

Association between omega-6 and omega-3 fatty acids intake, body mass index and depression in young Iranian adults: a cross sectional study

Received: 12 April 2025

Accepted: 26 May 2026

Published online: 12 June 2026

Cite this article as: Naderlou H., Abedimanesh N., Mohiti S. *et al.* Association between omega-6 and omega-3 fatty acids intake, body mass index and depression in young Iranian adults: a cross sectional study. *J Health Popul Nutr* (2026). <https://doi.org/10.1186/s41043-026-01360-4>

Hasti Naderlou, Nasim Abedimanesh, Saba Mohiti, Mohammad Asghari-Jafarabadi, Mohammad Bager Torabi & Mehdi Khajevand

We are providing an unedited version of this manuscript to give early access to its findings. Before final publication, the manuscript will undergo further editing. Please note there may be errors present which affect the content, and all legal disclaimers apply.

If this paper is publishing under a Transparent Peer Review model then Peer Review reports will publish with the final article.

Title page**Association between omega-6 and omega-3 fatty acids intake, body mass index and depression in young Iranian adults: A cross sectional study**

Hasti Naderlou¹, Nasim Abedimanesh^{1,2*}, Saba Mohiti¹, Mohammad Asghari-Jafarabadi^{3,4}, Mohammad Bager Torabi¹, Mehdi Khajevand¹

¹ Student Research Committee, Zanzan University of Medical Sciences, Zanzan, Iran

²Department of Nutritional Sciences, School of Health, Zanzan University of Medical Sciences, Zanzan, Iran

³ Cabrini Research, Cabrini Health, VIC 3144, Australia

⁴ Department of Psychiatry, School of Clinical Medicine, Faculty of Medicine, Nursing and Health Sciences, Monash University, Clayton, VIC, 3168, Australia

Running title: Association between omega-3 consumption, BMI and depression

Corresponding author: Nasim Abedimanesh, PhD in Nutritional Sciences, School of Health, Zanzan University of Medical Sciences, Zanzan, Iran. Tel: +98-2433140288, E-mail: abedimanesh@zums.ac.ir

Association between omega-6 and omega-3 fatty acids intake, body mass index and depression in young Iranian adults: A cross sectional study

Abstract

Background Omega-3 polyunsaturated fatty acids (PUFAs) play important roles in cardiometabolic and mental health, and the dietary omega-6/omega-3 ratio has emerged as a key determinant of inflammatory and psychological outcomes. Despite generally low omega-3 intake in Iran, little is known about how dietary fatty acid patterns relate to mental health in young adults, who may be particularly vulnerable due to nutritional constraints and high rates of depressive symptoms. Moreover, prior studies in Iran have not simultaneously examined omega-3 intake, the omega-6/omega-3 ratio, BMI, and depressive symptoms within the same analytical framework.

Objective This cross-sectional study aims to investigate the associations between the intake of omega-6 and omega-3 fatty acids, the omega-6:3 ratio, body mass index, and depressive symptoms in young Iranian adults.

Methods Dietary data on omega-3 and omega-6 fatty acids were obtained through semi-quantitative food-frequency questionnaire (FFQ). The Beck Depression Inventory-II (BDI-II) was used to measure depressive symptom. We applied logistic regression to assess the relationships between variables.

Results A total of 440 university students aged 18–30 years were included. After adjustment for age, sex, and total energy intake, higher BMI was associated with greater odds of depressive symptoms (OR: 1.11; 95% CI: 1.04–1.20). Compared with the lowest quintile, participants in the highest quintile of omega-3 intake had lower odds of depressive symptoms (OR: 0.34; 95% CI: 0.17–0.71). In contrast, a higher omega-6/omega-3 ratio was

associated with greater odds of depressive symptoms, with nearly tenfold higher odds observed in the highest versus lowest quintile (OR: 9.94; 95% CI: 3.89–25.43).

Conclusion Higher omega-3 intake was associated with lower odds of depressive symptoms, whereas higher BMI and a greater omega-6/omega-3 ratio were associated with higher odds. These findings suggest that dietary fatty-acid balance and body weight may be relevant correlates of mental health in young adults. Prospective and interventional studies are needed to clarify causal relationships.

Key words

Omega-3, Omega-6, Food Intake, Food Frequency Questionnaire, Depression, Body Mass Index

Introduction

Omega-3 polyunsaturated fatty acids (PUFAs) have been widely studied for their beneficial effects on cardiometabolic health, inflammation-related diseases, pregnancy outcomes, and mental health [1-7]. These effects are largely attributed to long-chain PUFAs such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are predominantly obtained from marine sources [1, 7-9]. In addition to total omega-3 intake, the dietary ratio of omega-6 to omega-3 PUFAs has emerged as an important determinant of health; higher omega-6 intake relative to omega-3 may adversely affect inflammatory pathways and mental health [10, 11]. Plant-based omega-3

sources such as walnuts and flaxseed can help reduce this ratio, particularly in populations with low fish consumption [12].

Despite these well-recognized benefits, data on omega-3 intake among the Iranian population remain limited. Evidence suggests that most individuals worldwide, including Iranians, do not meet recommended intakes of long-chain omega-3 PUFAs [13]. This issue may be exacerbated by recent socioeconomic challenges in Iran, where rising food prices and restricted access to nutrient-dense foods have contributed to suboptimal dietary patterns [14]. Young adults, especially university students, may be particularly vulnerable to nutritional inadequacies due to limited financial resources and lifestyle constraints [15].

At the same time, university students experience high rates of psychological problems such as stress, anxiety, and depression, which negatively affect their academic performance and daily functioning [16, 17]. In Iran, the prevalence of depression among university students has been estimated at approximately 28% in males and 23% in females [18]. Depression is multifactorial, arising from the interaction of genetic, environmental, and lifestyle factors [19]. Nutrition is increasingly recognized as one such modifiable factor, with several studies demonstrating links between dietary quality, fatty acid intake, and mental health outcomes [20-25].

Another important consideration is the relationship between diet, obesity, and depression. Poor access to high-quality foods and sedentary behaviors

may promote weight gain, while obesity itself has been associated with an increased risk of depressive symptoms [26-29]. Emerging evidence also suggests a link between obesity and lower circulating omega-3 status, further emphasizing the interconnected roles of dietary fatty acids, body weight, and mental health [6, 28, 29].

Although several randomized controlled trials have evaluated the effects of omega-3 supplementation on depressive symptoms (including studies conducted in Iran) these interventions typically focus on clinical or overweight populations and do not examine habitual dietary intake patterns or the dietary omega-6/omega-3 ratio in relation to mental health [8, 30]. Moreover, existing observational studies rarely consider the concurrent roles of dietary fatty acid composition, BMI, and depressive symptoms within the same analytical framework. This multidimensional perspective is particularly relevant for university students, who may be simultaneously exposed to inadequate dietary omega-3 intake, unfavorable omega-6/omega-3 ratios, and weight gain associated with lifestyle changes. To our knowledge, no study in Iran has simultaneously examined these interrelated factors in a young adult, university-based population, highlighting the need for the present investigation.

Given these gaps, the present study aimed to evaluate dietary intakes of omega-3 and omega-6 fatty acids and the omega-6/omega-3 ratio among young Iranian university students and to investigate their associations with BMI and depressive symptoms assessed by the Beck Depression Inventory-II

(BDI-II). This integrated approach provides novel insight into how nutritional factors and body weight may interact with mental health in this vulnerable population.

Material and Methods

Subjects

Between June 2022 and April 2023, 473 students aged 18–34 years from Zanjan University of Medical Sciences were initially recruited for this cross-sectional study. To maintain consistency with the study, focus on young adults, participants older than 30 years ($n = 12$) were excluded. Additional exclusion criteria included pregnancy or lactation, diagnosis of major psychiatric disorders other than depression (e.g., bipolar disorder or schizophrenia), adherence to medically prescribed therapeutic diets, use of omega-3 or fish-oil supplements during the past three months, chronic inflammatory diseases, and incomplete questionnaire or anthropometric data. After excluding 21 participants with incomplete data, the final analytic sample consisted of 440 students aged 18–30 years.

To obtain a random sample, we used a multistage cluster random sampling method, taking into account all schools and departments of Zanjan University of Medical Sciences. We used a multistage cluster random sampling method to select participants [31]. In the first stage, all schools within Zanjan University of Medical Sciences (including Medicine, Nursing and Midwifery, Dentistry, Pharmacy, Health, and Paramedical Sciences) were treated as

primary clusters. A total of six clusters were defined based on these schools. In the second stage, two to three academic departments were randomly selected from each school using a simple random selection procedure. In the final stage, students within the selected departments were randomly drawn from updated enrollment lists using a random number table. The number of students recruited from each cluster was proportionate to the size of the school to ensure representativeness. This approach allowed us to obtain a diverse and unbiased sample of students across different academic disciplines and grades. All participants provided written informed consent to participate in the research. The investigations were conducted in accordance with the principles outlined in the Declaration of Helsinki. The present study was approved by the research council and ethical committee of Zanjan University of Medical Sciences, Zanjan, Iran. The research team, consisting of two trained researchers, conducted all study measurements, including anthropometric assessments and questionnaire administrations.

Sample size calculation

The sample size was estimated to detect a difference in the prevalence of depressive symptoms between participants with lower and higher omega-3 intake levels. Because no prior data were available for young Iranian adults, conservative prevalence estimates were informed by previously published observational studies reporting inverse associations between omega-3 intake and depression [22, 32]. Based on these assumptions, with a two-sided $\alpha = 0.05$ and 80% power, the minimum required sample size was calculated as

310 participants. To account for incomplete questionnaires, exclusions, and the multistage sampling design, a larger sample was recruited. The final study sample exceeded the minimum calculated size, thereby increasing statistical precision.

Dietary assessment

Dietary intake was assessed using a 168-item semi-quantitative food-frequency questionnaire (FFQ) that has been culturally adapted and validated for use in Iranian populations [33]. The FFQ captures habitual consumption of commonly consumed Iranian foods and includes detailed items covering major dietary sources of polyunsaturated fatty acids, including vegetable oils (sunflower, corn, soybean, canola), nuts and seeds (such as walnuts and mixed seeds), fish and seafood, legumes, and grains. The FFQ does not differentiate between specific fish species; therefore, total fish and seafood intake was analyzed as a combined food group. This instrument has demonstrated acceptable validity and reliability for estimating macronutrient and fatty-acid intake, including omega-3 and omega-6 PUFAs, when compared with multiple 24-hour dietary recalls and biomarker data [34]. In addition to macronutrient intakes, micronutrient data (including vitamins D, E, B6, B9, B12, zinc, iron, magnesium, calcium, and selenium) were also extracted from the FFQ and calculated using Nutritionist IV (First Databank, Hearst Corp, San Bruno, CA, USA), which incorporates a comprehensive database appropriate for Iranian diets. These data are provided in

Supplementary Table 1 to allow a more comprehensive assessment of the nutritional profile of the study population.

Additionally, to allow a more accurate analysis of the study findings and to examine the associations between variables more appropriately, information on the consumption of omega-3-rich foods (seafood and plant-based sources) was extracted for each participant from the FFQ. Although flaxseed is occasionally consumed in some modern dietary patterns, it is not a commonly used omega-3 source in Iran. The FFQ used in this study does not include flaxseed as a separate food item; however, it captures foods containing mixed seeds, in which small amounts of flaxseed may be present. We added clarification that total omega-3 intake was calculated as the sum of dietary omega-3 fatty acids estimated from the FFQ, with the majority likely contributed by plant sources.

Depressive Symptom Assessment

The Beck Depression Inventory-II (BDI-II) was used to predict depressive symptoms. The BDI-II consists of 21 items scored from 0 to 3, yielding a total score between 0 and 63. In line with standard classification, scores of 0–13 were considered minimal depression, 14–19 mild depression, 20–28 moderate depression, and 29–63 severe depression. Consistent with previous Iranian studies, we classified participants with a score of ≥ 14 as having depressive symptoms for analytical purposes. Higher scores reflect more severe depressive symptoms.

The Persian version of the BDI-II has demonstrated strong internal consistency, with a Cronbach's alpha of 0.87 in university student samples [35].

Other variables

Demographic information, including age, sex, marital status, field of study, academic grade, and native or non-native student status, was collected using a self-administered questionnaire. Clinical information such as history of chronic diseases and current medication use was also obtained. In addition, participants reported their use of antidepressant or antipsychotic medications, including nortriptyline, amitriptyline, imipramine, fluoxetine, citalopram, fluvoxamine, and sertraline. Data on the use of omega-3 supplements were collected; however, the number of users was very low, and no participant in the depressive-symptom group reported supplement intake. Due to this extremely low prevalence and the lack of dosage information, supplement use was not included as a covariate in the multivariable analyses. Participants were also asked whether they were currently following any special diet. This variable was recorded as 'yes' or 'no' using a self-administered questionnaire. The term special diet referred to any intentional dietary pattern adopted for health, weight management, medical, or personal reasons. Reported diets included low-calorie or weight-loss diets, vegetarian/plant-based diets, high-protein diets, and physician-recommended diets for conditions such as diabetes or gastrointestinal disorders. These diets were not specifically related to omega-3 or omega-6 intake. Participants

reporting any of these dietary patterns were classified as following a special diet. Anthropometric measurements were taken while participants were minimally clothed and in a non-fasting state, which is standard practice for BMI assessment. Weight was measured using a calibrated digital scale, and height was measured with a wall-mounted stadiometer. We calculated body mass index (BMI) as weight (kg) divided by height (m²). The study employed the short form of the International Physical Activity Questionnaire (IPAQ) to evaluate the physical activity levels of the participants. The Persian version of this questionnaire was previously validated and confirmed (Cronbach's alpha of 0.79) [36]. According to the questionnaire, physical activity levels of participants categorized to low, medium and high.

Statistical Analysis

Statistical analyses were performed using SPSS version 17 (SPSS Inc., Chicago, IL). Continuous variables are presented as mean $\pm$ standard deviation (SD) or median (interquartile range: 25th-75th percentile), depending on their distribution, while categorical variables are reported as frequency (percentage). Normality of continuous variables was assessed using the Kolmogorov-Smirnov test and visual inspection of histograms.

Between-group comparisons (depressive vs. non-depressive) were conducted using the independent samples t-test for normally distributed variables and the Mann-Whitney U test for non-normally distributed variables. The chi-square test was used to compare categorical variables.

Associations between participant characteristics, dietary intakes, and depressive symptoms were examined using logistic regression models. In the crude model, unadjusted odds ratios (ORs) were estimated. Model 1 was adjusted for age, sex, and total energy intake. Model 2 was further adjusted for body mass index (BMI), physical activity level, chronic disease status, and special dietary history to assess the robustness of the associations. Depressive symptoms were coded as a binary outcome (1 = presence, 0 = absence [reference]).

Dietary exposures were analyzed both as categorical variables (quintiles, with the lowest quintile as reference) and as continuous variables. Tests for linear trend (P-trend) across quintiles were performed by assigning the median value of each quintile and modeling this variable as continuous in regression analyses.

In addition, multivariable linear regression analyses were conducted using continuous Beck Depression Inventory-II (BDI-II) scores as the outcome variable to evaluate associations across the full distribution of depressive symptoms.

Multicollinearity among independent variables was assessed using variance inflation factors (VIFs) and tolerance statistics. To account for potential confounding by total energy intake, energy-adjusted nutrient intakes were calculated using the nutrient density method (nutrient intake divided by total

energy intake), and sensitivity analyses were performed using these adjusted variables.

A two-sided P value < 0.05 was considered statistically significant.

Results

Of the 473 students initially recruited, 440 participants aged 18–30 years with complete data were included in the final analyses. On the basis of the Beck II questionnaire, participants were classified as either normal or with depressive symptoms. Table 1 summarizes the baseline demographics, clinical and anthropometric characteristics measurements of the study population. People reporting depressive symptoms had higher body weight and BMI than healthy people. The number of students taking omega-3 supplements and/or following special diets also varied considerably. However, in terms of age, sex, marital status, number of native and non-native students, chronic disease status and physical activity, there were no significant differences between the two groups.

Table 1. General and clinical characteristics of normal and depressive symptom groups.

	Normal (n= 320)	Depressive Symptoms (n=120)	<i>p</i>-Value
Age (years)	21.82 ± 2.35	22.28 ± 1.89	0.057

Weight (kg)	67.58 ± 11.24	70.98 ± 13.79	0.017
BMI (kg/m ²)	22.99 ± 2.77	24.09 ± 3.69	0.004
Sex, n (%)			0.770
Male	155 (48.4)	60 (50)	
Female	165 (51.6)	60 (50)	
Marriage status, n (%)			0.777
Married	19 (5.9)	8 (6.7)	
Single	301 (94.1)	112 (93.3)	
Native students, n (%)			0.552
Yes	126 (39.4)	51 (42.5)	
No	194 (60.6)	69 (57.5)	
Chronic Disease, n (%)			0.440
Yes	20 (6.3)	10 (8.3)	
No	300 (93.8)	110 (91.7)	
Following a special diet, n (%)			0.015
Yes	8 (2.5)	9 (7.5)	
No	312 (97.5)	111 (92.5)	
Physical activity, n (%)			0.226
Low	52 (16.3)	28 (23.3)	
Moderate	235 (73.4)	80 (66.7)	
High	33 (10.3)	12 (10)	

Omega-3 supplements, n (%)			0.005
Yes	20 (6.3)	0 (0)	
No	300 (93.8)	120 (100)	
BMI: Body Mass Index Data are means $\pm$ standard deviation unless indicated; <i>P</i> - values are related to Student's t- test and/or chi-square test.			

Table 2 shows that the intake of total energy and all macronutrients was significantly higher in students with depressive symptoms than in those without, except for omega-3 PUFAs. The consumption of food groups commonly contributing to omega-3 intake in Iran, fish/seafood and plant-based sources, also did not differ significantly between the two groups.

When macronutrients were expressed as percentages of total energy intake, both groups demonstrated distributions within commonly accepted dietary ranges for carbohydrates, proteins, and fats. However, depressive participants had slightly higher percentages of energy from total fat, PUFAs, and omega-6 fatty acids, indicating a less favorable fatty-acid profile. Importantly, the macronutrient and fatty-acid contributions to total energy were within physiologically plausible ranges, supporting the validity of the dietary data and confirming their suitability for subsequent statistical analyses.

Table 2. Dietary intakes of normal and depressive symptom groups.*

		Normal (n= 320)	Depressive Symptoms (n=120)	p-Value
Energy (kcal)		2088.49 ± 304.62	2293.78 ± 342.98	<0.001
Carbohydrate	(g)	273.61 ± 42.45	296.91 ± 50.58	<0.001
	(% energy)	52.39 ± 2.53	51.66 ± 2.46	0.007
Protein	(g)	75.77 ± 14.34	83.21 ± 15.34	<0.001
	(% energy)	14.52 ± 1.76	14.54 ± 1.80	0.892
Fat	(g)	76.77 ± 12.84	85.92 ± 13.09	<0.001
	(% energy)	33.09 ± 2.81	33.80 ± 2.65	0.017
SFAs	(g)	25.80 ± 4.67	28.24 ± 5.62	<0.001
	(% energy)	11.16 ± 1.43	11.11 ± 1.50	0.728
MUFAs	(g)	23.61 ± 3.12	24.73 ± 3.30	0.002
	(% energy)	10.27 ± 1.27	9.80 ± 1.25	0.001
PUFAs	(g)	27.36 ± 8.47	32.95 ± 7.97	<0.001
	(% energy)	11.66 ± 2.73	12.89 ± 2.32	<0.001
Omega-6 PUFAs	(g)	21.54 ± 8.29	27.05 ± 7.62	<0.001
	(% energy)	9.12 ± 2.88	10.56 ± 2.33	<0.001
Omega-3 PUFAs	(g)	2.65 ± 0.95	2.54 ± 1.11	0.373
	(% energy)	1.15 ± 0.41	1.01 ± 0.42	0.001
Omega-6 to Omega-3 ratio		8.55 ± 3.38	11.85 ± 4.42	<0.001
Dietary Sources rich				

in omega-3 PUFAs**			
Fish & Seafood (g)	6 (0.99-24.14)	4.08 (0.66-19.07)	0.053
Plant-based Foods (g)	4.71 (1.15-31.0)	4.89 (1.71-11.80)	0.495
SFA; Saturated Fatty Acids, MUFA; Mono Unsaturated Fatty Acids, PUFA; Poly Unsaturated Fatty Acids. * Mean $\pm$ SD is reported, **Median (25-75 percentiles) is reported. <i>P</i> -values are related to independent-samples T test or nonparametric Mann-Whitney test.			

Based on international dietary recommendations, participants' mean omega-3 intake (2.5–2.6 g/day, primarily from ALA) was well below suggested intakes for long-chain EPA and DHA, which generally range from 250 to 500 mg/day. We now state that the observed omega-3 intake should be interpreted mainly as total omega-3 intake, predominantly ALA, due to very low fish and seafood consumption. Although total omega-6 intake ($\approx$ 22–27 g/day) fell within or slightly above recommended ranges (5–10% of total energy), the resulting omega-6/omega-3 ratio was considerably higher than the commonly suggested range of 1:1 to 4:1. These findings indicate that while overall PUFA consumption was adequate, the qualitative fatty acid composition was imbalanced, with insufficient dietary omega-3 relative to omega-6 [31].

Micronutrient intakes derived from the FFQ are presented in Supplementary Table 1. These values provide additional context regarding the overall nutritional status of the participants.

Married	Refere nt	.....	.....	.....	Refere nt	.....	.....	.....
Single	0.884	0.38	2.08	0.777	1.276	0.47	3.47	0.632
Native students								
Yes	Refere nt	.....	.....	.....	Refere nt	.....	.....	.....
No	0.879	0.57	1.34	0.552	0.890	0.58	1.37	0.598
Chronic Disease								
Yes	Refere nt	.....	.....	.....	Refere nt	.....	.....	.....
No	0.733	0.33	1.62	0.442	0.678	0.31	1.53	0.361
Physical activity								
Low	Refere nt	.....	.....	.....	Refere nt	.....	.....	.....
Moderate	0.632	0.37	1.07	0.087	0.624	0.37	1.06	0.081
High	0.675	0.30	1.51	0.339	0.661	0.29	1.49	0.318
Special dietary history								
Yes	Refere nt	.....	.....	.....	Refere nt	.....	.....	.....

No	0.316	0.12	0.84	0.021	0.349	0.130	0.940	0.037
Weight	1.023	1.01	1.04	0.009	1.032	1.01	1.05	0.005
BMI	1.123	1.05	1.20	0.001	1.114	1.04	1.20	0.003
Energy	1.002	1.001	1.00	<0.00	1.003	1.001	1.004	<0.001
			3	1				
Carbohydrate	1.011	1.00	1.02	<0.00	0.976	0.96	0.99	0.004
				1				
Protein	1.034	1.02	1.05	<0.00	1.001	0.98	1.02	0.937
				1				
Fat	1.054	1.04	1.07	<0.00	1.045	1.01	1.08	0.010
				1				
SFA	1.095	1.05	1.14	<0.00	0.966	0.90	1.03	0.301
				1				
MUFA	1.113	1.04	1.19	0.001	0.921	0.84	1.01	0.094
PUFA	1.081	1.05	1.11	<0.00	1.035	0.99	1.08	0.135
				1				
BMI: Body mass index, SFA: Saturated fatty acid, MUFA: Monounsaturated fatty acid, PUFA: Polyunsaturated fatty acid								

Unadjusted and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) for depressive symptoms according to quintiles of total dietary omega-3 fatty acids, omega-6/omega-3 ratio, fish and seafood intake, and plant-based sources of omega-3 are presented in Table 4 and Table S2.

In multivariable logistic regression analyses, students in the third, fourth, and fifth quintiles of total omega-3 intake had 59%, 66%, and 64% lower odds of depressive symptoms, respectively, compared with those in the lowest quintile, after adjustment for total energy intake and sex. In contrast, a higher omega-6/omega-3 ratio was associated with greater odds of depressive symptoms. Participants in the highest quintile of the omega-6/omega-3 ratio had approximately 8.9-fold higher odds of depressive symptoms compared with those in the lowest quintile. These associations remained statistically significant after further adjustment for BMI, physical activity level, chronic disease status, and special dietary history.

A significant positive trend was observed across increasing quintiles of the omega-6/omega-3 ratio ($P\text{-trend} < 0.001$), whereas an inverse trend was found for omega-3 intake ($P\text{-trend} = 0.003$). In continuous-variable analyses, each 1-unit increase in the omega-6/omega-3 ratio was associated with higher odds of depressive symptoms (OR: 1.21; 95% CI: 1.13–1.29; $P < 0.001$), while each 1 g/day increase in total omega-3 intake was associated with lower odds (OR: 0.77; 95% CI: 0.61–0.98; $P = 0.033$). Restricted cubic spline analysis confirmed a significant positive association between the omega-6/omega-3 ratio and depressive symptoms ($P\text{-overall} < 0.001$), with no evidence of non-linearity ($P\text{-nonlinearity} = 0.545$). No evidence of problematic multicollinearity was observed among model covariates (all VIF values < 3.0).

In secondary analyses using continuous BDI-II scores, a higher omega-6/omega-3 ratio was significantly associated with greater depressive

symptom severity ($\beta = 1.046$; 95% CI: 0.811–1.281; $P < 0.001$), whereas total omega-3 intake was not significantly associated with BDI-II scores. BMI showed an inverse association with depressive symptom scores in the fully adjusted model (Table S3).

Sensitivity analyses using energy-adjusted omega-3 intake yielded similar findings. The association between the omega-6/omega-3 ratio and depressive symptoms remained statistically significant (OR: 1.32; 95% CI: 1.21–1.45; $P < 0.001$), whereas the association for omega-3 intake was attenuated and did not reach statistical significance ($P = 0.060$), although the direction of association remained consistent (Table S4).

Discussion

In this cross-sectional study of young Iranian university students, higher BMI and a higher dietary omega-6/omega-3 ratio were associated with greater odds of depressive symptoms, whereas higher omega-3 intake was associated with lower odds across intake quintiles. However, mean omega-3 intake did not differ between participants with and without depressive symptoms. Together, these findings suggest that both body weight status and overall dietary fatty-acid balance may be relevant correlates of mental health in young adults.

The positive association between BMI and depressive symptoms is consistent with previous studies in Iranian and international populations [37–41]. This relationship is likely bidirectional and multifactorial. Excess adiposity has

been linked to chronic low-grade inflammation, metabolic dysregulation, and alterations in neuroendocrine function, which may contribute to depressive symptoms [42-44]. Conversely, depression may promote weight gain through behavioral pathways such as reduced physical activity and changes in eating patterns. These mechanisms may help explain the observed association, although causal direction cannot be determined in the present study.

A key finding was the strong and consistent association between the omega-6/omega-3 ratio and depressive symptoms. Participants with depressive symptoms had a less favorable fatty-acid profile, characterized by relatively higher omega-6 intake in relation to omega-3. Similar associations have been reported across diverse populations [10, 11, 45]. One possible explanation is that an imbalance favoring omega-6 fatty acids may contribute to a more pro-inflammatory state, whereas omega-3 fatty acids are involved in anti-inflammatory and regulatory pathways [12, 46]. In this context, our findings support the relevance of overall fatty-acid balance, rather than absolute intake alone, in relation to depressive symptoms.

In contrast, mean total omega-3 intake did not differ between groups. This may be explained by the relatively low and homogeneous intake in this population. Although mean omega-3 intake was approximately 2.6 g/day, it was largely derived from plant-based alpha-linolenic acid (ALA), while fish and seafood consumption was minimal. Because conversion of ALA to the biologically active long-chain fatty acids EPA and DHA is limited, these findings should be interpreted as reflecting total dietary omega-3 intake,

primarily plant-derived, rather than direct intake of marine long-chain omega-3 fatty acids.

Notably, despite the lack of mean differences, quintile-based analyses showed lower odds of depressive symptoms among participants with higher omega-3 intake. This suggests that the association may not be fully captured by simple group comparisons and may instead reflect a threshold or graded relationship across the intake distribution. The absence of a significant association in linear regression models using continuous BDI-II scores further supports a potential non-linear relationship rather than a uniform dose-response pattern.

The differences observed between logistic and linear regression analyses likely reflect the distinct outcomes assessed. Logistic regression evaluated the presence of depressive symptoms based on a predefined cutoff, whereas linear regression assessed symptom severity across the full distribution. Similarly, the inverse association observed between BMI and continuous BDI-II scores contrasts with the positive association in logistic models. This discrepancy may reflect differences in model specification, potential over-adjustment, or shared variance with dietary variables, and should therefore be interpreted with caution.

Importantly, the association between the omega-6/omega-3 ratio and depressive symptoms remained consistent across all analytical approaches, including categorical, continuous, and energy-adjusted models. In sensitivity

analyses using energy-adjusted nutrient intakes, the omega-6/omega-3 ratio remained significantly associated with depressive symptoms, whereas the association for omega-3 intake was attenuated. These findings strengthen the evidence that overall fatty-acid balance may be more relevant than absolute omega-3 intake alone, particularly in populations with low intake of marine-derived omega-3 fatty acids.

This study has several strengths, including the simultaneous assessment of omega-3 intake, omega-6/omega-3 ratio, and BMI, as well as the use of validated instruments for dietary intake, depressive symptoms, and physical activity. However, several limitations should be considered. The cross-sectional design precludes causal inference, and reverse causation cannot be excluded; individuals with depressive symptoms may adopt poorer dietary habits. Dietary intake was self-reported and subject to recall bias, and residual confounding by unmeasured factors such as socioeconomic status, sleep quality, and stress is possible. In addition, the study population consisted of medical sciences students, which may limit generalizability to other groups of young adults.

Conclusion

In this cross-sectional study of young Iranian adults, higher BMI and a higher dietary omega-6/omega-3 ratio were associated with greater odds of depressive symptoms, whereas higher omega-3 intake was associated with lower odds across intake quintiles. Although mean omega-3 intake did not

differ between participants with and without depressive symptoms, the findings suggest that variations in habitual omega-3 intake across the distribution may still be relevant. The absence of associations for specific dietary sources of omega-3 further indicates that overall fatty-acid balance, rather than individual food groups, may be more closely related to depressive symptoms in this population.

These results highlight dietary fatty-acid composition and body weight as potential modifiable correlates of mental health in young adults. Given the generally low intake of marine-derived omega-3 fatty acids in this population, improving the omega-6/omega-3 balance may be of particular relevance. However, due to the cross-sectional design, causal relationships cannot be established. Further longitudinal and interventional studies are needed to clarify temporal relationships and inform evidence-based prevention strategies.

List of abbreviations

ALA Alpha-linolenic acid

BMI Body Mass index

CI Confidence Interval

DHA Docosahexaenoic Acid

EPA Eicosapentaenoic acid

FFQ Food Frequency Questionnaire

IPAQ International Physical Activity Questionnaire

LC-PUFA Long-chain Poly Unsaturated Fatty Acid

MUFA Mono Unsaturated Fatty Acid

OR Odds Ratio

PUFA Poly Unsaturated Fatty Acid

Acknowledgement

The authors would like to thank all the participants of present study. We also thank Student Research Committee, Zanjan University of Medical Sciences, Zanjan, Iran for financial support of this study.

Availability of data and materials

All data of present study are available from the corresponding author on reasonable request.

Funding

This work was supported by Student Research Committee, Zanjan University of Medical Sciences, Zanjan, Iran (A-12-1264-2).

Ethics approval and consent to participate

All procedures were according to the Ethics Committee of Zanjan University of Medical Sciences (IR.ZUMS.REC.1401.100). All participants provided written informed consent to participate in the research.

Competing interests

The authors declare no potential conflict of interest.

Consent for publication

No personal data is noted herein.

Authors' contributions

H.N., S.M., MB. T. and M.KH were involved in data collection and performance of experiment. N.A. contributed in conceptualization, methodology, editing, supervision and project administration. M.AJ. was contributed in statistical analysis

References:

1. Rimm EB, Appel LJ, Chiuve SE, Djoussé L, Engler MB, Kris-Etherton PM, Mozaffarian D, Siscovick DS, Lichtenstein AH. Seafood long-chain n-3 polyunsaturated fatty acids and cardiovascular disease: a science advisory from the American Heart Association. *Circulation*. 2018; 138:e35-e47.
2. Thota RN, Ferguson JJ, Abbott KA, Dias CB, Garg ML. Science behind the cardio-metabolic benefits of omega-3 polyunsaturated fatty acids: biochemical effects vs. clinical outcomes. *Food & func*. 2018; 9:3576-96.
3. Larqué E, Gil-Sánchez A, Prieto-Sánchez MT, Koletzko B. Omega 3 fatty acids, gestation and pregnancy outcomes. *Br J Nutr*. 2012; 107:S77-S84.
4. Bourre J. Roles of unsaturated fatty acids (especially omega-3 fatty acids) in the brain at various ages and during ageing. *J Nutr*. 2004; 8:163-74.
5. Park S-J, Lee D-K, Kim B, Na K-S, Lee C-H, Son Y-D, Lee H-J. The association between omega-3 fatty acid intake and human brain connectivity in middle-aged depressed women. *Nutrients*. 2020; 12:2191.
6. Young IE, Parker HM, Cook RL, O'dwyer NJ, Garg ML, Steinbeck KS, Cheng HL, Donges C, Franklin JL, O'connor HT. Association between obesity and omega-3 status in healthy young women. *Nutrients*. 2020; 12:1480.
7. Rajaei E, Mowla K, Ghorbani A, Bahadoram S, Bahadoram M, Dargahi-Malamir M. The effect of omega-3 fatty acids in patients with active rheumatoid arthritis receiving DMARDs therapy: double-blind randomized controlled trial. *Glob J Health Sci*. 2016; 8:18.
8. Van der Wurff I, Von Schacky C, Bergeland T, Leontjevas R, Zeegers MP, Kirschner P, de Groot R. Effect of one year krill oil supplementation on

- depressive symptoms and self-esteem of Dutch adolescents: A randomized controlled trial. *Prostaglandins Leukot Essent Fatty Acids*. 2020; 163:102208.
9. Zárata R, el Jaber-Vazdekis N, Tejera N, Pérez JA, Rodríguez C. Significance of long chain polyunsaturated fatty acids in human health. *Clin Transl Med*. 2017; 6:1-19.
 10. Berger M, Smesny S, Kim S, Davey C, Rice S, Sarnyai Z, Schlögelhofer M, Schäfer M, Berk M, McGorry P. Omega-6 to omega-3 polyunsaturated fatty acid ratio and subsequent mood disorders in young people with at-risk mental states: a 7-year longitudinal study. *Transl Psychiatry*. 2017; 7:e1220-e.
 11. Husted KS, Bouzinova EV. The importance of n-6/n-3 fatty acids ratio in the major depressive disorder. *Medicina*. 2016; 52:139-47.
 12. Simopoulos AP. An increase in the omega-6/omega-3 fatty acid ratio increases the risk for obesity. *Nutrients*. 2016; 8:128.
 13. Meyer B. Are we consuming enough long chain omega-3 polyunsaturated fatty acids for optimal health? *Prostaglandins Leukot Essent Fatty Acids*. 2011; 85:275-80.
 14. Rodríguez F. The human consequences of economic sanctions. *J Econ Stud*. 2024; 51:942-63.
 15. Shi Y, Davies A, Allman-Farinelli M. The association between food insecurity and dietary outcomes in university students: a systematic review. *J Acad Nutr Diet*. 2021; 121:2475-500. e1.
 16. Mahdavinoor SMM, Moghimi B, Mollaei A, Teimouri M, Abedi Yarandi MS, Loveneh Nasab P, Rafiee MH. Prevalence and factors related with depression in Iranian university students: a large sample cross-sectional study. *Middle East curr psychiatry*. 2025; 32:24.
 17. Ibrahim AK, Kelly SJ, Adams CE, Glazebrook C. A systematic review of studies of depression prevalence in university students. *J Psychiatr Res*. 2013; 47:391-400.
 18. S Sarokhani D, Delpisheh A, Veisani Y, Sarokhani MT, Manesh RE, Sayehmiri K. Prevalence of depression among university students: a systematic review and meta-analysis study. *Depress res treat*. 2013; 2013.
 19. Saveanu RV, Nemeroff CB. Etiology of depression: genetic and environmental factors. *Psychiatry Clin*. 2012; 35:51-71.

20. Sangsefidi ZS, Mirzaei M, Hosseinzadeh M. The relation between dietary intakes and psychological disorders in Iranian adults: a population-based study. *BMC psychiatry*. 2020; 20:1-9.
21. Anjom-Shoae J, Sadeghi O, Keshteli AH, Afshar H, Esmailzadeh A, Adibi P. The association between dietary intake of magnesium and psychiatric disorders among Iranian adults: a cross-sectional study. *Br J Nutr*. 2018; 120:693-702.
22. Suominen-Taipale AL, Partonen T, Turunen AW, Männistö S, Jula A, Verkasalo PK. Fish consumption and omega-3 polyunsaturated fatty acids in relation to depressive episodes: a cross-sectional analysis. *PLoS One*. 2010; 5:e10530.
23. Murakami K, Miyake Y, Sasaki S, Tanaka K, Arakawa M. Fish and n-3 polyunsaturated fatty acid intake and depressive symptoms: Ryukyus Child Health Study. *Pediatrics*. 2010; 126:e623-e30.
24. Sanchez-Villegas A, Henríquez P, Figueiras A, Ortuño F, Lahortiga F, Martínez-González MA. Long chain omega-3 fatty acids intake, fish consumption and mental disorders in the SUN cohort study. *Eur J Nutr*. 2007; 46:337-46.
25. Li F, Liu X, Zhang D. Fish consumption and risk of depression: a meta-analysis. *J Epidemiol Community Health*. 2016; 70:299-304.
26. Carey M, Small H, Yoong SL, Boyes A, Bisquera A, Sanson-Fisher R. Prevalence of comorbid depression and obesity in general practice: a cross-sectional survey. *Br J Gen Pract*. 2014; 64:e122-e7.
27. De Wit L, Luppino F, van Straten A, Penninx B, Zitman F, Cuijpers P. Depression and obesity: a meta-analysis of community-based studies. *Psychiatry res*. 2010; 178:230-5.
28. Micallef M, Munro I, Phang M, Garg M. Plasma n-3 polyunsaturated fatty acids are negatively associated with obesity. *Br J Nutr*. 2009; 102:1370-4.
29. Mingay E, Veysey M, Lucock M, Niblett S, King K, Patterson A, Garg M. Sex-dependent association between omega-3 index and body weight status in older Australians. *J Nutr Intermed*. 2016; 5:70-7.
30. Keshavarz SA, Mostafavi SA, Akhondzadeh S, Mohammadi MR, Hosseini S, Eshraghian MR, Chamari M. Omega-3 supplementation effects on body weight and depression among dieter women with co-morbidity of depression and obesity compared with the placebo: A randomized clinical trial. *Clin Nutr ESPEN*. 2018; 25:37-43.

31. Addis Z, Yalew A, Shiferaw Y, Alemu A, Birhan W, Mathewose B, Tachebele B. Knowledge, attitude and practice towards voluntary counseling and testing among university students in North West Ethiopia: a cross sectional study. *BMC public health*. 2013; 13:714.
32. Hoffmire CA, Block RC, Thevenet-Morrison K, van Wijngaarden E. Associations between omega-3 poly-unsaturated fatty acids from fish consumption and severity of depressive symptoms: an analysis of the 2005–2008 National Health and Nutrition Examination Survey. *Prostaglandins, leukotrienes and essential fatty acids*. 2012; 86:155-60.
33. Mirmiran P, Esfahani FH, Mehrabi Y, Hedayati M, Azizi F. Reliability and relative validity of an FFQ for nutrients in the Tehran lipid and glucose study. *Public Health Nutr*. 2010; 13:654-62.
34. Bahadorpour S, Hajhashemy Z, Mohammadi S, Mokhtari E, Heidari Z, Saneei P. Total fat and omega-3 fatty acids intake in relation to serum brain-derived neurotrophic factor (BDNF) levels and psychological disorders in Iranian adults. *Sci Rep*. 2023; 13:5392.
35. Rahimi C. Application of the beck depression inventory-II in Iranian University students. *Clinical Psychology and Personality*. 2014; 12:173-88.
36. Moghaddam MB, Aghdam FB, Jafarabadi MA, Allahverdipour H, Nikookheslat SD, Safarpour S. The Iranian Version of International Physical Activity Questionnaire (IPAQ) in Iran: content and construct validity, factor structure, internal consistency and stability. *World Appl Sci J*. 2012; 18:1073-80.
37. Blasco BV, García-Jiménez J, Bodoano I, Gutiérrez-Rojas L. Obesity and depression: Its prevalence and influence as a prognostic factor: A systematic review. *Psychiatry Investig*. 2020; 17:715.
38. Tashakori A, Riahi F, Mohammadpour A. The relationship between body mass index and depression among high school girls in Ahvaz. *Adv med*. 2016; 2016.
39. Romain K, Webb T, Kumar M. Depression and obesity: can the cycle be broken? *BJPsych advances*. 2018; 24:132-40.
40. Heidari-Beni M, Azizi-Soleiman F, Afshar H, Khosravi-Boroujeni H, Keshteli AH, Esmailzadeh A, Adibi P. Relationship between obesity and depression, anxiety and psychological distress among Iranian health-care staff. *East Mediterr Health J*. 2021; 27:327-35.

41. Rabiei S, Tabesh MR, Jahromi SR, Abolhasani M. The association between depression, obesity and body composition in Iranian women. *Clin Nutr Open Sci.* 2023; 47:44-52.
42. Miller AH, Raison CL. The role of inflammation in depression: from evolutionary imperative to modern treatment target. *Nat Rev Immunol.* 2016; 16:22-34.
43. Stetler C, Miller GE. Depression and hypothalamic-pituitary-adrenal activation: a quantitative summary of four decades of research. *Biopsychosoc Med.* 2011; 73:114-26.
44. Dallman MF. Stress-induced obesity and the emotional nervous system. *Trends Endocrinol Metab.* 2010; 21:159-65.
45. Zhang R, Sun J, Li Y, Zhang D. Associations of n-3, n-6 fatty acids intakes and n-6: n-3 ratio with the risk of depressive symptoms: NHANES 2009-2016. *Nutrients.* 2020; 12:240.
46. Calder PC. Omega-3 fatty acids and inflammatory processes: from molecules to man. *Biochem Soc Trans.* 2017; 45:1105-15.