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Adherence to the Healthy Eating Index-2015 and Its Association with Depression Score in A Sample of Iranian Adolescent Girls

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ABSTRACT

Background: Depression in adolescents is one of the major public health concerns that can affect educational attainment and social relationships and impose a high economic burden on society. Previous studies have provided limited information on the relationship between a healthy diet and depression in adolescents. The present study aimed to investigate the association of Healthy Eating Index-2015 (HEI-2015) with depression scores among adolescent girls. **Methods:** This cross-sectional study was conducted on 734 adolescent girls aged 12-18 years. Data on dietary intakes were collected using a valid and reliable food frequency questionnaire (FFQ), and diet quality was assessed based on HEI-2015. The Iranian validated version of Beck Depression Inventory (BDI) was used to evaluate depression. To explore the association between HEI-2015 and depression, logistic regression was used in crude and adjusted models. **Results:** The prevalence of a high depression score in the study population was 33.8%. After controlling for potential confounders, girls with the highest adherence to HEI-2015 compared to those with the lowest adherence had a 37% lower prevalence of depression (OR: 0.63; 95% CI 0.40 to 1.00, P_{trend}=0.03). This finding remained significant after adjustment for confounding variables (age, energy intakes, physical activity, and BMI percentile). **Conclusions:** Greater adherence to HEI-2015 was associated with lower odds of depression in female adolescents. Prospective studies are necessary to confirm these results and clarify whether a causal relationship exists.

Keywords: *Depression; Healthy eating index; HEI-2015; Diet quality; Adolescent*

Introduction

Depression in adolescents is an important public health concern that can impair educational achievement and interpersonal relationships, and also can increase the risk of drug abuse and suicide attempts (Gladstone and Beardslee, 2009). It is known that various physical

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and mental disorders including cardiovascular diseases, metabolic syndrome, type 2 diabetes, anxiety, and alcoholism are more prevalent among depressed people (Lasserre *et al.*, 2017). According to the World Health Organization, depression and anxiety disorders cost the global economy one trillion dollars a year through reduced productivity (World Health Organization, 2019). In addition, it has been shown that current treatments resolve only one-third of the disease burden of depressive disorders (van Zoonen *et al.*, 2014). Therefore, new approaches are required to prevent depression or delay its progression (Wu *et al.*, 2018).

Previous studies have indicated the role of diet as a modifiable risk factor in the development of depression (Khayyatzadeh *et al.*, 2021, Opie *et al.*, 2017). It has been shown that some nutrients such as n-3 long-chain polyunsaturated fatty acids, vitamins B, zinc, iodine, magnesium, and selenium are involved in brain function and could prevent or delay the onset of depression. However, some other nutrients including saturated fatty acid have been associated with increased risk of depression (Li *et al.*, 2020, Turan and Karaaslan, 2020, Van Dael, 2021, Wang *et al.*, 2018, Wu *et al.*, 2021). Dietary nutrient or food assessments are considered to be an inappropriate way to analyze the relationship between diet and health outcomes. The diet comprises food and nutrients that are not consumed as food or nutrients, but rather a pattern of food intake (Cespedes and Hu, 2015). Therefore, dietary pattern analyses have been developed as a comprehensive approach examining the effect of the whole diet rather than specific nutrients or food (Cespedes and Hu, 2015). The Healthy Eating Index 2015 (HEI-2015) assesses priori dietary patterns which reflect the 2015-2020 Dietary Guideline American (DGA) recommendations (Krebs-Smith *et al.*, 2018). Although previous studies have demonstrated an inverse association between adherence to the healthy dietary pattern, measured by HEI, and depression in adults (Kuczmarski *et al.*, 2010, Saneei *et al.*, 2016, Wang *et al.*, 2021), there are limited data for adolescents. Given the high prevalence of depression among Iranian adolescent girls (Moeini *et al.*, 2019, Sajjadi *et al.*, 2013), and its high socio-economic and health impact, the current study was designed to investigate the association between HEI-2015 and depression among Iranian adolescent girls.

Materials and Methods

Population and sampling: This cross-sectional study carried out on 734 adolescent girls aged 12-18 years in 2015. Participants were recruited from schools in the cities of Mashhad and Sabzevar, in northeastern Iran. Students who had no history of chronic disease (e.g. colitis, diabetes, cardiovascular diseases, cancer, and hepatitis) were included in the study. Moreover, participants were excluded if they were taking any medication related to anti-inflammatory, anti-depressant, anti-diabetic, or anti-obesity drugs, vitamin D or calcium supplement use, and hormone therapy during the past 6 months. Informed consent was obtained from the students and their parents. The study was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran (Ethic code: 931188).

Dietary assessment and HEI-2015 score computation: Dietary intakes of participants were collected using a valid and reliable food frequency questionnaire (FFQ), containing 168 food items (Esfahani *et al.*, 2010). The US Department of Agriculture's (USDA) data bank was used for analyzing nutrient intakes of each item (Pehrsson *et al.*, 2000). Overall diet quality was assessed using HEI-2015. The HEI-2015 is designed with a score range of 0 to 100 and includes thirteen dietary components including total fruits, whole fruits, total vegetables, greens and beans, whole grains, dairy, total protein foods, seafood and plant proteins, fatty acids, refined grains, sodium, added sugars, and saturated fats. The first nine items are adequacy components and the last four items are moderation components.

Assessment of outcomes: Depression was assessed using the Persian version of the Beck Depression Inventory (BDI). BDI is a 21-items self-administered questionnaire that each item has

different options and its total score ranged from 0 to 63 points. If the score was >13, the person was classified as depressed, and if the score was <13, the person was considered as not depressed. Previous studies have confirmed the validity and reliability of this questionnaire (Cronbach's α=0.87 and acceptable test-retest reliability (r)=0.74) (Bonnet *et al.*, 2005, Ghassemzadeh *et al.*, 2005, Norrby, 2002).

Covariate assessment: Demographic data (including age, family members, parental death or divorce, medical history, using supplements, smoking status, menstrual status, a positive history of mental therapy, and chronic diseases) were collected by experienced interviewers. Also, weight, height, waist circumferences (WC), and blood pressure measures were gathered according to standard protocol. All measurements were performed twice and their mean scores were reported. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Physical activity level was obtained using the validated modifiable activity questionnaire (MAQ), based on metabolic equivalent task (MET) minutes per week (Delshad *et al.*, 2015).

Ethical considerations: This study was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran (Ethic code: 931188). All methods of the current study were performed in accordance with the Declaration of Helsinki, and all students and their parents completed the informed written consent.

Data analyses: The participants were categorized based on the HEI-2015 quartiles score. To compare general characteristics and dietary intakes across quartiles of HEI-2015, one-way ANOVA and Ch-square tests were used. Age and energy-adjusted intakes of nutrients and food groups within quartiles of HEI-2015 were calculated using one-way ANOVA. To find the association between HEI-2015 and odds of depression, logistic regression was examined in different models. First, the reserchers controlled for age and energy intake. The additional adjustment was carried out for physical activity and BMI in the second and third models. To calculate the trend of OR, HEI-2015 quartiles were considered as an ordinal variable and the first quartile was designated as the reference category. In accordance with quartile categories of HEI-2015, for continuous and dichotomous variables, P_{trend} was determined by regression coefficient and logistic regression, respectively. Significance was set at two-tailed P-value<0.05 for all analyses. Statistical analyses were conducted using the statistical package for social sciences (SPSS), version 23.

Results

The mean age of the subjects was 14.51±1.53 years. The prevalence of depression with a high BDI score in the study population was 33.8%. The main characteristics of the participants according to quartile categories of HEI-2015 are provided in **Table 1**. Adolescents in the highest quartile of HEI-2015 were more likely to be younger and less depressed, compared to those in the lowest quartile. There were no significant differences in family members, parental death and divorce, being passive smoker, physical activity, and BMI percentile across categories of HEI-2015.

Adjusted intakes of several nutrients and food groups across HEI-2015 quartiles are presented in Table 2. The energy intake from saturated fatty acid and added sugars, and also intake of sodium and refined grains declined significantly across HEI-2015 quartiles. A greater adherence to the HEI-2015 was associated with higher consumption of cholesterol, n-3 fatty acids, vitamin B6, total fruits, whole fruits, total vegetables, greens and beans, whole grains, total protein foods, and seafood and plant proteins.

When depression was considered as a dichotomous variable, adolescents with the highest adherence to HEI-2015 had significantly 37% lower odds of depression compared to those with the lowest adherence (OR: 0.63; 95% CI 0·41, 0·99, P_{trend} = 0.03) (**Table 3**). After adjusting the effect of age and energy received in the first model, as well as further adjustments for physical activity and BMI in the second and third models,

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the observed relationship did not change considerably (OR: 0.62, 95 % CI 0.40-0.98, P_{trend} = 0.02, OR: 0.62, 95% CI 0.40-0.98, P_{trend} = 0.02 and OR: 0.63, 95% CI 0.40-1.00, P_{trend}=0.03, respectively).

Table 1. General characteristics of the participants according to quartile categories of the HEI-2015.

Variables		HEI-2015 quartile category				
		1 (n=183)	2 (n=184_	3 (n=184)	4 (183)	P-value[a]
HEI-2015 score (median)		62.12	70.86	76.90	83.36	<0.001
BMI percentile	<25	37 (20.2)[b]	29 (15.8)	31 (16.8)	22 (12.0)	
	25-50	41 (22.4)	38 (20.7)	50 (27.2)	47 (25.7)	0.02
	50-85	82 (44.8)	82 (44.6)	63 (34.2)	66 (36.1)	
	≥85	23 (12.6)	35 (19.0)	40 (21.7)	48 (26.2)	
Family members	2-4	79 (43.2)	87 (47.3)	82 (44.6)	93 (50.8)	0.54
	5-7	98 (53.6)	90 (48.9)	96 (52.2)	87 (47.5)	
	8-10	5 (2.7)	6 (3.3)	4 (2.2)	1 (0.5)	
	>11	1 (0.5)	1 (0.5)	2 (1.1)	2 (1.1)	
Parent death (yes)		8 (4.4)	10 (5.4)	7 (3.8)	4 (2.2)	0.52
Parent divorce (yes)		7 (3.8)	13 (7.1)	8 (4.3)	7 (3.8)	0.76
Passive smoker (yes)	None	153 (83.6)	149 (81.0)	148 (80.4)	144 (78.7)	0.65
	< 1h	13 (7.1)	22 (12.0)	22 (12.0)	27 (14.8)	
	1-3h	8 (4.4)	6 (3.3)	7 (3.8)	4 (2.2)	
	>3h	9 (4.9)	7 (3.8)	7 (3.8)	8 (4.4)	
Age (years)		14.88±1.50[c]	14.46±1.52	14.49±1.46	14.21±1.59	<0.001
Physical activity score (MET)		45.45±3.30	45.11±3.17	45.41±3.24	45.52±4.03	0.68
Depression score, mean		11.97±9.60	11.76±10.16	10.52±8.75	9.48±8.32	0.03

[a]: ANCOVA for quantitative variables and Chi-square for qualitative variables; [b]: N (%); [c]: Mean±SD; MET: Metabolic equivalents

Table 2. Mean (SE) dietary intake of participants across HEI-2015 quartile categories[a]

Variables	Mean± SD Overall	HEI-2015 quartile category								P-$_{trend}$[b]
		1		2		3		4		
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Total energy(kcal/d)[c]	2713±831	2459.3	61.0	2774.9	60.4	2831.3	60.3	2789.1	60.84	<0.001
Nutrients										
Carbohydrate (% of energy intake)	52.78±7.03	52.29	0.53	52.40	0.52	53.20	0.52	53.24	0.52	0.17
Protein (% of energy intake)	13.09±2.14	12.37	0.16	12.89	0.15	13.37	0.15	13.75	0.15	<0.001
Fat (% of energy intake)	33.22±7.56	33.81	0.56	33.70	0.55	32.74	0.55	32.65	0.56	0.12
Saturated fats (% of energy intake)	9.92±2.97	10.86	0.22	10.11	0.21	9.60	0.21	9.12	0.22	<0.001
Added sugars (% of energy intake)	5.06±3.17	5.41	0.24	5.25	0.23	4.90	0.23	4.69	0.23	0.003
n-3 Fatty acids (g/d)	1.53±0.90	1.39	0.06	1.50	0.05	1.50	0.05	1.74	0.05	<0.001
Cholesterol (mg)	237.9±137.5	232.71	9.41	239.93	9.22	237.60	9.23	241.48	9.29	0.02
Sodium (mg)	4185±1761	4651.42	98.06	4247.54	96.03	4235.90	96.19	3605.70	96.77	<0.001
Vitamin B6 (mg/d)	1.92±0.65	1.79	0.03	1.90	0.03	1.98	0.03	1.99	0.03	<0.001
Food groups										
Total Fruits (cup/d)	1.67±1.44	1.20	0.10	1.46	0.09	1.73	0.09	2.31	0.10	<0.001
Whole Fruits (cup/d)	1.58±1.32	1.12	0.09	1.40	0.09	1.63	0.09	2.16	0.09	<0.001
Total Vegetables (cup/d)	2.84±1.67	2.55	0.11	2.70	0.11	3.04	0.11	3.09	0.11	<0.001
Greens and Beans (cup/d)	0.82±0.56	0.70	0.04	0.73	0.04	0.89	0.04	0.98	0.04	<0.001
Whole grains (oz/d)	7.56±6.08	6.08	0.45	7.12	0.44	8.62	0.44	8.41	0.44	<0.001
Refine grains (oz/d)	5.18±3.37	7.29	0.22	5.54	0.22	4.22	0.22	3.67	0.22	<0.001

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Table 2. Mean (SE) dietary intake of participants across HEI-2015 quartile categories[a]

Variables	Mean± SD Overall	HEI-2015 quartile category								P-trend[b]
		1		2		3		4		
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Dairy products (cup/d)	1.95±1.27	2.01	0.09	1.84	0.09	2.03	0.09	1.93	0.09	0.86
Total protein foods (ozeq/d)	5.15±3.04	4.16	0.19	5.18	0.19	5.26	0.19	6.01	0.19	<0.001
Seafood and plant proteins (oz/d)	3.13±2.51	2.38	0.17	3.03	0.16	3.27	0.16	3.83	0.16	<0.001

[a]: Energy intake is adjusted for age, and all other values are adjusted for age and energy intake; [b]: P-value for trend was determined using linear regression; [c:] Obtained from ANCOVA.

Table 3. Odds ratio (95% CI) for depression score across quartile categories of HEI-2015.

	Quartiles of HEI-2015 score				P-trend[b]
	1	2	3	4	
Depression[a]					
Crude	1	1.09 (0.71-1.66)	0.86 (0.56-1.32)	0.63 (0.41-0.99)	0.03
Model I	1	1.07 (0.70-1.65)	0.85 (0.55-1.31)	0.62 (0.40-0.98)	0.02
Model II	1	1.08 (0.70-1.65)	0.85 (0.55-1.31)	0.62 (0.40-0.98)	0.02
Model III	1	1.09 (0.71-1.67)	0.85 (0.55-1.32)	0.63 (0.40-1.00)	0.03

[a:] Model I: Adjustment for age and energy intakes, Model II: Further adjustment for physical activity, Model III: Additional adjustments for BMI percentile; [b] : P-value for trend determined using logistic regression.

Discussion

Depression in adolescents has been independently related to a reduced quality of life and educational achievements, affected social behaviors, and increased risk of some health problems such as diabetes and obesity (Gladstone and Beardslee, 2009, Lasserre *et al.*, 2017). Therefore, depression can impose a considerable burden on the healthcare system (World Health Organization, 2019). Improvement in the diet may play a role in the prevention of this disorder (Pano *et al.*, 2021). The present study demonstrated an inverse association between adherence to HEI-2015 and the odds of developing depression in Iranian adolescents. After adjustment for potential confounders including age, energy intakes, physical activity, and BMI, the observed association remained significant.

Some studies have examined the association between dietary indices and depression in adults . Wang et al. reported that people with 70 or higher HEI-2015 score had 55% lower odds for developing depression (Wang *et al.*, 2021). Another study suggested that long-term adherence to HEI-2010 protects against recurrent depressive symptoms (Recchia *et al.*, 2020). Sanei et al. found a 45% reduction in depression odds by adherence to the AHEI-2010 in Iranian adults (Saneei *et al.*, 2016). In army soldiers, the highest concordance with AHEI-2010 was associated with an 80% lower risk of depression (Rahmani *et al.*, 2018). It has been also shown that adherence to the Mediterranean diet was associated with a 45% lower risk of moderate to severe depressive symptoms (Oddo *et al.*, 2022). However, some studies reported no association between diet quality (based on AHEI and HEI-2005) and symptoms of depression (Exebio *et al.*, 2011, Whitaker *et al.*, 2014). In adolescents, greater adherence to a Dietary Approach to Stop Hypertension (DASH) diet was related to lower odds of depression (by 53%) (Khayyatzadeh *et al.*, 2018), while the Mediterranean diet was not associated with depressive symptoms (Winpenny *et al.*, 2018).

In adults, a lower risk of depression was

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associated with a diet rich in fruits, vegetables, fish, whole grains, and olive oil, moderate in red and processed meat, low percent of calories from saturated fats and sugars, and low intake of sodium (Appelhans *et al.*, 2012, Kuczmarski *et al.*, 2010, Tarelho *et al.*, 2016, Vermeulen *et al.*, 2016). On the other hand, it has been shown that depressed people eat more fast foods, are more involved in emotional eating, and prefer sweet food (Paans *et al.*, 2019). It has not yet been determined whether depressive symptoms lead to more sugar and saturated fat intake or conversely, sugar and saturated fat intake leads to more depressive symptoms, or whether this is a two-way association. In addition, the preparation of unhealthy food is usually quicker and easier than healthy ones and requires less time and skill to cook (Gibson-Smith *et al.*, 2018). The mood and motivation of depressed people are usually low and they prefer food types that are easier and faster to prepare, like fast foods (Gibson-Smith *et al.*, 2018).

There are several mechanisms to explain the inverse relationship between HEI-2015 and depression. It has been suggested that factors such as oxidative stress, insulin resistance, inflammation, and changes in vascularization could lead to brain damage (Sarris *et al.*, 2015). All of these factors, modified by dietary intake, have been related to depression (Sarris *et al.*, 2015). Adherence to HEI-2015 results in high levels of antioxidants such as folate and vitamin E that could protect the nervous system from degenerative effects of inflammation and oxidative stress (Jiménez-Fernández *et al.*, 2015). Moreover, this index paid attention to the intake of seafood and unsaturated fatty acids such as omega-3 (Krebs-Smith *et al.*, 2018). Omega-3 fatty acids are one of the major components of synaptic nerve membranes and have a considerable role in neurotransmitter function, especially serotonin and dopamine (McNamara, 2016). The association between omega-3 fatty acids and depression symptoms may be explained by its neuroprotective effect.

The current study has some strengths. To the best of the auhors' knowledge, it is the first study, which has investigated the relationship between adherence to specific diet-related practices and the prevalence of depression in Iranian adolescents. The second strength point was the high quality of data collection. In addition, to avoid misleading conclusions in the analysis and interpretation of data, rigorous statistical analyses were conducted, including several adjustment models for confounding factors for depression. However, some limitations should be noted when interpreting the findings. The cross-sectional design of this study does not allow us to determine the direction of the relationship between depression and diet quality and causative effects. Prospective cohort studies should be conducted to investigate the causal relationship. The validated FFQ assessed usual dietary intakes (Esfahani *et al.*, 2010). However, it should be borne in mind that measuring food intake based on this questionnaire is memory dependent and this can lead to recall bias. In addition, depression was assessed by a self-administered questionnaire, BDI, and there was no specialized diagnosis of depression, which might lead to incorrect classification of study participants.

Conclusion

This study suggests that a greater adherence to HEI-2015 was associated with lower odds of depression in adolescents. These findings need to be confirmed with prospective studies and trials to clarify the causal association and determine the dose-response curve between diet quality and risk of depression. However, because of the complications and costs associated with treating depression in adolescents, its prevention is important.

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Conflict of interests

The authors declare that they have no conflict of interest.

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Authors' contributions

The paper was drafted by Mohseni-Takalloo S and Salehi-Abargouei A with contributions from all authors. SS. Khayyatzadeh, Ferns GA, and Ghayour-Mobarhan M designed the study. Ferns GA, and Khayyatzadeh SS participated in field implementation and sampling. Ferns GA, Ghayour-Mobarhan M, and Khayyatzadeh SS were involved in clinical examination and patient confirmation. Mohseni-Takalloo S and Salehi-Abargouei A contributed to statistical analyses. Khayyatzadeh SS, and Ghayour-Mobarhan M supervised the study. All authors contributed to developing,reading, and approving the final version of the manuscript.

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