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Impact of Sleep Patterns on Glycemic Control in Type 2 Diabetes Mellitus

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ABSTRACT

Background: Lack of sleep is harmful to your mental and physical health. Multiple studies have shown that insulin sensitivity and glucose metabolic regulation are both negatively impacted by inadequate sleep.
Objectives: To determine whether there is a correlation between the amount and quality of sleep and blood sugar levels in those who suffer from type 2 diabetes mellitus.
Materials and methods: At the National Centre for Diabetes in Baghdad, 224 people with type 2 diabetes who had been on anti-diabetic medication for at least a year participated in a 13-month cross-sectional study from February 2024 to February 2025. The Pittsburgh Sleep Quality Index was used to evaluate the prior month's sleep length and quality. Other information gathered included demographics, lifestyle variables, co-morbidities, length of diabetes, treatment compliance, and HbA1c levels.
Results: Most patients (80.8%) had poor sleep quality, and 68.3% had poorly managed type 2 diabetes mellitus. The results showed that low quality sleep (P-value = 0.001) and inadequate total nighttime sleep (P-value = 0.002) were two independent risk factors for inadequate glycemic management. In addition, the Pittsburgh Sleep Quality Index showed a somewhat positive connection with HbA1c levels, suggesting that greater levels of HbA1c were linked to worse sleep quality. However, there was a small but statistically significant negative connection between HbA1c levels and the amount of time people slept (P-value = 0.001 and 0.002, respectively), indicating that less sleep is associated with worse glycemic management.
Conclusion: There is a substantial correlation between insufficient glycemic control and poor sleep quality/length, both of which have a major influence on the management of type 2 diabetes mellitus.
Keywords: Diabetes Mellitus; Sleep Quality; Type 2 diabetes mellitus; Glycated hemoglobin.

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INTRODUCTION

Both insufficient insulin production by the pancreas and improper insulin utilization by the body lead to the development of severe and long-lasting diabetes mellitus (DM) [1]. Factors like urbanization, obesity, sedentary lifestyles, and ageing are contributing to the rising global prevalence of DM [2]. With an estimated 537 million individuals (or 10.5% of the population) living with DM in 2021, healthcare expenses for the condition reached $966 billion worldwide [3]. Diabetic complications are two to four times more common in people with diabetes than in the overall population, and they are the main cause of death and disability globally [4].

New risk factors for type 2 diabetes mellitus (T2DM) have recently been investigated, as have the links between poor glucose metabolism and insufficient sleep [5]. Nowadays, many people have chronic partial sleep deprivation as a result of irregular bedtimes and other interruptions to their sleep routines [6]. To stay alive, our bodies require sleep. During this time, the body secretes a plethora of hormones that play a pivotal role in regulating growth, sleep, energy, metabolism, and endocrine functions [7]. Decreased sleep duration and quality may have a negative impact on glucose management and raise the risk of T2DM, according to recent epidemiological and laboratory studies [8].

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Obesity and T2DM are metabolic diseases, and a recent study outlined various behavioral and molecular variables that may link sleep disruption with these conditions [9]. DM risk factors, such as obesity, visceral adiposity, and advanced age, have been associated with sleep-related respiratory disorders [10]. Reduced insulin sensitivity and increased food intake seem to be the primary mechanisms via which sleep deprivation impacts energy metabolism. In adults and teenagers alike, sleep disruptions have been linked to an increase in body fat and a host of health problems related to obesity [11]. Disruption of nocturnal sleep is associated with diminished secretion of testosterone and melatonin, indicating a possible connection between sleep disruption and DM via the processes of these hormones [12].

The primary difficulty facing the Iraqi population with T2DM is glycemic management. However, no research has been conducted on sleep duration and quality in individuals with DM. The aim of this study is to assess the association between sleep quality, sleep duration, and glycemic control in T2DM patients and to identify modifiable predictors of poor diabetes outcomes.

MATERIALS AND METHODS

Study design, setting, and time

A cross-sectional study with analytic components was conducted at the National Center for Diabetes, Al-Mustansiriya University, Baghdad during a period of 13 months from February 2024 to February 2025.

Study population and sample size

This study included 224 adult patients diagnosed with T2DM for more than one year on anti-diabetic medications. Patients with severe complications that make the interview not feasible, with connective tissue disease, those who were diagnosed with mental disorder and on treatment, patients with any comorbid conditions that might affect sleep quality, such as psychiatric disorders (depression, anxiety), respiratory diseases [chronic obstructive airway disease (COPD), asthma], or hyperthyroidism, and those who refused to participate in the study were excluded.

Sample size

The sample size was calculated using the following equation: n= $(z^2pq)/d^2$ [13]. n= Sample size, z= 1 - $\alpha/2$ percentile of a standard normal distribution = 1.96, d= Absolute precision = 0.05, p= Expected proportion (The reported prevalence of T2DM in Iraqis varies from 8.5% to 13.9%) [14], q= 1-p, the target sample size for the study was 185. To account for a 20% non-response rate, the final sample size was adjusted to 224 patients.

A simple random sample technique was used to collect the eligible target patients. It took how long to finish the interview with each patient to figure out how to go on to the next one. Prior to beginning data collecting, a pilot study was conducted with 10 patients to assess the research tool's clarity and application, the time required to complete the questionnaire, and potential challenges that may arise throughout the study.

Data collection

It was done by using a standard questionnaire to achieve the aim of the current study. The questionnaire consists of two parts:

1. Demographic and clinical characteristics and general variables concerning diabetes as age and sex, marital status, occupation, education level, smoking status, history of chronic diseases, duration of DM, adherence to treatment, and glycated hemoglobin (HbA1c) level. Hb1Ac cutoff of 7% is considered good DM management by the American Diabetes Association and this test was performed as a part of the study [15]. The interviewer determined the respondent's body mass index (BMI) by dividing their weight (in kilograms) by the square of their height (in meters). This calculation was part of the questionnaire. All of the participants use the same scale to measure their height and weight. There were three categories used to categorize patients: normal (18-24.99 kg/m^2), overweighed (25-29.99 kg/m^2), and obese ($\geq$ 30 kg/m^2) [16].
2. The second questionnaire assesses sleep quality and duration using the Pittsburgh Sleep Quality Index (PSQI), which has been extensively tested and validated across many clinical circumstances and non-clinical samples [17]. This is an instrument that measures sleep quality over a duration of one month. The interviewer provided brief, neutral explanations or clarifications of the question if the participant did not understand some terms, ensuring the participant understood what was being asked. The patients did not fill out the questionnaire on their own; the interviewer collected all responses. This tool includes seven components that assess different aspects of sleep. The component scores include [17]:

    1. Quality of subjective sleep: Evaluates the individual's perception of their sleep quality.
    2. Latency of sleep: Measures the time it takes to fall asleep.
    3. Duration of sleep: Assesses the total sleep time.
    4. Efficiency of Habitual Sleep: Looks at the ratio of sleep over time in bed.
    5. Disturbances of sleep: Evaluates the frequency of disruptions in sleep.
    6. Use of Sleeping Medication: Checks if any medication is used to help with sleep.
    7. Daytime Dysfunction: Considers the impact of sleep problems on daytime activities.

Each component is rated on a scale from 0 to 3, where 0 indicates no difficulty and 3 indicates severe difficulty. The total score can range from 0 to 21, with higher scores indicating poorer sleep quality. A global score of more than 5 indicates poor sleep quality.

Regarding duration of sleep, the American Academy of Sleep Medicine and Sleep Research Society advise that the average adult should consistently have seven or more hours of sleep per night to enhance overall health [18].

Ethical considerations and official approvals

The research followed all of the rules set out by the College of Medicine/Ibn Sina University of Medical and Pharmaceutical Sciences' ethical guidelines as well as the 1975 Declaration of Helsinki, as updated in October 2024. Each participant provided their informed consent after receiving a detailed description of the study's goals and procedures. Instead of names, identifying codes were utilized. All material was saved securely on a password-protected laptop and was accessed only for research purposes.

Statistical Analysis

We used SPSS 26 (IBM Corp., Armonk, NY) to analyze the data. Mean ± standard deviation (SD) and ranges were used to display continuous values, whilst frequencies and percentages were used to describe categorical variables. The Shapiro-Wilk test and Q-Q plots were used to evaluate normality. Logistic regression was performed with poor glycemic control as the dependent variable, including factors significant in the binary analysis as independent variables. Independent t-tests compared continuous variables by HbA1c level. Pearson's correlation coefficient (r) assessed associations between HbA1c, PSQI, and sleep duration. A P-value < 0.05 was considered statistically significant.

RESULTS

The age of patients ranged from 22 to 59 years with a mean of 47.81 ± 7.3 years; 149 (66.5%) of them were males; 176 (76.8%) were living in urban area; 83 (37.1%) were employees; 122 (54.5%) had finished secondary school; 78 (34.8%) were overweighed; 42 (18.8%) were current smokers; and 89 (39.7%) were hypertensive patients. We noticed that 103 (46%) of patients had diabetes for 1-5 years duration; 153 (68.3%) were poorly controlled; 116 (51.8%) of them were sleeping for ≥ 7 hours at night, and 181 (80.8%) of them showed poor quality of sleep (Table 1).

The strongest correlations between sleep pattern and poor sleep quality were observed among participants with the lowest educational level (P-value = 0.017), those who were obese (P-value = 0.005), and those with poorly controlled diabetes (P-value = 0.001). However, no statistically significant associations (P-value > 0.05) were found between sleep pattern and other demographic variables (Table 2).

Four factors emerged as important independent risk factors for poor T2DM control. These included lower educational level (illiteracy: OR = 4.42, 95% CI: 1.48-8.71), obesity (OR = 3.82, 95% CI: 1.77-6.29), poor sleep quality (OR = 8.28, 95% CI: 3.14-17.59), and inadequate night sleep (<7 hours; OR = 2.02, 95% CI: 1.21-5.32) as shown in Table 3.

A statistically significant moderate positive correlation was found between HbA1c levels and PSQI scores (r = 0.492, P-value = 0.001), while a weak negative correlation was observed between HbA1c levels and actual sleep duration (r = -0.372, P-value = 0.002), as illustrated in Table 4.

DISCUSSION

Sleep allows the body to regenerate and the brain to operate, it is crucial to both mental and physical health. Lack of sleep has detrimental effects on one's mental and physical health, making one more irritable, less focused, and more exhausting. Several health problems, including DM, cardiovascular disease, depression, and impaired decision-making, are linked to insufficient sleep length and frequent sleep disturbances [18, 19]. This study found that poor T2DM control is associated with poor quality of sleep and inadequate actual night sleep.

In this study, most diabetics (80.8%) didn't show good sleep quality. Moreover, poor sleep quality is 8.28 more likely to increase the poor T2DM controlling rate, and inadequate actual night sleep (Sleeping for less than seven hours) is 2.02 more likely increase the poor T2DM controlling prevalence. A similar result was found in study conducted by Barakat et al. in Jordan 2019 when they found that 81% of patients having a poor quality of sleep [20], while different findings were obtained in studies conducted by Kara et al. in Turkey 2015 (63.3%) [21], Tsai et al. in Taiwan 2012 (34.8%) [22], and Shibabaw et al. in Ethiopia 2023 [23]. Variations within research may be attributable to discrepancies in sample size and

Table 1. Distribution of study 244 patients according to the demographic and clinical characteristics*.

Variable	Number	Percentage
Age (Year)		
< 30	37	16.5
30-49	168	75.0
≥ 50	19	8.5
Gender		
Male	149	66.5
Female	75	33.5
Residence		
Urban	172	76.8
Rural	52	23.2
Occupation		
Student	32	14.3
Employee	83	37.1
Housewife	44	19.6
Private work	65	29.0
Educational Level		
Illiterate	7	3.1
Read and write	5	2.2
Primary	15	6.7
Intermediate	29	12.9
Secondary School	78	34.8
University	61	27.2
Higher Education	29	12.9
BMI Level*		
Normal	78	34.8
Overweight	92	41.1
Obese	54	24.1
Smoking status		
Current smoker	42	18.8
Non-smokers	182	81.2
Other chronic diseases		
Hypertension	89	39.7
Cardiac disease	33	14.7
Renal disease	41	18.3
COPD*	21	9.4
Non	96	42.9
Duration of Diabetes (Year)		
1-5	103	46.0
6-9	71	31.7
≥ 10	50	22.3
HbA1c (%)*		
≤ 7 (Well controlled)	71	31.7
> 7 (Poorly controlled)	153	68.3
Duration of actual sleep (Hrs.)*		
< 7	108	48.2
≥ 7	116	51.8
Quality of sleep level		
Poor	181	80.8
Good	43	19.2

* BMI: Body mass index, COPD: Chronic obstructive pulmonary diseases, HbA1C%: Glycated hemoglobin, Hrs.: Hours.

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Table 2. Association between sleep pattern and patients' demographic characteristics.

Variable	Sleep quality		Total (n, %) n=224	P-value
	Poor (n, %) n=181	Good (n, %) n=43		
Age (Year)				
< 30	28 (75.7)	9 (24.3)	37 (16.5)	
30–49	139 (82.7)	29 (17.3)	168 (75.0)	0.437
≥ 50	14 (73.7)	5 (26.3)	19 (8.5)	
Gender				
Male	117 (78.5)	32 (21.5)	149 (66.5)	0.221
Female	64 (85.3)	11 (14.7)	75 (33.5)	
Residence				
Urban	141 (82.0)	31 (18.0)	172 (76.8)	0.417
Rural	40 (76.9)	12 (23.1)	52 (23.2)	
Occupation				
Student	27 (84.4)	5 (15.6)	32 (14.3)	
Employee	65 (78.3)	18 (21.7)	83 (37.1)	0.085
Housewife	31 (70.5)	13 (29.5)	44 (19.6)	
Private work	58 (89.2)	7 (10.8)	65 (29.0)	
Educational level				
Illiterate/Read and write	11 (91.7)	1 (8.3)	12 (9.0)	
Primary	14 (93.3)	1 (6.7)	15 (11.2)	
Intermediate	26 (89.7)	3 (10.3)	29 (21.6)	0.017
Secondary School	67 (85.9)	11 (14.1)	78 (58.2)	
University/Higher Education	63 (70.0)	27 (30.0)	90 (61.6)	
BMI Level				
Normal	54 (69.2)	24 (30.8)	78 (34.8)	
Overweight	79 (85.9)	13 (14.1)	92 (41.1)	0.005
Obese	48 (88.9)	6 (11.1)	54 (24.1)	
Smoking Status				
Current smoker	33 (78.6)	9 (21.4)	42 (18.8)	0.683
Non-smokers	148 (81.3)	34 (18.7)	182 (81.3)	
Other chronic diseases				
Yes	104 (81.3)	24 (18.8)	128 (57.1)	0.844
No	77 (80.2)	19 (19.8)	96 (42.9)	
Duration of Diabetes (Years)				
1–5	84 (81.6)	19 (18.4)	103 (46.0)	
6–9	55 (77.5)	16 (22.5)	71 (31.7)	0.645
≥ 10	42 (84.0)	8 (16.0)	50 (22.3)	
HbA1c (%)				
≤ 7 (Well controlled)	44 (62.0)	27 (38.0)	71 (31.7)	0.001
> 7 (Poorly controlled)	137 (89.5)	16 (10.5)	153 (68.3)	

cultural factors. Furthermore, the PSQI score cutoff points varied among these trials, and the majority of T2DM patients experienced significant comorbidities, exacerbating poor sleep quality.

The lack of education and obesity are the primary contributors of uncontrolled T2DM. Obesity, especially with surplus abdominal adiposity, results in the buildup of fatty acids and inflammatory agents that might disrupt insulin function [24]. Individuals with elevated health literacy are more inclined to comprehend their ailment, comply with treatment regimens, and make informed lifestyle decisions [25].

A Comparable findings were reported by Al-Humairi et al. in Iraq 2018 [26], Bhagat et al. study in India 2023 [27] and in Shibabaw et al. in Ethiopia 2023 [23] studies when they concluded that poor sleep quality, both short and long sleep duration were statistically associated with poor glycemic control. Sleep quality and duration are important determinants of glycemic regulation in T2DM. Two complementary mechanisms have been proposed. First, sleep disturbance can engage the cerebral cortex, hypothalamus, and limbic system, triggering sympathetic activation and hypothalamic-pituitary-adrenal axis responses with increased catecholamines and cortisol that may raise plasma glucose. Second, sleep deprivation has been shown in physiological studies to elevate cortisol and increase insulin resistance, contributing to poorer glycemic control [28]. Clinically, this

Table 3. Logistic regression analysis of possible risk factors for poor diabetes control*.

Variables	Odd's ratio	95% CI for odd's ratio
Educational level (Reference is higher education)		
Illiterate / read and write	4.42	1.48-8.71
BMI level (Reference is normal BMI level)		
Obese	3.82	1.77-6.29
Characteristics of sleep		
Poor sleep quality	8.28	3.14-17.59
Less than seven hours of actual night sleep	2.02	1.21-5.32

* Poor diabetes control was used as the dependent variable.

Table 4. Correlation between HbA1c level and sleep characteristics.*.

Variable	HbA1c (%)	
	r	P-value
PSQI*	0.492	0.001
Duration of actual sleep (hours)	- 0.372	0.002

* PSQI: Pittsburgh Sleep Quality Index.

translates to associations between inadequate sleep and impaired glucose metabolism and insulin sensitivity. For example, Martorina et al. (2019) reported that insufficient sleep was linked to poorer glycemic regulation in Brazil [29], and other studies have found that shorter sleep duration correlates with diminished insulin sensitivity and that sleep loss elevates cortisol, a hormone linked to insulin resistance. Also, people with T2DM have a much harder time keeping their weight in check when they don't get enough sleep, since this is associated with an increase in the hunger hormone ghrelin and a decrease in the satiety hormone leptin [22]. Sleeping trouble can be caused by a number of things, including common mood disorders and the distressing effects of DM. Not only does coffee disrupt sleep, but many medications designed to treat multiple conditions at once, including beta-blockers or diuretics, can do the same. When considered collectively, these DM-related factors underscore the need of screening for sleep problems in the management of DM and may provide insight on the reasons why individuals with DM experience sleep difficulties at a higher frequency [21].

Because of these limitations, one should exercise caution when interpreting the data. To begin, there is no way to definitively state a cause-and-effect relationship between sleep features and glucose regulation due to the cross-sectional nature of the studies. Furthermore, memory or reporting mistakes may introduce bias into self-reported data about the amount and quality of sleep. Results may not be generalizable to other populations or healthcare systems due to the third constraint, which is that the study only involves one DM center. Furthermore, significant confounding variables such as sleep disorders, medication non-adherence, and dietary patterns were not fully controlled for. Finally, the findings may not be applicable outside of the Iraqi and Middle Eastern population that was the study's cultural environment.

CONCLUSION

This study found that the amount and quality of sleep are important modifiable risk factors that affect glycemic control in T2DM. An important link between insufficient sleep and uncontrolled diabetes. The findings emphasize the significance of incorporating sleep evaluation into routine DM treatment plans. An intervention that could improve glycemic outcomes while being cost-effective is sleep hygiene education. These findings support the need for large-scale interventions to improve sleep health and decrease healthcare costs and morbidity associated with diabetes, from a public health standpoint. A new era of therapeutic and preventative approaches has dawned with the recognition of sleep as a modifiable health determinant. Hence, it is imperative that public health workers, lawmakers, and healthcare providers work together to include sleep health as an integral part of effective, patient-centered treatment in complete DM management programs. In more complicated cases of diabetes, particularly when sleep difficulties are present, it may be appropriate to refer patients to behavioral health professionals or sleep specialists for more in-depth evaluations and treatment options. Additional longitudinal research and randomized controlled trials are required to fully comprehend the long-term effects of sleep treatments on DM outcomes.

ETHICAL DECLARATIONS

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Ethics Approval and Consent to Participate

All procedures were carried out in accordance with the principles outlined in the 1975 Declaration of Helsinki and the College of Medicine's and Ibn Sina University's Medical and Pharmaceutical Sciences' ethical guidelines. Following a thorough explanation of the study's purpose and methods, each patient gave their informed consent. Codes for identification purposes were used in lieu of the names. The data was utilized solely for research reasons, and all information was securely stored on a laptop that required a password.

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Consent for Publication

Not applicable as no need for participants photos or personal information.

Availability of Data and Material

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request, subject to ethical approval and data sharing agreements.

Competing Interests

The authors declare that there is no conflict of interest.

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Use of Artificial Intelligence

The authors used artificial intelligence for minor language editing; all scientific content and interpretation were done by the author.

Authors' Contributions

All authors were responsible for conceptualization, design, and writing the manuscript. All authors read and approved the final version of the manuscript.

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