Mental health is associated with nutrient patterns and Index of Nutrition Quality (INQ) in adolescent girls – analytical study

Article *in* Human Nutrition & Metabolism · December 2022

DOI: 10.1016/j.hnm.2022.200176

6 authors, including:

Hamed Jafari-Vayghan
Arak University of Medical Sciences
37 PUBLICATIONS **696** CITATIONS

Susan Mirmajidi
Alborz University of Medical Sciences
5 PUBLICATIONS **109** CITATIONS

Farhad Vahid
LIH Luxembourg Institute of Health
98 PUBLICATIONS **1,302** CITATIONS

Sevda Saleh-Ghadimi
Arak University of Medical Sciences
32 PUBLICATIONS **401** CITATIONS

31 (2023) 200176

Contents lists available at ScienceDirect

Human Nutrition & Metabolism

journal homepage: www.sciencedirect.com/journal/human-nutrition-and-metabolism

Mental health is associated with nutrient patterns and Index of Nutritional Quality (INQ) in adolescent girls - an analytical study

Hamed Jafari-Vayghan [a], Susan Mirmajidi [b,**], Zahra Mollarasouli [c], Farhad Vahid [d], Sevda Saleh-Ghadimi [e], Parvin Dehghan [f,*]

[a] Department of Nutrition, Faculty of Health, Arak University of Medical Sciences, Arak, Iran
[b] Non-communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran
[c] Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran
[d] Nutrition & Health Research Group, Department of Precision Health, Luxembourg Institute of Health, Strassen, Luxembourg
[e] Clinical Research Development Unit of Tabriz Valiasr Hospital, Tabriz University of Medical Sciences, Tabriz, Iran
[f] Nutrition Research Center, Faculty of Nutrition and Food Sciences, Tabriz University of Medical Sciences, Tabriz, Iran

ARTICLE INFO

Keywords:
Anxiety
Depression
Nutrient pattern
Mental health
Female adolescents
Index of nutritional quality (INQ)

ABSTRACT

Introduction: Mental health in adolescents is among the most critical health issues worldwide. The association between diet and mental health is undeniable. Nutrient patterns (NPs) and Index of Nutritional Quality (INQ) assessments are novel and valid methods for discovering nutritional effects on diseases. The INQ is an index that qualifies the individual's intake based on the amount of nutrients recommendations and the individual's energy intake. Principal Component Analysis is applied to the nutrients computed from the food record questionnaire to derive NPs. This study was designed to determine the association between the NPs/INQ and mental health among adolescents. We hypothesized that having a high-quality diet rich in nutrients has a protective effect(s) against psychological problems.

Method: This study included 365 female adolescents from five regions of Tabriz, Iran. The Depression, Anxiety, and Stress Scale was used to assess mental health. A 3-day food record questionnaire was used to assess dietary intakes. Food record-derived nutritional data were used in the modeling NPs and following formulae to calculate INQ= consumed the amount of a nutrient per 1000 kcal/RDA or AI of that nutrient per 1000 kcal.

Results: Four major NPs were identified: NP1: high intakes of essential amino acids, zinc, B-complex, phosphorus, selenium, and cholesterol; NP2: high intakes of fatty acids, biotin, vitamin E, folate, magnesium, chromium, copper, iron, sodium, potassium; NP3: high intakes of amino acids, and NP4: high intakes of calcium, β carotene, vitamin A, D, K, C, and dietary fiber. Subjects in the fourth quartile of NP1 and NP4 had lower depression, anxiety and stress scores than those in the first quartile. Beta estimates showed an inverse association between INQ of vitamins A (B=−3.83, p=0.002), D (B=−2.82, p=0.017), K (B=−0.61, p=0.025), B6 (B=−0.46, p=0.035), B12 (B=−0.94, p=0.040), and folate (B=−1.15, p=0.037) and anxiety and also a positive association between INQ of manganese (B=2.01, p=0.019) and stress.

Conclusion: High intake of calcium, β carotene, vitamins A, D, K, C, and dietary fiber led to lower depression, anxiety and stress. Also, essential amino acids, zinc, B-complex, phosphorus, selenium, and cholesterol had an inverse association with depression, anxiety and stress. According to the INQ analysis, vitamins A, D, K, B6, B12, and folate had protective effects against anxiety.

Abbreviations: AI, Adequate intake; BMI, Body mass index; DASS-21, Depression anxiety and stress scale-21; DRI, Dietary reference intake; EFA, Exploratory factor analysis; NP, Nutrient pattern; RDA, Recommended dietary allowance; SFA, Saturated fatty acid; SES, Socioeconomic status.

* Corresponding author. Nutrition Research Center, Faculty of Nutrition and Food Sciences, Tabriz University of Medical Sciences, Golgasht St., Tabriz, I. R, 5166614711, Iran.
** Corresponding author. Non-communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran.
E-mail addresses: susan_mirmajidi@yahoo.com (S. Mirmajidi), dehghan.nut@gmail.com (P. Dehghan).

https://doi.org/10.1016/j.hnm.2022.200176
Received 8 August 2022; Received in revised form 1 December 2022; Accepted 2 December 2022
Available online 5 December 2022

1. Introduction

Psychological disorders in adolescents are one of the most critical public health issues worldwide. These disorders cause depression, anxiety, and stress in many people globally [1]. Depression is a chronic and recurrent illness regarded as a significant cause of disability that can lead to self-destruction, the most dramatic manifestation if not addressed [2]. Mental disorders, especially anxiety, also tend to become chronic and can have deleterious effects. Such conditions impose high burdens on personal/social and public health costs [3].

In line with the increase in Western countries, chronic psychological diseases prevalence among general Iranian population was estimated to be 31.03% based on meta-analysis of studies between 2007 and 2018 [4]. Estimates indicate that the prevalence of these disorders in women is higher than men (14.9% in men, 29.8% in women) [5]. The increase in mental disorders is associated with changes in lifestyle factors [6,7], including decreased social support, increases in chronic stress, sedentary lifestyles, changes in sleeping patterns, a decrease in exposure to sunlight, and changes in dietary patterns and/or habits, among others [8].

However, evidence about the role of diet and dietary factors in the etiology and causality of these disorders is limited; the association between diet and mental health is undeniable [9]. Current evidence indicates that the association between mental health and diet/dietary factors has focused on dietary quality/patterns and nutrients intake [10, 11]. It is shown that dietary intakes of some nutrients, including iron [12], vitamin B6 [13], omega-3 fatty acids [14], zinc, vitamin B12, folate, and selenium [10], are associated with improvements in depression and anxiety. In addition, adherence to healthy and quality diets such as the Mediterranean-type diet is also related to a lower incidence of mental disorders while following a western-style/poor diet; e.g., high intake of red and processed meat, saturated fatty acids (SFA) and simple sugar is related to unfavorable outcomes [11,15].

Some studies have investigated the association between diet quality and various diseases using different nutritional tools/methods [16,17]. One of the extensively used methods that could be employed in a diversity of diseases/outcomes is the Index of Nutritional Quality (INQ). The INQ has an aggregate view of diet quality and can adjust the total energy intake. The INQ compares micronutrients intake to that micronutrient's recommended amount after adjusting for total energy intake [17]. Three situations might be achieved with the INQ. In the first case, the person consumes an equal amount of the nutrient comparing recommended values. In other modes, individual intakes a higher or less amount of micronutrient than the reference/recommended values. On this basis, we can determine the quality of a person's diet and relate it to the various outcomes/diseases [16]. Although several studies have used this method and interesting results have been reported, very few (if any) focus on mental disorders.

Studying dietary patterns and quality can provide a comprehensive view of dietary habits/quality. They can help predict disease risk with greater precision and power rather than merely evaluating food or nutrients alone [18]. Since food items consist of complex compounds with various nutrients [19], to recognize diseases' etiology and discover possible nutritional effects on the prevention/treatment/control of chronic diseases, it is necessary to examine the quality of diets and nutrients patterns comprehensively. Therefore, this study aimed to thoroughly determine the association between diet quality (assessed by INQ), nutrient patterns, and mental health among adolescent girls. In fact, we hypothesized that a high-quality, nutrient-rich diet is associated with lower odds of developing mental disorders and can contribute to alleviating them.

2. Methods

2.1. Participants

This analytical study was conducted in the northwest of Iran. In total, 365 female students aged 14–16 years were recruited after public announcements at five high schools in five regions of Tabriz, Iran. Female students were chosen rather than male ones since there is a drastic increase in the prevalence of psychological disorders among Iranian girls [5].

Participants were recruited voluntarily through announcement flyers distributed in the five schools after receiving permission from the Ministry of Education. Participants were excluded if they had any clinically apparent chronic diseases or if their calorie intake was outside the range of 800–4200 kcal/day (±3SD).

2.2. Assessment of dietary intake

Participants were asked to record the type and amount of foods and drinks they consumed in a 3-day food records questionnaire. They were asked to register their dietary intakes on two specific consecutive weekdays and one weekend day. Participants were trained to fill out the food records, and clear instructions were provided on how to record the quantity using standard household measures (portion size). Daily intakes of 53 nutrients (including individual amino acids, dietary fiber, vitamins, and minerals) were calculated for each participant using Nutritionist-IV Software (Nutritionist IV; First Data Bank, San Bruno, Calif., USA), and the nutrient patterns (NPs) were derived from these data using exploratory factor analysis (EFA).

2.3. Assessment of the INQ

Dietary data extracted from food records were used to calculate the INQ scores. We calculated the INQ for nutrients that had a defined recommended dietary allowance (RDA) or adequate intake (AI) in dietary reference intake (DRI) tables, using the following formulae: INQ = consumed amount of a nutrient per 1000 kcal/RDA or AI of that nutrient per 1000 kcal [16,17,20]. In this study, we calculated the INQs for vitamin A (IU/day), vitamin C (mg/day), Iron (mg/day), vitamin D (IU/day), vitamin E (mg/day), thiamin (mg/day), riboflavin (mg/day), niacin (mg/day), vitamin B6 (mg/day), folate (mcg/day), vitamin B12 (mcg/day), pantothenic (mg/day), vitamin K (mcg/day), magnesium (mg/day), zinc (mg/day), manganese (mg/day), selenium (mcg/day), and copper (mcg/day).

2.4. Psychological assessment

The 21-item Depression, Anxiety, and Stress scale (DASS-21) is a validated and reliable questionnaire for assessing psychological disorders [21]. The validity and reliability of the questionnaire have been established in a sample of the Iranian population with acceptable internal consistency ($\alpha = 0.84$ to 0.91) and satisfactory convergent validity [22]. The DASS-21 is a 21-item questionnaire, a shortened version of the original DASS-42 item [21]. The DASS-21 consists of three subscales for anxiety, depression, and stress, with seven items in each category. Each item is scored on a 4-point scale from 0 to 3, where 0 is "did not apply to me at all" and 3 is "applied to me very much or most of the time". Item scores are summed for each of the seven-item subscales for a score ranging from 0 to 21 for each subscale and a total possible score of 63 for the entire scale. Lovibond and Lovibond's [23] cut-off values were used for the severity classification of disorders.

2.5. Assessment of anthropometric variables and blood pressure

All anthropometric measurements were performed with light clothing and no shoes; weight and height were measured using a standardized scale (Seca, Germany) to the nearest 0.1 kg and a portable stadiometer (Seca, Germany) to the nearest 0.1 cm, respectively. Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2). BMI was reported as BMI z-score standardized for 5–19 years old girls [24]. World Health Organization cut-off points were used to define BMI categories. In this regard, participants were assigned to the severely thin (BMI z-score < -3), thin (BMI z-score < -2), normal weight ($-2 <$BMI z-score< 0 and $0 <$ BMI z-score$< +1$), overweight (BMI z-score $> +1$) or obese (BMI z-score $> +2$) groups. In addition, Waist Circumstance (WC) was measured at the narrowest part of the torso using a non-stretchable tape measure with a precision of 0.1 cm. A sphygmomanometer was used to measure systolic and diastolic blood pressure (SBP, DBP) to the nearest 5 mmHg value.

2.6. Statistical analysis

The Kolmogorov-Smirnov test was used to determine the normality of distribution for continuous variables. Median (percentile 25–75) was used to present the continuous variables since they were distributed non-normally. Qualitative data are presented as frequency (percent). The extraction of the NPs was carried out using exploratory factor analysis (EFA) with principal component analysis extraction method and varimax rotation. According to the reference, five participants per item is the acceptable sample size for EFA [25]. The correlation matrix was used as an input matrix. The screed test determined the number of factors; the factors characterized by the highest eigenvalues in the steepest part of the figure were extracted. The factor score was calculated using a weighted mean of items related to each factor. Participants received a factor score for each NP and were then categorized into quartiles. Univariate linear regression was conducted to assess the association between NPs and depression, anxiety, and stress. Simultaneous associations between the NPs and depression, anxiety, and stress were determined using a multiple regression model after adjusting for energy intake, age, BMI z-score, WC, and socioeconomic status (SES). To examine the SES, we used three variables, including family income, parents' job, and education, and categorized each of them. Finally, from the combination of these three variables, the SES variable was extracted with a score of less than two (1st tertile), two to three (2nd tertile), and more than three (3rd tertile); these variables were considered poor, moderate and good, respectively. P-values <0.05 are considered statistically significant. Data analyses were performed using SPSS 25 (SPSS Inc., Chicago, IL, USA).

3. Results

The demographic variables of the study participants are shown in Table 1. Participants mean (SD) of age was 15.45 (1.14) years. Severe depression, anxiety, and stress were present in 21.6%, 26.6%, and 25.8% of participants, respectively.

Four major NPs were identified using EFA (Table 2). The first pattern (NP1) was characterized as high intakes of essential amino acids, cysteine, histidine, tyrosine, zinc, vitamins B1, B2, B3, B6, and B12, pantothenic acid, phosphorus, selenium, and cholesterol. The second pattern (NP2) was high in SFA, monounsaturated fatty acids, polyunsaturated fatty acids, vitamin E-tocopherol, biotin, folate, magnesium, iron, copper, chromium, molybdenum, sodium, and potassium. High intakes of alanine, glycine, aspartate, glutamine, arginine, proline, serine, and manganese characterized the third pattern (NP3). Finally, the fourth pattern (NP4) was characterized by high intakes of calcium, β-carotene, vitamins A, D, K, C, and dietary fiber. These factors explained 64.6% of the variance in the EFA model.

The regression models revealed that depression, anxiety, and stress scores were significantly lower in the fourth quartile of NP1 and NP4 than in the first quartile (Table 3). After adjusting for energy intake, age, BMI z-score, WC, and SES, there was an inverse and significant association between depression, anxiety, and stress with NP1 and NP4.

According to Table 4, beta estimates showed a significant association

Table 1
Characteristics of the study subjects (n = 365).

Variable	NP1	NP2	NP3	NP4	P-value
Age (years)[a]	15.00 (15.00–16.00)	15.00 (14.00–16.00)	15.00 (15.00–16.00)	15.00 (14.75–16.00)	0.500
Energy (Kcal)[a]	1612.50 (1118.25–2502.00)	1659.00 (1256.00–2094.00)	1776.00 (1389.00–2274.00)	1950.00 (1597.00–2184.00)	0.263
Carbohydrate (g)[a]	248.55 (180.75–345.35)	261.00 (193.50–315.00)	273.00 (209.60–353.00)	275.15 (232.63–337.53)	0.224
Protein (g)[a]	58.11 (36.72–80.88)	56.02 (45.90–70.00)	60.50 (49.60–75.21)	60.73 (51.75–70.74)	0.285
Fat (g)[a]	42.15 (33.71–74.25)	45.43 (27.50–70.00)	49.80 (36.31–71.30)	52.00 (37.62–75.90)	0.209
Waist circumference (cm)[a]	75.50 (68.50–81.50)	76.00 (70.00–85.00)	77.00 (70.00–84.75)	76.00 (70.50–84.50)	0.640
Hip circumference (cm)[a]	95.00 (91.00–100.00)	95.00 (90.00–101.00)	94.00 (90.00–100.00)	97.00 (91.00–103.00)	0.420
SBP (mmHg)[a]	110.00 (100.00–120.00)	110.00 (100.00–120.00)	110.00 (100.00–120.00)	110.00 (100.00–120.00)	0.917
DBP (mmHg)[a]	70.00 (60.00–80.00)	70.00 (60.00–80.00)	70.00 (50.00–80.00)	70.00 (60.00–80.00)	0.591
BMI z-score [b]					
Severe Thin	0	3 (2.0)	2 (2.0)	2 (4.3)	0.683
Thin	3 (6.7)	12 (8.0)	13 (13.0)	2 (4.3)	
Normal	32 (72.1)	106 (70.7)	70 (70.0)	30 (65.2)	
Overweight	10 (22.2)	28 (18.7)	15 (15.0)	12 (26.1)	
Obese	0	1 (0.6)	0	0	
SES [b]					
Low	18 (39.1)	71 (45.8)	55 (53.4)	22 (47.8)	0.856
Middle	13 (28.3)	51 (32.9)	28 (27.2)	13 (28.3)	
High	15 (32.6)	33 (21.3)	20 (19.4)	11 (23.9)	
PAL[b]					
Low	21 (45.7)	50 (32.3)	37 (35.9)	20 (43.5)	0.418
Moderate	21 (45.7)	97 (62.6)	62 (60.2)	24 (52.2)	
High	4 (8.7)	8 (5.2)	4 (3.9)	2 (4.3)	
Thyroid disorders [b]					
Yes	0	0	0	1 (2.5)	0.085
No	40 (100)	132 (100)	92 (100)	39 (97.5)	
Diabetes[b]					
Yes	0	0	0	0	
No	40 (100)	132 (100)	92 (100)	39 (100)	
Other diseases [b]					
Yes	1 (2.50)	14 (10.60)	8 (8.70)	6 (15.40)	0.253
No	39 (97.50)	118 (89.40)	84 (91.30)	33 (84.60)	

SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SES: Socioeconomic status, PAL: Physical activity level.
[a] Vlalues are expressed as median (percentile 25–75) and p based on Kruskal–Wallis H test.
[b] Values are expressed as frequency (%) p based on Chi-square test.

Table 2
Factor loading of nutrients in major nutrient patterns.

NP1		NP2		NP3		NP4	
Nutrient Item	Factor Loading	Nutrient Item	Factor Loading	Nutrient Item	Factor Loading	Nutrient Item	Factor Loading
Methionine	0.90	PUFA	0.85	Alanine	0.94	Calcium	0.64
Cysteine	0.85	Linoleic acid	0.85	Glycine	0.93	Vitamin K	0.60
Histidine	0.84	Magnesium	0.67	Aspartic	0.92	Vitamin C	0.57
Tryptophan	0.81	MUFA	0.66	Glutamic	0.87	Vitamin A	0.57
Tyrosine	0.74	Oleic acid	0.64	Arginine	0.87	Dietary fiber	0.55
Threonine	0.74	Potassium	0.64	Proline	0.80	Vitamin D	0.47
Zinc	0.73	Tocopherol	0.64	Serine	0.80	β Carotene	0.37
Leucine	0.73	Molybdenum	0.60	Manganese	0.54		
Valine	0.71	Biotin	0.59				
Lysine	0.70	Vitamin E	0.59				
Vitamin B3	0.69	SFA	0.58				
Phenylalanine	0.69	Folate	0.57				
Isoleucine	0.68	Copper	0.55				
Vitamin B12	0.62	Iron	0.53				
Vitamin B2	0.59	Linolenic acid	0.45				
Pantothenic acid	0.55	Sodium	0.27				
Phosphorus	0.55	Chromium	0.20				
Selenium	.0.54						
Cholesterol	0.53						
Vitamin B6	0.43						
Vitamin B1	0.39						
Explained variance	44.97		8.99		6.09		4.57

NP: Nutrient pattern, SFA: Saturated fatty acid, MUFA: Monounsaturated fatty acid, PUFA: Polyunsaturated fatty acid.

between anxiety and the INQ of vitamins A (B=−3.83, p=0.002), D (B=−2.82, p=0.017), K (B=−0.61, p=0.025), B6 (B=−0.46, p=0.035), B12 (B=−0.94, p= 0.040), and folate (B=−1.15, p=0.037) and also between stress and INQ of manganese (B=2.01, p=0.019).

4. Discussion

This study on Iranian females identified a significant preventive association between NP1 (essential amino acids, zinc, vitamin B-complex, phosphorus, selenium, and cholesterol, found in animal sources) and psychological disorders. We also found a preventive association between NP4 (characterized by high intakes of calcium, β-carotene, vitamins A, D, K, and C, and dietary fiber) and psychological disorders.

Our findings align with a recent study indicating that adherence to a vegetarian diet is related to the development of depression more than in non-vegetarians [26]. Different mechanisms might describe such results. For instance, limited dietary protein consumption and isolated amino acids have been related to mental disorders [27]. As previously documented, S-adenosyl-L-methionine [26], tryptophan, and methionine are negatively associated with depression [28]. In addition, lysine [29], tryptophan [28], and tyrosine [30] have been indicated to have an anxiolytic capacity. Moreover, tryptophan acts as a substrate for the biosynthesis of protein, niacin, or serotonin, required for a niacinamide synthesis that may signal, via feedback prevention, to reduce the function of tryptophan pyrrolase. This causes more tryptophan to convert to 5-Hydroxytryptophan (5-HTP) and then to serotonin [31] which is related to proper neuronal function. Furthermore, vitamin B6 plays a vital role as a cofactor for various enzymes in serotonin and niacin pathways [32].

In our study, cholesterol was found to be high in NP1. Recent evidence has shown that decreased serum total cholesterol levels may elevate the risk of depression; however, this association's inherent features are unknown [33]. The association between diet and mental disorders is very complicated; as reported by neuropsychiatry and nutrition science researchers, several factors can be involved, and the effects of those factors can be two-way. On the other hand, in line with our study results, several studies have also demonstrated a negative correlation between zinc and vitamin B12 with depression [34,35]. Zinc is an antagonist of the glutamate/N-methyl D-aspartate (NMDA) receptor and suppresses depression via the up-regulation of the brain-derived neurotrophic factor (BDNF) gene expression and amplification of its synaptic pool level in the hippocampus [36]. Furthermore, one experimental study showed that zinc supplementation was an antidepressant agent [34]. Vitamin B deficiency, chiefly folate and cobalamin, has recently been found to contribute to psychological disorders by causing hyperhomocysteinemia. Homocysteine is an amino acid manufactured within the body's metabolic processes [37,38] and can be converted to cysteine or methionine through the involvement of cobalamin and folate [39,40]. In addition, vitamin B6, as pyridoxal phosphate, is needed to convert homocysteine to cysteine [37].

Furthermore, supplementation with selenium, a central mood modulator, over 5–6 weeks considerably ameliorated mood status [41]. Clinical trials also revealed that selenium improved mood and decreased anxiety [42]. The mechanism by which selenium alleviates mood is a matter of some debate. However, alterations in thyroid activity related to selenium have been linked to mental disorders, particularly depression symptoms. As selenium is needed for thyroid hormone synthesis and normal function. It is concluded that selenium deficiency can impair thyroid hormone metabolism and cause depression [43].

In addition, the principal nutrients in NP4 (calcium, β-carotene, vitamins A, D, K, and C, and dietary fiber) are found primarily in fruits and vegetables. Consumption of vegetables and fruits with high proportions of antioxidant compounds and fiber is beneficial for mental disorders [44,45], since antioxidative properties of nutrients are helpful in the reduction of the odds of depression. Conversely, lipid peroxidation and oxidative stress are related to depression, and some antidepressant medications targeting to lower oxidative stress [46]. Vitamin C (ascorbic acid) also has antioxidant potential and modulates oxidative stress; in fact, other antioxidants remain unchanged until ascorbic acid has been depleted. It has been shown that high doses of vitamin C (3 g/day) supplements have been shown to improve mental impairment severity [47]. In addition, the SENECA study indicated a positive but weak correlation between serum concentrations of α-carotene, β-carotene, total carotenes, and Mini-Mental State Examination (MMSE) score [48]. In elderly populations studied by Ortega et al. the consumption of vitamin C and α-carotene were positively associated with psychological diseases [49], as our study results showed.

Moreover, stress is associated with increased urinary calcium due to cortisol release [50,51]. Cortisol inhibits tubular calcium reabsorption mediated by aldosterone, increasing urinary calcium excretion [52,53].

Table 3
Linear regression analysis of nutrient pattern scores with depression, anxiety, and stress.

	Depression		Anxiety		Stress	
	B (95% CI)	*p**	B(95% CI)	*p**	B (95% CI)	*p**
Model 1[a]						
NPs1						
Q1	Ref	**0.038**	Ref	**0.017**	Ref	**0.013**
Q2	−0.18 (−1.28 to 0.93)		−0.88 (−2.33 to 0.56)		−0.64 (−1.90 to 0.62)	
Q3	−0.84 (−1.94 to 0.27)		−1.16 (−2.60 to 0.28)		−0.83 (−2.09 to 0.42)	
Q4	−1.47 (−2.58 to −0.37)		−2.33 (−3.77 to 0.89)		−2.07 (−3.32 to −0.81)	
NPs2						
Q1	Ref	0.942	Ref	0.997	Ref	0.903
Q2	0.32 (−0.80 to 1.45)		−0.05 (−1.52 to 1.42)		−0.12 (−1.40 to 1.16)	
Q3	0.07 (−1.05 to 1.19)		0.05 (−1.41 to 1.51)		0.34 (−0.93 to 1.61)	
Q4	0.22 (−0.89 to 1.34)		−0.10 (−1.55 to 1.35)		0.18 (−1.09 to 1.44)	
NPs3						
Q1	Ref	0.261	Ref	0.558	Ref	0.452
Q2	−0.20 (−1.31 to 0.91)		−0.39 (−1.85 to 1.07)		−0.09 (−1.36 to 1.18)	
Q3	0.82 (−0.30 to 1.94)		0.58 (−0.88 to 2.05)		0.85 (−0.43 to 2.13)	
Q4	−0.10 (−1.21 to 1.02)		−0.30 (−1.76 to 1.16)		0.40 (−0.87 to 1.67)	
NPs4						
Q1	Ref	**0.007**	Ref	**0.001**	Ref	**0.005**
Q2	−1.15 (−2.26 to −0.05)		−0.93 (−2.36 to 0.50)		−0.75 (−2.01 to 0.51)	
Q3	−1.66 (−2.76 to −0.56)		−2.31 (−3.74 to −0.89)		−2.02 (−3.27 to −0.76)	
Q4	−1.73 (−2.83 to −0.63)		−2.61 (−4.03 to −1.18)		−1.80 (−3.06 to −0.55)	
Model 2[b]						
NPs1						
Q1	Ref	**0.027**	Ref	**0.045**	Ref	**0.016**
Q2	−0.34 (−1.16 to 1.09)		−1.15 (−2.26 to −0.05)		−1.15 (−2.26 to −0.05)	
Q3	−0.64 (−1.78 to 0.50)		−1.66 (−2.76 to −0.56)		−1.66 (−2.76 to −0.56)	
Q4	−1.21 (−2.39 to −0.03)		−1.73 (−2.83 to −0.63)		−1.73 (−2.83 to −0.63)	
NPs2						
Q1	Ref	0.620	Ref	0.534	Ref	0.283
Q2	0.41 (−0.74 to 1.55)		0.01 (−1.49 to 1.49)		−0.10 (−1.43 to 1.23)	
Q3	0.14 (−1.03 to 1.30)		0.23 (−1.29 to 1.75)		0.52 (−0.84 to 1.87)	
Q4	0.42 (−0.88 to 1.71)		0.52 (−1.17 to 2.21)		0.70 (−0.80 to 2.21)	
NPs3						
Q1	Ref	0.357	Ref	0.566	Ref	0.142
Q2	−0.02 (−1.15 to 1.12)		−0.33 (−1.82 to 1.16)		0.06 (−1.27 to 1.38)	
Q3	0.90 (−0.24 to 2.03)		0.51 (−0.97 to 1.99)		0.96 (−0.36 to 2.28)	
Q4	0.24 (−0.92 to 1.40)		0.18 (−1.34 to 1.69)		0.74 (−0.60 to 2.09)	
NPs4						
Q1	Ref	**0.007**	Ref	**0.001**	Ref	**0.004**
Q2	−1.13 (−2.24 to −0.01)		−0.86 (−2.30 to 0.59)		−0.68 (−1.97 to 0.61)	
Q3	−1.49 (−2.61 to −0.37)		−2.18 (−3.63 to −0.73)		−1.95 (−3.24 to −0.65)	
Q4	−1.56 (−2.73 to −0.39)		−2.37 (−3.89 to −0.85)		−1.62 (−2.98 to −0.26)	

NPs: Nutrient Pattern score.
[a] Unadjusted.
[b] Adjusted for energy intake, age, BMI z-score, waist circumference, and socioeconomic status.

In addition, an inverse association has been found between vitamin D and mood disorders [54]. Research indicates that mood boosts during winter in young and middle-aged people may be due to vitamin D supplement intake [55–57].

In line with previous studies and EFA, the INQ analysis showed protective effects for vitamins A, D, K, B6, B12, and folate against anxiety. The advantage of the INQ compared to the previous methods is that INQ modifies nutrients intake based on calorie intake and compares it with the DRI. Some studies used the INQ for assessing dietary intakes in various conditions, such as breast cancer [16], gastric cancer [17], glioma [58], ulcerative colitis [59], and non-alcoholic liver disease [57]. These studies have concluded that INQ is a valid and reliable method to examine individuals' nutritional status in different situations. The evaluation of dietary intake by the INQ is much more comprehensive and complete than the raw assessments of the nutrient intakes. However, the limitation of the INQ is that it cannot be calculated for micronutrients that do not have DRI, including RDA or AI [57–59].

Besides the strengths mentioned, including using valid and reliable questionnaires and being the first study investigating the association between mental disorders with NPs and INQ, among others, this study had some limitations. One of the study's main limitations was the inclusion of only female adolescents. However, the reason for choosing only girls was the high prevalence of these disorders in them, but studies on both genders maybe will be able to explain better some discrepancies observed in our results. The other limitation of this study was the lack of cause-effect relationships, so studies with cohort and prospective designs would be necessary to understand these associations and causal network better. As another limitation, some measurement errors should be considered since we used a 3-day food record questionnaire for dietary estimation. However, since the validity and reliability of this questionnaire have already been examined, this error will be minimal. Another limitation that may be overlooked is that we used the Nutritionist IV software database, mainly developed for the USA, to extract the daily intake of nutrients. However, in cases where it was available, we used local databases, but as there is no comprehensive food composition database for Iran, we had to use this database. Considering that this database is used in almost all studies conducted in Iran, it seems that this limitation cannot affect our results. Some factors such as parent death or divorce may impress psychological profile effectively. However, these factors were not assessed in the study which can be considered as another limitation. Finally, subjective or arbitrary decisions in the use of factor analysis must be considered.

4.1. Conclusions

After adjusting for confounding variables, the NP characterized by

Table 4
Association between the index of nutritional quality and depression, anxiety, and stress.

	Depression		Anxiety		Stress	
	B (95% CI)	p[a]	B (95% CI)	p[a]	B (95% CI)	p[a]
Vitamin A	−1.51 (−3.41 to 0.40)	0.121	−3.83 (−6.29 to −1.37)	**0.002**	−1.02 (−3.24 to 1.20)	0.365
Vitamin D	−1.14 (−2.93 to 0.65)	0.211	−2.82 (−5.14 to −0.50)	**0.017**	−1.08 (−3.17 to 1.00)	0.307
Vitamin E	−0.13 (−0.84 to 0.58)	0.714	−0.48 (−1.41 to 0.45)	0.312	0.24 (−0.59 to 1.07)	0.569
Vitamin K	−0.40 (−0.81 to 0.01)	0.055	−0.61 (−1.15 to −0.08)	**0.025**	−0.26 (−0.74 to 0.22)	0.293
Vitamin B1	−0.04 (−0.31 to 0.23)	0.773	−0.24 (−0.59 to 0.12)	0.188	0.16 (−0.16 to 0.47)	0.320
Vitamin B2	−0.06 (−0.28 to 0.15)	0.555	−0.28 (−0.55 to −0.01)	0.052	0.01 (−0.24 to 0.25)	0.969
Vitamin B3	0.02 (−0.25 to 0.28)	0.909	−0.15 (−0.50 to 0.19)	0.375	0.24 (−0.06 to 0.54)	0.117
Vitamin B6	−0.16 (−0.50 to 0.17)	0.329	−0.46 (−0.89 to −0.03)	**0.035**	−0.15 (−0.53 to 0.24)	0.452
Folate	−0.54 (−1.37 to 0.28)	0.197	−1.15 (−2.22 to −0.07)	**0.037**	−0.18 (−1.15 to 0.78)	0.708
Vitamin B12	−0.38 (−1.07 to 0.31)	0.278	−0.94 (−1.84 to −0.05)	**0.040**	−0.45 (−1.25 to 0.36)	0.274
Vitamin C	−0.26 (−0.61 to 0.08)	0.138	−0.39 (−0.84 to 0.06)	0.087	−0.11 (−0.51 to 0.30)	0.599
Iron	−0.07 (−0.61 to 0.47)	0.802	−0.44 (−1.13 to 0.25)	0.210	0.22 (−0.41 to 0.84)	0.502
Magnesium	−0.01 (−0.53 to 0.51)	0.973	−0.37 (−1.05 to 0.30)	0.275	0.26 (−0.34 to 0.86)	0.391
Zinc	−0.14 (−0.54 to 0.26)	0.502	−0.39 (−0.91 to 0.13)	0.143	0.06 (−0.41 to 0.52)	0.802
Manganese	−0.12 (−1.56 to 1.33)	0.873	0.62 (−1.27 to 2.51)	0.521	2.01 (0.34–3.70)	**0.019**
Copper	−0.70 (−2.30 to 0.98)	0.428	−1.96 (−4.09 to 0.17)	0.071	−0.31 (−2.22 to 1.59)	0.747
Selenium	−0.59 (−2.42 to 1.24)	0.525	−0.96 (−3.36 to 1.43)	0.430	0.09 (−2.04 to 2.22)	0.931
Chromium	−0.02 (−0.30 to 0.26)	0.910	0.03 (−0.33 to 0.40)	0.848	0.01 (−0.31 to 0.34)	0.945

[a] P based on linear regression analysis and adjusted for energy intake, age, BMI z-score, waist circumference, and socioeconomic status.

high intakes of calcium, β-carotene, vitamins A, D, K, and C, and dietary fiber had a protective effect and an inverse association with depression, anxiety, and psychological stress. Moreover, an NP high in essential amino acids, zinc, vitamin B-complex, phosphorus, selenium, and cholesterol had a statistically significant inverse association with depression, anxiety, and psychological stress. The INQ analysis also showed protective effects for vitamins A, D, K, B6, B12, and folate against anxiety. Further studies at a larger scale and with prospective designs are needed to demonstrate the detailed association between psychological disorders and NPs and reveal its possible mechanisms.

Ethics approval and consent to participate

Approval was obtained from the ethics committee of the Tabriz University of Medical Sciences (IR.TBZMED.REC.1399.920). The procedures used in this study adhere to the tenets of the Declaration of Helsinki. All participants and their parents were informed of the study protocol and then asked to sign a written informed consent form. All individuals had individual rights that were not to be infringed.

Consent to publication

Not applicable.

Availability of data and materials

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

Funding

The study is supported financially by the Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran (No: 65792).

Authors' contributions

PD, SM, and ZM contributed to the study conception, design, data collection, and manuscript drafting. FV and SSG participated in data analysis and interpretation, writing the manuscript and revising the paper. HJV contributed to the study conception, design, and data interpretation, revising the paper and approving the version of the manuscript being submitted. All authors read and approved the final manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are grateful to all participants who kindly participated in this study. Also, we would like to thank the Clinical Research Development Unit of Tabriz Valiasr Hospital, Tabriz University of Medical Sciences, Tabriz, Iran for their assistance in this research.

References

[1] M. Abbasalizad Farhangi, P. Dehghan, L. Jahangiry, Mental health problems in relation to eating behavior patterns, nutrient intakes and health related quality of life among Iranian female adolescents, PLoS One 13 (4) (2018) e0195669.
[2] G.M. Slavich, R.P. Auerbach, Stress and its sequelae: depression, suicide, inflammation, and physical illness, in: APA Handbook of Psychopathology: Psychopathology: Understanding, Assessing, and Treating Adult Mental Disorders, American Psychological Association, Washington, DC, 2018.
[3] J.-P. Lépine, The epidemiology of anxiety disorders: prevalence and societal costs, J. Clin. Psychiatr. (2002).
[4] M.T. Mirghaed, H.A. Gorji, S. Panahi, Prevalence of psychiatric disorders in Iran: a systematic review and meta-analysis, Int. J. Prev. Med. 11 (2020).
[5] J. Hassanzadeh, et al., The prevalence of mental health problems and the associated familial factors in adolescents in the south of Iran, Int. J. Pediatr. 7 (4) (2019) 9317–9325.
[6] M. Garcia-Toro, et al., Persistence of chronic major depression: a national prospective study, J. Affect. Disord. 151 (1) (2013) 306–312.

[7] A.L. Lopresti, S.D. Hood, P.D. Drummond, A review of lifestyle factors that contribute to important pathways associated with major depression: diet, sleep and exercise, J. Affect. Disord. 148 (1) (2013) 12–27.
[8] M. García-Toro, et al., Adherence to lifestyle recommendations by patients with depression, Rev. Psiquiatía Salud Ment. 5 (4) (2012) 236–240.
[9] P. Dehghan, et al., The association between dietary inflammatory index, dietary antioxidant index, and mental health in adolescent girls: an analytical study, BMC Publ. Health 22 (1) (2022) 1–12.
[10] T. Popa, M. Ladea, Nutrition and depression at the forefront of progress, Journal of medicine and life 5 (4) (2012) 414.
[11] T.-T. Weng, et al., Is there any relationship between dietary patterns and depression and anxiety in Chinese adolescents? Publ. Health Nutr. 15 (4) (2012) 673–682.
[12] L. Zhang, et al., Multiple micronutrient supplementation reduces anemia and anxiety in rural China's elementary school children–4, J. Nutr. 143 (5) (2013) 640–647.
[13] M.C. De Souza, et al., A synergistic effect of a daily supplement for 1 month of 200 mg magnesium plus 50 mg vitamin B6 for the relief of anxiety-related premenstrual symptoms: a randomized, double-blind, crossover study, J. Wom. Health Gend. Base Med. 9 (2) (2000) 131–139.
[14] J.J. Liu, et al., Omega-3 polyunsaturated fatty acid status in major depression with comorbid anxiety disorders, J. Clin. Psychiatr. 74 (7) (2013) 732.
[15] F.N. Jacka, et al., Association of Western and traditional diets with depression and anxiety in women, Am. J. Psychiatr. 167 (3) (2010) 305–311.
[16] F. Vahid, et al., The association between the Index of Nutritional Quality (INQ) and breast cancer and the evaluation of nutrient intake of breast cancer patients: a case-control study, Nutrition 45 (2018) 11–16.
[17] F. Vahid, et al., The association between index of nutritional quality (INQ) and gastric cancer and evaluation of nutrient intakes of gastric cancer patients: a case-control study, Int J Cancer Manag 11 (1) (2018) e9747.
[18] M. Sadeghi, et al., The association between dietary patterns and breast cancer pathobiological factors progesterone receptor (PR) and estrogen receptors (ER): new findings from Iranian case-control study, Nutr. Cancer 71 (8) (2019) 1290–1298.
[19] H. Jafari-Vayghan, et al., Association between dietary patterns and serum leptin-to-adiponectin ratio in apparently healthy adults, J. Am. Coll. Nutr. 34 (1) (2015) 49–55.
[20] F. Vahid, et al., The association between index of nutritional quality and ulcerative colitis: a case-control study, J. Res. Med. Sci. : the official journal of Isfahan University of Medical Sciences 23 (2018), 67-67.
[21] I.N. Beaufort, et al., The depression, anxiety and stress scale (DASS-21) as a screener for depression in substance use disorder inpatients: a pilot study, Eur. Addiction Res. 23 (5) (2017) 260–268.
[22] A. Asghari, F. Saed, P. Dibajnia, Psychometric properties of the depression anxiety stress scales-21 (DASS-21) in a non-clinical Iranian sample, Int. J. Psychol. 2 (2) (2008) 82–102.
[23] S. Lovibond, P. Lovibond, Manual for the Depression Anxiety Stress Scales, Psychology Foundation of Australia, Sydney, 1995, 7334-1423-0.
[24] *https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age*.
[25] F.B. Bryant, P.R. Yarnold, Principal-components analysis and exploratory and confirmatory factor analysis, in: L. Grimm, R. Yarnold (Eds.), Reading and Understanding Multivariate Statistics, American Psychological Association, Washington, DC, 1995, pp. 99–136.
[26] J.R. Hibbeln, et al., Vegetarian diets and depressive symptoms among men, J. Affect. Disord. 225 (2018) 13–17.
[27] J.M. Glenn, E.N. Madero, N.T. Bott, Dietary protein and amino acid intake: links to the maintenance of cognitive health, Nutrients 11 (6) (2019) 1315.
[28] C. Bell, J. Abrams, D. Nutt, Tryptophan depletion and its implications for psychiatry, Br. J. Psychiatry 178 (5) (2001) 399–405.
[29] S.E. Lakhan, K.F. Vieira, Nutritional and herbal supplements for anxiety and anxiety-related disorders: systematic review, Nutr. J. 9 (1) (2010) 42.
[30] H. Lehnert, et al., Neurochemical and behavioral consequences of acute, uncontrollable stress: effects of dietary tyrosine, Brain Res. 303 (2) (1984) 215–223.
[31] H. Weinberg-Wolf, et al., The effects of 5-hydroxytryptophan on attention and central serotonin neurochemistry in the rhesus macaque, Neuropsychopharmacology 43 (7) (2018) 1589.
[32] H. Van Praag, C. Lemus, Monoamine precursors in the treatment of psychiatric disorders, Nutr. brain 7 (1986) 89–138.
[33] A.Z. Sahin, S. Sahin, S.O. Keskek, Relationship between cholesterol levels and suicide attempts in chronic psychosis, Trends Journal of Sciences Research 3 (3) (2018) 133–137.
[34] G. Nowak, B. Szewczyk, A. Pilc, Zinc and depression. An update, Pharmacol. Rep. 57 (6) (2005) 713–718.
[35] A. Sánchez-Villegas, et al., Association between folate, vitamin B6 and vitamin B12 intake and depression in the SUN cohort study, J. Hum. Nutr. Diet. 22 (2) (2009) 122–133.
[36] K. Mlyniec, Interaction between zinc, GPR39, BDNF and neuropeptides in depression, Curr. Neuropharmacol. 19 (11) (2021) 2012–2019.
[37] K. Pietrzik, A. Brönstrup, Causes and consequences of hyperhomocyst (e) inemia, Int. J. Vitam. Nutr. Res. 67 (5) (1997) 389–395.
[38] A. Hekmatdoost, et al., Methyltetrahydrofolate vs folic acid supplementation in idiopathic recurrent miscarriage with respect to methylenetetrahydrofolate reductase C677T and A1298C polymorphisms: a randomized controlled trial, PLoS One 10 (12) (2015) e0143569.
[39] L. Parnetti, T. Bottiglieri, D. Lowenthal, Role of homocysteine in age-related vascular and non-vascular diseases, Aging Clin. Exp. Res. 9 (4) (1997) 241–257.
[40] T. Bottiglieri, Folate, vitamin B12, and neuropsychiatric disorders, Nutr. Rev. 54 (12) (1996) 382–390.
[41] D. Benton, R. Cook, The impact of selenium supplementation on mood, Biol. Psychiatr. 29 (11) (1991) 1092–1098.
[42] D. Benton, Selenium intake, mood and other aspects of psychological functioning, Nutr. Neurosci. 5 (6) (2002) 363–374.
[43] W.N. Henley, T.J. Koehnle, Thyroid hormones and the treatment of depression: an examination of basic hormonal actions in the mature mammalian brain, Synapse 27 (1) (1997) 36–44.
[44] F. Saghafian, et al., Consumption of fruit and vegetables in relation with psychological disorders in Iranian adults, Eur. J. Nutr. 57 (6) (2018) 2295–2306.
[45] A. Tabrizi, et al., Prebiotics, as promising functional food to patients with psychological disorders: a review on mood disorders, sleep, and cognition, NeuroQuantology 17 (6) (2019).
[46] S.D. Khanzode, et al., Oxidative damage and major depression: the potential antioxidant action of selective serotonin re-uptake inhibitors, Redox Rep. 8 (6) (2003) 365–370.
[47] P. Cocchi, et al., Antidepressant effect of vitamin C, Pediatrics 65 (4) (1980) 862–863.
[48] J. Haller, et al., *Changes in the vitamin status of elderly Europeans: plasma vitamins A, E, B-6, B-12, folic acid and carotenoids. SENECA Investigators.* European journal of clinical nutrition 50 (1996) S32–S46.
[49] R.M. Ortega, et al., Dietary intake and cognitive function in a group of elderly people, Am. J. Clin. Nutr. 66 (4) (1997) 803–809.
[50] R. Goldsmith, Calcium metabolism under stress and in repose, Life Sci. Space Res. 10 (1972) 87–101.
[51] G.R. Najem, et al., Stressful life events and risk of symptomatic kidney stones, Int. J. Epidemiol. 26 (5) (1997) 1017–1023.
[52] P. Ferrari, et al., Modulation of renal calcium handling by 11β-hydroxysteroid dehydrogenase type 2, J. Am. Soc. Nephrol. 13 (10) (2002) 2540–2546.
[53] I. Reid, H. Ibbertson, Evidence for decreased tubular reabsorption of calcium in glucocorticoid-treated asthmatics, Hormone Research in Paediatrics 27 (4) (1987) 200–204.
[54] D. Armstrong, et al., Vitamin D deficiency is associated with anxiety and depression in fibromyalgia, Clin. Rheumatol. 26 (4) (2007) 551–554.
[55] W. Alam, B. Hollis, Vitamin D vs broad spectrum phototherapy in the treatment of seasonal affective disorder, J. Nutr. Health Aging 3 (1) (1999) 5–7.
[56] J. Dumville, et al., Can vitamin D supplementation prevent winter-time blues? A randomised trial among older women, J. Nutr. Health Aging 10 (2) (2006) 151.
[57] F. Vahid, et al., Association between index of nutritional quality and nonalcoholic fatty liver disease: the role of vitamin D and B group, Am. J. Med. Sci. 358 (3) (2019) 212–218.
[58] M. Shayanfar, et al., The Association between Index of Nutritional Quality (INQ) and Glioma and Evaluation of Nutrient Intakes of These Patients: A Case-Control Study, Nutr Cancer, 2017, pp. 1–8.
[59] F. Vahid, et al., The association between index of nutritional quality and ulcerative colitis: a case–control study, J. Res. Med. Sci. 23 (1) (2018), 67–67.