESULTS

Socio-demographic

Details:

Among the 100 patients with Type 2 Diabetes Mellitus (T2DM), the majority (47%) were in the age group of 1309-1316 years, followed by 39% in the 1309-1316 years range. The study cohort comprised 52% females and 48% males. Hypertension was present as a comorbidity in 75% of the participants, with a mean systolic blood pressure of 134 ± 14 mmHg and a mean diastolic blood pressure of 80 ± 7 mmHg. The mean BMI of the participants was 26 ± 2 kg/m², and 64% had a BMI in the range of 1309-1316 kg/m². The mean neck circumference was 36.2 ± 2.8 cm, with 88% of participants exhibiting an increased neck circumference.

Biochemical

characteristics:

The mean fasting blood sugar level was 159 ± 55 mg/dl, and the average HbA1c was $9.5 \pm 1.9\%$. Dyslipidemia was present in 41% of the participants, and 40% of the study group had diabetic retinopathy.

Clinical

parameters:

Snoring was reported by 48% of the participants, while 34% experienced excessive daytime

sleepiness. A history of apnea was noted in 7% of the subjects. The Mallampati score indicated that 97% of participants were in Class 1, with only 3% in Class 2. In terms of OSA symptoms, 42% of the participants reported no symptoms of OSA, 33% had mild OSA, and 25% had moderate OSA.

The association between various characteristics and the presence of Obstructive Sleep Apnea (OSA) in patients with Type 2 Diabetes Mellitus revealed that age, gender, and hypertension status did not show significant differences in OSA prevalence ($p > 0.05$). However, a significant association was observed with BMI, where a higher proportion of participants with OSA had a BMI greater than 25 kg/m² ($p = 0.003$). Dyslipidemia was also significantly related to OSA, with a larger percentage of OSA-positive individuals having dyslipidemia ($p = 0.03$). Furthermore, excessive daytime sleepiness (EDS) and a history of apnea were strongly associated with OSA ($p < 0.0001$ and $p = 0.02$, respectively). Additionally, high HbA1c levels ($>8\%$) and diabetic retinopathy were significantly more common in patients with OSA ($p < 0.0001$). (Table 1)

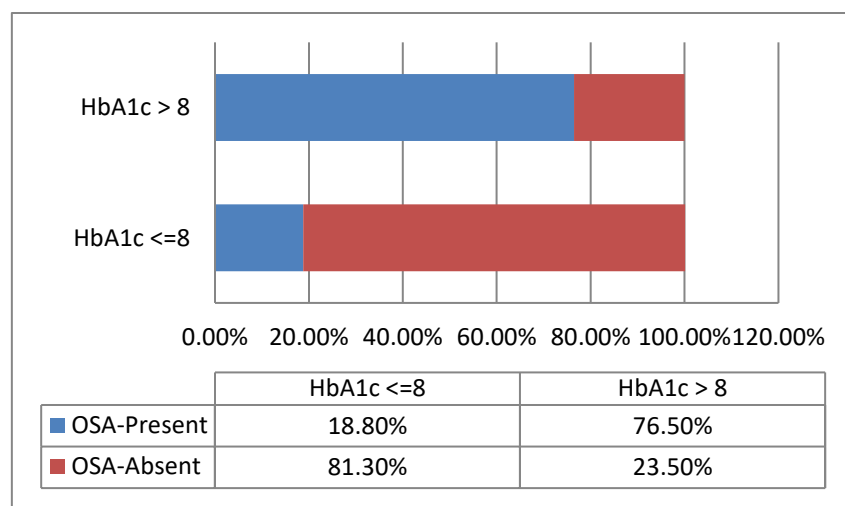
Table 1: Association of Socio-demographic, Clinical, and Biochemical Characteristics with the Presence of Obstructive Sleep Apnea (OSA) in Type 2 Diabetes Mellitus Patients

CHARACTERISTICS		OSA(Y/N)		P-value
		No	Yes	
		N (%)	N (%)	
Age in years	<50	3 (50%)	3 (50%)	0.9
	1309-1316	17 (43.6%)	22 (56.4%)	
	1309-1316	18 (38.3%)	29 (61.7%)	
	>71	4 (50.0%)	4 (50.0%)	
Gender	Female	20 (38.5%)	32 (61.5%)	0.5
	Male	22 (45.8%)	26 (54.2%)	
Hypertension	Normal	32 (42.7%)	43 (57.3%)	0.8
	Hypertension	10 (40.0%)	15 (60.0%)	

BMI kg/m² category	<25	6 (19.4%)	25 (80.6%)	0.003
	1309-1316	35 (54.7%)	29 (45.3%)	
	>30	1 (20.0%)	4 (80.0%)	
Dyslipedemia	No	30 (50.8%)	29 (49.2%)	0.03
	Yes	12 (29.3%)	29 (70.7%)	
Mallampati	Class1	42 (43.3%)	55 (56.7%)	0.1
	Class2	0 (0%)	3 (100.0%)	
Snoring	No	20 (38.5%)	32 (61.5%)	0.5
	Yes	22 (45.8%)	26 (54.2%)	
Eds	No	40 (60.6%)	26 (39.4%)	<0.0001
	Yes	2 (5.9%)	32 (94.1%)	
Ho_apnea	No	42 (45.2%)	51 (54.8%)	0.02
	Yes	0 (0%)	7 (100.0%)	
HbA1c%	≤8	26 (81.3%)	6 (18.8%)	<0.0001
	>8	16 (23.5%)	52 (76.5%)	
Diabetic retinopathy	No	35 (58.3%)	25 (41.7%)	<0.0001
	Yes	7 (17.5%)	33 (82.5%)	

A significant association was found between HbA1c levels and the presence of Obstructive Sleep Apnea (OSA) in Type 2 Diabetes Mellitus patients. Among those with HbA1c ≤8%, 81.3% did not have OSA, while only 18.8% had OSA. In contrast, 76.5% of individuals with HbA1c >8% had OSA, compared to just 23.5% without OSA ($p < 0.0001$). This indicates that higher HbA1c levels are strongly associated with an increased likelihood of OSA in these patients. (Figure 1)

Figure 1: Association between HbA1c Levels and the Presence of Obstructive Sleep Apnea (OSA) in Type 2 Diabetes Mellitus Patients



Significant differences were observed between the group with Obstructive Sleep Apnea (OSA) and the group without OSA in various parameters. The mean systolic blood pressure (SBP) was higher in the OSA group (137 mmHg) compared to the non-OSA group (131 mmHg), with a significant difference ($p = 0.03$). The OSA group also had a higher mean BMI (26.5 kg/m²) compared to the non-OSA group (25.6 kg/m²), which was statistically significant ($p = 0.03$). Fasting blood sugar (FBS) and HbA1c levels were

significantly higher in the OSA group, with mean FBS of 184 mg/dl and HbA1c of 10.5%, compared to 124 mg/dl and 8.1%, respectively, in the non-OSA group ($p < 0.0001$ for both). Neck circumference and diastolic blood pressure (DBP) showed no significant differences between the two groups ($p = 0.9$ and $p = 0.3$, respectively). These findings suggest that OSA is associated with poorer glycemic control and higher blood pressure in patients with Type 2 Diabetes Mellitus. (Table 3)

Table 2: Comparison of Clinical and Biochemical Parameters between Type 2 Diabetes Mellitus Patients with and without Obstructive Sleep Apnea (OSA)

PARAMETERS	OSA(Y/N)				P value
	No		Yes		
	Mean	SD	Mean	SD	
SBP mm of Hg	131	14	137	13	0.03
DBP mm of Hg	79	6	80	7	0.3
BMI kg/m2	26.5	1.7	25.6	2.1	0.03
Neck circumference in cm	36.2	2.6	36.3	3.0	0.9
FBS mg/dl	124	25	184	57	<0.0001
HbA1C%	8.1	.9	10.5	1.7	<0.0001

DISCUSSION

The current study aimed to assess the association between Obstructive Sleep Apnea (OSA) and various clinical, biochemical, and socio-demographic characteristics in patients with Type 2 Diabetes Mellitus (T2DM). Our findings underscore the significant relationships between OSA and several key parameters, notably body mass index (BMI), dyslipidemia, excessive daytime sleepiness (EDS), a history of apnea, and glycemic control.

In our study, most participants were over the age of 50. Interestingly, a higher percentage of women (67%) had OSA compared to men (33%), despite the mean HbA1c being similar in both genders. Tomilito et al.¹⁵ investigated the relationship between sleep quality and type 2 diabetes and found that changes in sleep duration increased the risk of type 2 diabetes in middle-

aged women, but not in men. While our findings were consistent with these results, we observed no gender-based predisposition regarding the severity of OSA. Other studies, such as one by Yagi et al.¹⁶ suggested that gender differences in OSA severity may exist, but they emphasized the need for more long-term studies to draw definitive conclusions.

In line with existing literature, our study revealed a high prevalence of OSA among T2DM patients, with those having a higher BMI and poor glycemic control (measured by HbA1c levels) being more likely to exhibit OSA. The association between higher BMI and OSA is well-documented. In this cohort, 64% of participants had a BMI within the overweight range (1309-1316 kg/m²), and a significant proportion of these individuals experienced OSA ($p = 0.003$). This finding mirrors studies that suggest obesity

is one of the most important risk factors for OSA, as excess adiposity, particularly in the upper airway, predisposes individuals to airway obstruction during sleep.¹³⁰⁹⁻¹³¹⁶

Furthermore, the association between dyslipidemia and OSA observed in our study ($p = 0.03$) has been reported in previous research.²² OSA leads to intermittent hypoxia and increased sympathetic activity, which may impair lipid metabolism and contribute to dyslipidemia. Elevated triglycerides and low HDL cholesterol are often observed in patients with OSA, further complicating the cardiovascular risks faced by patients with T2DM.²²

Our findings highlight the significant impact of poor glycemic control in patients with obstructive sleep apnea (OSA). The OSA group exhibited higher HbA1c levels (mean HbA1c 10.5% vs. 8.1% in the non-OSA group, $p < 0.0001$), suggesting that OSA negatively affects diabetes management. OSA increases the frequency of intermittent hypoxia, which may lead to insulin resistance, further impairing blood glucose control in individuals with diabetes.²³ This aligns with our observation that patients with HbA1c $>8\%$ had a significantly higher likelihood of having OSA (76.5% vs. 23.5%, $p < 0.0001$). Previous studies support these findings, with Loops et al.⁸ reporting that 45% of diabetics had poor sleep quality, and Konatson et al.⁹ noting that 71% of patients with uncontrolled diabetes exhibited low sleep quality. In Iran, Ghavami et al.²⁴ found that 42.6% of diabetics had poor sleep quality, and Monjamed et al.²⁵ reported that 40.7% of diabetics with complications experienced poor sleep. Additionally, patients with OSA are at a higher risk of diabetic complications, such as diabetic retinopathy, as observed in our study ($p < 0.0001$). The intermittent hypoxia associated with OSA is believed to contribute to the development of diabetic microvascular complications, including retinopathy.^{6,26}

Interestingly, despite a significant association between OSA and the clinical parameters of hypertension and BMI, we found no significant relationship between age and gender with OSA

prevalence in our study cohort. These findings suggest that the impact of OSA in T2DM patients may be more related to modifiable risk factors, such as BMI and glycemic control, rather than non-modifiable factors like age and gender. Previous research has indicated that while age and male gender are often linked to an increased risk of OSA in the general population, in the context of T2DM, metabolic factors like obesity and poor glycemic control may play a more substantial role in the development and severity of OSA.²⁷

In terms of blood pressure, our study found that patients with OSA had a significantly higher systolic blood pressure (SBP) than those without OSA (137 mmHg vs. 131 mmHg, $p = 0.03$). This is consistent with the well-established link between OSA and hypertension. The intermittent hypoxia and frequent arousals during sleep seen in OSA patients contribute to sympathetic nervous system activation and fluid retention, both of which can lead to elevated blood pressure (Pepperell et al., 2002). However, we found no significant difference in diastolic blood pressure between the two groups, which might reflect the complexity of blood pressure regulation in the context of OSA and T2DM.

The findings from this study are consistent with current clinical evidence and emphasize the importance of addressing OSA in patients with T2DM, particularly those with higher BMI, poor glycemic control, dyslipidemia, and excessive daytime sleepiness. Routine screening for OSA in this high-risk population may help improve both diabetes and sleep apnea management, thereby reducing the associated cardiovascular and metabolic risks.

Limitations: This study had several limitations. The cross-sectional design limits our ability to establish causal relationships between OSA and the observed clinical parameters. Moreover, polysomnography, the gold standard for diagnosing OSA, was not performed; instead, clinical and self-reported symptoms were used to categorize OSA status. Future studies with objective diagnostic methods and a longitudinal

design are warranted to confirm these findings and elucidate

the mechanisms underlying the relationship between OSA and T2DM.

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