The Relationship Between Sleep Quality and HbA1c of Patients with Type 2 Diabetes

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Abstract

Aim: Sleep disorders are common in patients with type-2 diabetes. This study aims to examine the relationship between sleep quality and sleep quality subdimensions and HbA1c levels of patients with type 2 diabetes.

Method: This correlative and cross-sectional design study was conducted in Istanbul/ Turkey between November 10, 2020, and December 10, 2020. The data collection form created by the researchers and the Pittsburgh Sleep Quality Index (PSQI) were used to collect data.

Result: Of the 186 patients with type 2 diabetes in the study 56.4% smokers. It was determined that the mean total PSQI score of the patients was 14.89±3.69 and 85.4% had low sleep quality (PSQI>5). A positive significant relationship was found between PSQI total score and HbA1c (r:0.245, p:0.042). In addition, a positive relationship was found between HbA1c and the scores of habitual sleep efficiency (r:0.145, p:0.036) and sleep disorder (r:0.223, p:0.032) sub-scale. The total PSQI scores of women were significantly higher (p: 0.042) and sleep duration was shorter (p<0.001) compared to men. It was determined that the sleep quality of non-smokers was better than that of smokers (p:0.017).

Conclusion: A positive relationship was found between impaired sleep quality and HbA1c in patients with type 2 diabetes. It was found out that this relationship was due to habitual sleep efficiency and sleep disorder and that sleep quality was worse in women and smokers. Often overlooked in the follow-up of patients with diabetes, assessment of sleep quality should be part of diabetes care.

Keywords: Type 2 diabetes, sleep quality, HbA1c, Pittsburgh sleep quality index.

Tip 2 Diyabetli Hastaların Uyku Kaliteleri ile HbA1c Düzeyleri Arasındaki İlişki

Öz

Amaç: Tip 2 diyabetli hastalarda uyku bozuklukları yaygındır. Bu çalışmanın amacı tip 2 diyabetli hastaların uyku kalitesi ve uyku kalitesinin alt boyutları ile HbA1c düzeyleri arasındaki ilişkiyi incelemektir.

Yöntem: Bu korelatif ve kesitsel tasarım tipindeki çalışma 10 Kasım 2020-10 Aralık 2020 tarihleri arasında İstanbul'da gerçekleştirilmiştir. Veriler, araştırmacılar tarafından oluşturulan veri toplama formu ve Pittsburgh Uyku Kalitesi İndeksi (PUKİ) ile toplanmıştır.

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ETHICAL STATEMENT: The study was conducted with 186 people. Approval was obtained from the University of Health Sciences Hamidiye Ethics Committee (Date:13/11/2020 Approval Number: 20/417) before the study commenced. The study was conducted in compliance with the "Ethical principles for medical research involving human subjects" of the Helsinki Declaration.

Bulgular: Çalışmaya katılan 186 tip 2 diyabetli hastanın %56.4'ü sigara kullanmaktadır. Hastaların PUKİ toplam puan ortalaması 14.89±3.69 olup %85.4'ünün düşük uyku kalitesine (PUKİ >5) sahip olduğu belirlenmiştir. PUKİ toplam puanı ve HbA1c arasında pozitif yönde anlamlı bir ilişki saptanmıştır (r: 0.245, p: 0.042). Ayrıca alışılmış uyku etkinliği (r: -0.145, p: 0.036) ve uyku bozukluğu (r: 0.223, p: 0.032) alt boyutları puanları ile HbA1c arasında da pozitif yönde ilişki saptanmıştır. Kadınların PUKİ toplam puanları erkeklerden anlamlı olarak daha yüksektir (p: 0.042) ve uyku süreleri daha kısadır p<0.001). Sigara kullanmayan kişilerin uyku kalitelerinin, kullanan kişilere göre daha iyi düzeyde olduğu belirlenmiştir (p:0.017).

Sonuç: Tip 2 diyabetli hastalarda bozulmuş uyku kalitesi ile HbA1c arasında pozitif yönde bir ilişki bulunmuştur. Bu ilişki alışılmış uyku etkinliği ve uyku bozukluğu tarafından yönlendirilmiştir, Kadınlar ve sigara içenlerde uyku kalitesinin daha kötü olduğu saptanmıştır. Diyabet hastalarının takibinde sıklıkla gözden kaçan uyku kalitesi değerlendirilmesi diyabet yönetiminin bir parçası olmalıdır.

Anahtar Sözcükler: Tip 2 diyabet, uyku kalitesi, HbA1c, Pittsburgh uyku kalitesi indeksi.

Introduction

Diabetes is one of the biggest global health problems of the century. It is stated that approximately 463 million people between 20-79 years old will have diabetes all over the world in 2019[1]. Only effective HbA1c reduction can prevent macrovascular and microvascular complications of diabetes[2]. However, it was seen considering real-world data that only 30-40% of type 2 diabetes patients in the United States reached the target HbA1c values[3]. Poor glycemic control rates have been reported to be between 70% and 85% in developing countries[4,5].

Despite all developing medication and lifestyle interventions, inadequacy in diabetes control has prompted researchers to investigate other factors that affect diabetes. In recent years, psychosocial factors that have effects on diabetes control have had an important role in diabetes care[6]. Sleep disorders, which adversely affect diabetes control, are common in patients with diabetes[7,8]. Poor diabetes control also leads to sleep disorders[9]. Being one of the most fundamental physiological needs of human beings, sleep affects the quality of life, the course of diabetes, and complications of individuals with diabetes in many ways.

It has been suggested that shortening of sleep duration, deterioration of sleep quality, and long sleep duration in the last 50 years increase metabolic and cardiovascular diseases[10]. Early bedtime habit (early chronotype) was found to be associated with better metabolic control than late bedtime habit (late chronotype)[11]. The study of the Korea National Health and Nutrition Examination Survey (KNHANES) determined that there was a relationship between sleep duration and HbA1c[12]. In addition, recent studies have reported that improving subjective sleep quality and adjusting sleep duration according to personal needs improve metabolic control in patients with diabetes[13,14].

Although the relationship of sleep quality with diabetes and poor glycemic control is well known, there are conflicting data on the relationship between poor glycemic control and subdimensions of sleep quality. Various dimensions of sleep are widely evaluated with subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime drowsiness parameters[15]. There are a limited number of studies evaluating all components of sleep quality and investigating its relationship with HbA1c in the literature. Sleep disturbances were found to be associated with HbA1c, but no relationship was found with other subscales in a study conducted in 2019 investigating the relationship between sleep disorders and diabetes control with Pittsburgh Sleep Quality Index (PSQI) and PSQI subscales[16]. Zhu et al.'s study on patients with type 2 diabetes found that subjective sleep disorder

and frequent night awakenings were associated with poor glycemic control[17]. Psychosocial factors and social habits highly affect the subdimensions of sleep quality. Therefore, it is important for each society to determine its own risk factors. This study aims to examine the relationship of sleep quality with sleep quality sub-scales and HbA1c levels of patients with type 2 diabetes.

Method

This correlative and cross-sectional design study was conducted in Istanbul/Turkey between November 10, 2020, and December 10, 2020.

Sample

The study consisted of individuals who volunteered to participate in the study, aged 18 and above, diagnosed with type 2 diabetes at least 6 months, and who were literate. The diagnoses recorded in the electronic medical records of the patients were examined. Patients with psychiatric disease (depression, mania, psychosis, obsessive-compulsive disorder, etc.), mental retardation, dementia, Alzheimer's disease, and medication use that affects sleep due to reasons other than sleep disorders were excluded from the study. Also, questionnaire questions include the question of the presence of existing diseases and using medication. The patient was excluded from the study even if these diagnoses and medications were reported by the patient.

A simple random sampling method performed by a computer was used in selecting the participants from 2,000 people who had been admitted to the Research and Training Hospital Diabetes Polyclinic and whose information was available in the hospital automation system. The computer program enumerates the items in the sampling frame, determines its own random numbers, and presents the selected items to the researcher in writing or digitally.

The number of samples with 88% reliability was determined as 200 as a result of G*Power analysis based on the sample numbers of similar studies. 260 patients with type 2 diabetes who met the research criteria were invited to the study and 211 people agreed to participate in the study. Since 7 people used medication that affects sleep, 4 people did not fully answer the questionnaire questions, and 14 people whose HbA1c values examined in the last 3 months could not be reached, they were excluded from the study. The study was conducted with 186 people. Approval was obtained from the University of Health Sciences Hamidiye Ethics Committee (Date:13/11/2020 Approval Number: 20/417) before the study commenced. The study was conducted in compliance with the "Ethical principles for medical research involving human subjects" of the Helsinki Declaration.

Patients with type 2 diabetes and contact information who were followed-up in two university hospitals in İstanbul were invited to participate via phone and internet. People who met the inclusion criteria and agreed to participate in the study were informed about the purposes, procedures, and data confidentiality of the study as a result of the phone call with the researcher; the patients were informed that participation was optional and they could leave the study at any time. People read and approved informed consent forms online.

Data Collection

Data collection forms were created using Survey Monkey (2005 SurveyMonkey.com), which provides electronic self-control and facilitates data collection and tracking by preventing multiple data entries by the same person. Privacy was guaranteed by the complete deactivation of electronic records and IP address records. The data collection form created by the researchers and the Pittsburgh Sleep Quality Index (PSQI) was used to collect data. In addition, HbA1c values were checked on the electronic medical records of the patients.

Data Collection Form: The Data Collection Form consists of the questions of age, gender, marital status, having a child, education level, drinking of alcohol and caffeinated drinking, chronic diseases, how long the patients were diabetic, and HbA1c value examined in the last 3 months.

Pittsburgh Sleep Quality Index (PSQI):

PSQI is a sleep survey that helps to evaluate one's sleep quality, amount of sleep, presence, and severity of sleep disorders. The Turkish validity and reliability study was conducted by Ağargün et al.[18]. This scale has 19 items and measures seven subcomponents of sleep quality: subjective sleep quality, sleep onset latency, sleep duration, habitual sleep efficiency, sleep disorders, use of sleep medication, and daytime dysfunction. The total PSQI score was obtained by adding seven subscores and was between 0-21. PSQI total score clearly distinguishes those who sleep well (PSQI total score≤5) from those who sleep poorly (PSQI >5)[18]. Ağargün et al. found the Cronbach's alpha coefficient to be 0.80 and it is 0.89 in this study.

Data Analysis

The frequency, percentage, mean, and standard deviation of the data were analyzed using SPSS (Statistical Package for Social Sciences, Chicago, Illinois) version 16.0. The Shapiro Wilks test was used to assess whether the data had a normal distribution. Descriptive statistical methods (mean, standard deviation, median, frequency, ratio, minimum, maximum) were used to evaluate the study data; Independent Sample t-test was used to compare two groups of normally distributed variables in the comparison of quantitative data; Mann-Whitney U test was used in non-normally distributed variables. Pearson's chi-square test was used to compare qualitative data. The dependent variable is the PSQI score. The independent variables are age, gender, marital status, chronic diseases, diabetes duration, and HbA1c. The Pearson correlation test was used to assess the variation of the variables. Significance was evaluated at $p<0.05$.

Result

Of the 186 patients with diabetes, 55.9% were men, 66.6% were married, 63.4% had children, and 47.9% were high school graduates. In addition, more than half (56.4%) of the individuals with diabetes participating in the study smoked, only 12.9% used alcohol, 75.8% stated that they drank caffeinated drinks (tea, coffee, coke, etc.) at least once a day. (Table 1) The mean duration of diabetes of the participants was 11.09±6.45 years and the mean HbA1c levels were 8.13%±4.38%.

Table 1. Distribution of descriptive characteristics (N: 186)

Age (years)	*Min-Max (Median)*	19-82 (51)
	Mean±SD	52.31±10.52
Diabetes duration (years)	*Min-Max (Median)* *Mean±SD*	11.09±6.45 1-20
HbA1c (%)	*Min-Max (Median)* *Mean±SD*	7-12 8.13±4.38
		n (%)
Gender	Female	82 (44)
	Male	104 (55.9)
Marital Status	Married	124 (66.6)
	Single	62 (33.3)
Child	Yes	118 (63.4)
	No	68 (36.5)
Education Level	Elementary-Secondary School	53 (28.4)

	High School University or Higher	89 (47.9) 44 (23.6)
Smoking	Yes No	105 (56.4) 81 (43.5)
Alcohol	Yes No	24 (12.9) 162 (87)
Caffeinated drink	Never or rarely At least once a day	45 (24.1) 141 (75.8)

The mean total PSQI score of the patients was 14.89±3.69 and 85.4% of the participants had poor sleep quality (PSQI>5). A positive significant relationship was found between PSQI total score and HbA1c (r:0.245, p:0.042) considering the relationship between PSQI subscales and HbA1c (Table 2). In addition, a positive relationship was found between HbA1c and the scores of habitual sleep efficiency (r:0.145, p:0.036) and sleep disorder sub-scales (r:0.223, p:0.032) (Table 2).

Table 2. The relationship between Pittsburgh Sleep Quality Index Subscales and Total Score Distribution and HbA1c (N: 186)

Pittsburgh Sleep Quality Index	**Scale Points**	**HbA1c**	
	Mean±SD	r*	p
Subjective Sleep Quality	1.15±0.45	0.069	0.521
Sleep Onset Latency	3.5±1.25	0.096	0.336
Sleep Duration	7.28±1.23	0.106	0.269
Habitual Sleep Efficacy	0.61±0.89	0.145	0.036**
Sleep Disorders	1.51±0.85	0.223	0.032**
Sleep Medication Use	0.61±1.12	0.163	0.196
Daytime Dysfunction	1.44±0.98	0.141	0.162
PSQI Total	14.89±3.69	0.245	0.042

*Pearson's correlation test. ** p< 0.05

The total PSQI scores of women were found to be significantly higher than men (p: 0.042). In addition, subjective sleep quality (p:0.008), sleep onset latency (p:<0.001), sleep disorder (p:0.014), and daytime dysfunction (p:0.031) scores of women were found to be higher than men (Table 3). The sleep duration of women was found to be significantly lower than men (p<0.001).

Table 3. Comparison of the Pittsburgh Sleep Quality Index and Subscales Scores by gender (N: 186)

Pittsburgh Sleep Quality Index	**Female (n:82) Mean±SD**	**Male (n:104) Mean±SD**	**Z***	**p**
Subjective Sleep Quality	1.17±0.78	1±0.67	2.646	0.008**
Sleep Onset Latency	3.6±1.59	2.85±1.40	3.763	<0.001**
Sleep Duration	7.12±1.36	7.72±0.98	4.372	<0.001**
Habitual Sleep Efficacy	0.50±0.84	0.47±0.75	0.378	0.705
Sleep Disorders	1.42±0.63	1.27±0.55	2.449	0.014**
Sleep Medication Use	0.52±1.03	0.45±0.95	1.732	0.083
Daytime Dysfunction	1.40±0.92	1.17±0.87	3	0.031**
PSQI Total	15.25±3.01	13.95±2.81	3.224	0.042**

Z* Mann-Whitney U Test ** p< 0.05

A statistically significant difference was found between subjective sleep quality (p: 0.033), sleep duration (p: 0.046), sleep disorder (p: 0.013), and daytime dysfunction (p: 0.013), and total PSQI scores (p: 0.017) considering that the PSQI and PSQI sub-scales scores of individuals with diabetes were compared according to their smoking status. It was determined that the sleep quality of non-smokers was better than that of smokers (Table 4).

Table 4. Comparison of the Pittsburgh Sleep Quality Index and Subscales Scores by smoking status (N: 186)

Pittsburgh Sleep Quality Index	**Those smoking Mean±SD (Min-Max)**	**Those not smoking Mean±SD (Min-Max)**	**Test Value t*, Z** p-value**
Subjective Sleep Quality	2.25±0.69 (0-3)	1.01±0.45 (0-3)	2.256 0.033***
Sleep Onset Latency	3.02±1.25 (1-5)	2.98±1.52 (1-5)	0.965 0.436
Sleep Duration	7.22±1.12 (3-9)	8.15±1.65 (4-9)	2.086 0.046***
Habitual Sleep Efficacy	0.75±0.48 (0-3)	0.48±0.12 (0-3)	1.652 0.225
Sleep Disorders	1..52±0.36 (0-3)	0.82±0.56 (0-3)	4.025 0.013***
Sleep Medication Use	0.63±0.12 (0-3)	0.45±0.26 (0-3)	0.703 0.052
Daytime Dysfunction	1.63±0.87 (1-3)	0.96±0.88 (1-3)	2.635 0.013***
PSQI Total	16.63±2.87 (7-21)	8.53±1.85 (2-19)	4.162 0.017***
*Independent sample t-test, **Mann-Whitney U non-parametric test *** p<0.05			

Discussion

The mean total PSQI score was 14.9 and 85.4% of these patients had poor sleep quality in this study investigating the relationship between sleep quality and HbA1c levels of patients with type 2 diabetes. Akca et al. found that the mean PSQI score was 10.7, and 86.3% of the patients had poor sleep quality[14]. Upon the examination of other studies investigating sleep quality in patients with diabetes, the rate of people with poor sleep quality was found to be 60% in the study of Jin et al. whereas it was 64.3% in the study of Keskin et al.[9,19]. The results of our study are in parallel with the literature. The reason why the rate of diabetic patients with poor sleep quality in the study was found to be high and the mean sleep disorder score was high was because the mean duration of diabetes was 11.1 years and the mean HbA1c was 8.1%.

In our study, a positive correlation was found between HbA1c and PSQI total score. Rajendran et al. found no relationship between HbA1c and PSQI and its sub-scales in their study[20]. However, it was determined that there was a strong relationship between PSQI and HbA1c in many studies conducted in the literature[21,22]. Our results confirm a positive relationship between sleep disorders and HbA1c. Sleep disorders in patients with diabetes affect glycemic regulation as well as poor glycemic control impairs sleep quality[23]. Diabetes and sleep quality affect each other in a vicious cycle with the effect of sympathetic systemic activation, appetite hormones, and inflammatory processes[24]. It has been shown that there is a relationship between inadequate sleep

and sleep disorder with dysglycemia even in non-diabetic patients in the literature[25]. It has been suggested that the underlying mechanisms have behavioral characteristics related to insulin resistance, increased inflammation, decreased leptin levels, increased ghrelin secretions, and obesity[25]. It is thought that long working hours and 24-hour global connectivity in modern societies affect the sleep behaviors of societies and this may be related to the increase in the frequency of cardiometabolic diseases in recent decades[26]. A positive correlation was found between habitual sleep efficiency and sleep disorder subscale scores considering the relationship between PSQI subscales and HbA1c. Previous studies have found a relationship between HbA1c and sleep quality, and different data have been obtained from different societies about which subdimensions of sleep are related to HbA1c. It was determined in a study conducted in the United States that the relationship between HbA1c and sleep quality was directed by the sleep disorder subscale[16]. It was found in the data obtained from Japan that sleep quality was associated with sleep duration, sleep efficiency, and sleep medication use subscales, and HbA1c[23]. It is thought that these differences are due to the fact that sleep is a parameter affected by socio-cultural factors. Habitual sleep efficiency and sleep disorder subscales were found to be associated with HbA1c in our study. It was also revealed that there was a correlation between these subscales and subjective sleep quality, delayed sleep, use of sleep medication, and daytime dysfunction and HbA1c in another study conducted in Turkey[21]. Attention should be especially paid to sleep efficiency and sleep disorder subdimensions common to two studies in diabetic patients in Turkish society according to these results.

It was found that the total PSQI scores, subjective sleep quality, sleep onset latency, sleep disorders, and daytime dysfunction scores of women were higher compared to men. In addition, the sleep duration of women was significantly lower compared to men. It has been reported sleep disorder is more common in women compared to men in the literature, and this is due to unstable sex hormone levels in women[27]. Although there was a u-shaped relationship between sleep duration and poor diabetes control, it was emphasized that short sleep time was associated with poor diabetes control in women[28]. Xu et al. found a relationship between HbA1c and subjective sleep disorder in women with diabetes in a study involving 1,5 years of follow-up; however, this relationship was not observed in men[29]. All these results emphasize the need to pay particular attention to sleep disorders and sleep duration in women with diabetes.

In this study, a statistically significant difference was found between total PSQI, subjective sleep quality, sleep duration, sleep disorder, and daytime dysfunction scores of patients with diabetes according to their smoking status. It was determined that the sleep quality of non-smokers was better than that of smokers. The data obtained from many studies have proved that smoking worsens sleep quality[22,30-32]. It was found that smoking negatively affected sleep quality and as nicotine addiction increased, sleep quality worsened in the study conducted by Karamus[33]. Smoking, which is one of the most important risk factors for cardiovascular diseases, does this with its many effects ranging from endothelial dysfunction to sleep disorders. Smoking status in patients with type 2 diabetes is one of the factors affecting sleep, especially one that needs to be emphasized.

Limitation of the Study

There are many limitations to our study. First, the cross-sectional design makes it difficult to infer causality. In addition, although a validated and reliable test was used to evaluate sleep disorder, long face-to-face interviews were not conducted in which all factors affecting sleep were evaluated. Another limitation of the study is that the data were obtained from patients admitted to two university hospitals. Other diseases patients have may affect sleep quality. According to

comorbidities and body mass index, no correction was made in the study. However, we think that the implementation of this test should be a multidisciplinary follow-up regimen in internal medicine practice. Other limitation is the study data can only be generalized for Turkey. The strengths of our study are that all sub-scales of sleep quality were evaluated with a high validity and reliability scale. This study is also an example of evaluating the sleep quality of patients through an online questionnaire considering a period where more telemedicine applications will be used.

Conclusion

In conclusion, a positive relationship was found between impaired sleep quality and HbA1c in patients with type 2 diabetes. This relationship was driven by habitual sleep efficiency and sleep disorder, and it was found that sleep quality was worse in women and smokers. Assessment of sleep quality, which is often overlooked in the follow-up of patients with diabetes, should be part of diabetes care.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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