

REVIEW

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Depression is related to dietary diversity score in women: a cross-sectional study from a developing country

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Abstract

Background: Substantial evidence provides support for the role of diet in the prevention and control of mental disorders. However, since there is no study regarding the relationship between dietary diversity and stress or depression, we aimed to determine the relationship between the dietary diversity score (DDS) and stress and depression in women.

Methods: This descriptive-analytical cross-sectional study was performed on 360 women aged 20–49 years attending health centers in the south of Tehran. The dietary intake and score of depression, anxiety, and stress were measured using a 24-h dietary recall and the 42-item depression, anxiety, stress scales questionnaire, respectively. The DDS was calculated based on the FAO 2013 guidelines. Data were analyzed using Chi-square, analysis of variance, Spearman correlation coefficient, and multivariable logistic regression tests.

Results: In total, 31.4 and 25.8% of the subjects suffered from depression and stress, respectively. After adjusting for confounders, a one-unit increase in DDS was associated with a 39% reduction in the risk of severe depression. The DDS was not significantly associated with mild or moderate depression, and no significant relationship was observed between the DDS and stress.

Conclusions: The DDS could be inversely associated with depression in women. Since we observed no significant relationship between stress and DDS, further studies are needed in this regard.

Keywords: Depression, Stress, Dietary diversity score, Women

Background

The burden of mental disorders continues to grow with significant impacts on health in all countries of the world [1]. According to the World Health Organization (WHO), unipolar depressive disorders are the third greatest burden of disease globally [2]. Several investigations have revealed that diet, as a modifiable lifestyle

factor, could have a major role in the prevention and control of mental disorders. These studies have mostly focused on the relationship between individual nutrients or dietary patterns with the risk of depression and stress [3–5]. However, despite the role of individual nutrients, it is important to note that there are still many unidentified compounds in different foods and potential interactions between the nutrients. Therefore, dietary pattern analysis seems more reasonable instead of evaluation of individual nutrients or foods [6].

Based on United States Department of Agriculture (USDA) guidelines and the Food Guide Pyramid, dietary diversity is one of the characteristics of a healthy diet. Dietary diversity represents the consumption of various food items within and between food groups [7].

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Several indices are available for dietary quality assessment, including the Healthy Eating Index (HEI) [8] and dietary diversity score (DDS) [9].

The DDS is a simple, efficient, and low-cost index for dietary quality assessment. In addition, it is easy to answer [10]. For calculating the DDS, the FAO recommends using a single 24-h recall since it is less cumbersome for the respondent. In addition, analysis of data based on a 24-h recall period is reported to be much easier than longer recall periods [11]. The HEI is specified by the Dietary Guidelines for Americans [12]. However, in contrast to the dietary diversity questionnaire, the HEI is reported to be dependent on the ethnicity and culture [13].

In addition to reports of a positive relationship between the DDS and macro- and micro-nutrients intake [14, 15], several investigations have revealed an inverse association between the DDS and chronic diseases, such as metabolic syndrome [16], cardiovascular diseases [17], cancer [18], and hypertension [19]. However, to our knowledge, no previous study has evaluated the relationship between dietary diversity and depression and stress. Women are more vulnerable to depression and stress [20]. Therefore, this study was conducted to determine the relationship between the DDS and depression and stress in women.

Methods

Study population

This was a descriptive-analytical cross-sectional study. The detailed methodology of the study has been already reported [21] and is briefly described here. The study was conducted on 360 women aged 20–49 years attending 10 health centers in the south of Tehran, Iran. These centers were randomly selected from 29 health centers in the area. In each selected health center, we defined the number of our subjects in proportion to the total number of patients attending the center. The inclusion criteria were age 20–49 years, a body mass index (BMI) 18.5–34.99 kg/m², and at least primary education. In total, 400 women were invited to participate in the study of whom 40 subjects declined, resulting in a response rate of 90%. The exclusion criteria were pregnancy and lactation, suffering from depression diagnosed by a psychiatrist or using anti-depressive drugs in the past 12 months, history of life stressors or tragic events (such as divorce, financial problems, love failure, death of first degree relatives or friends) in the past 6 months, history of any type of smoking or alcohol consumption, diseases such as diabetes, cardiovascular diseases, hypertension, multiple sclerosis, seizure attacks, or liver, kidney, or thyroid disorders, or regular consumption of any drugs. Since subjects who follow specific diets such as low-calorie diets

may have different dietary intakes, we excluded them from the study. Informed written consent form was obtained from all participants. The study protocol and the consent form were approved by the Ethics Committee of Tehran University of Medical Sciences.

Assessment of depression and stress score

The psychological status of the participants was measured by the Depression, Anxiety, and Stress Scales (DASS-42) questionnaire, which has been validated for use in non-clinical populations and research [22, 23]. This is a 42-item self-report questionnaire, developed by Lovibond and Lovibond [24]. The Cronbach alpha coefficient for the questionnaire was 0.81 for depression, 0.73 for anxiety, and 0.81 for stress in a study of 717 normal subjects in Australia [24]. In another study on 400 high school students in Kermanshah, west of Iran, the coefficient was 0.94 for depression, 0.85 for anxiety, and 0.87 for stress [25]. The DASS-42 contains 14 question items for depression, anxiety, or stress. The answers are divided into four categories as zero, medium–low, medium–high, and highest with a score of 0–3, respectively. Based on the total score, the subjects were divided into five groups of normal (0–9), mild (10–13), moderate (14–20), severe (21–27), and very severe (> 27) depression. These figures for five groups of stress were 0–14, 15–18, 19–25, 26–33, and > 33, respectively. However, due to the limited number of cases in some groups, they were divided into three groups of normal, mild/moderate, and severe.

Measurement of dietary diversity score

For all participants, a 24-h diet recall questionnaire was completed through face-to-face interviews. The participants' energy and nutrient intake was calculated by the Nutritionist IV software (N Squared Computing, San Bruno, CA) modified for Iranian foods. In addition, the DDS was calculated based on the FAO (2013) guideline which suggests a questionnaire for the measurement of dietary diversity [11]. This questionnaire contains nine main food groups: (1) cereals, (2) dark green leafy vegetables, (3) vitamin A-rich fruits and vegetables, (4) other fruits and vegetables, (5) organ meat, (6) meat, fish, and seafood, (7) eggs, (8) legumes, nuts, and seeds, and (9) milk and milk products. We defined a scoring system based on the values obtained from the 24-h diet recall questionnaire as described below. The DDS was calculated using a minimum consumption of at least half serving of one food from each mentioned food group. The score of dietary diversity was the total sum of the score of all food groups. A score of 1 was given score for each food group consumed, and the maximum score was 9.

Covariate assessment

Physical activity was assessed using the short form of the International Physical Activity Questionnaire (IPAQ) during 1 week. The subjects were then divided into three groups of low, moderate, and high physical activity according to the IPAQ criteria [26]. Weight was measured to the nearest 100 g in with minimal clothing and shoes removed. Height was measured in the standing upright position looking straight forward, with heels against the wall without shoes by a stadiometer to the nearest of 0.1 cm. The BMI was calculated as weight (kg) divided by height squared (m^2). Waist Circumference (WC) was measured midway between the lower rib margin and the iliac crest at the end of a gentle expiration and in the standing position to the nearest of 0.1 cm by a tape. Demographic data, including age, educational level, marital status, monthly household income, history of stressful life events, and dietary supplement intake, were collected.

Statistical analysis

Statistical analyses were performed by the Statistical Package for Social Sciences (SPSS, version 16; Chicago, IL). Chi square was used to test the relationship between qualitative variables and depression and stress. Analysis of Variance (ANOVA) was applied to assess the relationship between quantitative variables and depression and stress. The correlation between the DDS and energy and nutrient intake was evaluated using the Spearman's correlation test. Multinomial logistic regression was used to measure the relationship between the DDS and depression and stress, with adjustment for confounding variables.

Results

In the current study, the mean age of the participants was 32.1 ± 6.3 years, and the prevalence of depression and stress was 31.4 and 25.8%, respectively. The mean DASS score for depression was 27.7 in the severe group as compared to 14.2 in the mild/moderate group and 3.7 in the normal group. These figures were 30.9, 19.2, and 6.7 for stress, respectively.

Based on Tables 1 and 2, depression was significantly associated with age [$F(2, 357) = 6.16, p = 0.002$], educational level [$F(2, 357) = 4.53, p = 0.01$], energy intake [$F(2, 357) = 4.93, p = 0.008$], and monthly household income ($p = 0.007, df = 4$), and stress was significantly associated with age [$F(2, 357) = 2.20, p = 0.01$], monthly household income ($p = 0.01, df = 4$), and physical activity ($p = 0.01, df = 4$). There was a significant positive correlation between the DDS and the intake of energy, protein, carbohydrate, fat, B vitamins, fat-soluble vitamins, and minerals including iron, magnesium, zinc, and selenium

($p < 0.02$). In addition, the correlation between the DDS and the percentage of energy obtained from protein, saturated fatty acid (SFA), mono unsaturated fatty acid (MUFA), poly unsaturated fatty acid (PUFA), and docosahexaenoic acid (DHA) was significant ($p < 0.02$). However, we observed no significant correlation between the DDS and the percentage of energy obtained from carbohydrates, fat, and Eicosapentaenoic Acid (EPA) ($p > 0.05$) (Table 3).

Chi-square test revealed that with increase in DDS tertiles, the percentage of the individuals who consumed vitamin A-rich fruits and vegetables, dark green leafy vegetables, chicken eggs, milk and dairy products, legumes, nuts, and seeds increased ($p < 0.001, df = 2$). In addition, the percentage of the individuals who consumed meat, fish, and seafood decreased significantly with increase in the DDS tertiles ($p < 0.001, df = 2$). However, there was no significant relationship between the DDS and food groups such as cereals and white roots, organ meat, and other fruits and vegetables ($p > 0.05, df = 2$) (Table 4).

The relationship between the DDS and depression and stress is shown in Tables 5 and 6. In model 1, an increase in DDS led to 38% decrease in the odds ratio (OR) of severe depression. The OR was further reduced after adjustment for potential confounders. Regression models revealed no significant relationship between the DDS and mild or moderate depression (Table 5). As shown in Table 6, no relationship was observed between the DDS and stress in different stress groups in multinomial logistic regression models.

Discussion

We observed an inverse association between DDS and severe depression, which remained significant after adjustment for confounders. However, there was no significant association between DDS and stress. To our knowledge, there is no report of the relationship between DDS and depression and stress.

Recent studies have mainly focused on the relationship between nutrients and dietary patterns and depression and stress. One study showed an inverse relationship between depression and a healthy dietary pattern with high consumption of vegetables, fruits, nuts, legumes, olive oil, fish, and low consumption of meat and meat products [4]. In another study on Australian women, a traditional dietary pattern (characterized by vegetables, fruit, meat, fish, and whole grains) was associated with lower risk of depression and the Western dietary pattern (characterized by processed or fried foods, refined grains, and sugary products) was associated with a higher risk of depression [27]. In addition, a healthy dietary pattern is inversely related to depression [28, 29]. However, the

Table 1 Association of general characteristics of participants with depression status

Characteristics	Depression status			F	df ^a	df ^b	p value	p trend
	Normal (n = 247) M ± SD or n (%)	Mild/moderate (n = 81) M ± SD or n (%)	Severe (n = 32) M ± SD or n (%)					
DASS (score) for depression	3.7 ± 2.7	14.2 ± 3.1	27.7 ± 4.3					
Age (years)	32.8 ± 6.2	30.0 ± 6.6	32.3 ± 5.6	6.1*	2	357	0.002**	0.03
Education (years)	11.6 ± 3.2	10.9 ± 3.2	10.0 ± 3.08	4.5*	2	357	0.01**	0.003
Weight (kg)	67 ± 9.9	67.1 ± 10.9	69.5 ± 8	0.8*	2	357	0.4**	0.3
Height (cm)	158.4 ± 5.4	158.8 ± 4.8	160 ± 5.3	1.1*	2	357	0.3**	0.1
Body mass index (kg/m ²)	26.7 ± 3.5	26.6 ± 4.1	27.2 ± 3.1	0.3*	2	357	0.7**	0.6
Energy (kcal)	1664.4 ± 692.9	1933.6 ± 734.4	1585.9 ± 823.5	4.9*	2	357	0.008**	0.3
Marital status								
Married	233 (94.3)	72 (88.9)	27 (84.4)		2		0.06***	
Unmarried	14 (5.7)	9 (11.1)	5 (15.6)					
Household income (Toman)								
< 500,000	19 (7.8)	11 (13.9)	7 (21.9)		4		0.007***	
500,000–1,000,000	142 (58.2)	49 (62)	22 (68.8)					
≥ 1,000,000	83 (34)	19 (24.1)	3 (9.4)					
Dietary supplement use								
No ^c	197 (79.8)	64 (79)	23 (71.9)		2		0.6***	
Yes ^d	50 (20.2)	17 (21)	9 (28.1)					
Physical activity								
Low	137 (55.5)	47 (58)	19 (59.4)		4		0.07***	
Moderate	95 (38.5)	28 (34.6)	7 (21.9)					
High	15 (6.1)	6 (7.4)	6 (18.8)					

DASS depression, anxiety, stress scales

* F for ANOVA test

** p value is for ANOVA test, p < 0.05 is statistically significant *** p value is for X² test, p < 0.05 is statistically significant

^a Between groups df

^b Within groups df

^c Less than three times per week

^d Three or more times per week

result of a meta-analysis showed no association between Western dietary pattern and depression [30].

Based on the results of the current study, an increased DDS was associated with a higher percentage of individuals who consumed food groups such as milk and dairy products, vitamin A-rich fruits and vegetables, dark green leafy vegetables, eggs, legumes, nuts, and seeds. On the contrary, the percentage of individuals who consumed meat, fish, and seafood groups decreased with an increase in the DDS tertiles. This finding might reflect that with an increase in the DDS, subjects decrease their meat intake and increase the intake of other healthy food groups such as fruits, vegetables, and dairy products. In addition, since the price of meat and fish is high in Iran, their consumption is low in many households. The results of a randomized clinical trial suggested that restricting meat, fish, and poultry intake improved some domains of short-term mood state in omnivores [31].

These results are consistent with the findings of another cross-sectional study which showed that vegetarians had better mood than omnivores [32]. Therefore, it can be deduced that with an increase in the DDS, the dietary pattern of the individuals could become more similar to the Mediterranean dietary pattern which is characterized by high intake of fruits, vegetables, whole grains, legumes, nuts, and seeds and low consumption of red meat [33]. The protective role of the Mediterranean dietary pattern against depression has been shown in some studies [34]. In addition, milk and dairy products, fruits and vegetables, eggs, legumes, nuts, and seeds have a high content of B vitamins, particularly vitamins B6, B12, and folic acid [35]. In the current study, a positive correlation was observed between the DDS and dietary intake of vitamins B6, B12, and folic acid. Several epidemiological studies have reported the protective effect of these vitamins against depression [36, 37]. For instance, based on a

Table 2 Association of general characteristics of participants with stress status

Characteristics	Stress status			F	df ^a	df ^b	p value	p trend
	Normal (n = 267) M ± SD or n (%)	Mild/moderate (n = 70) M ± SD or n (%)	Severe (n = 23) M ± SD or n (%)					
DASS (score) for stress	6.7 ± 4.0	19.2 ± 3.0	30.9 ± 4.2					
Age (years)	32.5 ± 6.4	30.9 ± 6.3	31.1 ± 4.1	2.2*	2	357	0.01**	0.6
Education (years)	11.5 ± 3.3	11 ± 2.9	10.2 ± 3.1	2.1*	2	357	0.1**	0.003
Weight (kg)	67.2 ± 9.8	66.9 ± 10.6	69.3 ± 9.9	0.5*	2	357	0.6**	0.3
Height (cm)	158.5 ± 5.3	158.9 ± 5.2	160.4 ± 4.7	1.5*	2	357	0.2**	0.1
Body mass index (kg/m ²)	26.8 ± 3.6	26.5 ± 3.9	26.9 ± 3.7	0.2*	2	357	0.8**	0.6
Energy (kcal)	1724.1 ± 702.8	1734.3 ± 701.3	1597.7 ± 991.3	0.3*	2	357	0.7**	0.6
Marital status								
Married	249 (93.3)	61 (87.1)	22 (95.7)		2		0.2***	
Unmarried	18 (6.7)	9 (12.9)	1 (4.3)					
Household income (Toman)								
< 500,000	24 (9.2)	10 (14.3)	3 (13)		4		0.01***	
500,000–1,000,000	152 (58)	41 (58.6)	20 (87)					
≥ 1,000,000	86 (32.9)	19 (27.1)	0 (0)					
Dietary supplement use								
No ^c	214 (80.1)	54 (77.1)	16 (69.6)		2		0.4***	
Yes ^d	53 (19.9)	16 (22.9)	7 (30.4)					
Physical activity								
Low	148 (55.4)	41 (58.6)	14 (60.9)		4		0.01***	
Moderate	105 (39.3)	21 (30)	4 (17.4)					
High	14 (5.2)	8 (11.4)	5 (21.7)					

DASS depression, anxiety, stress scales

* F for ANOVA test

** p value is for ANOVA test, p < 0.05 is statistically significant

*** p value is for X² test, p < 0.05 is statistically significant

^a Between groups df

^b Within groups df

^c Less than three times per week

^d Three or more times per week

prospective study on American older adults, high intake of vitamins B6 and B12 is associated with lower incidence of depression after 12 years [36]. Moreover, one meta-analysis showed that after adjusting for confounders, low folate intake was significantly associated with the risk of depression [37]. Serotonin and dopamine deficiency are related to the etiology of depression. Vitamin B6-, B12-, and folate-derived coenzymes are involved in serotonin and dopamine synthesis and metabolism. Furthermore, vitamin B6 and B12 act as a cofactor for the conversion of homocysteine to methionine and cysteine, respectively. Insufficient dietary intake of these vitamins could lead to homocysteine accumulation and reduced synthesis of monoamines in the brain, which might play a crucial role in the etiology of depression [38]. We found a positive correlation between the DDS and the consumption of

alpha-linolenic (ALA) and DHA. Based on the percentage distribution of food groups in DDS tertiles, a high DDS was associated with lower consumption of meat and fish, and higher intake of dark green leafy vegetables. So it is possible that the intake of fish, as the primary source of omega-3, is very low in women, as only 6.6% of them declared regular fish intake (data not shown). Therefore, the minor intake of dietary omega-3 fatty acids in our subjects could be attributed to the intake of vegetables. ALA is found in vegetables; this fatty acid can be converted to EPA and DHA in human body. However, fish consumption is considered the main source of EPA and DHA [38]. The results of one meta-analysis revealed that EPA and DHA levels were significantly lower in patients with depression, in comparison with healthy individuals [39]. In neurons, DHA is the primary component of

Table 3 Spearman’s correlation between daily nutrients, energy intake, and dietary diversity score

Dietary diversity score					
Nutrients	<i>r</i> *	<i>p</i> value**	Nutrients	<i>r</i> *	<i>p</i> value**
Energy (kcal)	0.2	< 0.001	Vitamin D (µg)	0.2	< 0.001
Protein (g)	0.4	< 0.001	Vitamin K (µg)	0.3	< 0.001
Carbohydrate (g)	0.2	< 0.001	Vitamin C (mg)	0.2	< 0.001
Fat (g)	0.2	< 0.001	Folate (µg)	0.4	< 0.001
Protein (% energy)	0.28	< 0.001	Thiamin (mg)	0.3	< 0.001
Carbohydrate (% energy)	- 0.1	0.05	Riboflavin (mg)	0.4	< 0.001
Fat (% energy)	0.03	0.52	Niacin (mg)	0.3	< 0.001
SFA (g)	0.2	< 0.001	Pyridoxine (mg)	0.3	< 0.001
MUFA (g)	0.2	0.001	Cobalamin (µg)	0.3	< 0.001
PUFA (g)	0.1	0.006	Iron (mg)	0.3	< 0.001
DHA (g)	0.1	0.004	Zinc (mg)	0.4	< 0.001
EPA (g)	- 0.5	0.3	Magnesium (mg)	0.3	< 0.001
Vitamin A (RE)	0.4	< 0.001	Selenium (mg)	0.2	< 0.001
Vitamin E (mg)	0.1	0.01			

SFA saturated fatty acid, MUFA monounsaturated fatty acid, PUFA polyunsaturated fatty acid, DHA docosahexaenoic acid, EPA eicosapentaenoic acid

* *r* is Spearman’s correlation coefficient

** *p* value is for Spearman’s correlation test, *p* < 0.05 is statistically significant

plasma membrane phospholipids, and higher concentration of DHA improves serotonin receptor sensitivity in these cells via increasing the plasma membrane fluidity [40].

Regarding the role of oxidative stress in mental disorders, it has been shown that higher sensitivity of the

human brain to oxidative stress could be due to high O₂ consumption, high intake of iron and polyunsaturated fatty acids, and low activity of antioxidant enzymes [41]. Food groups such as fruits and vegetables are rich in vitamins, carotenoids, polyphenols, and other bioactive compounds, so they provide a great amount of antioxidants [42, 43]. In addition, the riboflavin in milk and dairy products, and flavonoids, plant sterols, and tocopherols in nuts mark these foods as the natural sources of antioxidants [35]. In the current study, the DDS was positively correlated with the consumption of antioxidant nutrients, and increased DDS was associated with higher intake of food groups rich in antioxidants, such as vitamin A-rich fruits and vegetables, legumes, nuts, and seeds. Therefore, since several studies have indicated a positive correlation between a higher DDS and nutrient adequacy [15], increased DDS could be associated with increased consumption of nutrients and antioxidants, which in turn could have an important role in reducing the risk of depression. Furthermore, we previously showed that with an increase in the DDS increased the mean level of blood antioxidant markers, including total antioxidant capacity, superoxide dismutase, and glutathione peroxidase [44].

In the present study, women with mild, moderate, or severe depression had a lower DDS compared to healthy individuals; however, no significant relationship was observed between stress and DDS. Some studies have shown a relationship between perceived stress and unhealthy food consumption [45–47]. Sedaqat et al. examined the association of snacking (fresh fruits, fruit juice, nuts and seeds, sweet beverage, salty snacks, sweet snacks, and fast food) with stress and depression in obese and non-obese women. They found that non-obese

Table 4 Food groups consumption across the tertiles of dietary diversity score in women

Food groups	Dietary diversity score			Total <i>n</i> (%)	<i>df</i> ^a	<i>p</i> value ^b
	Tertile 1 (score: 1–4) <i>n</i> (%)	Tertile 2 (score: 5) <i>n</i> (%)	Tertile 3 (score: 6–7) <i>n</i> (%)			
Cereals and white roots	170 (47.2)	120 (33.3)	70 (19.4)	360 (100)	2	0.06
Milk and dairy products	103 (36.8)	111 (39.6)	66 (23.6)	280 (100)	2	< 0.001
Vitamin A-rich vegetables and fruits	4 (9.8)	17 (41.5)	20 (48.8)	41 (100)	2	< 0.001
Green leafy vegetables	20 (15.5)	50 (38.8)	59 (45.7)	129 (100)	2	< 0.001
Other vegetables and fruits	153 (45.8)	114 (34.1)	67 (20.1)	334 (100)	2	0.1
Meat, fish and seafood	118 (41.3)	105 (36.7)	63 (22)	286 (100)	2	< 0.001
Organ meat	5 (33.3)	4 (26.7)	6 (40)	15 (100)	2	0.1
Eggs	14 (20.3)	25 (36.2)	30 (43.5)	69 (100)	2	< 0.001
Nut, seeds and legumes	43 (28.3)	54 (35.5)	55 (36.2)	152 (100)	2	< 0.001

The numbers represent subjects with consumption of at least 0.5 serving of each food group

^a Between groups *df*

^b *p* value is for *X*² test, *p* < 0.05 is statistically significant

Table 5 Odds ratios (OR) with 95% CI for the association between depression and dietary diversity score

Dietary diversity score	Depression status OR (95% CI)			df ^a
	Normal (n = 247)	Mild/moderate (n = 81)	Severe (n = 32)	
Model 1	Reference	0.83 (0.65–1.06)*	0.62 (0.43–0.90) [‡]	1
Model 2	Reference	0.90 (0.68–1.19)*	0.60 (0.41–0.89) [‡]	1
Model 3	Reference	0.82 (0.60–1.11)*	0.61 (0.40–0.91) [‡]	1

Model 1: crude model

Model 2: adjusted for age, education, marital status, household income, physical activity, and energy

Model 3: further adjusted for body mass index (BMI) and dietary supplement intake based on model 2

* $p > 0.05$

[‡] $p < 0.05$

^a Between groups *df*

Table 6 Odds ratios (OR) with 95% CI for the association between stress and dietary diversity score

Dietary diversity score	Stress status OR (95% CI)			df ^a
	Severe (n = 23)	Mild/moderate (n = 70)	Normal (n = 267)	
Model 1	Reference	0.80 (0.68–1.18)*	0.72 (0.48–1.01)*	1
Model 2	Reference	0.90 (0.68–1.18)*	0.72 (0.48–1.01)*	1
Model 3	Reference	0.89 (0.67–1.18)*	0.76 (0.40–1.16)*	1

Model 1: crude model

Model 2: adjusted for age, education, household income and physical activity

Model 3: further adjusted for body mass index, dietary supplement, and energy intake based on model 2

* $p > 0.05$

^a Between groups *df*

subjects in higher tertiles of natural fruit juice had higher ORs for stress, which might reflect higher energy intake with stress [45]. In another study, stress was associated with a lower intake of fruits, vegetables, protein, and higher consumption of salty snacks [46]. Oliver et al. reported a higher consumption of snack-type foods and lower intake of healthy foods such as fruits, vegetables, meat, and fish in stressful periods among university students [47]. Since the causal direction between nutrition and stress is not clear in most of the studies, further investigations are needed to determine the contribution of nutrition, particularly dietary diversity, to the incidence and development of stress.

This study has several limitations. First, the 24-h dietary recall is the main limitation for our study which has several limitations including difficulty in recalling consumed foods, their exact serving size, and under or over reporting [48]. In addition, using one 24-h recall period does not indicate an individual's habitual diet. Second,

no cause-and-effect relationship between DDS and stress and depression could be inferred in this cross-sectional study. There is even the possibility that food inadequacy or low dietary diversity could be the consequence of depression, and not its cause. Some studies have shown that depressed individuals seek to self-medicate with high-fat and high-sugar foods [49, 50]. Third, the sample size of this study is small which affects generalization of the results to the general population, since our subjects were 20- to 45-year-old women attending health centers. Despite these limitations, this is the first study to examine the relationship between DDS and stress and depression. The inclusion and exclusion criteria were well defined, and numerous potential confounding factors were controlled. In conclusion, we observed a significant inverse relationship between dietary diversity and severe, but not mild or moderate, depression in women. These results highlight the importance of a diet characterized by a greater variety and suggest important public health implications for depression prevention. Encouraging the consumption of various foods is important in nutritional interventions aimed at preventing depression. Future research exploring the effect of improved dietary diversity on mental health is warranted.

Authors' contributions

GS, FS, and MQ conceived and developed the idea for the paper and revised the manuscript. MP and RSK contributed to data collection. MP, NP, and AM wrote numerous drafts and revised the manuscript; MQ and JK contributed to data analysis and interpretation of the data. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol and the consent form was approved by the Ethics Committee of Tehran University of Medical Sciences.

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