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ORIGINAL ARTICLE

The Relationship between Glycemic Index, Social Support and Sleep Quality in Patients with Type 2 Diabetes

Mohammadreza Mirzaei[1], Mohammad Hossein Sharifi[2], Sepideh Mahboobi[1], Hossein Shahinfar[3], Mina Karimi[3], Mohammad Hassan Eftekhari[1*]

1. Department of Clinical Nutrition, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
2. Research Center for Traditional Medicine and History of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran
3. Department of Nutrition, School of Public Health, Iran University of Medical Science, Tehran, Iran

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**Corresponding author:*
Mohammad Hassan Eftekhari, PhD;
Department of Clinical Nutrition,
School of Nutrition and Food
Sciences, Shiraz University of
Medical Sciences,
Shiraz, Iran.
Tel: +989177088717
Email: h_eftekhari@yahoo.com
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ABSTRACT

Background: Social support and sleep quality can be beneficial in both self-care behaviors and health outcomes in subjects with type 2 diabetes (T2DM). The aim of this study was to analyze the relationship between glycemic index, social support and sleep quality in patients with T2DM.

Methods: In a cross-sectional study, 156 men and 144 women with T2DM were enrolled from July to September 2020. Level of self-care activities, social support, and sleep quality were measured with validated and appropriate questionnaires, and clinical characteristics were acquired from patients' medical records.

Results: The mean age of the participants was 50.83±7.14 years. According to this study, more than 60% of participants had poor self-care behaviors (37.68±12.94) and poor sleep quality (7.55±3.80) and the overall average of the social support score was moderate (67.73±19.85). A significant negative association was noticed between HbA1c and self-care activities and social support score (r=-0.346, p<0.001 and r=-0.309, p<0.001, respectively). There was a significant positive relationship between HbA1c and Pittsburgh Sleep Quality Index (PSQI) score (r=0.469, p<0.001). Also, a significant negative association was observed between social support and PSQI score (r=-0.393, p<0.001).

Conclusion: Glycemic control, self-care behaviors, high social support, and optimal sleep quality are suggested to be considered in diabetes management guidelines and policy making.

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Introduction

Over the last years, there has been a significant increase in the global prevalence of type 2 diabetes mellitus (T2DM) (1). By 2025, developing countries are expected to account for >75% of the total number of diabetic patients in the world (2). Previous epidemiologic evidence suggests that prevalence of diabetes mellitus in the Iranian population amounts to approximately 5.5% (3). However, the International Diabetes Federation (IDF) has

recently estimated that 5.5 million Iranians aged 20-79 years (corresponding prevalence: 9.1%) had diabetes in 2021 (4). This number is expected to rise to 9.24 million cases of diabetes mellitus by 2030 (5).

Most of the diabetes care is provided by the patient, making it known as a disease of self-management (6). The concept of self-care is that a patient uses her/his knowledge and ability to perform healthy behaviors (6). A healthy eating plan, physical activity, self-monitoring of blood glucose, taking prescribed medication, and foot care are accounted as constituents of diabetes self-care program. For adults with T2DM, self-care behaviors can be challenging (6) and complicated by competing demands of psychosocial and physiological factors, like social support and sleep disturbances (7). According to a study by Miller *et al.*, social support can play a crucial role in diabetes management (8).

Social support is perceived as a benefit and help that are easily available in case they are needed. When it comes to T2DM, the concept of social support can be assumed as the presence of people who empower patients (physically and psychologically) for a better management of their disease (9). There are many sources of social support, including family members, friends, colleagues, classmates, organizations, and community (10). In 2016, a study reported top 10 research priorities to improve the health of people with T2DM (11). This study was performed in four phases to prioritize research topics in the field of T2DM worldwide. The 9th priority of this report was "How can psychological or social support be best used to help people with, or at risk of T2DM, and how should this be delivered to account for individual needs?" (11).

For the first time, in 2017, the American Diabetes Association's Standards of Medical Care recommended that patients with diabetes to undergo a comprehensive medical evaluation that assesses sleep pattern and duration (12). Either short or long sleep duration is associated with increased mortality risk (13), and sleep duration has been found to have a U-shaped relationship with diabetes prevalence (14). Evidence is repeatedly suggestive of adverse effects of reduced sleep quality and quantity on blood glucose control and diabetes progression risk (18). Clearly, inadequate social support and poor sleep quality can gradually increase the burden of disease in patients with T2DM (15). On the other hand, no single study has been conducted to assess the simultaneous effect of social support and sleep quality in T2DM patients. Accordingly, the aim of this study was to analyse the relationship between glycemic index with social support and sleep quality in patients with T2DM in Shiraz, southern Iran.

Materials and Methods

This cross-sectional study was conducted from July to September 2020 to collect data from medical and diabetic clinics affiliated with Shiraz University of Medical sciences, Shiraz, Iran. Participants were men and women with T2DM. A total of 300 cases with T2DM aged 18 to 60 years were selected according to inclusion criteria. Those with diagnosis of T2DM for at least 6 months, who were able and willing to participate in the study, were eligible. The exclusion criteria were pregnancy or lactation, having major psychiatric disorders which have been approved, working in night shifts, type 1 diabetes mellitus, drug-induced diabetes or use of corticosteroid therapy, other endocrine disorders such as thyroid disease, and presence of other serious diseases in addition to diabetes, such as liver cirrhosis. After obtaining a written informed consent, data regarding demographic characteristics, medical history, self-care behaviors, social support, and sleep quality were collected through pre-designed or standard questionnaires. Glycemic control was evaluated through glycated hemoglobin (HbA1c) and fasting plasma glucose (FPG) level acquired from patients' records. Body mass index (BMI) was calculated as body weight (kg)/height (m^2), based on patients' weight and height measured during their outpatient department (OPD) visits.

Patients completed a demographic questionnaire regarding their age, gender, employment status (employed, retired, unemployed or housekeeper), marital status, level of education (primary school or lower, middle school, high school, university/college or higher), family income (income lower than expenses, income equal to expenses, income greater than expenses), smoking and drinking habits, duration of diabetes, presence of diabetes chronic complications, antidiabetic medication regimen (use of oral hypoglycemic agents, insulin alone, or oral hypoglycemic agents plus insulin). Self-care behavior was assessed using items from the Summary of Diabetes Self-Care Activities (SDSCA) measure as a reliable multidimensional questionnaire that has been developed by Toobert and colleagues (8). This self-report tool assesses how often participants (over the past 7 days) engage in self-care behaviors related to diabetes, which include a healthy diet, physical activity, blood sugar testing, foot care, and medication and/or insulin use. There are 12 questions in the SDSCA questionnaire that are scored on a Likert scale from 0 to 7; while higher scores represent better self-management, whereas

lower scores indicate poor self-management. Previous Iranian studies confirmed the reliability and validity of SDSCA (16).

The Medical Outcomes Study Social Support Survey (MOS-SS) is a general tool to measure social support that was developed by Sherbourne and Stewart (17) and its reliability and validity has been confirmed by previous Iranian studies (18). This questionnaire contains 19 items assessing different aspects of accessible support. These items have been categorized as five major subscales of social support including emotional/informational support (items 1-8), tangible support (items 9-12), affectionate support (items 13-15), positive social interaction (items 16-18), and an additional item. A five-point Likert scale was used to measure the respondents´ view, with the score ranging from 1 (none of the time) to 5 (all the time). The ultimate score ranges from 19 to 95 and higher scores are indicative of better social support.

The Pittsburgh Sleep Quality Index (PSQI) is a validated self-rated questionnaire that evaluates sleep quality and sleep disturbances over one month (19). The PSQI includes 19 items, which are divided into seven categories in the areas of subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction. A four-grade system (0, 1, 2, and 3) is used to determine each component's score and the global score is a sum of these sub-scores, ranging from 0 to 21. A higher global PSQI score is indicative of a poorer sleep quality, and the cut-off score of 5 distinguishes poor sleepers from good sleepers.

Data analysis was performed by SPSS software (Statistical Package for the Social Sciences Windows, version 17, Chicago, IL, USA). A p less than 0.05 was considered statistically significant. Data normality was evaluated using Kolmogorov–Smirnov test and it was found that the distribution was not normal. Variables were described using frequency distribution

Table 1: General characteristics of study participants.

Characteristics	All (n=300)	Men (n=156)	Women (n=144)
Age (year)	50.83±7.14	50.37±7.70	51.33±6.46
Weight (kg)	79.01±16.01	83.37±16.25	74.28±14.38
BMI (kg/m^2)	27.92±4.93	27.40±4.74	28.49±5.08
Duration of diabetes (year)	9.08±6.01	8.73±5.81	9.46±6.21
FPG (mg/dL)	153.83±48.30	150.88±48.47	157.03±48.09
HbA1c (%)	7.87±1.70	7.60±1.47	8.17±1.87
Employment status			
Employed	120 (40.0%)	93 (59.6%)	27 (18.8%)
Retired	64 (21.3%)	46 (29.5%)	18 (12.5%)
Unemployed or housekeeper	116 (38.7%)	17 (10.9%)	99 (68.8%)
Marital status			
Married	273 (91.0%)	148 (94.9%)	125 (86.8%)
Single/divorced/widow	27 (9.0%)	8 (5.1%)	19 (13.2%)
Educational level			
Primary school or lower	18 (6.0%)	5 (3.2%)	13 (9.0%)
Middle school	34 (11.3%)	15 (9.6%)	19 (13.2%)
High school	114 (38.0%)	52 (33.3%)	62 (43.1)
University/college or higher	134 (44.7%)	84 (53.8%)	50 (34.7%)
Income level			
Income less than expenses	148 (49.3%)	74 (47.4%)	74 (51.4%)
Income equal to expenses	130 (43.3%)	67 (42.9%)	63 (43.8%)
Income more than expenses	22 (7.3%)	15 (9.6%)	7 (4.9%)
Smoking			
Never	240 (80.0%)	102 (65.4%)	138 (95.8%)
Occasionally	38 (12.7%)	33 (21.2%)	5 (3.5%)
Regular	22 (7.3%)	21 (13.5%)	1 (0.7%)
Drinking			
Never	261 (87.0%)	121 (77.6%)	140 (97.2%)
Occasionally	35 (11.7%)	31 (19.9%)	4 (2.8%)
Regular	4 (1.3%)	4 (2.6%)	0 (0.0%)
Medication			
Oral hypoglycemic agents	249 (83.0%)	133 (85.3%)	116 (80.6%)
Insulin	26 (8.7%)	16 (10.3%)	10 (6.9%)
Oral hypoglycemic agents + insulin	25 (8.3%)	7 (4.5%)	18 (12.5%)

Values are based on mean±standard deviation or reported percentage. BMI: Body Mass Index; FPG: Fasting plasma glucose; HbA1c: Hemoglobin A1c

for categorical variables and the mean and standard deviation for continuous variables. An independent t-test was used to compare the distribution of two-tier categorical and continuous variables and one-way analysis of variance (ANOVA) was used to compare the distribution of categorical and continuous variables of three ties or more. Associations between continuous variables were described by Spearman's correlation coefficients. Linear regression analyses were performed to assess the relationship between demographic and clinical variables with self-care activities, social support, and sleep quality.

Results

We enrolled 300 patients (156 men and 144 women) with T2DM who participated in this study. Table 1 shows general characteristics of study participants. The mean age was 50.83±7.14 years, the mean BMI was 27.92±4.93 kg/m^2 and the mean duration of diabetes was 9.08±6.01 years. The mean levels of FPG and HbA1c were 153.83±48.30 mg/dL and 7.87±1.70%, respectively. Among participants, only 3% showed proper self-care behavior, 33.3% had moderate scores, and 63.7% had poor self-care performance. In the present study, the overall average of the social support score was moderate (67.73±19.85) and the mean score of PSQI in patients was 7.55±3.80 which drops within poor sleep quality scores. Totally, 206 patients (68.7%) had a PSQI score of 6 or higher, which indicates poor sleep quality.

Table 2: T test and ANOVA analysis exploring the association of demographic and clinical characteristics with self-care activities, social support and sleep quality.

Variable		Self-care activities	*P* value	Social support	*P* value	Sleep quality	*P* value
Age (year)	31-40	14.58±38.86	0.841	18.70±71.24	0.437	3.63±6.97	0.588
	41-50	12.67±37.40		22.01±66.27		3.57±7.64	
	51-60	12.61±37.74		18.97±67.74		3.97±7.67	
BMI (kg/m^2)	Normal	13.36±40.27	0.004	18.89±75.47	<0.001	3.27±6.53	0.026
	Overweight	12.77±38.38		19.09±66.99		4.11±7.84	
	Obese	12.02±33.51		20.05±61.35		3.47±8.00	
duration of diabetes	0-5	12.33±35.25	0.005	21.26±69.75	0.215	3.73±7.20	0.290
	5-10	13.05±37.07		18.95±65.09		3.39±7.45	
	>10	12.90±41.19		19.31±68.62		4.26±8.04	
FPG	<100	14.73±43.33	0.044	21.43±72.78	0.062	2.57±5.44	<0.001
	100-120	12.27±40.02		19.17±72.76		3.67±6.02	
	>120	12.82±36.75		19.72±66.28		3.78±8.04	
HbA1c	≤7	13.01±43.65	<0.001	17.06±75.61	<0.001	3.09±5.48	<0.001
	>7	11.73±34.46		19.99±63.49		3.69±8.67	
Gender	Men	12.77±37.11	0.433	20.52±70.01	0.038	3.44±6.63	<0.001
	Women	13.14±38.29		18.86±65.26		3.93±8.56	
Employment status	Employed	12.99±37.60	0.427	19.95±70.61	0.006	3.38±6.58	<0.001
	Retiree	12.34±39.42		18.62±70.67		3.59±6.80	
	Unemployed or housekeeper	13.22±36.79		19.70±63.13		3.93±8.97	
Marital status	Married	12.95±37.71	0.872	20.11±68.04	0.385	3.87±7.53	0.709
	Single/divorced/widow	13.11±37.29		17.04±64.56		3.15±7.81	
Educational level	Primary school or lower	11.69±34.27	0.002	17.96±69.06	0.046	5.34±9.33	0.005
	Middle school	12.36±31.58		19.33±61.97		4.48±8.88	
	High school	13.52±36.91		20.20±65.45		3.44±7.70	
	University/college or higher	12.13±40.33		19.53±70.96		3.53±6.85	
Income level	Income less than expenses	13.88±36.32	0.112	20.81±65.48	0.104	3.89±8.45	<0.001
	Income equal to expenses	12.07±39.46		18.19±70.50		3.64±6.80	
	Income more than expenses	10.26±36.22		21.50±66.50		2.65±6.00	
Smoking	Never	13.45±38.78	0.010	19.98±67.35	0.298	3.94±7.60	0.668
	Occasionally	9.44±34.10		19.33±66.50		3.24±7.08	
	Regular	9.83±31.81		19.07±74.00		3.26±7.91	
Drinking	Never	13.19±38.14	0.110	19.55±67.67	0.900	3.85±7.55	0.985
	Occasionally	10.81±34.58		22.01±68.10		3.55±7.56	
Medication	Oral hypoglycemic agents	13.06±36.47	0.002	20.09±67.22	0.196	3.47±7.22	0.001
	Insulin	11.30±43.53		19.16±74.35		3.89±8.23	
	Oral hypoglycemic agents + insulin	10.16±43.56		17.38±65.92		5.63±10.12	

P values were reported using independent t-test and ANOVA.

There was a significant difference between mean scores of selfcare behaviors, social support, and sleep quality based on HbA1c levels (p<0.001), BMI (p=0.004, p≤0.001 and p=0.026, respectively) and educational level (p=0.002, p=0.046 and p=0.005, respectively). Furthermore, a significant difference was seen between the mean score of selfcare behaviors and duration of diabetes, FPG, smoking, and medication (p≤0.05). As shown in Table 2, no significant difference was found between the mean score of social support and FPG, income, and medication. However, the mean score of sleep quality was significantly different with FPG, income and medication (p<0.001, p<0.001 and p=0.001, respectively). Also, there was a significant difference between mean score of social support and sleep quality regarding gender and employment status (p≤0.05, Table 2).

Table 3 demonstrates the association between glycemic status with self-care activities, social support and sleep quality. The correlation analysis between clinical variables and self-care activity level indicated that there was a positive significant weak association between duration of diabetes with the level of self-care activities (r=0.167, p=0.004). Also, there was a negative significant association between HbA1c level (r=-0.346, p<0.001), FPG (r=-0.236, p<0.001), and BMI (r=-0.172, p=0.003) with the level of self-care activity. The significant association (p<0.001) between social support and HbA1c, FPG, and BMI was negative (r=-0.309, r=-0.230 and r=-0.251, respectively). On the other hand, the sleep quality scale showed a positive significant association with BMI (r=0.129, p=0.025), FPG (r=0.439, p<0.001), and HbA1c (r=0.469, p<0.001). A significant negative relationship was found between sleep quality with self-care activities and social support (r=−0.259, p<0.001 and r=−0.393, p<0.001, respectively) implying that a better sleep quality can increase social support and self-care activities. There was also a significant positive association between social support and self-care activities (r=0.311, p<0.001). Hence, if social support increased, self-care activities increased, accordingly (Table 3).

Table 4 demonstrates the association of demographic and clinical characteristics with self-care activities, social support and sleep quality. A negative significant linear relationship was found between self-care activities and BMI (p=0.002), HbA1c (p=0.020), and smoking (p=0.012). Also, there was a positive significant linear relationship between self-care activities and duration of diabetes (p=0.015), educational level (p<0.001) and medication (p<0.001). Thus, by decreasing the level of HbA1c, decreasing smoking, and decreasing BMI, the score of self-care activities increased. On the other hand, the score of self-care activities increased with increasing educational level and prolonged diabetes. Furthermore, there was a negative significant linear correlation between social support and BMI (p=0.002), as well as a positive significant linear relationship between sleep quality and FPG (p=0.039), HbA1c (p=0.001), employment status (p=0.048) and medication (p=0.027). There was a negative significant linear relationship between sleep quality and income (p=0.010). Thus, by decreasing the level of FPG and HbA1c, taking oral hypoglycemic agents alone, and better employment status, the sleep quality increases.

Discussion

In the present study, we explored the association between glycemic status, social support and sleep quality in 300 patients with T2DM in Shiraz, southern Iran. To achieve the ideal glycemic control, a variety of factors could contribute. The findings of this study indicated that HbA1c and FPG levels were negatively correlated with self-care activities. This finding was in line with previous researches (7) demonstrating that patients with high levels of Hb1Ac and FPG had low self-care activities. Amelia *et al.* reported a correlation between self-care behaviors and HbA1c levels in patients with T2DM. The inverse correlation

Table 3: Spearman's correlation analysis.

	Self-care activities		Social support		Sleep quality	
	Correlation (r)	***P* value**	**Correlation (r)**	***P* value**	**Correlation (r)**	***P* value**
Age	0.049	0.401	-0.016	0.786	-0.007	0.901
BMI	-0.172	0.003	-0.251	<0.001	0.129	0.025
duration of diabetes	0.167	0.004	-0.037	0.527	0.069	0.236
FPG	-0.236	<0.001	-0.230	<0.001	0.439	<0.001
HbA1c	-0.346	<0.001	-0.309	<0.001	0.469	<0.001
Sleep quality	-0.259	<0.001	-0.393	<0.001		
Social support	0.311	<0.001				

P value less than 0.05 was considered significant. BMI: Body Mass Index; PG: Fasting plasma glucose; HbA1c: Hemoglobin A1c; *The association is expressed using Spearman correlation analysis.

Table 4: Multiple regression analysis models exploring the association of demographic and clinical characteristics with self-care activities, social support and sleep quality.

Variable	β±SE	*P* value	95% CI
	Self-care activities		
BMI (kg/m^2)	-0.44±0.14	0.002	(-0.72, -0.17)
Duration of diabetes	0.28±0.11	0.015	(0.05, 0.51)
FPG	-0.02±0.02	0.330	(-0.06, 0.02)
HbA1c	-1.41±0.60	0.020	(-2.59, -0.22)
Educational level	2.79±0.79	<0.001	(1.23, 4.36)
Smoking	-3.22±1.28	0.012	(-5.75, -0.70)
Drinking	-0.94±1.96	0.633	(-4.81, 2.93)
Medication	5.15±1.18	<0.001	(2.81, 7.48)
	Social support		
BMI (kg/m^2)	-0.69±0.22	0.002	(-1.12, -0.26)
FPG	-0.34±0.33	0.305	(-0.98, 0.31)
HbA1c	-1.66±0.94	0.080	(-3.53, 0.20)
Sex	-0.23±2.57	0.929	(-5.30, 4.84)
Employment status	-2.77±1.45	0.058	(-5.63, 0.09)
	Sleep quality		
BMI (kg/m^2)	0.03±0.03	0.364	(-0.04, 0.10)
FPG	0.12±0.006	0.039	(0.001, 0.02)
HbA1c	0.54±0.16	0.001	(0.22, 0.87)
Sex	0.79±0.44	0.073	(-0.07, 1.66)
Employment status	0.52±0.26	0.048	(0.006, 1.04)
Educational level	-0.11±0.23	0.618	(-0.58, 0.35)
Income level	-0.79±0.30	0.010	(-1.39, -0.19)
Medication	0.69±0.31	0.027	(0.008, 1.31)

P value less than 0.05 was considered significant. BMI: Body Mass Index; FPG: Fasting plasma glucose; HbA1c: Hemoglobin A1c; SE: Standard error; β coefficient obtained from linear regression. *P* value less than 0.05 was considered statistically significant.

indicated that a better behavior of T2DM patients was associated with lower HbA1c values (20). Similarly, the results of our study confirm the findings of others demonstrating an association between inappropriate self-care behavior and poor glycemic control (21).

This study found that patients with low and normal BMI, longer duration of diabetes, high educational level, and without smoking habits showed high levels of self-care activities. Another study by Baghaei *et al.* demonstrated that prolonged diabetes results in good self-care scores (22). This might be due to the fact that patients become more familiar with their disease over time, leading them to take better self-care as well. Consistent with this study, Ayele *et al.* (23) found that self-care activities were appropriate among diabetic patients with higher education. Evidence has shown that social support has a profound influence on individuals' health and a greater social support can result in better diabetes outcomes (24). In the present study, we found that participants with higher HbA1c and FPG levels had less social support. Similar to our results, Ha *et al.* found an inverse relationship between social support and HbA1 c levels (25).

However, these results contradict some findings revealing that social support was associated with high levels of HbA1c and FPG (26). On the other hand, no significant relationship was found between social support and glycemic control (26). In the study conducted by Mohebi *et al.*, no significant association was observed between social support and HbA1c level, which might be due to the effect of confounding factors (7). This study found that social support increases as BMI decreases. Boas *et al.* (27) found no significant association between social support and BMI in their study. Furthermore, we did not find any significant association between social support and duration of diabetes, although some researchers found a significant correlation (6).

Diabetes control might be affected by sleep quality (28). Sleep duration and HbA1c levels were co-associated in a U-shaped manner in a study of 4870 Japanese T2DM patients (29). The amount of sleep needed varies from an individual to another. Thus, the PSQI was used to assess the quality and quantity of sleep in our study population. The PSQI is a reliable and valid questionnaire designed for evaluating sleep quality and quantity. The results of the present study showed that there was a significant

positive relationship between FPG and HbA1c levels with the global PSQI score; while patients with the highest HbA1c level had a high global PSQI score and greater BMI. In line with this study, a study of 3249 patients with T2DM by Sakamoto *et al.* showed that the global PSQI score was significantly higher in the top HbA1c quartile (≥7.9%) than that of other quartiles (30). Knutson *et al.* have also shown a significant positive relationship between HbA1c level and the global PSQI score (31). On the other hand, some researchers illustrated no significant relationship between the global PSQI score, FPG and HbA1c levels (32).

In the present study, patients with high BMI had higher global PSQI score, a finding that is consistent with the results of a study by Sakamoto *et al.* (30) and is contradictory to the findings of Rajendran *et al.* (32). Therefore, weight control in T2DM patients is very important for better sleep. Another finding of this study was that global PSQI score that had no statistically significant relationship with age and duration of T2DM. Findings of this study can be justified by a number of reasons. A short sleep duration was shown to increase the secretion of ghrelin, a potent stimulator of appetite, and decreases the secretion of leptin, a hormone that suppresses food intake and reduces energy expenditure (33). Furthermore, insufficient sleep might increase food intake, possibly associated with changes in peptide YY (PYY) and glucagon-like peptide 1 (GLP-1) levels, which could result in weight gain. These changes, in turn, may promote obesity and lead to the deterioration of glycemic control (34). Sakamoto *et al.* found that high HbA1c level is associated with more symptoms of hyperglycemia including thirst, nocturia and neuropathic pain that could contribute to short sleep durations and poor sleep quality (30). Modest chronic sleep loss is related to an increase in secretion of interleukin-6 (IL-6) and/or tumor necrosis factor-alpha (TNF-α), and a significant drop of maximum values of cortisol. TNFα and IL-6 are both markers of systemic inflammation that may contribute to insulin resistance. Poor sleep quality can reduce quality of life (35) and negatively affect daytime activities, as well as patients' ability to follow a diet and exercise program (30). However, more researches are needed to confirm these explanations.

Based on our findings, there was a significant association between sleep quality and some demographic variables including employment status, income level, and medication. Sleep quality in employed patients was better than unemployed patients and a lower global PSQI score was found in people with better income level and in those taking insulin with oral hypoglycemic agents. According to the results, the patients' self-care behaviors would increase in accordance with social support. In other words, there is a statistically significant positive relationship between self-care activities and social support which is consistent with results of previous studies (36). According to the study findings, social support might play a significant role in the management of diabetes. In this way, the findings of a study by Mohebi *et al.* suggest that perceived social support improves motivation and self-care behaviors in patients with T2DM (7). Different definitions and measurement scales for social support could explain variations in results from different studies. In this study, sleep quality was directly related to diabetes self-care. In a study of 361 T2DM adults, Nefs and colleagues reported that T2DM participants with poor sleep quality exhibited suboptimal glycemic control (HbA1c ≥7% or 53 mmol/mol) more often than those with good sleep quality (37).

The quality of sleep may be affected by some psychosocial factors such as social support (38). It was shown that a higher social support is related to better psychological health, quality of life, cognition, daily activities, and social participation, but the relationship between social support and sleep quality remains unknown. The findings of the present study denoted to a significant negative relationship between social support and PSQI score. This means that people with higher social support have lower PSQI scores and better sleep quality. According to our research, no study has been done on the relationship between these two variables in diabetic patients, but other findings were in line with our study (39). There is evidence that positive psychosocial resources are correlated with better sleep, a link that could be explained by the fact that the reduction of neurohormonal changes due to positive psychological indicators induces a positive sleep impact (40). In addition, other persuasive explanations suggest that positive psychological characteristics can enhance sleep by improving both physical and mental well-being (39). Nevertheless, experimental and prospective studies are needed to examine the causal mechanisms linking sleep to psychosocial characteristics.

According to our research, this is the first study to examine the three variables of self-care behaviors, social support and sleep quality simultaneously in patients with T2DM. Other strengths of this study were the appropriate sample size. There were several limitations for the present study. First, the present study was a cross-sectional study; therefore, this study could not infer a causal association between cause and effect. Second, due to the limited nature

of the inclusion criteria, we were not able to evaluate this hypothesis on a larger population, so the sample size of our study may not be representative of all diabetic patients. Third, due to the concomitance of this study and coronavirus 2019 (COVID-19) pandemic, there were issues in data collection and communication with patients. Also, detrimental effects of COVID-19 pandemic on patients' lives, especially on the three variables investigated in our study (self-care behaviors, social support and sleep quality), cannot be excluded. For this reason, we used convenience sampling, which was another limitation of this study, and only patients who referred to medical centers on an outpatient basis entered the study. Finally, the subjective nature of self-reported questionnaires is also the concern. Possible individual biases in answering the questionnaires might also have influenced the results. Future prospective studies are therefore needed to define the existence of causal relationships between all the variables investigated in our study. Considering that only patients who referred to medical centers on an outpatient basis entered the study, it is suggested that sampling can be performed in a broader form in future studies.

Conclusion

The current findings showed that the performance of self-care behaviors, social support received from others and good sleep quality was associated with a decrease in HbA1c. Hence, it is recommended that an educational package for healthcare providers in primary care centers should be developed and set to convey a proper message for promoting self-care behaviors, social support, and sleep quality among patients with T2DM.

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Authors' Contribution

MM wrote and drafted the manuscript. MM and MK Contributed to investigation, data collection and Validation. MHS designed the study and conducted the methodology. HS, MM and SM performed analysed and interpreted the results. MHE Contributed to the research concept, supervised the work and revised the manuscript. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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