Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity (2022) 27:1513–1521
https://doi.org/10.1007/s40519-021-01294-2

ORIGINAL ARTICLE

Diet quality indices are associated with sleep and mental health status among diabetic women: a cross-sectional study

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Received: 13 July 2020 / Revised: 6 August 2021 / Accepted: 23 August 2021 / Published online: 4 September 2021

Abstract

Objective Diabetes is a common chronic disease with many complications. Controlling these complexities may enhance the quality of life. This study was conducted to investigate the association between diet quality indices and sleep, stress, anxiety, and depression among diabetic women.

Design Cross-sectional study.

Setting A validated and reliable food frequency questionnaire was filled to assess the dietary intake and adherence to the diet quality indices. Pittsburgh Sleep Quality Index and 21 items Depression, Anxiety, and Stress Scale were used to assess the sleep and mental disorders, respectively.

Participants This study was conducted on 230 Tehrani women with type 2 diabetes.

Results Patients who were in the top tertile of diet quality index consumed less fat, saturated mono-and poly-unsaturated fatty acids, and sodium ($P < 0.05$). Participants who were in top tertile of diet quality indices consumed more fruits, and vegetables. Patients in the highest tertile of diet quality index-international had less risk of depression (OR: 0.17; 95% CI: 0.07; 0.41), anxiety (OR: 0.36; 95% CI: 0.16; 0.80), stress (OR: 0.09; 95% CI: 0.04; 0.21), and poor sleep (OR: 0.12; 95% CI: 0.04; 0.36). Patients in the highest tertile of healthy eating index-international had less risk of depression (OR: 0.06; 95% CI: 0.02; 0.21), anxiety (OR: 0.10; 95% CI: 0.04; 0.26), stress (OR: 0.11; 95% CI: 0.05; 0.26), and poor sleep (OR: 0.08; 95% CI: 0.03; 0.20).

Conclusion Patients with higher adherence to diet quality indices were likely less to have mental disorders or poor sleep.

Level of evidence Level V: based on descriptive studies (a Cross-sectional study).

Keywords Diet quality index · Healthy eating index · Sleep · Depression · Anxiety · Diabetic patients

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Introduction

Type 2 diabetes is a common chronic disease with many complications which influences mood. Diabetes impacts sleep patterns, as like as psychological symptoms such as stress, anxiety, and depression [1]. Furthermore, sleep disorders and physiological disturbances could impact each other and exaggerate the severity of diabetes complications [2]. Several studies have shown that sleep disorders are more common in diabetic patients and that these patients are poor sleepers with higher glucose levels than those who are non-diabetic [1, 3, 4]. Moreover, sleep disturbances such as sleep deprivation are associated with some chronic diseases for instance obesity, diabetes, metabolic syndrome, and coronary heart disease as well as psychological symptoms and lower diet quality [5–7]. Diet is an environmental factor that has a well-known and important role in health status, diabetes improvement and reduction of its complication. Based on several studies, sleep deprivation was associated with lower vegetables [8], more fat [9], and energy-dense foods [10]. Moreover, some studies have presented that healthy dietary patterns including vegetables, fruits, nuts, and legumes have protective effects on depression [11].

Today, prior dietary patterns known as diet quality indices have been used for the assessment of chronic diseases in many studies. Healthy eating index (HEI) and diet quality index- international (DQI-I) are two major indices that emphasize consuming diverse types of vegetables, healthier kinds of fat, and having variety and balance in nutrient consumption. To the best of the author's knowledge, no study evaluates the association of these two methods of prior dietary patterns and sleep patterns as well as psychological symptoms. Diabetes promotes other chronic diseases, and this may have more strengthened among women [12]. Therefore, regarding the importance of sleep and psychological symptoms on health status, especially in diabetic patients, the present study aimed to investigate the association of diet quality indices and sleep, stress, anxiety, and depression among diabetic women.

Methods

This cross-sectional study was conducted among 230 type 2 diabetic women who were referred to a diabetes research or health centers in Tehran, Iran. All subjects were included in the study by conducting a simple random selection with a lottery method. All of them participated with their willingness which was revealed by written informed consent and filled the questionnaires in presence of a nutritionist. Women with type 2 diabetes which have no complicated medical problems were included in this study. Individuals who were involved with another important or chronic disease such as cancer, thyroid dysfunction, cardiovascular disease, and kidney dysfunction were excluded. Also, individuals who reported a total energy intake of < 800 and > 4200 were excluded. The information from the participants was collected by face-to-face interviews. This study was approved by the ethics committee of Tehran University of Medical Sciences (grant number: 34260).

Assessment of anthropometric measures

Weight was measured minimally clothed using a calibrated digital SECA scale (803, German). Height was measured while patients were in a standing position by using an unstretched tape measure nearest to 0.1 mm. Body mass index (BMI) was calculated as weight divided by height (kg/m^2). Waist circumference was measured using an unstretched tape measure nearest to 0.1 cm at the narrowest cite of the waist with light clothing.

Assessment of dietary intake

A validated and reliable semi-quantitative food frequency questionnaire (FFQ) consisting of 168 food items was used to obtain dietary intakes of individuals through the past year [13]. All patients filled the amount and frequency of consumption of each food on a daily, weekly, or monthly during the past year. All the portion sizes of consumed foods are converted to grams per day. Nutritionist IV software (Version 7.0; N-Squared Computing, Salem, OR, USA) which is adapted for Iranian foods was used for nutrients analysis.

Assessment of Diet Quality Index-International

Diet quality index-international (DQI-I) was calculated based on four aspects of a healthy diet which including adequacy, variety, moderation, and balance [14]. Variety was evaluated by two components as follows: "between-food groups" (0–15 points) and "within-protein sources group" (0–5 points). Intake of a half-serving from protein sources presented the maximum score for the within-protein group. Adequacy assesses the fruit, vegetable, and grain group, protein, fiber, calcium, iron, and vitamin C intakes (40 scores). Moderation was assessed based on total fat, saturated fat, cholesterol, sodium, and empty calorie foods (30 scores). Sodium was scored based on the distribution of the subject's intake. Subjects who consumed sodium less than the 15th and over than 85th percentile had 6 and 0 points, respectively. The balance means the equilibrium of micronutrient distribution in diet and fatty acid ratio (10 points). The total

DQI-I score is 100 which a higher score indicates a better quality of the diet.

Assessment of Healthy Eating Index-2010

Twelve components were considered to calculate the healthy eating index (HEI-2010) [15, 16]. The frequency of consumption of total vegetables, total fruits, whole fruits, greens, and beans, total protein foods, and seafood, and plant proteins in the highest and lowest consumption per day was scored 5 and zero, respectively. The frequency of consumption of whole grains, dairy, and fatty acids ((polyunsaturated fatty acid + monounsaturated fatty acid)/ saturated fatty acid) in the highest and lowest consumption was scored 10 and zero, respectively. Refined grains and sodium scored 0 in the highest consumption and 10 in the lowest consumption. Empty calories (energy from solid fats, added sugars, and any alcohol) scored 0–20 in which the highest and lowest frequency of consumption scored as 0 and 20, respectively. Finally, the total HEI score was calculated by summing the scores of these 12 mentioned components. HEI-2010 scores a total score of 100 points.

Assessment of sleep

Pittsburgh Sleep Quality Index (PSQI) is a self-report sleep instrument that has been validated in several studies [17, 18]. This questionnaire measures the quality and pattern of sleep over the past month and consists of nine items which differentiate poor to good value with a range of 0–3 (0, not in the past month; 1, less than once per week; 2, once or twice per week; and 3, three or more times per week). These items explain sleep latency, duration, and efficiency, using sleep medication, sleep disturbances, and daytime dysfunction. PSQI scale by a total score of 0–21. A score of five and greater indicates poor sleep quality and shows a problem in at least two components of the instrument.

Assessment of stress, anxiety, and depression

Depression, Anxiety and Stress Scale (DASS-21) is a self-reported questionnaire that contains 21 items to assess the severity of negative emotional states and symptoms in depression, anxiety, and stress in the past week. These subscales include seven questions which each item scores from 0 (never) to three (always). For depression, a total score of zero to nine is normal, and greater is depression. For anxiety, a total score of zero to seven is normal, and greater means anxiety. For stress, a total score of zero to 14 is normal, and greater means having stress. The validity and reliability of DASS-21 have been investigated in Iran [19, 20].

Assessment of other variables

Sociodemographic information including age, women and their husband's education level and job, and income was assessed by a questionnaire. Physical activity levels were recorded in a week and finally were expressed by a metabolic equivalent hour per week (MET.h/wk) [21]. Blood pressure was measured twice using a sphygmomanometer and the average amount of two measurements was considered as participant's blood pressure. Biochemical markers including fasting blood sugar (FBS), 2-h postprandial blood sugar (2hpp), hemoglobin A1C (Hb A1C), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglyceride (TG) were recorded from patient's medical profile.

Statistical analysis

Participant's characteristics were compared by analysis of variance (ANOVA) or chi-square tests through the dietary scores for continuous and categorical variables, respectively, and reported as mean ± standard deviation (SD) or percentage. Dietary intakes were adjusted for age and energy intake. The association between dietary quality indices and sleep and psychological status was presented in crude and adjusted models using binary logistic regression and linear regression by interpreting odds ratio (OR). In this regard, the highest tertile of DQI-I and HEI scores was compared with the lowest tertile as a reference group. In the adjusted model, we adjusted for age, physical activity, SES, vitamin D intake, sleep duration at night, supplemental consumption, nap time, BMI, and energy intake.

Results

Table 1 presents the general characteristics of patients. The mean age of patients was 59.90 ± 9.20 years. Moreover, the mean weight and WC of them were 73.42 ± 11.83 kg and 95.28 ± 9.83 cm, respectively. Regarding correlation with BMI, we do not present wright and WC measures among tertiles of diet quality indices in Table 1. However, there was no significant association between quality indices and weight as well as WC ($P > 0.05$). Also, there was no significant association between diet quality indices and supplements intake (DQI-I; $P = 0.531$, HEI; $P = 0.373$). The mean years of involving diabetes were 6.58 ± 6.51 years. There was no significant association between diet quality indices and years of involvement with diabetes (DQI-I; $P = 0.486$, HEI; $P = 0.837$).

There was a significant association between DQI-I and age and PA ($P < 0.05$). Patients in the top tertile of DQI-I and HEI fall to sleep sooner than patients in the first tertile

Table 1 Characteristics of participants among tertiles of healthy eating index and diet quality index-international

Variables	Total	DQI-I tertiles			*P* value*	HEI tertiles			*P* value
		1	2	3		1	2	3	
Number	230	77	76	77		80	74	76	
Age (Year)	59.9 ± 9.20	61.97 ± 7.70	57.55 ± 10.91	60.16 ± 8.27	**0.011**	61.34 ± 8.79	59.96 ± 10.39	58.34 ± 8.21	0.127
BMI (kg/m^2)	29.31 ± 4.52	29.44 ± 4.59	28.88 ± 4.20	29.61 ± 4.78	0.580	29.26 ± 4.88	29.52 ± 4.38	29.17 ± 4.32	0.890
Nap (min/d)	29.53 ± 36.93	23.68 ± 36.31	30.00 ± 34.55	34.93 ± 39.36	0.167	26.58 ± 35.81	27.32 ± 29.85	34.80 ± 43.64	0.315
How long does it take to sleep at night (min)	40.53 ± 44.35	52.18 ± 44.08	32.72 ± 35.57	36.62 ± 50.22	**0.016**	41.10 ± 29.55	59.44 ± 60.12	21.52 ± 29.13	**< 0.0001**
How much sleep at night (hours)	6.51 ± 2.79	6.40 ± 4.36	6.47 ± 1.39	6.67 ± 1.58	0.824	6.80 ± 4.27	5.81 ± 1.50	6.90 ± 1.30	**0.031**
Years of post-menopause	10.81 ± 8.87	12.22 ± 8.63	9.93 ± 10.37	10.26 ± 7.30	0.226	10.90 ± 7.65	12.04 ± 10.12	9.51 ± 8.68	0.218
PA (met.h/wk)	30.11 ± 5.31	28.85 ± 4.08	30.41 ± 4.98	31.09 ± 6.43	**0.027**	29.76 ± 6.05	30.08 ± 5.11	30.52 ± 4.69	0.672
SES n (%)					**0.003**				**< 0.0001**
Poor	73 (31.7)	34 (46.6)	21 (28.8)	18 (24.7)		33 (45.2)	29 (39.7)	11 (15.1)	
Moderate	87 (37.8)	29 (33.3)	33 (27.9)	25 (28.7)		30 (34.5)	27 (31.0)	30 (34.5)	
Rich	70 (30.5)	14 (20.0)	22 (31.4)	34 (48.6)		17 (24.3)	18 (25.7)	35 (50.0)	

DQI-I Diet quality index-international; *HEI* healthy eating index; *BMI* body mass index; *PA* physical activity; *SES* socio-economic status

*Calculated by Chi-square and *T*-Test for qualitative and quantitative variables, respectively

Bold *P*-values represent significant association

Data presented as mean (SD)

($P < 0.05$). A significant difference was observed in SES across tertiles of DQI-I, and HEI ($P < 0.05$).

Table 2 documents age and energy-adjusted dietary intakes across DQI-I and HEI tertiles. Based on results, dietary intakes of protein, vitamin D and low-fat dairy products were greater in the third tertile of DQI-I and HEI than the first tertile ($P < 0.05$).

Table 3 indicates the odds ratio and 95% confidence interval for having mental disorders and poor sleep-in the crude model and adjusted model across tertiles of DQI-I and HEI. The risk of being a poor sleeper decreased by 88% in participants in the top tertile of DQI-I. Moreover, the risk of having depression, anxiety, and stress in participants who were in the highest tertile of DQI-I decreased by 83, 64, and 91%, respectively. In addition, the risk of depression, anxiety, and stress in participants in the highest tertile of HEI decreased by 94, 90, and 89%, respectively. Also, the risk of being a poor sleeper in participants who were in the highest tertile of HEI decreased by 92%.

Table 4 indicates the association of anxiety, stress, and depression score, as well as sleep score with healthy eating index and diet quality index-international by linear regression. According to the results, all three mental disorder scores and PSQI score significantly decreased with higher adherence to healthy dietary indices and these results confirmed the previous results found Table 3.

Discussion

This cross-sectional study revealed that higher adherence to the HEI and DQI is associated with decreased poor sleeping and psychological disorders including depression, anxiety, and stress among diabetic patients. This association remained statistically significant even after the adjustment of the potential confounders. To the best of our knowledge, this is the first study that assessed the association between DQI and HEI indices and psychological disorders and sleeping status in diabetic patients.

Mental and sleep disorders are common complications in diabetic patients [22, 23]. These problems are associated with poor quality of life and are a cause of great burden to the healthcare system and social outcomes [24, 25]. Dietary factors play a strong role in the etiology and treatment of psychological and sleep problems. The high content of antioxidants, folate, and B vitamins which are effective to reduce neuronal damage may be an important

Table 2 Dietary intake across tertiles of the healthy eating index and diet quality index-international among diabetic women

Variables	Total	DQI-I tertiles			*P* value*	HEI tertiles			*P* value
		1	2	3		1	2	3	
Energy (kcal/d)	2294.8 ± 496.34	2249.3 ± 422.18	2374.4 ± 605.23	2261.8 ± 439.34	0.230	2295.9 ± 434.72	2199.5 ± 463.49	2386.5 ± 571.43	0.069
CHO (g/d)	330.70 ± 70.50	319.7 ± 5.63	326.6 ± 5.69	345.8 ± 5.58	**0.003**	351.9 ± 5.25	331.4 ± 5.47	307.7 ± 5.42	**< 0.0001**
Protein (g/d)	70.81 ± 17.53	64.21 ± 0.98	71.32 ± 0.99	76.90 ± 0.97	**< 0.0001**	63.24 ± 0.85	70.53 ± 0.89	79.05 ± 0.88	**< 0.0001**
Fat (g/d)	84.93 ± 37.04	91.94 ± 2.37	87.10 ± 2.40	75.80 ± 2.35	**< 0.0001**	76.68 ± 2.31	84.71 ± 2.40	93.84 ± 2.38	**< 0.0001**
SFA (mg/d)	20.45 ± 6.68	22.54 ± 0.49	20.32 ± 0.50	18.48 ± 0.48	**< 0.0001**	21.47 ± 0.50	20.86 ± 0.52	18.97 ± 0.51	**0.002**
MUFA (mg/d)	29.40 ± 16.68	30.94 ± 1.20	31.14 ± 1.22	26.12 ± 1.19	**0.004**	23.94 ± 1.07	28.69 ± 1.12	35.83 ± 1.10	**< 0.0001**
Vitamin D	1.18 ± 0.81	1.01 ± 0.09	1.14 ± 0.09	1.41 ± 0.09	**0.005**	0.97 ± 0.09	1.21 ± 0.09	1.38 ± 0.09	**0.006**
Red meat (g/d)	20.42 ± 10.89	20.50 ± 1.24	19.54 ± 1.25	21.21 ± 1.23	0.639	19.13 ± 1.20	21.77 ± 1.25	20.45 ± 1.24	0.319
Processed meat(g/d)	3.57 ± 8.78	8.18 ± 0.94	1.09 ± 0.95	1.39 ± 0.93	**< 0.0001**	6.10 ± 0.96	3.41 ± 1.01	1.06 ± 0.99	**0.002**
Fish (g/d)	6.89 ± 7.77	3.96 ± 0.85	6.76 ± 0.86	9.96 ± 0.84	**< 0.0001**	5.64 ± 0.84	5.26 ± 0.88	9.80 ± 0.87	**< 0.0001**
Poultry (g/d)	14.50 ± 8.84	11.25 ± 0.97	15.79 ± 0.98	16.48 ± 0.96	**< 0.0001**	13.01 ± 0.96	13.40 ± 1.01	17.15 ± 0.99	**0.006**
Whole grains (g/d)	57.44 ± 55.77	58.65 ± 6.41	60.79 ± 6.48	52.94 ± 6.35	0.669	30.04 ± 5.82	66.19 ± 6.06	77.77 ± 6.01	**< 0.0001**
Refined grains (g/d)	362.08 ± 151.14	361.0 ± 17.13	333.2 ± 17.33	391.6 ± 16.97	0.058	462.8 ± 14.20	353.7 ± 14.79	264.2 ± 14.66	**< 0.0001**
Low-fat dairy (g/d)	169.86 ± 147.16	88.88 ± 14.66	167.8 ± 14.83	252.8 ± 14.52	**< 0.0001**	100.8 ± 14.43	154.4 ± 15.03	257.7 ± 14.89	**< 0.0001**
High-fat dairy (g/d)	104.62 ± 128.01	165.1 ± 13.79	73.72 ± 13.95	74.59 ± 13.67	**< 0.0001**	140.5 ± 13.42	129.6 ± 13.97	42.49 ± 13.85	**< 0.0001**
Vegetables (g/d)	430.08 ± 191.22	285.7 ± 17.59	437.8 ± 17.79	566.9 ± 17.43	**< 0.0001**	359.4 ± 20.23	416.5. ± 21.08	517.7 ± 20.88	**< 0.0001**
Fruits (g/d)	270.78 ± 113.78	206.7 ± 10.82	273.1 ± 10.95	332.6 ± 10.72	**< 0.0001**	209.9 ± 10.89	288.0 ± 11.34	318.1 ± 11.23	**< 0.0001**

DQI-I Diet quality index-international; *HEI* healthy eating index; *CHO* carbohydrate; *SFA* saturated fatty acid; *MUFA* monounsaturated fatty acid

†Calculated by *T*-Test for energy intake and multivariate analysis of covariance (ANCOVA) for other variables. All the variables, except energy, adjusted for age and energy intake and presented as mean and standard error. Data in the Total column presented as mean and SD

Bold *P*-values represent significant association

Table 3 Odds ratio and confidence intervals for mental disorders and having poor sleep among tertiles of healthy eating index and diet quality index-international

Variables	Diet Quality Index-International			*P* trend†	Healthy Eating Index			*P* trend
	T1	T2	T3		T1	T2	T3	
Poor sleep ($n=164$)								
Crude model	1	0.14 (0.05; 0.37)	0.12 (0.04; 0.30)	**< 0.0001**	1	0.65 (0.25; 1.65)	0.08 (0.04; 0.20)	**< 0.0001**
Adjusted model	1	0.14 (0.05; 0.42)	0.12 (0.04; 0.36)	**< 0.0001**	1	0.53 (0.19; 1.43)	0.08 (0.03; 0.20)	**< 0.0001**
Depression ($n=68$)								
Crude model	1	0.26 (0.13; 0.53)	0.15 (0.07; 0.33)	**< 0.0001**	1	0.66 (0.35; 1.27)	0.06 (0.02; 0.19)	**< 0.0001**
Adjusted model	1	0.27 (0.12; 0.60)	0.17 (0.07; 0.41)	**< 0.0001**	1	0.68 (0.33; 1.39)	0.06 (0.02; 0.21)	**< 0.0001**
Anxiety ($n=77$)								
Crude model	1	0.52 (0.26; 1.01)	0.39 (0.19; 0.78)	**0.007**	1	0.34 (0.17; 0.67)	0.13 (0.06;0.30)	**< 0.0001**
Adjusted model	1	0.48 (0.23; 1.01)	0.36 (0.16; 0.80)	**0.012**	1	0.33 (0.16; 0.69)	0.10 (0.04; 0.26)	**< 0.0001**
Stress ($n=101$)								
Crude model	1	0.20 (0.10; 0.40)	0.09 (0.04; 0.19)	**< 0.0001**	1	0.45 (0.23; 0.87)	0.10 (0.04; 0.22)	**< 0.0001**
Adjusted model	1	0.21 (0.10; 0.46)	0.09 (0.04; 0.21)	**< 0.0001**	1	0.42 (0.21; 0.85)	0.11 (0.05; 0.26)	**< 0.0001**

Data presented as the odds ratio and 95% Confidence Interval

Adjusted model: All the variables were adjusted for age, socio-economic status, physical activity, sleep duration at night, vitamin D intake, supplement intake, nap time, BMI, and energy intake

†Calculated by logistic regression

Bold *P*-values represent significant association

Table 4 Linear regression for the association of mental disorders and having poor sleep among tertiles of healthy eating index and diet quality index-international

Variables	Diet Quality Index-International		Healthy Eating Index	
	β	*P* value	*β*	*P* value
PSQI score				
Crude model	− 0.34	**< 0.0001**	− 0.46	**< 0.0001**
Adjusted model	− 0.29	**< 0.0001**	− 0.42	**< 0.0001**
Depression score				
Crude model	− 0.35	**< 0.0001**	− 0.43	**< 0.0001**
Adjusted model	− 0.31	**< 0.0001**	− 0.40	**< 0.0001**
Anxiety score				
Crude model	− 0.11	**0.078**	− 0.40	**< 0.0001**
Adjusted model	− 0.09	0.167	− 0.42	**< 0.0001**
Stress score				
Crude model	− 0.38	**< 0.0001**	− 0.47	**< 0.0001**
Adjusted model	− 0.35	**< 0.0001**	− 0.44	**< 0.0001**

Adjusted model: All the variables were adjusted for age, socio-economic status, physical activity, sleep duration at night, vitamin D intake, supplement intake, nap time, BMI, and energy intake

*Calculated by linear regression

Bold *P*-values represent significant association

mechanism that is associated with the reduction of depression and anxiety [26, 27].

Nowadays, it is established that persons who adhered to high-quality diets had a lower risk of all mortality and diabetes [28]. Previous studies strongly revealed that higher scores of HEI are associated with a lower risk of other chronic diseases such as the risk of heart failure [29], cardiovascular disease [30], colorectal [31], and breast cancer [32]. It seems that adherence to a high-quality diet can decrease psychological disorders and sleep complications in diabetic patients. Similar to our findings, a cross-sectional study was conducted in 3363 Iranian adults which revealed that greater adherence to the HEI-2010 was associated with a reduced risk of depression and anxiety [33].

HEI and DQI both emphasize on increased consumption of fruits, vegetables, plant proteins, and whole grains, and reducing intake of refined grains, empty calories, added sugar, sodium, and saturated fatty acids [14, 15]. A case–control study among Iranian women has indicated that adherence to a healthy dietary pattern was associated with decreased risk of depression [34]. Moreover, a study in 1118 African-American and white adults of age 30–64 years has shown that a high-quality diet assessed by HEI-2005 was inversely associated with depression [35]. A population-based study in Peru revealed that greater consumption of fruits and vegetables was associated with a lower prevalence of depressive symptoms [36]. Dietary antioxidants of vegetables and fruits defend against oxidative stress and inflammatory markers which are strongly associated with depression [37, 38]. Dietary intake of sulforaphane and glucoraphanin which are present in cruciferous vegetables may prevent depression through suppression of chronic inflammation [39, 40].

The HEI-2010 emphasize on a high intake of unsaturated fatty acids and n-3 fatty acids and oily fish consumption. A meta-analysis of six randomized clinical trials with 4605 included patients has shown that omega-t fatty acids are effective in the treatment of even depressed patients [41]. Omega-3 fatty acids can modulate brain-derived neurotrophic factor and their cAMP-response element-binding protein expression. This modulation occurs by suppressing proinflammatory cytokines, reduction of inflammation, and decrease the production of inflammatory eicosanoids [42]. Moreover, studies have shown that patients with obstructive sleep apnea, as a common multifactorial sleep disorder, have higher levels of tumor necrosis factor (TNF-α) in plasma, and serum [43]. TNF-α as a well-known pro-inflammatory cytokine leads to necrosis and apoptosis of cells, while n-3 fatty acids protect against. Therefore, omega-3 fatty acids have neuroprotective and therapeutic effects against mental and sleep disorders [44].

The western dietary pattern which is rich in refined grains, sugary products, fried and processed foods indicated a positive statistical association with mental disorders in 3663 Australian individuals in a cohort study [45]. A cross-sectional study conducted on Iranian adults revealed that adherence to fast food and the western dietary pattern was associated with an increased risk of anxiety [46]. One other study among the Iranian population has shown that greater consumption of processed foods can increase the risk of anxiety [47]. A longitudinal study in individuals aged 45–60 years has indicated that more consumption of western, high snack, high fat, and high sweets diets was associated with higher depressive symptoms [48].

A cross-sectional study in 118,462 participants of the age 12–18 years has shown that higher consumption of unhealthy foods such as sugar-sweetened beverages, instant noodles, confectionaries, and fast foods are associated with poor sleep quality (49). Both DQI-I and HEI as prior healthy dietary patterns emphasize on reduction in empty calorie foods, sugar-sweetened beverages, refined grains, and red meats which can play a role to promote sleep and mental health.

This is the first time which HEI-2010 and DQI-I were assessed with sleep and psychological status among diabetic patients. We randomly included diabetic women from different socioeconomic statuses and this study could be a representative sample of diabetic women in Tehran. Participants did not differ for metabolic and dietary intakes due to the fact that diabetes is pharmacologically and clinically

controlled among all of them. Besides these strengths, the present study has some limitations including the cross-sectional nature of the study which does not reveal the causal association and use of semi-quantitative FFQ which have recall bias and misclassification. Also, various unknown confounders which are unmeasured can affect the results.

In summary, the HEI-2010 and DQI-I were found inversely associated with the risk of poor sleeping and psychological disorders including depression, anxiety, and stress among diabetic women. Hence, it seems that greater adherence to a high-quality diet can reduce the risk of these complications. Prospective cohort studies with a larger sample size of both genders are needed to prove our findings.

What is already known on this subject?

Based on several studies, sleep deprivation was associated with lower vegetable and more fat and energy-dense foods. Also, it seems that healthy dietary patterns including vegetables, fruits, nuts, and legumes have protective effects on depression.

What does this study add?

To the best of the author's knowledge, no study has evaluated the association of DQI and HEI and sleep patterns as well as psychological symptoms. Therefore, regarding the importance of sleep and psychological symptoms on health status, especially in diabetic patients, the present study aimed to investigate the association of diet quality indices and sleep, stress, anxiety, and depression among diabetic women.

What do we now know as a result of this study that we did not know before?

In the present study, patients with higher adherence to diet quality indices were less likely to have mental disorders or poor sleep.

Acknowledgements We would like to express our thankfulness to Dr. Nasli, secretary of the Diabetes Research Center of Tehran University of Medical Sciences, and all staff in this center in Tehran, Iran.

Author contribution LA provided the idea of this study. ED, BL and LA designed this study. LA supervised the study. ED conducted the study and performed the statistical analyses. ED, MM, JH and TR prepared a first draft of the manuscript, and LA finalized it. ABP and BL read the manuscript and commented on it.

Funding This study is supported by the Tehran University of Medical Sciences (grant number: 34260).

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the ethical committee of the Tehran University of Medical Sciences.

Informed consent Written informed consent was obtained from all patients.

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