



Sleep Quality and Blood Lipid Composition Among Patients with Diabetes

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Abstract

Background: Recent literature has mentioned that people with sleep disorder, experience insulin sensitivity reduction and accordingly higher levels of blood glucose.

Objectives: This study aimed to investigate the relationship between sleep quality and blood lipid composition in patients with diabetes referring to Minoodar health center in Qazvin, Iran in 2017.

Methods: Sleep duration and quality were assessed in 347 patients with diabetes using the Pittsburgh sleep quality index (PSQI). The glycosylated hemoglobin A1c (HbA1c) test was used to measure the glycemic control and total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C) were used to determine blood lipid composition of the patients. Multiple regression analyses were applied to examine the associations between sleep measures and HbA1c and lipid parameters using SPSS version 20.

Results: The patients in the poor sleep quality group had higher levels of fasting blood sugar (FBS) (146.07 ± 57.06 versus 132.8 ± 53.3 mg/dL, $P = 0.02$), body mass index (BMI) (29.1 ± 3.9 versus 27.6 ± 4.2 kg/m², $P = 0.005$) and total cholesterol (209.9 ± 53.4 versus 193.4 ± 45.8 , $P = 0.02$). Furthermore, the patients with short sleep duration had higher total cholesterol level compared with long sleep and medium sleep duration group (202.3 ± 50.2 versus 196.6 ± 47.7 and 195.7 ± 47.4 , respectively, $P = 0.05$). Among different PSQI measures, subjective sleep quality was associated with lower TC and TG in unadjusted models ($\beta = -0.01$, $P = 0.05$). Furthermore, greater sleep disturbance was positively linked with higher levels of TC and TG ($\beta = 0.1$, $P = 0.01$ and $\beta = 0.02$, $P = 0.05$).

Conclusions: In an Iranian population with diabetes living in Qazvin city, sleep disorder is common and as study findings revealed sleep quality was recognized as an influencing factor on some of the lipid profiles, including TC and TG. Thus sleep assessment of patients with type 2 diabetes to find the early recognition of their sleep disorder should be considered an important part of the patients' treatment.

Keywords: Diabetes, Lipid Composition, Glycemic Control, Sleep Disorder

1. Background

Type 2 diabetes mellitus (DM) is a widespread metabolic disorder accounting for 95% of all diagnosed diabetes, which has affected approximately 190 million people around the world. The rising trend indicates that by 2030, this population is expected to reach 366 million; which 77.6% of them belongs to developing countries (1). The prevalence of type 2 DM is between 4.6% to 40% in the Middle East and 1.3% to 14.5% in Iran (2).

Several studies have acknowledged sleep disorder both in terms of sleep quality and quantity as an important risk factor for the incidence and progress of DM. Large-scale studies have also confirmed the associations between sleep duration and the probability of diabetes mellitus oc-

currence (3-5). Recent literature has mentioned that people with sleep disorder, experience insulin sensitivity reduction and accordingly higher levels of blood glucose. In fact, sleep duration and quality were found to be significant predictors of glycated hemoglobin (HbA1c) as an indicator of long-term glycemic control (6, 7).

A great number of adults experience lipid profile disorders, including higher levels of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), and low levels of high-density lipoprotein cholesterol (HDL-C), which potentially are associated with main morbidities (8). In assessing the relationship between lipid composition and type 2 DM, special attention should be paid to changes in insulin sensitivity and glucose effec-

tiveness (9). Considering these parameters revealed that in type 2 DM, the level of two mentioned parameters is decreased. In this regard, Borkman et al. suggested that lipid composition indirectly affected insulin sensitivity and acted as an indicator of the effect of some unknown factors that altered insulin sensitivity level (10).

Several factors have been established to be associated with lipid composition, including body mass index (BMI), diet and cardio-respiratory fitness (11, 12). Some of the studies have also mentioned that the lack of appropriate sleep might negatively affect plasma lipid levels (13). Although such findings confirmed the impact of sleep quality, there is still a lack of evidence to clarify possible associations between sleep factor and serum lipid composition, particularly among the Iranian population. Literature review in the field of sleep disorder and diabetes markers demonstrates that most of the studies have been conducted among healthy population rather than those suffering from type 2 diabetes mellitus. Moreover, the majority of them focused on obstructive sleep respiratory disorder rather than sleep hours or quality and there are also a few studies, which include data on lipid parameters in their analysis (14-17).

2. Objectives

As there are substantial differences in various regions of Iran in terms of demographic characteristics, socioeconomic status, habits and lifestyle, and also due to the high prevalence of type 2 diabetes mellitus in Qazvin, we conducted the current study to investigate the relationship between sleep quality, sleep duration, glycemic control, and blood lipid composition among the patients with diabetes referring to the Department of Endocrinology in Minoodar diabetes clinic during January and June 2017.

3. Methods

3.1. Data Sets and Subjects

A cross-sectional design was used for the study of all patients with type 2 DM referring to the Department of Endocrinology in Minoodar diabetes clinic during January and June 2017. The participants were selected among patients who were under routine outpatient follow-up for diabetes control and randomly recruited in the research within the six-month period of the study. The inclusion criteria were age above 18 years old, having type 2 DM, living in Qazvin city, and being able to give consent. Those with major complications affecting their sleep quality, including other types of diabetes, metabolic disorders, severe heart, lung or cerebral diseases, and consumption of

sedating medications and blood pressure regulators, were excluded from the research process. In total, 347 type 2 DM patients, which constituted 82.6% of all registered individuals referring for an annual clinic review of diabetes in the study period were enrolled to take part in the research. All subjects completed written informed consent and the study protocol was approved by the Ethics Committee of Qazvin University of Medical Sciences. The ethical approval number was IR.IUMS.REC 1395.95-02-27-9221324206.

3.2. Measurements of the Study Components

Anthropometric data, including blood pressure, weight, and BMI were collected from all study participants and recorded in special forms designed for data collection. While waiting to visit the physician, the patients were also asked to fill in the study questionnaire. At the same time, the research team collected the required patients' medical data, including the history of hypertension, hyper-lipidaemia, lipid-lowering, and antihypertensive medications by reviewing their medical records. Moreover, the results of patients' blood tests, including HbA1c, fasting blood sugar (FBS), TC, LDL-C, TG, HDL-C, and creatinine ratio (CR) that have been performed three months prior to their visit were recorded. All laboratory measurements were performed in a single laboratory. Inter-assay coefficients of variation (CVs) for HbA1c, FBS, TC, TG, HDL-C, and CR were 1.1, 1.5, 1.2, 1.2, 1.1, and 1.5, respectively.

To assess the sleep quality of the patients, the Pittsburgh sleep quality index (PSQI) containing 19 items was used. This validated questionnaire is composed of seven sleep components scoring in a range of 0 to 21. The score greater or equal to 6 indicates poor sleepers (18-20). Data regarding sleep duration were also extracted from PSQI and accordingly, the patients were categorized into three groups of short (SSD, < 6 hours daily), medium (MSD, 6 - 8 hours daily), and long sleep durations (LSD, > 8 hours daily).

3.3. Statistical Analysis

Using observational study formulae, the sample size was calculated at 420 subjects. After excluding the patients who were not eligible for participation based on the exclusion criteria, a total of 390 qualified individuals remained; in which 347 individuals were available for required information needed to perform the study analysis. Collected data were analyzed using the SPSS 20.0 (SPSS Inc. Chicago, IL, USA). Student's independent *t*-test was applied to compare normally distributed means, while Mann-Whitney test was used for non-normally distributed ones. To compare the three groups with different sleep

duration, analysis of variance (ANOVA) was used for parametric means, while Kruskal-Wallis test was used for non-parametric data. Pearson's correlation was used to examine the relationship between sleep quality score and dependent variables. The linear regression was used to examine the association between sleep quality dimensions, HbA1c, and lipid profiles. Three models were constructed for regression analyses; model 1 was used to examine the crude associations between sleep quality dimensions and lipid parameters. Using multiple regression modeling, we repeated the analysis adjusted for background variables, including age, BMI, FBS, TG, TC, and BP because of significant differences between study groups based on sleep quality and sleep duration. Finally, the model was adjusted for age, gender, BMI, and blood pressure as significantly correlated variables (model 3). P value < 0.05 was considered statistically significant.

4. Results

Of 347 participants, 256 (73.9%) were female, 18 (5.2%) were smokers, and 134 (69.4%) had a family history of diabetes. Overall, 69 patients (19.9%) had poor sleep quality (PSQI score ≥ 6) and 278 patients (80.1%) had good sleep quality (PSQI score < 6). An average of 5 hour-nocturnal sleep was reported in 22.8% of the patients, 4 hours in 19.9%, 3 hours in 14.4%, 6 hours in 13%, and 7 hours in 5.5%.

Findings related to the comparison of the patients' characteristics based on two groups of sleep quality are summarized in Table 1. As data are shown, those in poor sleep quality group had higher levels of FBS (146.07 ± 57.06 versus 132.8 ± 53.3 mg/dL, $P = 0.02$), BMI (29.1 ± 3.9 versus 27.6 ± 4.2 kg/m², $P = 0.005$) and total cholesterol (209.9 ± 53.4 versus 193.4 ± 45.8 mg/dL, $P = 0.02$).

Comparison of the patients' characteristics was also done regarding their sleep duration. According to the results in Table 2, the patients with long sleep duration had higher levels of systolic blood pressure compared with medium sleep duration and short sleep duration groups (125.4 ± 19.1 versus 123.8 ± 16.9 and 123.5 ± 16.6 mmHg, respectively, $P = 0.01$). Furthermore, the patients in short sleep duration group had higher total cholesterol level compared with long sleep and medium sleep duration group (202.3 ± 50.2 versus 196.6 ± 47.7 and 195.7 ± 47.4 mg/dL, respectively, $P = 0.05$).

The participants were categorized into two groups regarding their HbA1c level. Those with HbA1c lower than 7% were categorized into a good glycemic control group and those with HbA1c over 7% were mentioned as poor glycemic control group. Then the relationship between sleep quality, including its six dimensions and glycemic control were assessed.

The findings in Table 3 indicate the statistically significant differences between the two groups of the patients based on their glycemic control and three dimensions of sleep quality, including subjective sleep quality, sleep duration, and sleep disturbance ($P < 0.05$). The patients with good glycemic control had higher levels of subjective sleep quality and sleep duration, while their sleep disturbance was lower. Overall, those with good glycemic control had lower PSQI score compared to those with poor glycemic control ($P < 0.01$).

The results of multiple regression analyses examining the relationship between sleep quality dimensions, HbA1c, and lipid profiles are shown in Table 4. A higher score of subjective sleep quality was associated with lower TC and TG in unadjusted models ($\beta = -0.01$, $P = 0.05$). Furthermore, a greater sleep disturbance was positively linked with higher levels of TC and TG ($\beta = 0.1$, $P = 0.01$ and $\beta = 0.02$, $P = 0.05$). After adjusting for age, sex, weight, and blood pressure, the predictive role of mentioned sleep quality measures remained significant ($P < 0.05$).

5. Discussion

Study results showed that 19.9% of the patients with type 2 diabetes had low sleep quality. In comparison to similar studies, this value is much lower, which may be due to different PSQI cut-off values chosen for measuring sleep quality in this research (21-23). Similar to other studies, the percentage of patients with poor glycemic control was relatively high (54.9%) in the current research describing that a significant number of patients with diabetes do not have a controlled blood glucose, which is regarded as an important failure in the effective management of patients with diabetes (24, 25).

The findings also revealed that the levels of FBS, TC, and TG were higher in patients with poor sleep quality. Similarly, Khorasani et al. found that serum levels of TG in patients with poor sleep quality were higher than those with sufficient sleep (26). In the current research, a significant relationship was also found between BMI and low sleep quality; thus the patients with low sleep quality had significantly higher BMI. In agreement with our findings, Jennings et al. declared that patients with poor sleep quality belonged to higher BMI group. Furthermore, our study results were consistent with their study, which no significant relationship was reported between blood pressure and sleep quality (27). Despite this consistency, some other studies found that higher score of PSQI was significantly related to higher levels of blood pressure among study patients (28, 29). The reason for such dissimilarities might be due to the differences in demographic characteristics

Table 1. Comparison of the Patients' Characteristics Based on Their Sleep Quality

Patients' Characteristics	Poor Sleep Quality, N = 69 ^a	Good Sleep Quality, N = 278 ^b	P Value
Married	65 (94.2)	256 (92.1)	0.1
Smoking	4 (5.8)	14 (5)	0.43
Age, y	55.1 ± 9.04	53.3 ± 8.4	0.3
Weight, kg	75.6 ± 9.3	72.8 ± 11.8	0.06
BMI, kg/m ²	29.1 ± 3.9	27.6 ± 4.2	0.005
Systolic blood pressure, mmHg	127.3 ± 21.03	122.9 ± 15.7	0.2
FBS, mg/dL	146.07 ± 57.06	132.8 ± 53.3	0.02
HbA1c (%)	6.9 ± 3.7	6.1 ± 2.1	0.09
TG, mg/dL	202.5 ± 85.6	183.9 ± 9.8	0.05
HDL, mg/dL	40.6 ± 13.2	40.9 ± 12.01	0.7
LDL, mg/dL	166.5 ± 19.6	117.04 ± 46.1	0.1
Total cholesterol, mg/dL	209.9 ± 53.4	193.4 ± 45.8	0.02
Serum creatinine level, mg/dL	3.01 ± 0.1	1.3 ± 0.28	0.4
Sleep duration	7.9 ± 2.2	7.8 ± 2.1	0.4

Abbreviations: BMI, body mass index; FBS, fasting blood sugar; HbA1c, hemoglobin A1c; HDL, high-density lipoprotein; LDL, low-density lipoprotein TG; triglycerides.

^aScore greater or equal to 6 indicates poor sleepers.

^bScore below 6 indicates good sleepers.

Table 2. Comparison of the Patients' Characteristics Based on Their Sleep Duration

Patients' Characteristics	Short Sleep Duration, N = 198 ^a	Medium Sleep Duration, N = 64 ^b	Long Sleep Duration, N = 85 ^c	P Value
Age, y	53.3 ± 8.8	53.6 ± 8.6	55.4 ± 7.1	0.002
Weight, kg	73.7 ± 11.2	73.4 ± 11.4	71.4 ± 12.7	0.3
BMI, kg/m ²	27.9 ± 4.2	27.9 ± 4.2	27.8 ± 4.2	0.5
Systolic blood pressure, mmHg	123.5 ± 16.6	123.8 ± 16.9	125.4 ± 19.1	0.01
FBS, mg/dL	141.6 ± 55.9	143.4 ± 56.5	155.2 ± 59.4	0.2
HbA1c (%)	6.7 ± 0.36	6.7 ± 0.35	6.8 ± 0.29	0.8
Total cholesterol, mg/dL	202.3 ± 50.2	195.7 ± 47.4	196.6 ± 47.7	0.03
TG, mg/dL	185.7 ± 98.5	187.3 ± 96.4	197.1 ± 83.2	0.05
HDL, mg/dL	40.9 ± 12.3	40.8 ± 12.2	40.3 ± 11.3	0.8
LDL, mg/dL	129.5 ± 10.9	126.8 ± 9.4	97.9 ± 39.2	0.9
Serum creatinine level, mg/dL	1.6 ± 0.54	1.6 ± 0.57	1.2 ± 0.7	0.9

Abbreviations: BMI, body mass index; FBS, fasting blood sugar; HbA1c, hemoglobin A1c; HDL, high-density lipoprotein; LDL, low-density lipoprotein TG; triglycerides.

^aShort sleep duration (SSD < 6 hours daily).

^bMedium sleep duration (MSD, 6 - 8 hours daily).

^cLong sleep duration (LSD, >8 hours daily).

of study populations or their lower levels of blood pressure compared to those in other researches. However, no significant associations were found between sleep quality or sleep duration and HbA1c. This finding is inconsistent with some of the previous studies, which confirmed a significant association between sleep duration or quality and levels of glycemic control among patients with type 2 DM (30). Differences in the sample size of study participants

and self-reported nature of the questionnaire used to collect data on sleep quality and duration might justify existing variations in the findings (31).

Furthermore, those with long sleep duration had higher levels of systolic blood pressure and TG, also belonged to older age groups. However, those with short sleep duration had higher total cholesterol in comparison to those with long and medium sleep duration. In

Table 3. Sleep Quality in Two Groups of Patients Based on Glycemic Control

Sleep Quality Dimensions	Good Glycemic Control, N = 157	Poor Glycemic Control, N = 190	P Value
Subjective sleep quality	0.54 ± 0.06	0.53 ± 0.05	0.001
Sleep latency	3.2 ± 1.1	3.3 ± 0.9	0.3
Sleep duration	1.6 ± 0.7	1.1 ± 0.07	0.04
Sleep efficiency	3.5 ± 1.1	3.5 ± 0.8	0.9
Sleep disturbance	0.8 ± 0.06	0.96 ± 0.07	0.001
Daytime dysfunction	0.53 ± 0.06	0.56 ± 0.05	0.1
Overall	4.1 ± 1.6	4.2 ± 1.6	0.001

Table 4. Multiple Regression Model Predicting HbA1c and Lipid Profiles Based on Sleep Quality

Sleep Quality	Outcome					
	Total Cholesterol			TG		
	Model 1 (Unadjusted) ^a	Model 2 (Adjusted) ^b	Model 3 (Adjusted) ^c	Model 1 (Unadjusted) ^a	Model 2 (Adjusted) ^b	Model 3 (Adjusted) ^c
Subjective sleep quality						
β	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01
P value	0.05	0.04	0.05	0.05	0.05	0.03
Sleep disturbance						
β	0.13	0.12	0.11	0.02	0.06	0.05
P value	0.01	0.02	0.00	0.05	0.05	0.02

Abbreviation: TG, triglycerides.

^aModel 1 represents the crude model.

^bModel 2 is adjusted for all background and intervening variables.

^cModel 3 is adjusted for age, gender, body mass index, and blood pressure.

this regard, Bjorvatn et al. declared that participants with higher levels of TC were those with shorter sleep duration. Conversely, they added that patients with higher levels of TG and lower HDL had shorter sleep duration than those with normal levels of such lipid profiles (32). Additionally, Petrov et al. found a significant association between longer sleep duration and an increase in the level of blood pressure and TG (33).

Our findings revealed that patients with sleep disturbance had significantly higher levels of HbA1c, while those with good glycemic control had subjective sleep quality and longer sleep duration. Literature has proven that various types of sleep disorders were associated with higher levels of blood glucose and poor glycemic control (30, 34-37). Overall, those with good glycemic control had much better sleep quality compared to those with poor ones. As findings confirm, good glycemic control can be an effective therapeutic strategy for diabetic patients. For this purpose, setting a proper sleep time to optimize sleep duration of patients as well as helping them to improve their sleep quality can be very beneficial.

In compliance with several studies, sleep quality measures, including sleep disturbance and subjective sleep quality, have been proven to be the predictors of TG and TC in our study (26, 32). In this regard, Ekstedt et al. mentioned that greater sleep disturbance was associated with higher levels of TC (38). Despite such significant associations, nothing was found between PSQI dimensions and HDL, LDL, and HbA1c. This result is in line with Jennings et al. study, which found no significant associations between PSQI score and HDL (25). Lack of such relationships might be due to variations in measurement methods of sleep quality among different studies.

The present study has a number of limitations. First, sleep quality had not been measured by an objective tool, and sleep duration was estimated by a self-reported questionnaire. Second, the research was cross-sectional and therefore, could not establish the causal relationships between sleep quality and lipid profiles. The scarcity of data regarding personal and family health history of the patients, particularly those relevant to their psychiatric, social and spiritual health condition besides information

about their nutrition, physical activity, and medications were among other limitations.

5.1. Conclusions

In summary, in an Iranian population with diabetes living in Qazvin city, a sleep disorder is common and as study findings revealed it was recognized as an influencing factor on some of the lipid profiles, including TC and TG. Thus sleep assessment of patients with type 2 diabetes mellitus for the purpose of early recognition of their sleep disorder should be considered an important part of the patients' treatment to facilitate the management of diabetes.

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Footnotes

Authors' Contribution: All authors contributed equally.

Conflict of Interests: The authors declare no conflict of interest.

Ethical Approval: All subjects completed written informed consent and the study protocol was approved by the Ethics Committee of Qazvin University of Medical Sciences (ethical code: IR.QUMS.REC.1394.814).

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