Journal of Affective Disorders 256 (2019) 96–102

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research paper

Adherence to the MIND diet and prevalence of psychological disorders in adults

Asma Salari-Moghaddam[a,b], Ammar Hassanzadeh Keshteli[c,d], Seyed Mohammad Mousavi[b], Hamid Afshar[e], Ahmad Esmaillzadeh[f,b,g,*], Peyman Adibi[d]

[a] Students' Scientific Research Center, Tehran University of Medical Sciences, Tehran, Iran
[b] Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran
[c] Department of Medicine, University of Alberta, Edmonton, Alberta, Canada
[d] Integrative Functional Gastroenterology Research Center, Isfahan University of Medical Sciences, Isfahan, Iran
[e] Department of Psychiatry, Psychosomatic Research Center, Isfahan University of Medical Sciences, Isfahan, Iran
[f] Obesity and Eating Habits Research Center, Endocrinology and Metabolism Molecular-Cellular Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[g] Department of Community Nutrition, School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran

ARTICLE INFO

Keywords:
MIND diet
Depression
Anxiety
Psychological distress

ABSTRACT

Background: There is no study that examined the association of the MIND diet and odds of psychological disorders. We investigated the association between adherence to the MIND diet and odds of psychological disorders.
Methods: A total of 3176 adults were included in this cross-sectional study. Dietary intakes of study participants were collected using a validated dish-based 106-item semi-quantitative food frequency questionnaire (DS-FFQ). The MIND diet score was calculated based on participants' dietary intakes obtained from DS-FFQ. To assess depression and anxiety, the Iranian validated version of Hospital Anxiety and Depression Scale (HADS) was used. Psychological distress was examined using General Health Questionnaire (GHQ).
Results: After taking potential confounders into account, participants in the highest quartile of the MIND diet score had a lower odds of depression (OR: 0.68; 95% CI: 0.53–0.89) and psychological distress (OR: 0.68; 95% CI: 0.52–0.89) than those in the lowest quartile. No significant association was observed between consumption of MIND diet and odds of anxiety (OR: 0.72; 95% CI: 0.51–1.03). When we did gender-stratified analyses, no significant association was seen between adherence to the MIND diet and odds of psychological disorders in men; however, women in the top quartile of the MIND diet score had lower odds of depression (OR: 0.60; 95% CI: 0.45–0.81) and psychological distress (OR: 0.66; 95% CI: 0.48–0.90) than those in the bottom quartile.
Conclusion: We found that greater adherence to the MIND diet was inversely associated with odds of depression and psychological distress. No significant association was observed between consumption of MIND diet and odds of anxiety.

1. Introduction

High prevalence of common mental disorders has been reported in Iran (Noorbala et al., 2004) and worldwide (Whiteford et al., 2013). Several factors, including dietary intakes, have long been reported to be associated with psychological health. High intakes of fruit, vegetables, tomato and low fat dairy products and low intakes of snacks, high fat dairy products, chocolate, carbonated drinks, sweets and deserts were associated with a lower risk of psychological disorders (Hosseinzadeh et al., 2016). Combining these earlier findings, it seems that adherence to healthy dietary patterns might be protective against psychological disorders.

Consumption of Mediterranean diet was inversely associated with depressive symptoms (Rienks et al., 2013). In addition, adherence to

Abbreviations: MIND, Mediterranean-DASH Intervention for Neurodegenerative Delay; OR, Odds Ratio; CI, Confidence Interval; DS-FFQ, Dish-based Semi-quantitative Food Frequency Questionnaire; HADS, Hospital Anxiety and Depression Scale; GHQ, General Health Questionnaire; SEPAHAN, Study on the Epidemiology of Psychological, Alimentary Health and Nutrition; FGIDs, Functional Gastrointestinal Disorders; GPPAQ, General Practice Physical Activity Questionnaire; BMI, Body Mass Index; WC, Waist Circumference

* Corresponding author at: Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran P.O. Box 14155-6117, Iran.
E-mail address: a-esmaillzadeh@tums.ac.ir (A. Esmaillzadeh).

https://doi.org/10.1016/j.jad.2019.05.056
Received 5 November 2018; Received in revised form 9 April 2019; Accepted 27 May 2019
Available online 28 May 2019
0165-0327/

DASH eating pattern was also inversely associated with psychological disorders (Sanchez-Villegas et al., 2015). In our previous study, we found that individuals with moderate adherence to DASH-style diet had significantly lower odds for depression, but not for anxiety and psychological distress (Valipour et al., 2017). Combination of Mediterranean and DASH diet has recently been proposed as MIND diet (Mediterranean-DASH diet Intervention for Neurodegenerative Delay). This dietary pattern emphasizes on dietary factors associated with psychological health (Morris et al., 2015a). It has been shown that consumption of MIND diet has been associated with reduced risk of Alzheimer disease (Morris et al., 2015b). In addition, MIND diet has been inversely associated with cognitive decline; such that those with greater adherence to the MIND diet had lower odds of cognitive decline, even compared with the Mediterranean and DASH dietary patterns (Morris et al., 2015a). Given its components, it seems that MIND diet is an appropriate choice for prevention of psychological disorders. However, in the only prospective study available, adherence to the MIND diet was not associated with depression (Fresan et al., 2018). However, they did not assess anxiety and psychological distress. This study; therefore, conducted to examine the association between adherence to the MIND diet and psychological disorders.

2. Methods and materials

2.1. Subjects

This cross-sectional study was carried out within the framework of the Study on the Epidemiology of Psychological, Alimentary Health and Nutrition (SEPAHAN) project, a cross-sectional study that investigates the prevalence of functional gastrointestinal disorders (FGIDs) and their relationship with lifestyle factors and psychological disorders. Details about SEPAHAN project have been published elsewhere (Adibi et al., 2012). This study was performed among Iranian general adults working in 50 different healthcare centers affiliated to Isfahan University of Medical Sciences (IUMS) across Isfahan province. In this project, data were collected in two main phases between April 2010 and May 2010. To collect information about anthropometric indices, demographic and lifestyle factors, including dietary intakes and physical activity, self-administered questionnaires distributed among 10,087 subjects aged 18–55 years in the first phase, and 8691 participants returned the completed questionnaires (response rate: 86.16%). In the second phase, data regarding psychological factors were collected. Finally, we were able to match 4763 questionnaires in the second phase with their equivalent questionnaires in the first phase. In the current study, we excluded subjects who had total daily energy intakes outside the range of 800–4200 kcal/d ($n = 878$) as well as those that had missing data on any relevant variable ($n = 130$). We also excluded individuals with anti-depressant use ($n = 187$) from the current analysis. Therefore, data from 3176 subjects, for whom complete information about both dietary intakes and psychological profile were available, were included in the current analysis. All participants provided written informed consent forms. The study protocol was ethically approved by the Regional Bioethics Committee of Isfahan University of Medical Sciences.

2.2. Assessment of dietary intakes

Dietary data were collected using a Willett-format dish-based 106-item semi-quantitative food frequency questionnaire (DS-FFQ) which was designed and validated specifically for Iranian adults. Detailed information about the design, foods included, and the validity of this questionnaire has been published elsewhere (Keshteli et al., 2014). Briefly, the questionnaire contained five categories of foods and dishes: 1) mixed dishes (cooked or canned, 29 items); 2) grains (different types of bread, cakes, biscuits and potato, 10 items); 3) dairy products (dairies, butter, and cream, 9 items); 4) fruits and vegetables (22 items); and 5) miscellaneous food items and beverages (including sweets, fast foods, nuts, desserts and beverages, 36 items). For each food item, a commonly consumed portion size was defined. Participants were asked to report their dietary intakes of foods and mixed dishes based on nine multiple choice frequency response categories varying from “never or less than once a month” to “12 or more times per day”. The frequency response categories for the food list varied from six to nine choices. For foods consumed infrequently, we omitted the high-frequency categories, while for common foods with a high consumption, the number of multiple choice categories increased. For instance, the frequency response for tuna consumption included six categories, as follows: never or less than once/month, 1–3 times/month, 1 time per week, 2–4 times/week, 5–6 times/week, 1–2 times/day; and for tea consumption that is highly prevalent among Iranians, the frequency response included nine categories, as follows: never or less than 1 cup/month, 1–3 cups/month, 1–3 cups/week, 4–6 cups/week, 1 cup/day, 2–4 cups/day, 5–7 cups/day, 8–11 cups/day, ≥12 cups/day). Finally, to convert the food items into grams, we computed the amount of each portion size based on the booklet of “household measures” (Ghaffarpour and Kianfar, 1999) and then computed the amount of intake by considering the frequency of consumption of each food item. The validity of the DS-FFQ was examined in a subgroup of 200 randomly selected participants of SEPAHAN project. All participants in the validation study completed the DS-FFQ at study baseline and 6 months later. During this validation study, participants provided three detailed dietary records that were used as gold standard. As shown in earlier studies (Keshteli et al., 2014; Haghighatdoost et al., 2016), it seems that this questionnaire provides reasonably valid measures of long-term dietary intakes. For instance, correlation coefficients for dietary carbohydrate intake derived from the DS-FFQ, compared with the average of 3-d dietary records was 0.81, which indicates that the DS-FFQ provides a reasonable measure of total carbohydrate intake over a long period.

2.3. Development of the MIND diet score

The DS-FFQ derived data was used for the MIND diet score calculation. The MIND diet components used in this study are presented in Table 1. In the original scoring of MIND diet, 15 dietary parameters were considered, of them 10 were so-called as brain healthy food groups (green leafy vegetables, other vegetables, nuts, berries, beans, whole grains, fish, poultry, olive oil, and wine) and 5 as brain unhealthy food groups (red meats, butter and stick margarine, cheese, pastries and sweets, and fried/fast food) (Morris et al., 2015a). In the current study, olive oil and wine consumption were not considered in the score calculation, because of the lack of information in the original data set. The other 13 food groups were used in the MIND construction. To do this, participants were first classified based on tertile categories of intakes of these 13 components. Individuals in the lowest tertile of green leafy vegetables, other vegetables, nuts, berries, beans, whole grains, fish, and poultry intake were given the score of 0, those in the middle tertile were given the score of 0.5 and those in the highest tertile were given the score of 1. With regards to red meats, butter and stick margarine, cheese, pastries and sweets, and fried/fast food intake, we did vice versa; that is individuals in the lowest tertile were given the score of 1 and those in the highest tertile were given a score of 0. Individuals in the middle tertile of these components were assigned the score of 0.5. Then, the overall MIND diet score was calculated by summing up of all dietary components scores. Therefore, each participant has a score between 0 and 13.

2.4. Assessment of psychological profile

The Iranian validated version of Hospital Anxiety and Depression Scale (HADS) was used to screen for anxiety and depression (Montazeri et al., 2003b). HADS is a brief and useful questionnaire to assess psychological disorders and symptom severity of depression and anxiety disorders. The HADS contains 14 items and include two

Table 1
Components of MIND diet.

Brain healthy foods	
Green leafy vegetables	Cabbage, greens, lettuce
Other vegetables	Green/red peppers, raw carrot, potato, peas or lima beans, tomatoes, tomato sauce, eggplant, onion, cucumber
Berries	Strawberries (strawberry, cherries, fresh berries)
Nuts	Walnuts, pistachios, hazelnuts, almonds, peanuts
Whole grains	Dark bread (Iranian)
Fish	Fish
Beans	Beans, lentils, peas, chickpea, mung bean
Poultry	Chicken
Brain unhealthy foods	
Butter, margarine	Butter, margarine, animal fats
Cheese	Cheese
Red meat and products	Red meat, hamburger, sausages
Fast fried foods	French fries, pizza
Pastries and sweets	Biscuit, cake, chocolate, ice cream, confections, cocoa, Gaz (an Iranian confectionery made of sugar, nuts and tamarisk), Gooshfil (an Iranian confectionery made of white flour and sugar)

subscales: anxiety and depression. Each item includes a four-point scale; higher scores indicate an elevated level of anxious and depressive symptomatology. Maximum score is 21 for anxiety and depression. Scores of 8 or more on either subscale were considered as psychological disorders and scores of 0–7 were defined as “normal” in the current study.

The convergent validation of translated version of HADS questionnaire was examined in 167 Iranian adults using the correlation of each item with its hypothesized scale. Pearson's correlation coefficients varied from 0.47 to 0.83 ($P < 0.001$) for anxiety subscale and from 0.48 to 0.86 ($P < 0.001$) for depression subscale, indicating that the questionnaire provides relatively valid measures of psychological health (Montazeri et al., 2003b).

The Iranian validated version of General Health Questionnaire (GHQ) with 12-items was used to assess psychological distress (Montazeri et al., 2003a). GHQ-12 is a brief, simple, easy to- complete instrument for measuring current and primary mental health that asks the respondents whether they have experienced a particular symptom of psychological distress or a change in their behavior recently. Each item consists of a four-point scale (less than usual, no more than usual, rather more than usual, or much more than usual). There are two most common scoring methods, bimodal (0-0-1-1) and Likert scoring (0-1-2-3), and it gives a total score of 12 or 36 on the basis of the scoring method selected. In this study, we used the bimodal scoring style. This gives scores ranging from 0 to 12. Higher scores indicate a greater degree of psychological distress. In the current study, the score of 4 or more was defined as psychological distress (Schmitz et al., 1999). The convergent validity of GHQ-12 was examined in 748 Iranian young people. Significant inverse correlation was seen between the GHQ-12 and global quality of life scores ($r = -0.56$, $P < 0.001$) (Montazeri et al., 2003a).

2.5. Assessment of other variables

Required information on other variables including age, sex, marital status, smoking status, chronic conditions (diabetes, asthma, colitis, stroke, myocardial infarction, heart failure, and cancers), and antidepressant and supplements’ (vitamins, minerals, calcium and iron) use was obtained from demographic and medical history questionnaires. Physical activity was assessed using the General Practice Physical Activity Questionnaire (GPPAQ) (Department of Health, 2009), and participants were classified into two categories: physically active (≥ 1 h/week) and physically inactive (< 1 h/week). Although this level of activity might seem low, earlier publications have revealed that even 1 h per week of walking can reduce the risk of chronic conditions (Oguma and Shinoda-Tagawa, 2004). Anthropometric measures including weight, height, and waist circumference were assessed using a self-administered questionnaire. The validity of self-reported values of weight, height, and waist circumferences (WC) was examined in a pilot study on 200 participants from the same population. In the validation study, self-reported values of anthropometric indices were compared with actually measured values. The correlation coefficients for self-reported weight, height, and WC versus corresponding measured values were 0.95 ($P < 0.001$), 0.83 ($P < 0.001$), and 0.60 ($P < 0.001$), respectively. Body mass index (BMI) was calculated by dividing weight (kg) to height (m^2). The correlation coefficient for computed BMI from self-reported values, and the one from measured values was 0.70 ($P < 0.001$) (Aminianfar et al., 2019).

2.6. Statistical methods

First we classified participants based on quartile cut-off points of the MIND diet score. General characteristics of study participants across quartiles of the MIND diet score were expressed as means ± SDs for continuous variables and percentages for categorical variables. To examine the differences across quartiles, we used ANOVA for continuous variables and a chi-square test for categorical variables. The multivariable-adjusted means for scores of depression, anxiety and psychological distress across quartiles of the MIND diet score were computed and compared using ANCOVA. We also used binary logistic regression to estimate ORs and 95% CIs for the presence of psychological disorders across quartiles of the MIND diet score in crude and multivariable-adjusted models. In these analyses, age (continuous), sex (male/female) and total energy intake (continuous) were controlled for in the first model. Further adjustments were made for marital status (married/single/divorced and widowed), education (diploma or under-diploma/university graduate), vitamin supplements use (yes/no), smoking (non-smoker/former smokers and current smokers), and physical activity (< 1 h/week/≥ 1 h/week) in the second model. Additional adjustments for BMI were done in the third model. All statistical analyses were done using the Statistical Package for Social Sciences (version 20; SPSS Inc.). $P < 0.05$ was considered as statistically significant.

3. Results

Overall, the prevalence of depression, anxiety and psychological distress among study participants was 26.4%, 11.9% and 20.9%, respectively. General characteristics of study participants across quartiles of the MIND diet score are provided in Table 2. Compared with those in the bottom quartile, participants in the top quartile of the MIND diet score were older, more likely to be females, physically active, and vitamin supplements user. No other significant differences were seen in terms of other variables across quartiles of the MIND diet score.

Crude and multivariable-adjusted means for scores of psychological

Table 2
General characteristics of study participants across quartiles of the MIND diet score[a].

Variables	Quartiles of the MIND diet score Q_1	Q_2	Q_3	Q_4	P-value[b]
Subjects, n	966	415	851	943	
Age, y	35.4 ± 7.6	35.9 ± 7.5	36.1 ± 8.01	37.02 ± 7.8	0.001
Energy, kcal/d	2289 ± 822	2309 ± 839	2398 ± 839	2514 ± 794	<0.001
BMI, kg/m^2	24.7 ± 3.8	24.9 ± 3.6	24.7 ± 3.8	25.04 ± 3.7	0.30
Female, %	52.3	53.5	59.5	62.6	<0.001
Married, %	80.8	84.1	82.8	79.8	0.24
Physically active (≥1 h/week), %	29.6	32.4	35.3	36.3	0.01
Overweight or obese, %	45.6	47.0	43.2	48.9	0.12
Current smokers, %	3.5	4.5	2.4	2.5	0.16
Education (university graduate), %	61.4	59.8	62.7	66.0	0.09
Vitamin supplements use, %	6.5	5.8	8.3	9.4	0.03

[a] Data are mean ± standard deviation (SD).
[b] Obtained from ANOVA or chi-square test, where appropriate.

Table 3
Mean scores of psychological disorders across quartiles of the MIND diet score[a].

	Quartiles of the MIND diet score Q_1	Q_2	Q_3	Q_4
Depression				
Crude	6.16 ± 0.10	6.32 ± 0.15	5.85 ± 0.11	5.63 ± 0.10
Model I[b]	6.21 ± 0.10	6.35 ± 0.16	5.81 ± 0.11	5.59 ± 0.11
Model II[c]	6.07 ± 0.11	6.31 ± 0.17	5.78 ± 0.12	5.50 ± 0.11
Model III[d]	6.10 ± 0.11	6.29 ± 0.18	5.76 ± 0.12	5.49 ± 0.12
Anxiety				
Crude	3.48 ± 0.11	3.61 ± 0.17	3.23 ± 0.12	3.09 ± 0.11
Model I[b]	3.54 ± 0.11	3.69 ± 0.18	3.18 ± 0.12	3.10 ± 0.12
Model II[c]	3.39 ± 0.12	3.67 ± 0.19	3.15 ± 0.13	3.04 ± 0.12
Model III[d]	3.44 ± 0.12	3.59 ± 0.19	3.15 ± 0.13	3.01 ± 0.13
Psychological distress				
Crude	2.13 ± 0.08	2.04 ± 0.13	1.92 ± 0.09	1.76 ± 0.08
Model I[b]	2.15 ± 0.09	2.13 ± 0.13	1.91 ± 0.09	1.78 ± 0.09
Model II[c]	2.14 ± 0.09	2.11 ± 0.14	1.94 ± 0.10	1.77 ± 0.09
Model III[d]	2.17 ± 0.10	2.08 ± 0.15	1.92 ± 0.10	1.75 ± 0.10

[a] Data are mean ± standard error (SE).
[b] Model I: adjusted for age, sex and energy intake.
[c] Model II: additionally, adjusted for marital status, education, vitamin supplements use, smoking status, and physical activity.
[d] Model III: additionally, adjusted for BMI.

disorders across quartiles of the MIND diet score are shown in Table 3. After controlling for potential confounders, individuals in the top quartile of the MIND diet score had lower scores of depression (5.49 ± 0.12 vs. 6.10 ± 0.11, $P < 0.001$), anxiety (3.01 ± 0.13 vs. 3.44 ± 0.12, $P = 0.03$), and psychological distress (1.75 ± 0.10 vs. 2.17 ± 0.10, $P = 0.03$) compared with those in the bottom quartile.

Crude and multivariable-adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for depression, anxiety and psychological distress across quartiles of the MIND diet score are presented in Table 4. In the fully adjusted model, participants in the highest quartile of the MIND diet score had a lower odds of depression (OR: 0.68; 95% CI: 0.53–0.89) and psychological distress (OR: 0.68; 95% CI: 0.52–0.89) than those in the bottom quartile. However, we found no significant association between the MIND diet score and odds of anxiety (OR: 0.72; 95% CI: 0.51–1.03).

Gender-stratified crude and multivariable-adjusted ORs and 95% CIs for psychological disorders across quartiles of the MIND diet score are presented in Table 5. Among men, we observed no significant association between the MIND diet score and depression (OR: 0.92; 95% CI: 0.58–1.47). We also observed no significant association between adherence to the MIND diet and odds of anxiety (OR: 0.57; 95% CI: 0.27–1.18). In addition, we failed to find any significant association between the MIND diet score and odds of psychological distress (OR: 0.75; 95% CI: 0.46–1.20). When potential confounders were taken into account, women with greater adherence to the MIND diet were 40% less likely to be depressed (OR: 0.60; 95% CI: 0.45–0.81) than those with the lowest adherence. We also found that women in the highest quartile of the MIND diet score were 34% less likely to have psychological distress than those in the lowest quartile (OR: 0.66; 95% CI: 0.48–0.90). No significant relationship was seen between adherence to the MIND diet and odds of anxiety among women (OR: 0.82; 95% CI: 0.56–1.20).

4. Discussion

In this cross-sectional study, we examined the association between adherence to the MIND diet and odds of psychological disorders. We found that adherence to the MIND diet was significantly associated with a lower chance of depression and psychological distress, but not with anxiety, in the whole population. However, such findings were not seen in men. To our knowledge, this is among first studies that examined the adherence to the MIND diet in relation to psychological disorders.

Recently, MIND diet has been developed as a combination of the Mediterranean and DASH diets to protect brain health (Morris et al., 2015a). We found that greater adherence to the MIND diet was inversely associated with odds of depression. In contrast to our findings, a prospective study reported no significant association between adherence to the MIND diet and risk of depression (Fresan et al., 2018). However, the components they used for construction of MIND diet were slightly different to ours. The MIND diet emphasizes on natural plant-based foods and limited intakes of animal and high saturated fat foods. Components of the MIND diet were linked with lower odds of depression in previous studies. For instance, an inverse association was seen between greater adherence to the dietary patterns rich in fruits, vegetables, olive oil and legumes and odds of depression (Khosravi et al., 2015). In a cross-sectional study, fruit and vegetables intake was protectively associated with depression (Saghafian et al., 2018). In addition, the relationship between Mediterranean and DASH diets and psychological disorders has separately been reported (Valipour et al., 2017; Lassale et al., 2018). Like the Mediterranean and DASH diets, MIND diet emphasizes on natural plant-based foods and limited intake of animal and high saturated fat foods. However, there are some differences between the MIND diet and these healthy dietary patterns. For instance, green leafy vegetables and berries are unique components of the MIND diet that are not considered in the Mediterranean and DASH diets. In addition, unlike the Mediterranean and DASH diets, the MIND diet does not focus on high intake of fruit, high dairy products and potato. The other difference between MIND and other healthy dietary patterns is about fish intake. In the MIND that, individuals with even 1 serving of fish consumption per week are receiving a positive score, while in Mediterranean diet, one would need to consume greater amounts of fish to gain the score. Overall, it seems that MIND diet have

Table 4
Crude and multivariable-adjusted ORs and 95% CIs for psychological disorders across quartiles of the MIND diet score[a].

	Quartiles of the MIND diet score			
	Q_1	Q_2	Q_3	Q_4
Depression				
Crude	1.00	1.26 (0.98–1.62)	0.97 (0.79–1.20)	0.76 (0.62–0.94)
Model I[b]	1.00	1.29 (0.98–1.69)	0.93 (0.74–1.16)	0.72 (0.57–0.91)
Model II[c]	1.00	1.35 (1.00–1.83)	0.99 (0.77–1.28)	0.72 (0.56–0.94)
Model III[d]	1.00	1.31 (0.96–1.78)	0.95 (0.73–1.24)	0.68 (0.53–0.89)
Anxiety				
Crude	1.00	1.15 (0.83–1.60)	0.78 (0.58–1.04)	0.73 (0.55–0.96)
Model I[b]	1.00	1.25 (0.88–1.78)	0.75 (0.55–1.02)	0.70 (0.51–0.95)
Model II[c]	1.00	1.42 (0.96–2.10)	0.78 (0.55–1.12)	0.77 (0.54–1.09)
Model III[d]	1.00	1.28 (0.86–1.92)	0.76 (0.53–1.09)	0.72 (0.51–1.03)
Psychological distress				
Crude	1.00	0.93 (0.70–1.22)	0.78 (0.62–0.98)	0.73 (0.58–0.91)
Model I[b]	1.00	0.98 (0.73–1.31)	0.74 (0.58–0.95)	0.68 (0.54–0.87)
Model II[c]	1.00	0.98 (0.71–1.36)	0.74 (0.56–0.97)	0.71 (0.54–0.92)
Model III[d]	1.00	0.92 (0.66–1.28)	0.70 (0.53–0.92)	0.68 (0.52–0.89)

[a] Data are OR (95% CI).
[b] Model I: adjusted for age, sex and energy intake.
[c] Model II: additionally, adjusted for marital status, education, vitamin supplements use, smoking status, and physical activity.
[d] Model III: additionally, adjusted for BMI.

some unique characteristics, over other healthy dietary patterns, that could be recommended to prevent psychological disorders.

Adherence to the MIND diet was inversely linked with psychological distress in this study; however, we failed to find such findings for anxiety. There is no study available that examined MIND diet in relation to psychological distress and anxiety. Protective effects of Mediterranean diet against anxiety and psychological distress have previously been reported (Olveira et al., 2014; Hodge et al., 2013). However, limited studies are available on the association of the DASH diet and psychological disorders. Previous cross-sectional study found no association between the DASH diet and odds of anxiety and psychological distress (Valipour et al., 2017). Such evidence for

Table 5
Gender-stratified crude and multivariable-adjusted ORs and 95% CIs for psychological disorders across quartiles of the MIND diet score[a].

	Quartiles of the MIND diet score			
	Q_1	Q_2	Q_3	Q_4
Men				
Depression				
Crude	1.00	1.42 (0.95–2.11)	0.96 (0.67–1.38)	0.85 (0.59–1.23)
Model I[b]	1.00	1.52 (0.96–2.41)	0.99 (0.65–1.49)	0.95 (0.63–1.44)
Model II[c]	1.00	1.44 (0.86–2.39)	1.11 (0.71–1.73)	0.98 (0.62–1.54)
Model III[d]	1.00	1.28 (0.75–2.18)	1.11 (0.71–1.75)	0.92 (0.58–1.47)
Anxiety				
Crude	1.00	1.24 (0.73–2.12)	0.42 (0.23–0.77)	0.50 (0.28–0.88)
Model I[b]	1.00	1.69 (0.92–3.09)	0.36 (0.16–0.77)	0.63 (0.33–1.20)
Model II[c]	1.00	1.53 (0.78–3.00)	0.35 (0.15–0.81)	0.63 (0.31–1.28)
Model III[d]	1.00	1.37 (0.68–2.78)	0.36 (0.16–0.83)	0.57 (0.27–1.18)
Psychological distress				
Crude	1.00	0.80 (0.51–1.27)	0.58 (0.39–0.87)	0.76 (0.52–1.11)
Model I[b]	1.00	0.87 (0.52–1.43)	0.50 (0.32–0.80)	0.74 (0.48–1.13)
Model II[c]	1.00	0.77 (0.44–1.34)	0.52 (0.32–0.85)	0.76 (0.48–1.20)
Model III[d]	1.00	0.69 (0.38–1.24)	0.48 (0.29–0.81)	0.75 (0.46–1.20)
Women				
Depression				
Crude	1.00	1.16 (0.83–1.61)	0.89 (0.69–1.16)	0.64 (0.49–0.83)
Model I[b]	1.00	1.17 (0.83–1.64)	0.89 (0.68–1.17)	0.65 (0.49–0.85)
Model II[c]	1.00	1.20 (0.84–1.74)	0.90 (0.67–1.20)	0.64 (0.48–0.86)
Model III[d]	1.00	1.20 (0.82–1.75)	0.84 (0.62–1.14)	0.60 (0.45–0.81)
Anxiety				
Crude	1.00	1.09 (0.72–1.66)	0.89 (0.63–1.24)	0.75 (0.53–1.05)
Model I[b]	1.00	1.10 (0.71–1.69)	0.89 (0.63–1.27)	0.74 (0.52–1.05)
Model II[c]	1.00	1.17 (0.74–1.86)	0.96 (0.66–1.40)	0.83 (0.57–1.21)
Model III[d]	1.00	1.09 (0.68–1.76)	0.94 (0.64–1.38)	0.82 (0.56–1.20)
Psychological distress				
Crude	1.00	0.99 (0.70–1.42)	0.83 (0.63–1.10)	0.65 (0.49–0.87)
Model I[b]	1.00	1.04 (0.72–1.50)	0.87 (0.65–1.16)	0.67 (0.50–0.90)
Model II[c]	1.00	1.13 (0.77–1.66)	0.89 (0.66–1.21)	0.69 (0.51–0.93)
Model III[d]	1.00	1.10 (0.74–1.62)	0.84 (0.62–1.15)	0.66 (0.48–0.90)

[a] Data are OR (95% CI).
[b] Model I: adjusted for age and energy intake.
[c] Model II: additionally, adjusted for marital status, education, vitamin supplements use, smoking status, and physical activity.
[d] Model III: additionally, adjusted for BMI.

Mediterranean diet is lacking. Due to lack of any study on the association of MIND diet and anxiety, our findings must be repeated in other populations to reach a definite conclusion.

We found a gender difference on the association between adherence to the MIND diet and odds of psychological disorders. Prevalence of psychological disorders is higher among women than that in men (Steel et al., 2014). In addition, hormonal differences between the two genders might also provide some explanations (Piccinelli and Wilkinson, 2000).

The underlying mechanisms through which the MIND diet might influence brain health are not fully understood. However, given the role of oxidative stress in psychological disorders (Salim, 2014), it seems that MIND diet might protect brain through its antioxidant and anti-inflammatory properties. Fruit and vegetables, main components of MIND diet, are rich sources of vitamins, minerals, flavonoids and antioxidants. In addition, MIND diet contain limited amounts of unhealthy foods including red meat and products, butter, fast foods and pastries and sweets which might be harmful for brain health.

This study has several strengths. Being among the first studies, having a large sample size and statistical controlling for potential confounders are among the strengths of the present study. Some limitations, however, should also be considered. The major limitation of the present study is its cross-sectional design which prohibits inferring causal relationships between the MIND diet and psychological disorders. Poor diets might dispose people to depression and psychological distress. On the other hand, it is possible that people who are depressed consume high amounts of sweets and sugar containing foods as an effort to cool down symptoms of depression. Therefore, prospective studies are needed to confirm our findings. Findings from prospective cohort studies are much stronger than the ones from cross-sectional studies. However, observational studies should be repeated in several parts of the world to come to a definite conclusion. In addition to being among the first investigations in this regard, it must be kept in mind that appropriate analysis of cross-sectional data represents a valuable initial step in identifying relationships between diet and disease. Moreover, prospective cohort studies and clinical trials have their own weaknesses. In addition, we did not collect information on menopausal status in this study; however, it is unlikely that menopausal status affects our findings because the study subjects were relatively young population and the number of menopausal women should not be so high in this age range. Although we controlled for several potential confounders, the effect of residual confounding cannot be excluded. In the current study, we used a validated FFQ for dietary intakes assessment; however, measurement errors and misclassification of study participants in terms of exposure cannot be avoided. In addition, for assessment of psychological disorders, we used questionnaire-based data in this study. Although we used the Iranian validated version of HADS and GHQ questionnaires, the possibility of participants' misclassification in terms of outcome is also inevitable. In addition, we had no data on olive oil and wine in our FFQ; therefore, we excluded these components in the construction of MIND diet.

In conclusion, in this cross-sectional study we found that greater adherence to the MIND diet might be inversely associated with odds of depression and psychological distress. No significant association was observed between consumption of MIND diet and odds of anxiety.

CRediT authorship contribution statement

Asma Salari-Moghaddam: Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing. **Ammar Hassanzadeh Keshteli:** Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing. **Seyed Mohammad Mousavi:** Formal analysis, Writing - original draft. **Hamid Afshar:** Conceptualization, Investigation, Methodology. **Ahmad Esmaillzadeh:** Supervision, Conceptualization, Methodology, Investigation, Funding acquisition, Formal analysis, Writing - original draft, Writing - review & editing. **Peyman Adibi:** Conceptualization, Investigation, Methodology.

Declaration of Competing Interest

None of the authors had any personal or financial conflicts of interest.

Acknowledgments

The authors are thankful to participants of SEPAHAN project and authorities of Isfahan University of Medical Sciences for their excellent cooperation.

Funding

This study was financially supported by Tehran University of Medical Sciences, Tehran, Iran (code: 97-03-161-41093).

References

Adibi, P., Keshteli, A.H., Esmaillzadeh, A., Afshar, H., Roohafza, H., Bagherian-Sararoudi, R., Daghaghzadeh, H., Soltanian, N., Feinle-Bisset, C., Boyce, P., 2012. The study on the epidemiology of psychological, alimentary health and nutrition (SEPAHAN): overview of methodology. *J. Res. Med. Sci.* 17.

Aminianfar, A., Saneei, P., Nouri, M., Shafiei, R., Hassanzadeh-Keshteli, A., Esmaillzadeh, A., Adibi, P., 2019. Validity of self-reported height, weight, body mass index and waist circumference in Iranian adults. Int. J. Prevent. Med.

Department of Health, 2009. The General Practice Physical Activity Questionnaire. London, Department of Health.

Fresan, U., Bes-Rastrollo, M., Segovia-Siapco, G., Sanchez-Villegas, A., Lahortiga, F., De La Rosa, P.A., Martinez-Gonzalez, M.A., 2018. Does the MIND diet decrease depression risk? A comparison with Mediterranean diet in the SUN cohort. *Eur. J. Nutr.* 7, 018–1653.

Ghaffarpour M, H.-R.A., Kianfar, H., 1999. The manual for household measures, cooking yields factors and eligible protion of foods. Tehran. Iran: Nashre Olume Keshavarzy 1–40.

Haghighatdoost, F., Azadbakht, L., Keshteli, A.H., Feinle-Bisset, C., Daghaghzadeh, H., Afshar, H., Feizi, A., Esmaillzadeh, A., Adibi, P., 2016. Glycemic index, glycemic load, and common psychological disorders. *Am. J. Clin. Nutr.* 103, 201–209.

Hodge, A., Almeida, O.P., English, D.R., Giles, G.G., Flicker, L., 2013. Patterns of dietary intake and psychological distress in older Australians: benefits not just from a Mediterranean diet. *Int. Psychogeriatr.* 25, 456–466.

Hosseinzadeh, M., Vafa, M., Esmaillzadeh, A., Feizi, A., Majdzadeh, R., Afshar, H., Keshteli, A.H., Adibi, P., 2016. Empirically derived dietary patterns in relation to psychological disorders. *Public Health Nutr.* 19, 204–217.

Keshteli, A.H., Esmaillzadeh, A., Rajaie, S., Askari, G., Feinle-Bisset, C., Adibi, P., 2014. A dish-based semi-quantitative food frequency questionnaire for assessment of dietary intakes in epidemiologic studies in Iran: design and development. *Int. J. Prevent. Med.* 5, 29.

Khosravi, M., Sotoudeh, G., Majdzadeh, R., Nejati, S., Darabi, S., Raisi, F., Esmaillzadeh, A., Sorayani, M., 2015. Healthy and unhealthy dietary patterns are related to depression: a case-control study. *Psychiatry Investig.* 12, 434–442.

Lassale, C., Batty, G.D., Baghdadli, A., Jacka, F., Sanchez-Villegas, A., Kivimaki, M., Akbaraly, T., 2018. Healthy dietary indices and risk of depressive outcomes: a systematic review and meta-analysis of observational studies. *Mol. Psychiatry*.

Montazeri, A., Harirchi, A.M., Shariati, M., Garmaroudi, G., Ebadi, M., Fateh, A., 2003a. The 12-item General Health Questionnaire (GHQ-12): translation and validation study of the Iranian version. *Health Qual. Life Outcomes* 1, 66.

Montazeri, A., Vahdaninia, M., Ebrahimi, M., Jarvandi, S., 2003b. The Hospital Anxiety and Depression Scale (HADS): translation and validation study of the Iranian version. *Health Qual. Life Outcomes* 1, 14.

Morris, M.C., Tangney, C.C., Wang, Y., Sacks, F.M., Barnes, L.L., Bennett, D.A., Aggarwal, N.T., 2015a. MIND diet slows cognitive decline with aging. Alzheimers Dement. 11, 1015–1022.

Morris, M.C., Tangney, C.C., Wang, Y., Sacks, F.M., Bennett, D.A., Aggarwal, N.T., 2015b. MIND diet associated with reduced incidence of Alzheimer's disease. Alzheimers Dement. 11, 1007–1014.

Noorbala, A., Yazdi, S.B., Yasamy, M., Mohammad, K., 2004. Mental health survey of the adult population in Iran. *Brit. J. Psychiatry* 184, 70–73.

Oguma, Y., Shinoda-Tagawa, T., 2004. Physical activity decreases cardiovascular disease risk in women: review and meta-analysis. Am. J. Prev. Med. 26, 407–418.

Olveira, C., Olveira, G., Espildora, F., Giron, R.M., Vendrell, M., Dorado, A., Martinez-Garcia, M.A., 2014. Mediterranean diet is associated on symptoms of depression and anxiety in patients with bronchiectasis. *Gen. Hosp. Psychiatry* 36, 277–283.

Piccinelli, M., Wilkinson, G., 2000. Gender differences in depression. Critical review. *Br. J. Psychiatry* 177, 486–492.

Rienks, J., Dobson, A.J., Mishra, G.D., 2013. Mediterranean dietary pattern and prevalence and incidence of depressive symptoms in mid-aged women: results from a

large community-based prospective study. *Eur. J. Clin. Nutr.* 67, 75–82.
Saghafian, F., Malmir, H., Saneei, P., Keshteli, A.H., Hosseinzadeh-Attar, M.J., Afshar, H., Siassi, F., Esmaillzadeh, A., Adibi, P., 2018. Consumption of fruit and vegetables in relation with psychological disorders in Iranian adults. *Eur. J. Nutr.* 57, 2295–2306.
Salim, S., 2014. Oxidative stress and psychological disorders. *Curr. Neuropharmacol.* 12, 140–147.
Sanchez-Villegas, A., Henriquez-Sanchez, P., Ruiz-Canela, M., Lahortiga, F., Molero, P., Toledo, E., Martinez-Gonzalez, M.A., 2015. A longitudinal analysis of diet quality scores and the risk of incident depression in the SUN Project. *BMC Med.* 13, 197.
Schmitz, N., Kruse, J., Heckrath, C., Alberti, L., Tress, W., 1999. Diagnosing mental disorders in primary care: the General Health Questionnaire (GHQ) and the Symptom Check List (SCL-90-R) as screening instruments. Soc. Psychiatry Psychiatr. Epidemiol. 34, 360–366.
Steel, Z., Marnane, C., Iranpour, C., Chey, T., Jackson, J.W., Patel, V., Silove, D., 2014. The global prevalence of common mental disorders: a systematic review and meta-analysis 1980-2013. Int. J. Epidemiol. 43, 476–493.
Valipour, G., Esmaillzadeh, A., Azadbakht, L., Afshar, H., Hassanzadeh, A., Adibi, P., 2017. Adherence to the DASH diet in relation to psychological profile of Iranian adults. Eur. J. Nutr. 56, 309–320.
Whiteford, H.A., Degenhardt, L., Rehm, J., Baxter, A.J., Ferrari, A.J., Erskine, H.E., Charlson, F.J., Norman, R.E., Flaxman, A.D., Johns, N., Burstein, R., Murray, C.J., Vos, T., 2013. Global burden of disease attributable to mental and substance use disorders: findings from the Global Burden of Disease Study 2010. Lancet 382, 1575–1586.