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Emine Elibol, Zehra Çelik, Havva Dereli

Department of Nutrition and Dietetics. Ankara Yıldırım Beyazıt Üniversitesi. Ankara, Turkey

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Correspondence: Emine Elibol. Department of Nutrition and Dietetics. Ankara Yıldırım Beyazıt Üniversitesi. Dumlupınar Mahallesi, 06760 Çubuk. Ankara, Turkey
e-mail: semilay.5252@gmail.com

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ABSTRACT

Background: diabetes *mellitus* is increasing globally. The macronutrient content of food consumed by diabetic patients plays a critical role in the course of the disease.

Objective: this study aimed to evaluate the effect of carbohydrate quality on sleep quality and depression in patients with type 2 diabetes.

Method: a total of 150 individuals with type 2 diabetes were included in the study. A demographic questionnaire, sleep quality scale (SQS) (where higher scores indicate poorer sleep quality), and the depression, anxiety, and stress scale (DASS) were administered to participants. Additionally, a food frequency questionnaire consisting of 132 foods was used. To determine the Carbohydrate Quality Index (CQI) score, four components (fiber intake, whole grain ratio, glycemic index, and total carbohydrate ratio) were assessed on a scale of 1-5 points. The total CQI score was calculated, with Q5 representing the highest carbohydrate quality and Q1 the lowest. Data were analyzed using the SPSS 24 program.

Results: the mean age of participants was 53.9 ± 16.38 years. The mean CQI score was 15.5 ± 2.57 in men and 13.2 ± 3.02 in women. Anxiety and depression levels were higher in women than in men. The highest SQS scores were observed in the Q1 group, indicating poorer sleep quality. Anxiety and depression scores were highest in the Q5 group and lowest in the Q1 group ($p < 0.05$). A positive correlation was found between CQI scores and sub-scores of depression, anxiety, and stress, while a negative correlation was observed with SQS scores.

Conclusion: the study found that as carbohydrate quality was associated with worsened sleep quality, and higher levels of anxiety, stress, and depression, although the relationship was weak. Further research on this topic is needed.

Keywords: Carbohydrate quality. Type 2 diabetes *mellitus*. Sleep quality. Depression. Stress.

RESUMEN

Antecedentes: la diabetes *mellitus* está aumentando a nivel mundial. El contenido de macronutrientes de los alimentos consumidos por los pacientes diabéticos desempeña un papel fundamental en la evolución de la enfermedad.

Objetivo: este estudio tuvo como objetivo evaluar el efecto de la calidad de los carbohidratos sobre la calidad del sueño y la depresión en pacientes con diabetes de tipo 2.

Método: se incluyó en el estudio un total de 150 personas con diabetes de tipo 2. A los participantes se les administró un cuestionario demográfico, la escala de calidad del sueño (ECS), en la que las puntuaciones más altas indican una peor calidad del sueño, y la escala de depresión, ansiedad y estrés (DASS). Además, se utilizó un cuestionario de frecuencia alimentaria que incluía 132 alimentos. Para determinar la puntuación del Índice de Calidad de los Carbohidratos (ICC) se evaluaron cuatro componentes (ingesta de fibra, proporción de cereales integrales, índice glucémico y proporción total de carbohidratos) en una escala de 1 a 5 puntos. Se calculó la puntuación total de ICC, en la que Q5 representaba la mayor calidad de carbohidratos y Q1 la menor. Los datos se analizaron con el programa SPSS 24.

Resultados: la edad media de los participantes fue de 53,9 ± 16,38 años. La puntuación media del ICC fue de 15,5 ± 2,57 en los hombres y de 13,2 ± 3,02 en las mujeres. Los niveles de ansiedad y depresión fueron mayores en las mujeres que en los hombres. Las puntuaciones más altas de ECS se observaron en el grupo Q1, lo que indica una peor calidad del sueño. Las puntuaciones de ansiedad y depresión fueron más altas en el grupo Q5 y más bajas en el grupo Q1 ($p < 0,05$). Se encontró una correlación positiva entre las puntuaciones de ICC y las subpuntuaciones de depresión, ansiedad y estrés, mientras que se observó una correlación negativa con las puntuaciones de SQS.

Conclusión: el estudio encontró que la calidad de los carbohidratos estaba asociada con una peor calidad del sueño y niveles más altos de ansiedad, estrés y depresión, aunque la relación fue débil. Se necesita más investigación sobre este tema.

Palabras clave: Calidad de los carbohidratos. Diabetes *mellitus* de tipo 2. Calidad del sueño. Depresión. Estrés.

INTRODUCTİON

The prevalence of diabetes is increasing globally. The International Diabetes Federation (IDF) estimates that 536.6 million people were living with diabetes (diagnosed or undiagnosed) in 2021, and this number is expected to rise by 46 % to 783.2 million by 2045 (1). Type 2 diabetes is closely associated with increased morbidity and mortality (2,3). It is a metabolic disorder caused by insufficient insulin secretion from pancreatic β-cells or by tissues not responding appropriately to insulin (4). Genetic, metabolic, and environmental factors contribute to the development of type 2 diabetes. In particular, modifiable factors such as obesity, unhealthy diets, and physical inactivity have been shown to have a greater impact on the development of type 2 diabetes than unmodifiable genetic factors (5,6).

Dietary patterns, along with both macro- and micronutrients, significantly affect the development of degenerative and chronic diseases (7,8). Carbohydrate quality, rather than the quantity, is crucial in the development of many chronic diseases, particularly type 2 diabetes *mellitus* (9). Indicators of carbohydrate quality include dietary fiber, whole grains, legumes, glycemic index, and glycemic load (10). In addition, carbohydrate sources such as sugar, fructose, added sugars, and sucrose also influence carbohydrate quality (11).

Long-term treatments for diabetes are primarily designed to manage blood glucose levels, as individuals with diabetes often experience poor sleep quality due to symptoms related to hyperglycemia or hypoglycemia (12). Studies have shown a relationship between diabetes and insomnia, with individuals who have high HbA1c levels experiencing shorter sleep durations. Hyperglycemic symptoms (e.g., thirst, dry mouth) and hypoglycemic symptoms (e.g., tachycardia, nocturia, sweating) may also disrupt sleep in diabetic individuals (13,14). Furthermore, natural carbohydrate sources (e.g., rice, cherries, milk) have been shown to improve sleep quality, while processed carbohydrates (e.g., confectionery) can increase insulin release and impair sleep quality (15). Consuming natural carbohydrate foods has been linked to less fragmented sleep (16).

Stress is common among diabetic patients. A meta-analysis found that the risk of depression is higher in people with Type 2 diabetes compared to non-diabetics (17). Stress in diabetic patients can impair blood glucose control and increase HbA1c levels (18). Carbohydrate quality also plays an important role in managing stress in diabetes, as consuming foods with a high glycemic index and low carbohydrate quality negatively affects blood glucose control (19). A cohort study showed that low-carbohydrate diets in diabetic patients were associated with a reduced incidence of mental disorders (20).

This research aims to examine the relationship between carbohydrate quality, sleep patterns, and depression in individuals with type 2 diabetes. It seeks to shed light on how the dietary habits of diabetic patients impact not only blood glucose levels but also sleep quality and emotional well-being. The significance of this study lies in its contribution to clinical practice by emphasizing the importance of dietary regimes and carbohydrate quality in improving the quality of life for diabetic patients.

METHOD

The present descriptive and cross-sectional study was conducted in Turkey over a four-month period, from January 1 to May 1, 2023. Participants were male and female individuals aged 19 to 64 years, all of whom had been diagnosed with type 2 diabetes *mellitus* at least six months prior to enrollment. To ensure data quality and consistency, individuals who were pregnant or lactating, as well as those with physician-diagnosed psychiatric disorders, were excluded. The minimum required sample size was calculated as 103 using the G*Power 3.1 software, assuming a 5 % margin of error and 80 % power. Although 162 individuals were initially approached, those with missing demographic, anthropometric, or dietary information were not included in the analysis. As a result, the study was completed with a final sample of 150 participants (Fig. 1).

Ethical approval

The study was conducted following the principles of the Declaration of Helsinki and received ethical approval from the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (approval date: December 08, 2022; decision number: 19-1236).

Data collection tools

The Demographic Structure Questionnaire, Sleep Quality Scale (SQS), Depression Anxiety and Stress Scale (DASS) and Food Consumption Frequency Form were applied to the participants as data collection tools.

Demographic Structure Questionnaire

The demographic structure questionnaire consisted of 31 items designed to collect participants' demographic and health-related information, including gender, age, body weight, height, education level, occupation, and details related to type 2 diabetes. Additionally, specific variables such as physical activity status, diet therapy, and comorbidities were assessed.

Participants who had been regularly visiting a dietitian for at least the past year and whose diets were being monitored and adjusted by a professional were classified as receiving diet therapy. Regular physical activity was defined as engaging in exercise at least three times per week for a minimum of eight consecutive weeks, with each session lasting no less than 60 minutes. Comorbidity was defined as the presence of one or more chronic diseases accompanying type 2 diabetes, such as cardiovascular diseases

Body weight (kg) and height (cm) were measured by the researchers using standard procedures. Measurements were taken with participants standing upright, facing forward, and positioned according to the Frankfort plane, in which the top of the ears and the outer corners of the eyes are aligned on a horizontal plane (21). Body mass index (BMI) was calculated using the standard formula (weight in kilograms divided by height in meters squared), and body weight, height, and BMI values were classified according to the World Health Organization (WHO) criteria (22).

Sleep Quality Scale

The Sleep Quality Scale (SQS) developed by van den Wittenboer and Meijer in 2004 (23) was used to evaluate the sleep quality of individuals diagnosed with type 2 diabetes *mellitus*. The scale consists of a total of 8 questions with 3 options and a minimum score of 7 and a maximum score of 21 is obtained from the scale. As the score obtained from the scale increases, sleep quality decreases. Questions 5 and 6 were reversed and a total score was obtained. The validity and reliability of the scale in Turkey were performed by Önder et al., and Cronbach's Alpha value was found to be 0.72 (24).

Depression Anxiety and Stress Scale

The Depression Scale developed by Lovibond and Lovibond in 1995 (25) aims to evaluate the psychological status of patients with type 2 diabetes during this process. The scale consists of a total of 21 questions, the questions consist of 5 grades as normal-mild-moderate-severe-advanced-very advanced. It has three sub-dimensions: depression, anxiety, and stress. The validity and reliability of the scale in Turkey were performed by Hakan Sariçam, and Cronbach's Alpha value was found to be α = 0.87 for depression subscale, α = 0.85 for anxiety subscale and α = 0.81 for stress subscale (26).

Carbohydrate Quality Index calculation

A total of 132 food groups obtained from the food consumption frequency questionnaire were analyzed using the BeBiS program, which features an international database. Average daily energy and nutrient intake were calculated. The Carbohydrate Quality Index was prepared using the Glycaemic Index (GI) and the amounts of dietary pulp ratio, whole grain ratio (whole grains and refined grains), and total carbohydrate (liquid and solid carbohydrates). Intake (g/day) was calculated using the BeBiS programme with a global database, taking into account the amount and frequency of food consumed by the participant. Glycaemic Index (GI) values were determined using the BeBiS programme with a global database for nutrients, taking into account the amount and frequency of food consumed by the participant. Also, we obtained the GI for some food from the University of Sydney GI database (27).

The whole grain/total grain (whole and refined grain) ratio was calculated by identifying whole and refined grain foods from the participant's food consumption records and calculating their amounts individually (refined grain foods: phyllo dough, white bread, pasta, white rice, cakes, noodles, pastries, etc.; whole grain foods: whole grain bread, whole grain crackers and bagels, whole grain pasta-noodles, etc.). The solid carbohydrate/total carbohydrate (solid and liquid) ratio was calculated by determining the foods containing liquid carbohydrate from the participant's food consumption records and calculating the carbohydrate content. The amount of solid carbohydrate was calculated by subtracting the foods containing liquid carbohydrate from the total amount of carbohydrate (7).

To determine the Carbohydrate Quality Index score, the four components were individually scored on a scale from 1 to 5. Notably, the glycaemic index was scored in reverse order, with the highest values receiving a score of 1 and the lowest receiving 5, whereas the other components were scored in the standard direction. The cumulative carbohydrate quality score was subsequently categorized into quintiles (Q1 through Q5) to generate the Carbohydrate Quality Index (CQI), where Q1 indicated the lowest and Q5 the highest level of carbohydrate quality (7) (Table I). Importantly, no predefined cutoff point was applied to distinguish between high and low carbohydrate quality.

Analysing the data

Statistical analyses will be performed using the SPSS software (IBM SPSS Statistics 24) An independent sample *t*-test (*t*-table value) will be used to compare the measurement values of two independent groups with normal distribution; the Mann-Whitney U-test (Z-table value) will be used for non-normally distributed groups. The ANOVA test (F-table value) will be used to compare three or more groups with normal distribution of measurement values, and the Kruskal-Wallis H-test (χ^2-table value) will be employed for non-normally distributed groups. Pearson's correlation coefficient will be used to analyse the relationship between two quantitative variables with normal distribution and the Spearman correlation coefficient will be used for the data that do not have normal distribution. Multiple linear regression was performed to determine the effect of the variables on the CQI score.

RESULTS

A total of 150 participants, consisting of 79 women and 71 men, were included in the study. As shown in table II, the SQS score was lower in women (13.2 ± 3.02) compared to men, whereas CQI, depression, and anxiety scores were statistically higher in women ($p < 0.05$). The anxiety level of obese individuals (6.03 ± 4.70) was statistically higher than that of over weight (4.21 ± 3.40) and lean individuals (4.29 ± 3.32) ($p < 0.05$). It was determined that factors such as regular exercise, type of diabetes treatment, and the comorbidity were not statistically significant concerning sleep quality, depression, anxiety, and stress levels ($p > 0.05$). The depression levels of individuals receiving diet therapy (5.93 ± 3.98) were found to be statistically higher than those not receiving diet therapy (4.47 ± 4.14) ($p < 0.05$).

The amount of snack consumption in individuals within the highest Q3 group was found to be statistically higher than those in the Q1 and Q5 groups. The SQS score of patients in the Q1 group was statistically higher than in the Q5 group ($p < 0.05$). The highest values for anxiety (7.2 ± 5.02), stress (8.3 ± 5.28), and depression (7.1 ± 4.34) were observed in patients in the Q5 group ($p < 0.05$) (Table III).

The fiber intake in the Q5 group was statistically higher than in the other groups ($p < 0.05$). The carbohydrate amounts for the Q1, Q2, Q3, Q4, and Q5 groups were 254.2 ± 81.79 g, 287.8 ± 126.60 g, 300.6 ± 152.51 g, 232.5 ± 117.70 g, and 258.4 ± 55.36 g, respectively. The highest levels of vitamins K, B1, and C, as well as folate, potassium, magnesium, and iron, were observed in the Q5 group (Table IV).

A positive correlation was found between carbohydrate quality and depression ($r = 0.27$; $p = 0.001$), anxiety ($r = 0.31$; $p = 0.001$), and stress ($r = 0.20$; $p = 0.016$), and a negative correlation with sleep quality score ($r = -0.21$; $p = 0.010$). Additionally, there was a moderate positive correlation between depression, anxiety, and stress, and a low negative correlation with sleep quality score ($p < 0.05$) (Table V).

Single regression analysis showed that depression, anxiety, energy intake, carbohydrates, protein, fiber, phosphorus, potassium, and magnesium levels were positively associated with CQI, while fat and folate were negatively associated ($p < 0.05$). Multiple regression analysis further revealed that depression, anxiety, stress, energy, vitamin B1, and phosphorus levels were positively associated with CQI, while carbohydrate, vitamin B6, folate, and calcium levels were negatively associated with CQI ($p < 0.05$) (Table VI).

DISCUSSION

Depression is commonly observed in individuals with diabetes, with a higher prevalence compared to healthy individuals (28). Norouzi et al. (29)

found that women with type 2 diabetes experience higher levels of depression than men. This finding is supported by a study conducted by Khan et al., which revealed that approximately 30.2 % of 140 diabetic patients evaluated in a psychiatric clinic were diagnosed with depression, with women exhibiting significantly higher levels of stress than men (30). Furthermore, a clinical study by Khiro demonstrated that the risk of developing depression in women with diabetes is nearly twice as high as in men (31). Other research has also shown that women with type 2 diabetes tend to experience higher levels of stress compared to their male counterparts (32,33). In line with these findings, the present study showed that depression and anxiety scores were statistically higher in women than in men. This may be attributed to the fact that women are generally more emotionally affected by environmental factors and health conditions.

Both obesity and depression are globally prevalent conditions. A systematic review revealed that the incidence of depression in obese individuals is approximately double that of those with normal weight (34). In line with this, Huang et al. found that obesity and elevated CRP levels were associated with higher depression levels in diabetic patients (35). Furthermore, Svenningsson et al. showed that diabetic patients with a BMI between 30 and 40 kg/m² had higher depression scores compared to those with a BMI between 18.5 and 25 kg/m² (36). Consistent with these findings, this study also observed the highest levels of anxiety, stress, and depression among obese individuals ($p < 0.05$).

Sleep duration and quality are closely associated with metabolic diseases such as diabetes (37). Yılmaz et al. found that individuals with HbA1c levels above 7 % had lower sleep quality (38). Another study on diabetic patients revealed that women undergoing insulin therapy were 2.55 times more likely to develop subjective sleep disturbances than men (39). Lou et al. (40) found that poor sleep quality was more common among women than men. Similarly, Zhang (41) observed higher rates of poor sleep quality in women. In contrast, the present study found that men had poorer sleep quality than women. This could be attributed to several factors, such as the higher prevalence of sleep apnea in men with diabetes, which is a condition that significantly impacts sleep quality.

Dietary habits often differ between men and women. A study by Zengin et al. found that men had a lower Healthy Eating Index-2005 score than women (42). Similarly, Artegoitia et al. observed that women consumed more fruits and vegetables, while men tended to consume more saturated fats (43). Consistent with these findings, 76.7 % of participants in the highest carbohydrate quality group (Q5) were women, while only 23.3 % were men. Zazpe et al. (7) also reported that women were more likely to have a higher carbohydrate quality index score than men, with similar results from other studies (44). In this study, the CQI score of women was statistically higher than that of men ($p < 0.05$). This finding may be attributed to the fact that women are generally more engaged in controlling their body weight and maintaining overall health, which further motivates them to adopt healthier eating behaviors (45,46).

Dietary fiber, which increases carbohydrate quality, is found in whole grains, vegetables, and fruits. These foods are also rich in essential micronutrients. In Yüksel et al.'s study, the highest intake of potassium, magnesium, vitamin C, thiamine, and folate was observed in the Q5 group (47). Another study found that zinc, iron, calcium, magnesium, and vitamins B3, C, A, E, and B9 were higher in the Q5 group compared to other groups (7). Similarly, in this study, the intake of potasyum, magnesium, iron, vitamins K, B1, B9, and C was highest in the Q5 group. Additionally, both single and multiple regression analyses revealed that folate, phosphorus, potassium, magnesium, and certain vitamins had a significant effect on the CQI score. These findings can be attributed to the high intake of whole grains and low glycemic index foods in the Q5 group, which are richer in micronutrients.

Carbohydrate consumption can cause a change in the amount of serotonin and cause changes in the emotional state of individuals (48). Dang et al. found a negative relationship between high-quality carbohydrate intake and depression symptoms (49). In another study, a positive relationship was found between low carbohydrate intake from refined sugars and processed foods and depression symptoms (50). In the study conducted by Yüksel et al., no significant relationship was found between carbohydrate quality and depression, anxiety, and stress (47). However, another study found no relationship between low carbohydrate intake and stress, while a positive relationship was observed between depression and anxiety (51). Interestingly, in the current study, a positive relationship was found between carbohydrate quality score and depression, anxiety, and stress. Moreover, the highest anxiety, depression, and stress scores were observed in the Q5 group. This could be due to diabetic patients focusing on carbohydrates to regulate blood glucose levels, which might lead to stress.

Carbohydrates are considered to be the main macronutrient for sleep duration and sleep quality due to their important effects on brain function (52). In a study conducted by Metin, it was shown that the type of carbohydrate consumed, rather than the total amount, is more strongly associated with sleep quality (53). In a study investigating the effect of low carbohydrate intake on sleep quality, it was demonstrated that low carbohydrate intake was associated with better sleep quality (51). Additionally, a study found a statistically weak positive correlation between carbohydrate quality score and sleep quality, with the highest sleep quality score being found in the Q1 group and the lowest in the Q5 group (47). However, in the present study, sleep quality was observed to be lowest in the Q5 group and highest in the Q1 group ($p < 0.05$). Moreover, a statistically weak negative relationship was found between carbohydrate quality score and sleep quality ($p < 0.05$). This suggests that, contrary to other studies, there might be an inverse relationship between carbohydrate quality and sleep quality in this cohort. In another study, it was found that individuals with shorter sleep duration consumed more refined products compared to those with longer sleep duration (52). Similarly, noodle and dessert consumption was associated with poor sleep quality (54). These findings suggest that a dietary pattern characterized by poor carbohydrate quality may lead to changes in sleep quality, or individuals with poor sleep quality may be more inclined to consume foods with low carbohydrate quality.

There are several limitations in this study. First, as a cross-sectional design, the study cannot establish causal relationships. The data collected regarding participants' diabetes treatment and lifestyle are based on retrospective self-reports, which could introduce potential biases or inaccuracies. Additionally, the study only assessed the health and dietary conditions of participants at a single time point, lacking long-term follow-up data, which may limit the generalizability of the findings. The use of tools such as the Carbohydrate Quality Index (CQI) relies on self-reported dietary habits, which may be subject to self-report bias. These limitations suggest that future research should utilize larger and more diverse samples, as well as longitudinal designs, to further investigate these relationships more comprehensively.

CONCLUSION

In conclusion, individuals with higher carbohydrate quality demonstrated higher levels of anxiety, depression, and stress. In addition, a low-level negative correlation was observed between the sleep quality scale score and the carbohydrate quality index score. However, when examining the subject in the literature, very few studies were found that directly address this relationship. Therefore, further research is needed to investigate these associations more comprehensively in future studies.

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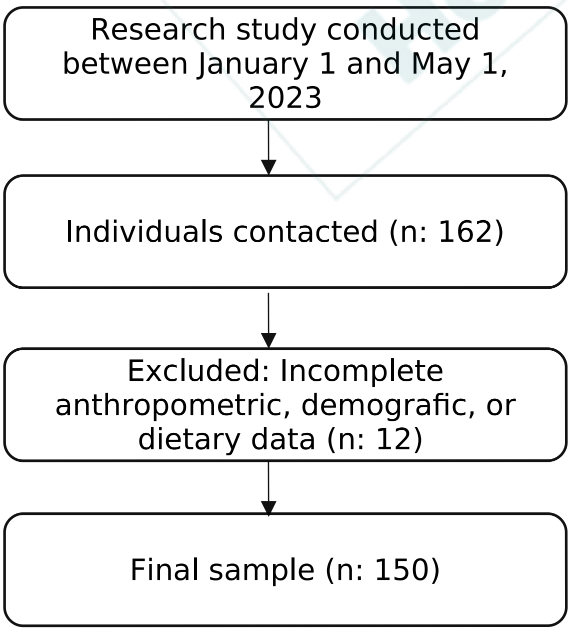

Figure 1. Flowchart of study sample selection.

Table I. Criteria used to calculate carbohydrate quality

Components of dietary index	**Criteria for maximum index**	**Criteria for minimum index**	**Index range (points)***
Dietary fibre intake (g/d)	Maximum dietary fibre intake (fifth quintile)	Minimum dietary fibre intake (first quintile)	1-5
Glycaemic index	Minimum glycaemic index (first quintile)	Maximum glycaemic index (fifth quintile)	1-5
Ratio of solid carbohydrates (solid and liquid carbohydrates)	Minimum value of this ratio (first quintile)	Minimum value of this ratio (first quintile)	1-5
Ratio of whole grains (whole and refined grains or their products)	Maximum value of this ratio (fifth quintile)	Minimum value of this ratio (first quintile)	1-5
Total index (range)			4-20

*Dietary indices were calculated proportionally based on intake values falling within the defined maximum and minimum criteria.

Table II. Scale and CQI scores of patients by demographic characteristics and various variables

Değişken		**SQS score**	***p***	**Depression Score**	***p***	**Anxiety Score**	***p***	**Stress Score**	***p***	**CQI score**	***p***
		X ± SS		**X ± SS**		**X ± SS**		**X ± SS**			
Gender	Female (*n*: 79)	13.2 ± 3.02	*0.000*	5.8 ± 4.34	*0.011*	6.1 ± 4.66	*0.000*	7.2 ± 4.36	0.053	13.7 ± 2.71	*0.043*
	Male (*n*: 71)	15.5 ± 2.57		4.1 ± 3.68		3.6 ± 2.58		5.9 ± 3.71		12.7 ± 2.10	
BMI	Under-Normal weight (*n*: 24)	15.1 ± 2.83	0.413	5.75 ± 3.98	0.063	4.29 ± 3.32	*0.027 [3-1.2]*	7.08 ± 3.53	*0.021 [2-3]*	13.2 ± 2.29	*0.004 [2-3]*
	Overweight (*n*: 70)	14.2 ± 2.98		4.24 ± 3.78		4.21 ± 3.40		5.64 ± 3.81		12.6 ± 2.27	
	Obes (*n*: 56)	14.2 ± 3.20		5.85 ± 4.45		6.03 ± 4.70		7.62 ± 4.45		14.0 ± 2.63	
Regular physical activity	Yes (*n*: 52)	14.7 ± 2.85	0.287	4.76 ± 3.52	0.494	4.5 ± 2.82	0.366	6.75 ± 3.53	0.678	12.9 ± 2.20	0.188
	No (*n*: 98)	14.1 ± 3.13		5.25 ± 4.42		5.12 ± 4.50		6.54 ± 4.40		13.4 ± 2.61	
Comorbidity	Yes (*n*: 17)	14.4 ± 3.26	0.949	5.05 ± 5.36	0.977	5.64 ± 5.88	0.420	6.94 ± 5.49	0.728	23.3 ± 2.47	0.893
	No (*n*: 133)	14.3 ± 3.02		5.09 ± 3.96		4.81 ± 3.71		6.57 ± 3.92		13.2 ± 2.67	

Diet therapy	Yes (*n*: 63)	14.6 ± 2.69	0.320	5.93 ± 3.98	*0.031*	5.41 ± 3.61	0.188	7.17 ± 3.53	0.155	13.2 ± 2.23	
	No (*n*: 87)	14.1 ± 3.27		4.47 ± 4.14		4.54 ± 4.23		6.20 ± 4.45		13.3 ± 2.67	0.845
Diabetes treatment	Oral antidiabetic (*n*: 86)	14.5 ± 3.00	0.619	4.68 ± 4.03	0.059	4.48 ± 4.00	0.319	5.91 ± 4.21	0.055	13.1 ± 2.38	
	İnsuline (*n*: 26)	14.5 ± 3.27		4.42 ± 3.89		5.65 ± 4.56		7.57 ± 3.34		12.9 ± 2.50	
	Other (*n*: 38)	13.9 ± 2.99		6.44 ± 4.27		5.34 ± 3.54		7.52 ± 4.11		13.4 ± 2.57	0.369

BMI: body mass index; SQS: sleep quality scale; CQI: carbohydrate quality index.

Table III. Demographic characteristics and scale scores of patients by CQI quartiles

	Q1 (*n*: 37)	**Q2 (*n*: 46)**	**Q3 (*n*: 17)**	**Q4 (*n*: 25)**	**Q5 (*n*: 25)**	
	X ± SS	**X ± SS**	**X ± SS**	**X ± SS**	**X ± SS**	***P değeri***
Age (yrs)	53.4 ± 17.56	50.4 ± 19.57	53.7 ± 14.88	50.6 ± 19.18	60.3 ± 9.91	0.223
Body weight (kg)	80.5 ± 12.55	83.3 ± 16.07	83.1 ± 12.73	78.0 ± 13.37	83.1 ± 19.49	0.820
BMI (kg/m^2)	28.9 ± 4.42	28.5 ± 4.64	29.6 ± 5.00	28.8 ± 4.85	31.2 ± 6.74	0.293
Age at diagnosis of diabetes (yrs)	42.2 ± 14.21	40.2 ± 15.59	42.9 ± 102.47	38.3 ± 15.28	50.1 ± 12.58	0.051
Duration of diabetes (yrs)	11.5 ± 8.90	10.1 ± 8.60	10.5 ± 7.69	12.3 ± 10.12	11.5 ± 7.23	0.842
Number of main meals	2.4 ± 0.50	2.4 ± 0.58	2.6 ± 0.61	2.6 ± 0.60	2.44 ± 0.51	0.557
Number of snacks	1.3 ± 0.77	1.5 ± 0.77	1.8 ± 0.70	1.4 ± 0.80	1.4 ± 0.92	*0.033 [3-1.5]*
Sleep duration (hrs)	8.3 ± 1.45	8.1 ± 1.01	8.1 ± 1.68	7.59 ± 1.97	7.44 ± 1.76	0.283
SQS score	15.5 ± 3.19	14.6 ± 2.61	14.1 ± 2.97	13.5 ± 2.58	13.5 ± 3.33	*0.048 [1-5]*
Anxiety sub-dimension score	3.6 ± 3.23	4.1 ± 3.53	4.7 ± 3.28	6.0 ± 4.87	7.2 ± 5.05	*0.025 [5-1.2].*

						[1-4]
Depression sub-dimension score	3.7 ± 3.57	4.2 ± 4.11	5.37 ± 4.07	5.59 ± 4.20	7.08 ± 4.34	*0.021. [1-5]*
Stress sub-dimension score	6.6 ± 3.94	4.7 ± 3.05	6.2 ± 3.90	8.0 ± 3.30	8.3 ± 5.28	*0.027 [4-2]. [5-2]*

BMI: body mass index; SQS: sleep quality scale.

Table IV. Nutrient and carbohydrate amounts by carbohydrate quality index

	Q1	**Q2**	**Q3**	**Q4**	**Q5**	***p***
	X ± SS	**X ± SS**	**X ± SS**	**X ± SS**	**X ± SS**	
Energy (kcal)	2126.2 ± 586.39	2284.9 ± 733.5	2399.9 ± 916.49	2027.6 ± 692.51	2386.9 ± 553.48	0.187
CH (g)	254.2 ± 81.79	287.8 ± 126.60	300.6 ± 152.51	232.5 ± 117.70	258.4 ± 55.36	0.266
Protein (g)	93.9 ± 30.29	98.6 ± 30.95	105.7 ± 37.47	80.6 ± 23.53	101.9 ± 36.44	0.108
Fat (g)	81.5 ± 23.92	82.1 ± 22.54	86.1 ± 26.02	86.1 ± 54.37	105.1 ± 43.29	0.061
Fibre (g)	32.2 ± 15.90	38.2 ± 19.36	44.7 ± 23.15	38.2 ± 16.96	52.3 ± 40.00	*0.001* *[1-3.5].* *[5-2.4]*
Cholesterol (mg)	527.0 ± 279.85	525.9 ± 243.57	5213.5 ± 247.60	359.4 ± 163.95	442.3 ± 165.62	0.168
Vitamin A (µg)	639.3 ± 181.53	618.6 ± 160.11	675.7 ± 143.92	573.9 ± 182.00	725.2 ± 227.74	0.054
Vitamin E (mg)	17.1 ± 8.12	16.4 ± 5.02	18.1 ± 7.44	21.0 ± 16.66	22.3 ± 9.70	0.62
Vitamin K (µg)	41.9 ± 18.91	50.3 ± 22.02	58.5 ± 24.51	57.5 ± 22.50	60.7 ± 18.34	*0.029* *[1-3.5].* *[5-2]*
Vitamin B1 (mg)	1.3 ± 0.57	1.5 ± 0.72	1.7 ± 0.81	1.3 ± 0.48	1.7 ± 0.64	*0.035* *[5-1].* *[3.1]*
Vitamin B2 (mg)	1.9 ± 0.63	2.0 ± 0.68	2.0 ± 0.52	1.7 ± 0.37	1.81 ± 0.34	0.322

Vitamin B3 (mg)	33.4 ± 9.78	35.5 ± 12.91	37.3 ± 12.08	30.7 ± 7.82	38.02 ± 9.11	*0.114*
Vitamin B5 (mg)	7.4 ± 2.53	7.7 ± 3.13	7.8 ± 2.60	5.8 ± 1.97	6.8 ± 1.51	0.054
Vitamin B6 (mg)	1.9 ± 0.81	2.22 ± 1.39	2.2 ± 0.89	1.7 ± 0.50	2.2 ± 0.61	0.121
Vitamin B12 (µg)	5.4 ± 2.07	4.9 ± 2.01	4.3 ± 2.16	4.2 ± 1.53	5.2 ± 2.01	0.157
Folate (µg)	209.9 ± 159.58	166.7 ± 177.69	240.7 ± 245.15	228.1 ± 163.82	442.48 ± 215.04	*0.001* *[5-1.2.3.4]*
Vitamin C (mg)	75.7 ± 35.56	66.4 ± 37.33	92.1 ± 59.31	80.8 ± 40.76	104.6 ± 47.19	*0.007* *[5-1.2.3.4]. [2-3]*
Sodium (mg)	2250.6 ± 695.83	2276.8 ± 891.98	2338.1 ± 1013.94	2089.9 ± 696.19	2138.6 ± 427.24	0.830
Potassium (mg)	3207.2 ± 1124.8	3454.6 ± 1316.92	3998.1 ± 1700.37	3078.1 ± 896.13	3702.2 ± 1157.7	*0.047* *[1-3.5].* *[3-4].* *[4-5]*
Calcium (mg)	882.5 ± 250.83	824.7 ± 188.8	938.2 ± 281.09	789.9 ± 149.52	869.6 ± 214.34	0.163
Magnesium (mg)	392.2 ± 156.1	464.8 ± 211.89	501.2 ± 209.29	424.9 ± 156.83	484.6 ± 123.03	*0.039* *[1-3.5]*
Phosphorus(mg)	1565.8 ± 531.33	1736.2 ± 613.64	1861.3 ± 652.12	1543.6 ± 497.63	1710.4 ± 483.55	0.143
Iron (mg)	13.9 ± 6.57	16.7 ± 8.53	18.2 ± 8.82	14.0 ± 6.13	18.2 ± 6.40	*0.016* *[1-3.5]* *[4-5]*

CH: carbohydrate.

Table V. Relationship between carbohydrate quality score and scale scores

		Depression sub-dimension score	**Anxiety sub-dimension score**	**Stress sub-dimension score**	**SQS score**	**CQI score**
Depression sub-dimension score	*r*	1				
	p					
Anxiety sub-dimension score	*r*	0.61				
	p	*< 0.001*				
Stress sub-dimension score	*r*	0.66	0.62			
	p	*< 0.001*	*< 0.001*			
SQS score	*r*	-0.32	-0.25	-0.28		
	p	*< 0.001*	*0.002*	*< 0.001*		
CQI score	*r*	0.27	0.31	0.20	-0.21	1
	p	*0.001*	*< 0.001*	*0.016*	*0.010*	

CQI: carbohydrate quality index. SQS: sleep quality scale.

Table VI. Multiple regression analysis of the determinants of CQI scores

Variables	Univariable					Multivariable				
	B	**SE**	**Standard**	***t***	**P**	**B**	**SE**	**Standard**	***t***	**P**
Depression sub-dimension score	0.093	0.027	0.270	30.409	*0.001*	0.022	0.028	0.064	0.022	*0.028*
Anxiety sub-dimension score	0.067	0.029	0.188	20.324	*0.022*	0.054	0.030	0.151	0.054	*0.030*
Stress sub-dimension score	0.051	0.028	0.148	10.818	0.071	0.002	0.027	0.007	0.002	*0.027*
Energy	0.001	0.000	0.386	50.091	*0.000*	0.000	0.000	-0.218	0.000	*0.000*
Carbohydrate (%)	0.051	0.014	0.293	30.731	*0.000*	-0.001	0.013	-0.004	-0.001	*0.013*
Protein (%)	0.108	0.039	0.224	20.800	*0.006*	-0.130	0.062	-0.270	-0.130	0.062
Fat (%)	-0.064	0.013	-0.371	-40.863	*0.000*					
Posa	0.027	0.004	0.473	60.523	*0.000*	-0.018	0.018	-0.316	-10.00	0.317

									3	
Vitamin B1	-0.001	0.006	-0.016	-0.199	0.842	0.534	0.189	70.165	20.819	*0.006*
Vitamin B6	-0.001	0.006	-0.018	-0.217	0.828	-0.478	0.189	-60.406	-20.537	*0.012*
Folate	-0.002	0.000	-0.326	-40.190	*0.000*	-0.002	0.001	-0.268	-30.367	*0.001*
Vitamin B12	-0.004	0.006	-0.056	-0.681	0.497	-0.025	0.082	-0.329	-0.304	0.761
Calcium	0.001	0.000	0.127	10.555	0.122	-0.002	0.001	-0.257	-20.271	*0.025*
Phosphorus	0.002	0.000	0.631	90.902	*0.000*	0.002	0.001	0.962	20.772	*0.006*
Potassium	0.001	0.000	0.565	80.323	*0.000*	0.000	0.000	0.348	10.507	0.134
Magnesium	0.005	0.000	0.679	110.237	*0.000*	-0.035	0.00	-0.004	-	0.98

						1	3		0.013	9