Clinical and Experimental Health Sciences

Analysis of Sleep Quality and Related Factors in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Objective: Diabetes Mellitus is one of the most common diseases which affects life quality. The aim of the study was to examine sleep quality and sleeping related factors in patients with Type 2 Diabetes Mellitus (T2DM).

Methods: An observational, cross-sectional study was conducted between 01.09.2018-01.12.2018 in Sisli Hamidiye Etfal Research and Training Hospital. Sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI) questionnaire. Moreover, we used Patient Health Questionaire-9 (PHQ-9) scale to diagnose depression degree.

Results: The study included 227 individuals with T2DM, with a mean age of 60.26 ± 9.13 years, 59.5% of whom were female. The mean disease duration was 10.46 ± 7.65 years, and 70% had accompanying hypertension. Poor sleep quality (PSQI ≥ 6) was identified in 54.2% of participants, with significantly poorer sleep quality observed in females, obese individuals, unemployed participants, and those with diabetes-related complications such as neuropathy and retinopathy ($p < .05$). Although no significant correlation was found between PSQI and glycemic control markers (HbA1c or fasting blood glucose), participants with higher levels of these markers tended to report poorer sleep. Depression severity (PHQ-9) was strongly associated with poor sleep quality ($p < .001$), with higher scores observed in females, low-income and unemployed participants, obese individuals, and those with diabetes-related complications.

Conclusion: This study underscores the high prevalence of sleep disturbances among individuals with T2DM, with factors such as female gender, obesity, unemployment, hypertension, and diabetes-related complications like neuropathy and retinopathy significantly impairing sleep quality. The bidirectional relationship between poor sleep and depression highlights the need for integrated mental health support in diabetes care. Although no significant correlations were found between sleep quality and glycemic markers, trends suggest a potential link, warranting further research.

Keywords: Diabetes Mellitus, Sleep Disorders, Quality of Life, Diabetic Neuropathy, Pittsburgh Sleep Quality Index

1. INTRODUCTION

Diabetes mellitus (DM) is a chronic disease characterized by defects in insulin secretion and action, requiring continuous care (1). The prevalence of diabetes is increasing globally. 10.5% of the American population (roughly 35 million individuals) were living with DM in 2018, and the incidence in Türkiye was calculated at 13.5% in the same year (2).

Among the various forms of DM, Type 2 Diabetes Mellitus (T2DM) is linked with comorbidities like cardiovascular disease, diabetic neuropathy, retinopathy, and nephropathy. These complications adversely affect quality of life (3-4). Research indicates that sleep disturbances are prevalent with T2DM compared to the general population (5-6).

Sleep is a physiological need for maintaining health, quality of life, and daily performance (7). Sleep disturbances, including insufficient or irregular sleep, contribute to cognitive dysfunction, psychological stress in general health (8). In T2DM, these disruptions are further compounded by complications such as peripheral neuropathy and psychological stress. Painless diabetic neuropathy has been shown to be associated with poor sleep quality (9).

The relationship between T2DM and sleep quality is bidirectional. Poor sleep exacerbates glycemic dysregulation by increasing insulin resistance, reducing glucose tolerance, and elevating stress hormone levels (10). Conversely,

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T2DM-related complications, including sleep apnea, restless leg syndrome, and other sleep disorders, worsen metabolic outcomes (11). Chronic sleep deprivation is a risk factor for the development of T2DM, mediated through mechanisms like obesity and metabolic syndrome (12).

This article examines the interplay between T2DM and sleep quality, focusing on the prevalence of sleep disturbances, and underlying mechanisms for improving outcomes of individuals with T2DM.

2. METHODS

Individuals who had been diagnosed with T2DM, who applied to the Family Practice Outpatient Clinic of Health Scince University (HSU) Sisli Hamidiye Etfal Training and Research Hospital for routine check-ups between 01.09.2018-01.12.2018, were included in the study. Patients who had T1DM diagnosis, who used medicine that could affect sleep quality, who had a psychiatric disorder, who received treatment for a diagnosed sleep problem, and who did not agree to participate were excluded from the study.

In this study, a power analysis was conducted to ensure the adequacy of the sample size by using open source R software (Version 4.3.3.). The sample size required for this study was calculated based on an effect size (d) of 0.415, a significance level (α) of 0.05, and a desired power of 0.80. Using these parameters, the sample size was determined to be 227 individuals with 95% reliability, calculated based on the number of patients with Type 2 diabetes who visited the outpatient clinic during the same period in the previous year, which is consistent with typical sample size estimations for non-parametric tests like the Wilcoxon-Mann-Whitney test (13).

2.1. Data Collection Tools

Sociodemographic Information Form, Pittsburgh Sleep Quality Index (PSQI), and Patient Health Questionnaire-9 (PHQ-9) were used in order to collect data for the study, and the questionnaire was administered face-to-face. The Sociodemographic Information Form was developed by the researchers in line with similar studies, and it consisted of descriptive questions such as the individual's age, gender, marital status, educational status, and disease (how long the patient has been diagnosed with the disease).

Following the administration of the questionnaire, the patients' HbA1c and fasting blood glucose (FBG) values obtained in the routine check-ups were examined over the system. Those who had a HbA1c level of 7 and below were evaluated as under control. Those who had a FBG level of 130 and below were evaluated as normal FBG (14).

2.2. Pittsburgh Sleep Quality Index

Pittsburgh Sleep Quality Index (PSQI) is a scale used to determine the sleep quality of an individual within the last month, whether the individual experienced a sleep disorder, and the severity of this disorder. The scale has a total of 24 questions. With the scale, sleep is evaluated under 7 subscales, which are subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The total PSQI score is calculated by adding up the scores obtained from the seven subscales. The score of each subscale varies between 0 and 3. The total PSQI score, on the other hand, ranges from 0 to 21. Those who score 5 and below in total are evaluated to have "good" sleep quality. The Turkish reliability and validity study of the scale was conducted by Agargun et al. (1996), which they reported a Cronbach's alpha coefficient of 0.77 for the overall scale (15). Consistent with Agargun et al., we found Cronbach's alpha coefficient of 0.755, indicating good internal consistency (The mean values (M) and standard deviations (SD) for the subscales of PSQI were as follows: subjective sleep quality (M = 0.634, SD = 0.965), sleep latency (M = 1.59, SD = 1.06), sleep duration (M = 1.04, SD = 1.07), habitual sleep efficiency (M = 1.39, SD = 0.67), sleep disturbances (M = 0.25, SD = 0.78), and use of sleeping medication (M = 0.41, SD = 0.76).

2.3. Patient Health Questionaire-9

PHQ-9 is a scale developed to diagnose depression and to determine its severity by questioning the 9 diagnostic criteria included in the Diagnostic and Statistical Manual of Mental Disorders (DSM-4). Kroenke, Spitzer, and Williams introduced the Patient Health Questionnaire-9 (PHQ-9) as a brief measure for assessing depression severity (16). The authors reported a high internal consistency for the PHQ-9, with a Cronbach's alpha of 0.89, indicating that the items on the scale are strongly correlated and effectively measure the underlying construct of depression severity. The Turkish validity and reliability of the scale was conducted by Sari et al. in 2016. In their study, they reported the **Cronbach's alpha** for the PHQ-9 to be **0.84,** which reflects a high level of internal consistency in this population as well (17).

In this study, "not at all" is scored as 0, and "nearly every day" is scored as 3. The minimum score to be obtained from the scale is 0, while the maximum score is 27. According to the original questionnaire scoring evaluation, 1-4 points indicate minimal depression, 5-9 points mild depression, 10-14 points moderate depression, 15-19 points moderately severe depression, and 20-27 points severe depression. As the score obtained increases, the severity of depression increases as well (17). In our study, we found a high internal consistency, with a Cronbach's alpha of 0.874. M and SD for the nine criteria of PHQ-9 were as follows, respectively: M = 0.894 (SD = 1.07), M = 1.00 (SD = 1.06), M = 1.12 (SD = 1.28), M = 1.34 (SD = 1.08), M = 0.67 (SD = 1.03), M = 0.55 (SD =

0.95), M = 0.37 (SD = 0.77), M = 0.33 (SD = 0.74), and M = 0.22 (SD = 0.60).

2.4. Statistical Method

SPSS 16.0 (Chicago, U.S.A.) for Windows was used for statistical analyses. Frequencies and percentages were calculated for categorical variables. Standard deviation, minimum, maximum, and median were employed for numerical variables. Prior to conducting the statistical analyses, the normality of the data for each variable was assessed using the Shapiro-Wilk test. The results of this test revealed that the normality assumption was not satisfied for the variables ($p<.05$). Consequently, non-parametric methods were employed to analyze the data. Mann-Whitney U test was performed to compare two independent groups, while the Kruskal-Wallis test was used for comparisons involving more than two independent groups. Due to the violation of the normality assumption, Spearman's rank correlation was utilized to investigate the relationship between the variables. Significance level was set at $p<.05$.

3. RESULTS

227 individuals with T2DM were included in the study. 135 (59.5%) of the participants were female, and 92 (40.5%) were male. The mean age of the participants was found as 60.26±9.13 (min=40, max=87). When the participants were asked about the duration of their diabetes disease, the mean duration was determined to be 10.46±7.65 (min=1, max=35) years. Those who were treated for 11 years and above was 87 (38.3%) individuals. The number of the patients diagnosed with accompanying hypertension was 159 (70%). The number of patients who had one or a few of the complications related to diabetes (retinopathy, neuropathy, nephropathy, or diabetic foot) was determined to be 37 (38.3%). And, the number of the patients who were using insulin injection in addition to oral medication was found as 80 (35.2%).

The mean score of the participants obtained from PSQI was determined to be 6.79±4.06 (min=0, max=19). The rate of those with poor sleep quality was 54.2% (n=123). As shown in Table 1, it was determined that there was no significant relationship of sleep quality with age, education level, income level, and smoking status ($p\geq.05$). It was found that the sleep quality of female patients was significantly poorer than that of male patients, as was the sleep quality of obese patients than that of non-obese patients ($p=.000$). The sleep quality of unemployed patients was significantly poorer compared to employed patients ($p=.001$). The sleep quality of the patients who had the disease for 11 years and above was determined to be poorer than those who had the disease for 10 years and below ($p=.024$). The PSQI scores of the diabetic patients with accompanying hypertension were higher compared to those with no accompanying hypertension ($p=.001$). It was also found that the sleep quality of the patients who had diabetic complications of retinopathy ($p=.047$); and neuropathy ($p=.049$) was significantly poorer compared to those who did not have these complications.

According to the laboratory test results of the patients, it was found that BFG mean value was 149.26±53.78 (min=56, max=384), and HbA1c mean value was 7.39±1.52 (min=5.10, max=13.0). When the relationship between PSQI, HbA1c, and BFG was examined through correlation analysis (Table 3), no significant association was found between PSQI and HbA1c or between PSQI and BFG. Similarly, no significant difference in PSQI scores was observed between the group with T2DM under control and the group with uncontrolled T2DM in terms of HbA1c and BFG values ($p=.343$ and $p=.107$, respectively). However, as shown in Table 1, participants with elevated HbA1c and BFG levels demonstrated poorer sleep quality.

The mean score of the patients obtained from PHQ-9 was 6.52±5.42 (min=0, max=23) as presented in Table 2. Women had significantly higher PHQ-9 scores (7.93 ± 5.67) compared to men (4.46 ± 4.30), indicating a significant difference in PHQ-9 between genders ($p=.000$). Participants in the low-income group (≤1700 TL) had the highest mean PHQ-9 scores (7.91 ± 5.77), followed by the medium-income group (6.00 ± 5.26) and the high-income group (5.18 ± 4.58). The differences across income levels were statistically significant ($p=.017$). Unemployed participants exhibited significantly higher PHQ-9 scores (7.97 ± 5.86) compared to employed individuals (4.81 ± 4.29) ($p=.000$). Participants with BMI ≥ 30 had significantly higher PHQ-9 (7.86 ± 5.55) compared to those with a BMI of 25–29.9 (4.90 ± 4.81), with a p-value of .000. There was also no statistically significant difference in PHQ-9 scores between participants with a disease duration of <11 years (6.21 ± 4.79) and those with ≥11 years (7.02 ± 6.31) ($p=.302$). Participants with HbA1c ≥ 7 had higher PHQ-9 scores (6.94 ± 5.86) compared to those with HbA1c < 7 (6.13 ± 4.98), but the difference was not statistically significant ($p=.260$). Participants on insulin and oral treatment had significantly higher PHQ-9 scores (7.69 ± 6.42) compared to those on oral treatment only (5.88 ± 4.70) ($p=0.016$). Those with diabetes-related complications reported significantly higher PHQ-9 scores (7.53 ± 6.24) than participants without complications (5.89 ± 4.76) ($p=.038$). Participants with a PSQI score ≥6 exhibited significantly higher PHQ-9 scores (8.83 ± 5.66) compared to those with scores <6 (3.79 ± 3.56) ($p=.000$), suggesting a strong association between poor sleep quality and higher depression levels. As stated in Table 3, there was no significant correlation between PHQ-9 and HbA1c ($r = 0.019$, $p=.770$) or between PHQ-9 and BFG ($r = 0.098$, $p=.793$).

Table 1. *Analyses performed on the factors affecting the sleep quality of the diabetic patients for PSQI*

PSQI Scores					
(N;%)	**Mean±Std.**	**p**		**Mean±Std.**	**p**
Gender			**HbA1c**		
Women (n=135; 59.5%)	7.95±4.11	**.000**	<7(n=118; 52.0%)	6.57±3.91	.343
Men (n=92; 40.5%)	5.10±3.34		≥ 7(n=109; 48.0%)	7.04±4.22	
Income level			**Blood Fasting Glucose**		
Low(≤1700 TL)(n=76; 33.5%)	7.50±4.20	.130	<131(n=105; 46.3%)	**6.32**±3.72	.107
Medium(1701-3499 TL)(n=118; 52.0%)	6.58±3.93		≥131(n=122;53.7%)	7.19±4.29	
High(≥3500 TL)(n=33; 14.5%)	5.94±4.07		**Treatment Style**		
Education Status			Only oral treatment (n=147; 64.8%)	6.50±3.77	.248
Below high school(n=182; 80.2%)	6.92±3.99	.247	Insulin and oral treatment(n=80; 35.2%)	7.33±4.52	
High School and over(n=45; 19.8%)	6.29±4.34		**Hypertension disease**		
Employment			Yes(n=159; 70.0%)	7.32±4.11	**.001**
Unemployed(n=123; 54.2%)	7.62±4.21	**.001**	No (n=68; 30.0%)	5.56±3.68	
Employed(n=104; 45.8%)	5.82±3.67		**Complications Related to Diabetes**		
Smoking Status			Yes(n=87;38.3%)	7.32±4.44	.170
Yes(n=50; 22.0%)	6.76±4.04	.944	No(n=140;61.7%)	6.46±3.78	
No(n=177; 78.0%)	6.80±4.08		**Diabetic retinopathy**		
Body Mass Index distribution			Yes(n=31; 13.7%)	8.58±5.22	**.047**
25-29.9(n=103; 45.4%)	5.65±3.50	.000	No(n=196; 86.3%)	6.51±3.78	
≥ 30(n=124; 54.6%)	7.74±4.26		**Diabetic nephropathy**		
Duration of disease			Yes(n=35; 15.4%)	7.57±4.76	.286
<11 years (n=140; 61.7%)	6.24±3.69	.024	No(n=192; 84.6%)	6.65±3.92	
≥11 years (n=87; 38.3)	7.62±4.46		**Diabetic neuropathy**		
Diabetic foot			Yes(n=62; 27.3%)	7.74±4.60	**.049**
Yes(n=9; 4.0%)	6.78±6.30	.698	No(n=165; 72.7%)	6.45±3.79	
No(n=218; 96.0%)	6.79±3.96				

Note: Mann-Whitney U and Kruskal-Wallis tests were used.

Table 2. *The relationship of PHQ-9 results with sociodemographic information*

PHQ-9 Scores		
(N;%)	**Mean±Std.**	**p**
Gender		
Women(n=135; 59.5%)	7.93±5.67	**.000**
Men(n=92; 40.5%)	4.46±4.30	
Income level		
Low(≤1700 TL)(n=76; 33.5%)	7.91±5.77	**.017**
Medium(1701-3499 TL)(n=118; 52.0%)	6.00±5.26	
High(≥3500 TL)(n=33; 14.5%)	5.18±4.58	
Education Level		
Below high school(n=182; 80.2%)	6.74±5.51	.216
High School and over(n=45; 19.8%)	5.62±5.01	
Employment		
Unemployed(n=123; 54.2%)	7.97±5.86	**.000**
Employed(n=104; 45.8%)	4.81±4.29	
Smoking Status		
Yes(n=50; 22.0%)	5.48±4.24	.073
No(n=177; 78.0%)	6.81±5.69	
Body Mass Index		
25-29.9(n=103; 45.4%)	4.90±4.81	**.000**
≥ 30(n=124; 54.6%)	7.86±5.55	
Duration of Disease		
<11 years (n=140; 61.7%)	6.21±4.79	.302
≥11 years (n=87; 38.3%)	7.02±6.31	
HbA1c		
<7(n=118; 52.0%)	6.13±4.98	.260
≥ 7(n=109; 48.0%)	6.94±5.86	
Blood Fasting Glucose		
<131(n=105; 46.3%)	6.26±5.21	.497
≥131(n=122; 53.7%)	6.75±5.61	
Treatment Style		
Only oral treatment(n=147; 64.8%)	5.88±4.70	**.016**
Insulin and oral treatment(n=80; 35.2%)	7.69±6.42	
Complications Related to Diabetes		
Yes(n=87;38.3%)	7.53±6.24	**.038**
No(n=140;61.7%)	5.89±4.76	
PSQI Scores Avarage		
<6 points(n=104; 45.8%)	3.79±3.56	**.000**
≥6 points(n=123; 54.2%)	8.83±5.66	

Note: Mann-Whitney U and Kruskal-Wallis tests were used.

Table 3. *Correlation of HbA1c, BFC, PHQ-9, and PSQI*

		HbA1c	BFC	PHQ-9	PSQI
HbA1c	r	-	-	—	-
	p	.	-	-	-
BFC	r	.629*	-	-	-
	p	<.001	.	-	-
PHQ-9	r	.019	.018	-	-
	p	.770	.793	.	-
PSQI	r	.081	.096	.614*	-
	p	.222	.149	<.001	.

**Spearman's correlation coefficient is significant at the .05 level (2-tailed).*

4. DISCUSSION

Sleep is a fundamental human need, and disruptions in sleep quality can have profound effects on both physical and mental health. This study is the first to reveal that factors such as unemployment, diabetes-related neuropathy and retinopathy, and hypertension significantly impair sleep quality in patients with T2DM.

In this study, 54.2% of participants had poor sleep quality, which aligns closely with the prevalence reported by Solinska et al. (53%) (18). Similarly, Keskin et al. identified poor sleep quality in 60.9% of their participants (mean PSQI = 6.18 ± 3.42) (19), and Tsai et al. reported a comparable prevalence (20). However, studies conducted in Iran and Egypt showed divergent results, with one reporting a lower prevalence of 38% (21) and the other a much higher rate of 81% (PSQI ≥ 8) (22). These variations likely stem from differences in cultural, environmental, and living conditions across populations.

Gender differences were evident, with women exhibiting significantly poorer sleep quality than men (OR = 1.24). This finding is consistent with previous studies (19, 20, 22, 23) and may be attributed to women's heightened emotional sensitivity and greater exposure to stressors (24). Employment also played a role, with employed participants showing better sleep quality. This may be due to more structured daily routines and better regulation of sleep-wake cycles, as suggested in prior research (22, 25).

Obesity emerged as a critical factor influencing sleep quality. Consistent with studies by Hung et al. (26) and Keskin et al. (19), higher BMI was positively associated with poorer sleep quality. Excess weight can contribute to physical conditions such as hypoventilation and hypoxemia, which disrupt sleep (27). Additionally, the relationship between sleep disturbances and neuroendocrine changes, including increased appetite and altered glucose metabolism, highlights a complex interplay that could exacerbate both obesity and T2DM (28-29).

Although our study did not find significant correlations between PSQI scores and HbA1c or fasting blood glucose (BFG) levels, participants with higher HbA1c and BFG levels tended to report poorer sleep quality. This finding aligns with Şahin et al. (31) but contrasts with studies by Keskin et al. (19) Tsai et al. (20), and Barakat et al. (22), which showed poorer sleep quality in patients with uncontrolled HbA1c. The lack of statistical significance in our study may be attributed to the relatively small sample size.

The relationship between treatment style and sleep quality remains unclear, with conflicting findings reported in the literature (31). Our study found no significant association. However, diabetes-related complications, particularly neuropathy and retinopathy, were strongly linked to poorer sleep quality. These findings contrast with Solinska et al., who did not observe such associations (18). Neuropathy symptoms such as pain, tingling, and electric shock-like sensations, which worsen at night, are likely contributors

to disrupted sleep (32). Further research is needed to substantiate these results.

Depression was another critical determinant of poor sleep quality. In this study, PSQI scores increased with the severity of depression, with each 1-point increase in PSQI corresponding to a 1.25-fold increase in PHQ-9 scores. This finding is consistent with Shamshigaran et al., who also reported a strong association between psychological distress and sleep quality (21). Factors such as female gender, unemployment, obesity, combined therapy, and diabetes-related complications were linked to higher PHQ-9 scores. For instance, Kara et al. highlighted that patients undergoing combined insulin and oral therapy reported greater depressive symptoms, likely due to the psychological burden associated with complex treatment regimens (33).

Overall, this study identifies key factors contributing to poor sleep quality in individuals with T2DM, including female gender, obesity, unemployment, hypertension, and depression. Moreover, diabetes-related complications such as neuropathy and retinopathy were found to have a detrimental impact on sleep, a less frequently reported observation. The bidirectional relationship between sleep disturbances and depression underscores the importance of addressing both conditions comprehensively (34).

In conclusion, it is essential to routinely evaluate and manage sleep disorders and depression in patients with T2DM, particularly in those who are female, obese, unemployed, or suffering from diabetes-related complications. Although this study found no significant correlations between fasting blood glucose, HbA1c, and sleep quality, future research with larger sample sizes is recommended to better understand these associations.

LIMITATIONS OF THE STUDY

In this current study, the fact that groups differing in terms of diabetes duration and complications were evaluated together may have been a limitation in showing the strength of the effect. Conducting studies with similar groups and observing the situation after treatment may reveal the latent relationships clearly. The study being carried out in a single center and inadequate number of the patient population are the limitations of the study.

5. CONCLUSION

In the study, we determined the factors affecting sleep quality in diabetic patients as being female, obesity,being unemployed, having diabetes-related neuropathy and retinopathy, having hypertension, and having a high level of depression.

Therefore, all patients, especially female, obese, unemployed, diabetic patients with complications, should be evaluated and treated for sleep disorders and depression. Accordingly, in order to improve sleep quality in patients with Type 2 DM, it can be recommended to get them to lose weight, to prevent development of complications by getting them to have primary care check-ups, and to evaluate them psychologically in a regular manner. Although there was no significant correlation between fasting blood glucose and HbA1c and sleep quality in our study, we think that further studies should be conducted on this subject.

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Research idea: ESE, GZÖ
Design of the study: ESE, GZÖ
Acquisition of data for the study: ESE
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