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Association between carbohydrate quality index and dietary patterns, sleep quality, anxiety level, and depression symptoms: A cross-sectional study

Asociación entre el índice de calidad de carbohidratos y patrones dietéticos, calidad del sueño, nivel de ansiedad y síntomas de depresión: Un estudio transversal

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ABSTRACT

Aim: This study was conducted to determine the relationship between carbohydrate quality and sleep quality, depression, anxiety, stress and anthropometric measurements. Methods: The carbohydrate quality was calculated using the total fiber intake, ratio of whole grains to total grains, the ratio of solid carbohydrates to total carbohydrates, and the glycemic index. Sleep status was determined using the Pittsburgh Sleep Quality Index (PSQI) and nutritional status was determined by taking a 1-day food consumption record and food consumption frequency. Results: It was found that 20% of the participants with the highest carbohydrate quality had the highest sleep quality and the lowest body mass index. Conclusion: Adults should be informed that the quality of carbohydrates that they consume, was associated with better sleep quality and some micronutrients (potassium, magnesium, vitamin A-D-K-C-B1-B6, Folate) but no significant correlation was found between anxiety, depression, and stress scores

Keywords: Carbohydrate Quality; Fiber; Glycemic Index; Sleep Quality; Solid Carbohydrates; Total Carbohydrates; Whole Grain.

RESUMEN

Objetivos: Este estudio se realizó para determinar la relación entre la calidad de los carbohidratos y la calidad del sueño, la depresión, la ansiedad, el estrés y las medidas antropométricas. Métodos: La calidad de los carbohidratos se calculó

utilizando la ingesta total de fibra, la proporción de granos integrales a granos totales, la proporción de carbohidratos sólidos a carbohidratos totales y el índice glucémico. El estado del sueño se determinó utilizando el índice de calidad del sueño de Pittsburgh (PSQI) y el estado nutricional se determinó tomando un registro de consumo de alimentos de un día y la frecuencia de consumo de alimentos. Resultados: Se encontró que el 20% de los participantes con la mayor calidad de carbohidratos tenían la mejor calidad de sueño y el índice de masa corporal más bajo. Conclusión: Se debe informar a los adultos que la calidad de los carbohidratos que consumen, se asoció con una mejor calidad del sueño y algunos micronutrientes (potasio, magnesio, vitamina A-D-K-C-B1-B6, folato), pero no se encontró una correlación significativa entre las puntuaciones de ansiedad, depresión y estrés.
Palabras clave: Carbohidratos sólidos; Carbohidratos totales; Fibra; Grano Integral; Índice glucémico.

INTRODUCTION

Carbohydrates, which are macronutrients, are the main energy source and are essential for optimal health, longevity, and sustainability[1]. As a result of a meta-analysis and reviews with evidence from strong epidemiological studies, it was emphasized that the quality of carbohydrates is more important than the amount, especially in the development of major health problem[2]. Carbohydrate quality is determined with dietary fiber, whole grain or legumes, and glycemic index (GI) or glycemic-load[3]. There is evidence suggesting that these carbohydrate quality components may be beneficial or detrimental to human health[4,5]. It is a known fact that dietary sources of carbohydrates are related with obesity, coronary heart disease, insulin resistance, metabolic syndrome, and diabetes due to their high GI and low fiber content[6]. It was stated that this index has a more important role in the prevention of chronic diseases than the ratio of dietary energy that is obtained from carbohydrates[7].

Due to the hormonal role of carbohydrates in brain functions and sleep, they are considered to be essential macronutrients for sleep duration and sleep quality (sleep depth, rapid eye movement attainment, duration of wake during the night). Carbohydrates are considered not only the primary source of energy for all human cells, but also a critical macronutrient for sleep due to their association with brain function and sleep-related hormonal regulation. Glucose metabolism is highly correlated with sleep by altering plasma tryptophan concentration, a precursor of serotonin and melatonin, which has a significant effect on sleep initiation and maintenance[8]. It is a common finding that individuals with a short sleep duration can obtain more energy from carbohydrates and fats[9,10]. Insomnia is the most common sleep problem in women, affecting 42% of middle-aged women and 54% of postmenopausal women. Hormones and gender-specific responses to environmental stress can make women more vulnerable to poor sleep[11]. Epidemiological studies have revealed that individuals with a short sleep duration consume higher amounts of refined carbohydrates and high-energy foods when compared with individuals with longer sleep duration[8]. Meanwhile it has been determined that a diet low in carbohydrates increases the deep sleep phase and decreases the dreaming phase[12]. It has also been determined that a high sugar intake from sweet foods/drinks causes widespread depressive symptoms in women. It can affect the gut-microbiota composition and activity, including some mechanisms associated with the gut-brain axis in the development of depression, as well as the immune, neural and metabolic pathways involved in the pathogenesis of depression[13]. It has been reported that a diet consisting of refined carbohydrates and sweets, and a Western-style diet that is high in refined carbohydrates and sugars causes psychological problems by increasing the levels of inflammatory cytokines, such as interleukin-6 and C-reactive protein and is especially related to an increased risk of depression[14,15].

This study was conducted to determine the relationship between carbohydrate quality and sleep quality, depression, anxiety, stress and anthropometric measurements. Considering that the traditional diet in Turkey includes bread and refined grains, there is no similar study.

METHODS

Study design and participants

Our cross-sectional study was conducted in November-December 2020 on the University Campus in Istanbul, Turkey and included 251 adult individuals. This campus has a population of roughly 5,000 individuals, however owing to the pandemic, most classes were conducted online and most of the university staff worked online at the time of the study. The study involved individuals who alternately came to the school, students who received face-to-face education, and academics who provided face-to-face education. Data were collected in line with the Helsinki declaration and with the approval of the Ethics Committee of the University of Health Sciences (Decision No. 46418926-050.01.04). The inclusion criteria of this study consisted of being between 19 and 64 years of age, not having any chronic diseases, not currently using any nutritional supplements or pre/probiotics and answering all of the survey questions.

Data collection tools included a questionnaire consisting of 20 questions on demographics and nutritional habits, a retrospective 24-h dietary recall, a food consumption frequency form, a 24-h physical activity recall form corresponding to food consumption, an index of sleep quality [Pittsburgh Sleep Quality Index (PSQI)]. the Depression Anxiety Stress Scale (DASS) and anthropometric measurements (height, body weight and waist circumference). All data were recorded by the researchers.

Assessment of dietary intake and dietary carbohydrate quality

The frequency and amount of food consumed over the last 30 days (1 time per week-7 times per week) was recorded. Foods were divided according to food groups (dairy products, meat and meat products, legumes, oilseeds, vegetables, fruits, bread, and cereals, oil/sweet and beverages) in the food frequency questionnaire.

1. Data obtained from the one-day food consumption record and frequency were analyzed using the Nutrition Information System (BeBiS)®, and one-day average energy and nutrient intake were calculated. Both the 24-hour food consumption record and the food consumption frequency-quantity were calculated when calculating the CHO quality components. The average of the outcomes was calculated.
2. The CQI was calculated using glycemic index (GI) and the amount of fiber, whole grains, refined grains, and total carbohydrates (liquid and solid carbohydrates) of a diet[16,17]. Details of these components, including calculations used are given below.
3. Fiber intake (g/day): Calculated using the national and international food content tables according to the amount and frequency of food consumed by each participant.
4. Glycemic Index: Calculated using the BeBIS program according to the amount and frequency of food consumed for each participant. The BeBIS program created a database by obtaining GI values for foods from international databases.
5. Whole grain/total grain (whole and refined grain) ratio: Whole and refined grain foods were determined from the food consumption records of each participant and their amounts were calculated separately. The total amount of grain was determined using the sum of the amount of whole and refined grains. Refined grain foods included white bread, phyllo pastry, pasta, noodles, white rice, pastries, biscuits, cakes, and cookies. Whole grain foods consisted of whole-grain bread, whole-grain pasta-noodles, and whole-grain crackers and bagels.
6. Solid carbohydrate/total carbohydrate (solid and liquid) ratio: Foods containing liquid carbohydrates (sweetened beverages and fruit juices, etc.) were determined one by one from the food consumption and frequency records of each participant, and carbohydrate content was calculated. Total carbohydrates were determined using the BeBIS program. The amount of solid carbohydrates were calculated by subtracting the amount of liquid carbohydrates from total carbohydrates.

To determine CQI score, participants were divided into quintiles (20%) for each of the four components. Each of these quintiles was given a score from 1 to 5 from the first (1st) quintile to the last (5th) quintile (for only the GI component, 1 point was given for the participants in the 5th quintile, and 5 points were given to those in the first quintile). The CQI score (ranging from 4 to 20 points) was then determined by adding the score of the 4 components.

Physical activity assessment

Participant physical activity level over a 24 h (1440 min) period was recorded retrospectively. The calculated basal metabolic rate (BMR) values for the participants was divided by 1440 and the final value was multiplied by the duration of each activity and the physical activity ratio (PAR) of each activity. Total daily energy expenditure was calculated by summing results. The physical activity level (PAL) was calculated as the proportion of total energy to the BMR, according to the classification determined by the World Health Organization (WHO)/Food and Agriculture Organization (FAO)[18].

Sleep assessment

For sleep, we used the Pittsburgh Sleep Quality Index (PSQI), which assesses the sleep quality of adults over the past month and includes a total of 24 questions. The 18 items used in the scoring are grouped as 7 component scores. Total PSQI score ranges from 0 to 21 and scores ≥5 indicates poor sleep quality. The PSQI was developed by Buysse et al.[19] in 1989, and its Turkish validity and reliability was conducted in 1996 by Agargun et al.[20]

Assessment of stress, anxiety level, and depressive symptoms

The 21-item Depression, Anxiety, and Stress Scale (DASS-21) was used to assess depression, anxiety, and stress symptoms in the past week[21]. There are 7 items in total for each factor in this scale. It is a 5-point Likert-type response scale and the lowest score that can be obtained from each subdimension is 7, while the highest score is 35. Higher scores indicate increased symptoms. A Turkish validity and reliability study was conducted for this study by Yilmaz et al.[22]

Assessment of anthropometric measures

Body mass index (BMI) was calculated using the height and body weight of the participants and was classified according to WHO guidelines[23]. Waist circumference (cm) was also measured and classified[1]. In addition, the basal metabolic rate (BMR) of each participant was calculated using the Harris Benedict formula according to their sex and age.

Statistical analysis

The Number Cruncher Statistical System (NCSS) 2007 (Kaysville, Utah, USA) program was used for the statistical analysis. Descriptive statistical methods (mean, standard deviation, median, frequency, ratio, minimum, maximum) were used while evaluating the study data, and the conformity of the quantitative data to normal distribution was tested using the Shapiro-Wilk Test. The Kruskal-Wallis test was used to compare quantitative data of three or more groups without normal distribution, and the Mann-Whitney U test was used to compare quantitative data of two groups that did not have a normal distribution. Spearman correlation analysis was used to determine the relationship between

quantitative data. On the other hand, Chi square analysis was used to determine the relationship between the qualitative data. Multiple linear regression was performed to determine the effect of the variables on the CQI score. P<0.05 was determined as statistically significant.

RESULTS

This study was conducted with 251 adults (60.2% female) whose mean age was 31.9 ± 11.5 years and mean BMI was 24.3 ± 4.83 kcal/m^2. Participant distribution according to CQI score can be seen in table 1. Nearly 15% of participants were in the lowest 20% quantile (Q1), 19.9% in the second 20% quantile (Q2), 25.9% in the third quantile (Q3), 15.5% in the fourth quantile (Q4), and 23.9% in the fifth quantile (Q5) of CQI score.

A statistically significant relationship was found between CQI score and sex, regular exercise, and BMI (p=0.041, p=0.026 and p=0.014, respectively). There was no statistically significant relationship between CQI score and education, profession, marital status, number of meals and skipping meals (p>0.05) (Table 2).

Table 1. Demographic characteristics of participants.

	n (251)	%
Age (yr)		
19-34	142	56.6
35-49	88	35.0
50-64	21	8.4
Sex		
Male	100	39.8
Female	151	60.2
Education status		
Primary school	29	11.5
High school	30	12.0
University	150	59.8
Master's or doctorate degree	42	16.7
Profession		
Employed	133	53.0
Unemployed	29	11.5
Retired	11	4.4
Student	78	31.1
Marital status		
Married	110	43.8
Single	141	56.2
Smoking		
Yes	56	22.3
No	195	77.7
Regular exercise		
Yes	63	25.1
No	188	74.9
Carbohydrate Quality Index		
Q1	37	14.7
Q2	50	19.9
Q3	65	25.9
Q4	39	15.5
Q5	60	23.9

BMR and PSQI values were statistically different by quintile of CQI score (Table 3). BMR values were significantly lower in the Q5 compared the other groups (p=0.001). The PSQI score in the Q1 group was significantly higher than in the other groups, and the PSQI score in the Q2 and Q3 groups was significantly higher than that in the Q5 group (p=0.001, p<0.01). Depression, Anxiety, Stress, and PSQI scores according to CQI are shown in figure 1.

Comparison of daily energy and nutrient intake according to CQI scores is given in table 4. A statistically significant difference was found between the average daily energy intake and the CQI score (p=0.044, p<0.05). Average energy intake in the Q1 group was significantly higher than that in the Q4 and Q5 groups and average energy intake in the Q2 group was significantly higher than in the Q5 group (p=0.001, p<0.01). The average intake of fiber, potassium, magnesium, vitamins A, D, K, C, and B_6, and folate and the percentage of dietary fat were significantly higher in the Q5 group than in the Q1 group (p<0.05).

A negative and weakly significant relationship was found between the CQI and PSQI scores (r= –0.26, p<0.01). A positive and moderate relationship was found between PSQI and anxiety scores (r= 0.40, p<0.01), and a positive and weakly significant relationship (r= 0.36, p<0.01) was found between the PSQI and stress scores. However, no statistically significant relationship was determined between the anxiety and the SQI scores (p>0.05). A positive and highly significant relationship was found between the stress and the depression scores (r= 0.73, p<0.01) (Table 5).

In multiple linear regression analysis, which was performed to determine the effect of independent variables on the CQI score, we observed a statistically significant result (F= 20.968, p<0.01). There was a positive and highly significant relationship between the independent variables and the CQI score (r= 0.72, p<0.001). The independent variables in the model explained 51.4% of the total variance in CQI score (p<0.01). When the regression coefficients were examined, PSQI score (β= –0.15, p<0.01), energy intake (β= –0.835, p<0.01), and vitamin K level (β= –0.184, p<0.01) had a negative effect on CQI score. On the other hand, variables including the fat (%) (β= 0.33, p<0.01), vitamin C (β= 0.139, p<0.01), folate (β= 0.195, p<0.01) and magnesium (β= 0.881, p<0.01) levels appeared to have a positive and significant effect (Table 6).

DISCUSSION

In this cross-sectional study, average daily energy intake was significantly higher in the Q1 group when compared with the Q4 and Q5 group, and in the Q2 group when compared with the Q5 group. In the study of Santiago et al.[17] which was conducted with obese individuals, it was

Table 2. General characteristics of the participants according to Carbohydrate Quality Index scores.

	Carbohydrate Quality Index					P
	Q1 n (%)	Q2 n (%)	Q3 n (%)	Q4 n (%)	Q5 n (%)	
Sex						
Male	19[a] (51.4)	23[a,b] (46)	27[a,b] (41.5)	17[a,b] (43.6)	14[b] (23.3)	0.041*
Female	18[a] (48.6)	27[a,b] (54)	38[a,b] (58.5)	22[a,b] (56.4)	46[b] (76.7)	
Education status						
Primary school	2 (5.4)	8 (16)	6 (9.2)	2 (5.1)	11 (18.3)	0.483
High school	6 (16.2)	7 (14)	7 (10.8)	5 (12.8)	5 (8.3)	
University	22 (59.5)	24 (48)	43 (66.2)	27 (69.2)	34 (56.7)	
Master's or doctorate degree	7 (18.9)	11 (22)	9 (13.8)	5 (12.8)	10 (16.7)	
Profession						
Employed	23 (62.2)	28 (56)	36 (55.4)	17 (43.6)	29 (48.3)	0.584
Unemployed	2 (5.4)	7 (14)	10 (15.4)	3 (7.7)	7 (11.7)	
Retired	1 (2.7)	1 (2)	2 (3.1)	4 (10.3)	3 (5)	
Student	11 (29.7)	14 (28)	17 (26.2)	15 (38.5)	21 (35)	
Marital status						
Married	15 (40.5)	24 (48)	28 (43.1)	19 (48.7)	24 (40)	0.867
Single	22 (59.5)	26 (52)	37 (56.9)	20 (51.3)	36 (60)	
Smoking						
Yes	12 (32.4)	13 (26)	15 (23.1)	7 (17.9)	9 (15)	0.300
No	25 (67.6)	37 (74)	50 (76.9)	32 (82.1)	51 (85)	
Alcohol consumption						
Yes	3 (8.1)	7 (14)	11 (16.9)	6 (15.4)	7 (11.7)	0.760
No	34 (91.9)	43 (86)	54 (83.1)	33 (84.6)	53 (88.3)	
Regular exercise						
Yes	4[a] (10.8)	8[a] (16)	19[a] (29.2)	10[a] (25.6)	22[a] (36.7)	0.026*
No	33[b] (89.2)	42[a] (84)	46[a] (70.8)	29[a] (74.4)	38[b] (63.3)	
Constipation						
es	4 (10.8)	5 (10)	5 (7.7)	1 (2.6)	4 (6.7)	0.687
Sometimes	26 (70.3)	35 (70)	41 (63.1)	30 (76.9)	38 (63.3)	
No	7 (18.9)	10 (20)	19 (29.2)	8 (20.5)	18 (30)	
BMI						
Underweight (<18.5 kg/m^2)	3[a,b] (8.1)	2[a,b] (4)	4[a,b] (6.2)	0b (0)	12[a] (20)	0.014*
Normal (18.5-24.9 kg/m^2)	18[a] (48.6)	28[a] (56)	36[a] (55.4)	21[a] (53.8)	28[a] (46.7)	
Overweight (25.0-29.9 kg/m^2)	8[a] (21.6)	11[a] (22)	17[a] (26.2)	15[a] (38.5)	17[a] (28.3)	
Obese (≥30.0 kg/m^2)	8[a] (21.6)	9[a] (18)	8[a] (12.3)	3[a] (7.7)	3[a] (5)	
Number of main meals						
1	2 (5.4)	1 (2)	0 (0)	1 (2.6)	0 (0)	0.332
2	10 (27)	23 (46)	28 (43.1)	14 (35.9)	26 (43.3)	
3	25 (67.6)	26 (52)	37 (56.9)	24 (61.5)	34 (56.7)	
Number of snacks						
None	12 (32.4)	14 (28)	13 (20)	10 (25.6)	4 (6.7)	0.126
1	12 (32.4)	16 (32)	18 (27.7)	12 (30.8)	19 (31.7)	
2	10 (27)	17 (34)	25 (38.5)	10 (25.6)	28 (46.7)	
3	3 (8.1)	3 (6)	9 (13.8)	7 (17.9)	9 (15)	

continuation table 2.....

Skips main meals						
Yes	12 (32.4)	17 (34)	16 (24.6)	11 (28.2)	16 (26.7)	0.154
No	4 (10.8)	8 (16)	16 (24.6)	13 (33.3)	21 (35)	
Sometimes	21 (56.8)	25 (50)	33 (50.8)	15 (38.5)	23 (38.3)	
Skipped meal						
Breakfast	10 (30.3)	16 (38.1)	18 (36.7)	6 (23.1)	9 (23.1)	0.538
Lunch	19 (57.6)	21 (50)	26 (53.1)	19 (73.1)	23 (59)	
Dinner	4 (12.1)	5 (11.9)	5 (10.2)	1 (3.8)	7 (17.9)	

*p<0.05; a-b: differences according to Chi-Square test.

Table 3. Comparisons of age, anthropometric measurements, physical activity levels, energy expenditure, PSQI, Depression, Anxiety and Stress Scores by Carbohydrate Quality Index scores.

	Q1	Q2	Q3	Q4	Q5	P-value
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Age (yr)	30.6 (10.5)	32.1 (11.6)	32.0 (11.7)	33.28 (13.0)	31.8 (10.9)	0.976
Weight (kg)	73.2 (18.2)	71.9 (17.0)	70.5 (17.6)	71.03 (17.2)	64.4 (14.32)	0.067
Height (cm)	170 (8.9)	170 (10.5)	168 (9.04)	170 (10.2)	167 (8.32)	0.327
WC (cm)	86.2 (17.3)	84.5 (14.3)	83.1 (17.2)	82.3 (12.8)	78.3 (13.5)	0.111
BMI (kg/m^2)	24.9 (5.2)	25.1 (4.86)	24.7 (5.28)	24.3 (4.02)	22.9 (4.39)	0.158
BMR (kcal)	1568 (280)	1536 (287)	1505 (261)	1519(281)	1406 (208)	0.026*
PAL	1.65 (0.180)	1.72 (0.190)	1.69 (0.240)	1.72 (0.300)	1.72 (0.230)	0.416
Energy intake (kcal/day)	2575 (552)	2650 (681)	2562 (670)	2611 (618)	2427 (504)	0.434
PSQI score	6.24 (2.56)	5.1 (2.14)	4.89 (1.62)	4.72 (1.57)	4.22 (2.07)	0.001**
Depression score	6.35 (5.65)	4.32 (4.16)	3.75 (3.60)	4.41 (4.39)	4.28 (4.42)	0.277
Anxiety score	3.14 (3.06)	3.08 (3.12)	2.46 (2.25)	3.44 (4.01)	3.37 (3.94)	0.921
Stress score	7.11 (4.37)	4.92 (4.20)	5.42 (3.93)	5.36 (4.49)	6.22 (5.31)	0.143

**p<0.01 *p<0.05; WC: Waist Circumference; BMI: Body Mass Index; BMR: Basal Metabolic Rate; PAL: Physical Activity Level; PSQI: Pittsburg Sleep Quality Index, Kruskal-Wallis Test.

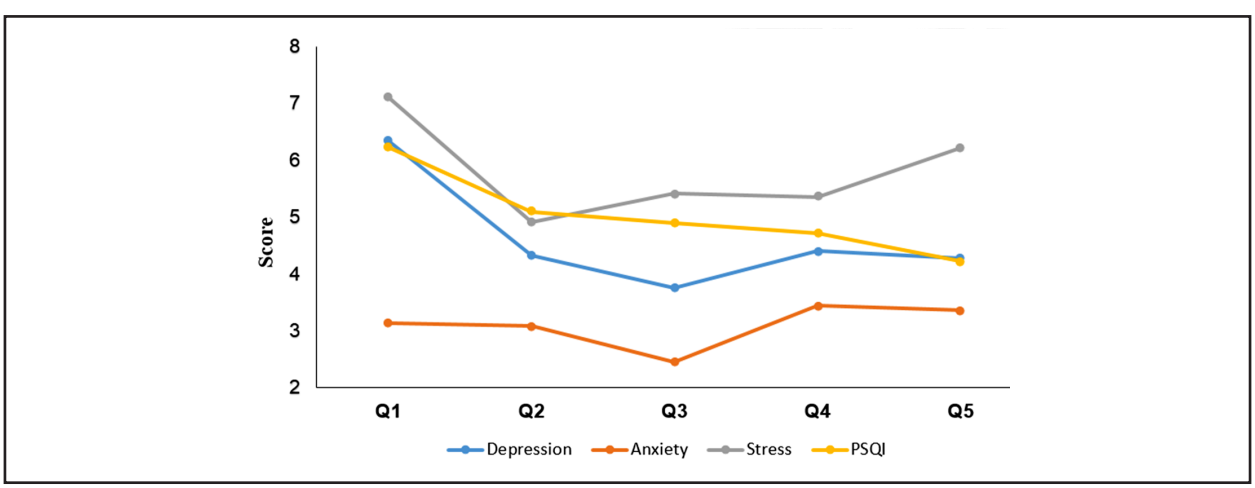

Figure 1: Depression, Anxiety, Stress, and PSQI scores graph according to Carbohydrate Quality Index. PSQI: Pittsburgh Sleep Quality Index(n= 251).

Table 4. Comparison of daily energy and nutrient intake according to the Carbohydrate Quality Index scores.

	Q1	Q2	Q3	Q4	Q5	P
	Mean (SD	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Energy (kcal)	1791 (413)	1700 (452)	1634 (514)	1604 (425)	1549 (463)	0.044*
Carb. (g)	211 (64.8)	180 (64.3)	171 (75.8)	161 (52.1)	153 (64.1)	0.001**
Carb. (%)	48.0 (6.83)	42.5 (6.85)	42.2 (9.30)	40.8 (6.28)	40.2 (8.00)	0.001**
GI	207 (87.3)	145 (70.6)	123 (74.4)	101 (44.6)	89 (48.70)	0.001**
Fiber (g)	16.7 (5.45)	17.0 (4.9)	19.0 (8.82)	21.6 (8.73)	25.5 (10.7)	0.001**
Liquid Carb. (g)	13.3 (13.60)	6.24 (7.98)	3.23 (5.12)	2.54 (3.99)	0.630(1.39)	0.001**
Solid Carb. (g)	199 (58.4)	171 (56.5)	167 (75.3)	159 (50.7)	153 (64.2)	0.003**
Whole grain (g)	3.95 (5.15)	9.42 (8.74)	13.3 (12.60)	28.6 (22.9)	39.3 (25.1)	0.001**
Refined grain (g)	131 (46.5)	100 (47.1)	88 (57.3)	62.4 (34.7)	41.1 (30.9)	0.001**
Total grain (g)	141 (50.7)	119 (59.4)	103 (58.1)	91.7 (36.2)	80.9 (41.5)	0.001**
Protein (g)	65.3 (20.3)	64.9 (15.2)	61.2 (20.9)	61.8 (19.9)	59.5 (19.4)	0.224
Protein (%)	14.9 (3.02)	16.2 (3.28)	15.7 (3.19)	16.1 (3.56)	16.1 (3.02)	0.358
Fat (g)	74.1 (15.7)	77.9 (22.5)	75.4 (23.4)	77.3 (20.8)	75.4 (22.00)	0.967
Fat (%)	36.9 (5.49)	40.8 (5.63)	41.4 (7.24)	42.9 (4.83)	43.5 (6.83)	0.001**
Alcohol (g)	0.060 (0.170)	0.700 (3.10)	2.08 (10.0)	0.220 (0.95)	0.400 (1.8)	0.375
Alcohol (%)	0.010 (0.080)	0.320 (1.60)	0.660 (3.21)	0.090 (0.48)	0.170 (0.780)	0.819
Cholesterol (mg)	257 (141)	271 (106)	253 (131)	314 (171)	332 (232)	0.139
PUFA (g)	15.9 (5.43)	16.9 (6.77)	16.7 (9.30)	15.8 (6.31)	15.1 (7.46)	0.554
MUFA (g)	24.3 (5.85)	26.5 (7.13)	26.5 (8.71)	27.6 (7.28)	26.9 (9.06)	0.430
Calcium (mg)	632 (189)	650 (234)	653 (205)	680 (233)	724 (199)	0.097
Phosphorus (mg)	959 (244)	983 (258)	980 (304)	1036 (295)	1072 (304)	0.254
Potassium (mg)	1924 (401)	2046 (592)	2142 (770)	2329 (854)	2472 (841)	0.012*
Magnesium (mg)	233 (57.9)	247 (73.9)	263 (97.8)	272 (79.1)	291 (85.7)	0.001**
Iron (mg)	8.01 (2.46)	8.23 (2.42)	8.34 (2.61)	9.50 (2.98)	9.22 (2.98)	0.055
Zinc (mg)	9.42 (3.04)	9.06 (2.64)	8.94 (3.44)	9.53 (2.81)	9.17 (2.80)	0.628
Vitamin A (mcg)	903 (1992)	1072(2182)	896 (891)	1610(3063)	1352(1165)	0.001**
Vitamin D (mcg)	1.23 (0.670)	2.04 (3.63)	1.43 (1.27)	2.14 (2.28)	1.99 (1.47)	0.008**
Vitamin E (mcg)	15.8 (6.78)	16.7 (6.29)	15.4 (8.95)	16.2 (6.97)	14.2 (6.53)	0.142
Vitamin K (mcg)	48.6 (44.7)	77.3 (101)	86.1 (95.8)	134 (118)	110(100)	0.001**
Vitamin C (mg)	55.9 (33.5)	63.3 (29.8)	71.6 (40.9)	91.2 (45.8)	92.1 (45.1)	0.001**
Vitamin B_1 (mg)	0.780 (0.280)	0.800 (0.240)	0.850 (0.390)	0.910 (0.320)	0.950 (0.330)	0.026*
Vitamin B_2 (mg)	1.2 (0.48)	1.4 (0.55)	1.2 (0.40)	1.5 (0.72)	1.4 (0.46)	0.067
Vitamin B_6 (mg)	1.0 (0.26)	1.1 (0.36)	1.1 (0.53)	1.3 (0.67)	1.3 (0.50)	0.019*
Vitamin B_{12} (mcg)	5.1 (6.40)	5.9 (7.32)	3.7 (2.55)	6.2 (10.23)	3.7 (1.8)	0.143
Folate (mcg)	236 (103)	261 (98)	269 (122)	330 (152)	332 (141)	0.001**

*p<0.05 **p<0.001, Carb.: Carbohydrate, GI: Glycemic Index, PUFA: Polyunsaturated fatty acid, MUFA: Monounsaturated fatty acid, Kruskal-Wallis Test.

Table 5. Correlation analysis of some quantitative variables.

		1	2	3	4	5	6	7	8	9
1. Age (yr)	r	1								
	p	•								
2. WC (cm)	r	0.51**	1							
	p	0	•							
3.BMI (kg/m^2)	r	0.51**	0.85**	1						
	p	0	0	•						
4. PAL	r	0.29**	0.11	0.10	1					
	p	0	0.083	0.094	•					
5. PSQI Score	r	-0.07	-0.00	-0.00	0.02	1				
	p	0.229	0.977	0.936	0.669	•				
6. Anxiety Score	r	-0.15*	-0.10	-0.10	-0.00	0.40**	1			
	p	0.012	0.097	0.111	0.979	0	•			
7. Stress Score	r	-0.17**	0	-0.10	-0.03	.35**	0.62**	1		
	p	0.005	0.141	0.084	0.596	0	0	•		
8. Depression Score	r	-.26**	-0.09	0	-0.06	0.36**	0.56**	0.72**	1	
	p	0	0.131	0.123	0.274	0	0	0	•	
9. CQI score	r	0.03	-0.14*	-0.11	0	-0.26**	-0.01	-0.06	-0.10	1
	p	0.608	0.019	0.06	0.39	0	0.862	0.322	0.087	•

WC: Waist Circumference, BMI: Body Mass Index; PAL: Physical Activity Level; PSQI: Pittsburg Sleep Quality Index; CQI: Carbohydrate Quality Index, Spearman Correlation Test
*p<0.05 **p<0.01

Table 6. Multiple linear regression analysis of the determinants of Carbohydrate Quality Index scores.

Variables	Univariable					Multivariable				
	B	SE	Standard (β)	t	P	B	SE	Standard (β)	t	P
BMR	-0.002	0.001	-0.167	-2.671	0.008**	0	0.001	-0.023	-0.447	0.655
PSQI score	-0.439	0.089	-0.298	-4.919	0.001**	-0.22	0.07	-0.15	-3.132	0.002**
Energy intake	-0.001	0	-0.184	-2.952	0.003**	-0.005	0.001	-0.835	-9.475	0.001**
Fat (%)	0.137	0.028	0.294	4.851	0.001**	0.154	0.053	0.33	2.896	0.004**
CHO (%)	-0.104	0.023	-0.275	-4.505	0.001**	0.048	0.044	0.128	1.102	0.272
Vitamin K	0.007	0.002	0.241	3.925	0.001**	-0.006	0.002	-0.184	-2.697	0.008**
Vitamin C	0.025	0.004	0.343	5.76	0.001**	0.01	0.005	0.139	1.995	0.047*
Vitamin B_1	1.768	0.587	0.188	3.014	0.003**	-0.839	1.174	-0.089	-0.715	0.475
Vitamin B_6	1.371	0.377	0.224	3.634	0.001**	-0.523	0.619	-0.086	-0.845	0.399
Folate	0.007	0.001	0.29	4.776	0.001**	0.005	0.002	0.195	2.066	0.040*
Potassium	0.001	0	0.253	4.135	0.001**	0	0.001	0.095	0.716	0.475
Magnesium	0.008	0.002	0.23	3.726	0.001**	0.032	0.005	0.881	7.057	0.001**

**p<0.01 *p<0.05 BMR: Basal Metabolic Rate; CHO: Carbohydrate; PSQI: Pittsburg Sleep Quality Index, Multiple linear regression.

determined that participants with the highest CQI score had higher energy intake, but the percentages of total energy taken from carbohydrates were similar among the CQI groups, ranging from 43.2% to 44.6%. In our study, participants in the highest CQI quantile had a significantly lower average energy intake when compared to the participants in the lowest quantile. It was also determined that the ratio of total energy from carbohydrates in the group with the highest inclusion CQI score was significantly lower. The CQI score increased as the energy intake decreased in the individuals included in this study, in contrast to the study of Santiago et al.[17] This can be explained by considering that the glycemic response to foods with a high CQI score is a factor that may affect repletion and food intake. A high CQI score affects insulin secretion due to the intake of foods that are high in fiber with a low GI, and cause repletion[24]. Reynolds et al.[2] reported that a high fiber intake provides a decrease in cardiovascular-related deaths and the incidence of coronary heart disease, stroke, type 2 diabetes mellitus (DM), and colorectal cancer, at a rate of 15%-31%. Furthermore, a statistically significant decrease was found in the incidence of type 2 DM (11%) when individuals consuming a high- and low-glycemic diet were compared. In the study, the BMR value of the group with the best carbohydrate quality was found to be significantly lower. However, both the height and bodyweight of the participants in that group were lower than those in the other group. BMR value calculation depends on these parameters hence it is normal for it to be lower.

A negative and weakly significant relationship between the CQI and PSQI scores was determined. In other words, the quality of sleep increased as the quality of dietary carbohydrate increased. Epidemiological studies have shown that individuals with a short sleep duration have a higher intake of refined carbohydrates and energy-rich foods when compared to individuals who have a longer sleep duration8. In a study conducted among female Japanese workers, it was determined that the consumption of sweets and noodles was found to be associated with poor sleep quality, whereas a high intake of fish and vegetables was associated with good sleep quality. In that study, it was also stated that the quality of the carbohydrates was more important than the amount consumed, and the frequent consumption of energy drinks (≥ once/week) and sugary beverages (≥ once/day) was associated with poor sleep quality[25]. In this study, the PSQI scores in the Q1 group were higher than the in the other groups, which support these findings. Accordingly, replacing carbohydrates from refined grains with those from whole grains, that is, choosing foods with high fiber and a low GI, can be thought to increase the CQI score in parallel with sleep quality.

In our study, no statistically significant relationship was found between CQI score and anxiety, depression, and stress scores. In a study indicating that dietary carbohydrate quality is associated with psychological symptoms, 45 women with major depression and 90 women without any psychological problems were evaluated and it was determined that individuals who had an unhealthy diet and consumed more refined grains, French fries, cookies, and sugar had a higher risk of major depression[26]. This result was in line with the Women's Health Initiative cohort study, which reported that excessive consumption of processed foods was inversely related to depression[27].

There is a strong direct correlation between added sugar and foods with a higher dietary GI and depression. It was found in an observational study, conducted with postmenopausal women, that a higher intake of refined grains, sugary beverages, and high-fat foods increased the incidence of depression and stress[28]. Contrary to these results, we did not observe a statistically significant relationship between CQI and stress and depression scores in the current study.

Moreover, the average intake of fiber, potassium, magnesium, vitamins A, D, K, C, and B6, and folate and the percentage of dietary fat were significantly higher in the Q5 group, which had the highest CQI score, than in the Q1 group, which had the lowest score. These findings suggested that the high carbohydrate quality of a diet may also be an indicator of diet quality. In a similar study conducted among Iranian adults, higher CQI scores were shown to be related with a higher intake of various micro-nutrients, such as vitamin A, C, D, E, B1, and B2, and folic acid, calcium, iron, and zinc6. These results showed that reaching micro-nutrient diet goals is much more probable when high-quality carbohydrates are consumed. In the same study, it was determined that the majority of those in the highest quartile of the CQI scores were women. Similarly, in this study, most of the individuals in the lowest CQI quintile were men (51.4%) and majority of individuals in the highest CQI quintile were women (76.6%).

There were some limitations to this study that should be considered. First, the relationship between the CQI score and sleep quality did not reveal a cause-effect relationship due to the cross-sectional design of the study. Second, the use of a 24-h dietary recall for the evaluation of the diet of the participants might have resulted in an incomplete recall. The third limitation was the small sample size due to limitations from the COVID-19 pandemic. Finally, the majority of the sample of the study consisted of university students, which might have worse sleep quality because of night studying, having fun, etc. In addition, BMI values of these age groups were lower than those in older age groups in Turkey. This may affect the relationship between sleep quality and BMI.

CONCLUSIONS

In this study, the poor quality of carbohydrates was associated with poor sleep, some micronutrients (potassium, magnesium, vitamin A-D-K-C-B1-B6, Folate) and higher BMI. However, no significant correlation was found between CQI score and scores on anxiety, depression, and stress. Higher quality of dietary carbohydrate intake showed a significant association with sleep quality, which shows that strategies for prevention of sleep diseases should highlight the quality

of this macronutrient. Eating less refined grains and more whole-grain foods seems to be an important healthy dietary recommendation in order to protect against sleep diseases. However, more studies are required.

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