Journal of Nutrition and Food Security
Shahid Sadoughi University of Medical Sciences
School of Public Health
Department of Nutrition

Shahid Sadoughi University of Medical Sciences School of Public Health Nutrition Department

eISSN: 2476-7425 pISSN: 2476-7417 JNFS 2024; 9(3): 496-507 Website: jnfs.ssu.ac.ir

Exploring the Interaction between Major Dietary Patterns and Overweight/Obesity Status in Relation to the Chance of Anxiety among Iranian Population: A YaHS-TAMYZ study

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ARTICLE INFO

ORIGINAL ARTICLE

Article history:
Received:14 Oct 2023
Revised:7 Nov 2023
Accepted: 7 Nov 2023

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ABSTRACT

Background: Anxiety is one of the most prevalent mental illnesses globally. While there are long-established, separate, and bidirectional connections between nutrition, excess body weight, and anxiety, it is still unclear how these variables interact and affect anxiety state. The aim of the current investigation was to determine whether there was a significant interaction between major dietary patterns (DPs) and overweight/obesity status in relation to the chance of anxiety among Iranian individuals in Yazd, Iran. **Methods:** This cross-sectional study was conducted on baseline data of a large Iranian cohort study (Yazd Health Study: YaHS-TAMYZ). Dietary intakes were collected via a validated food frequency questionnaire. Major DPs were identified by principal component analysis (PCA). Then, body weight was assessed via an accurate body analyzer. Anxiety score was also evaluated using the validated scale-21 (DASS-21) questionnaire. Finally, the interaction between DPs and overweight/obesity in relation to the odds of anxiety was assessed using a multivariable adjusted binary logistic regression. **Results:** In total, 5781 participants were included in the present investigation. Individuals with the highest adherence to "high animal protein" DP and with overweight/obesity state had significantly lower odds of anxiety compared to those with the lowest imitation and normal body weight (P for interaction: 0.03). **Conclusion:** Findings of the current study revealed that the “high animal protein” DP may be inversely linked to the lower chance of anxiety in participants with overweight/obesity. Yet, further long-term prospective investigations are required to confirm the results.

Keywords: *Diet; Anxiety; Body mass index; Health; Nutritional sciences.*

Introduction

Anxiety disorder is recognized as a serious neuropsychiatric condition (Zou *et al.*, 2023), which is defined as the “experience of worry, apprehension, or nervousness in association with

This paper should be cited as: Parastouei K, Salehi-Abargouei A, Rahmati-Najarkolaei F, Nadjarzadeh A, Mirzaei M. ***Exploring the Interaction between Major Dietary Patterns and Overweight/Obesity Status in Relation to the Chance of Anxiety among Iranian Population: A YaHS-TAMYZ study.*** *Journal of Nutrition and Food Security (JNFS)*, 2024; 9(3): 496-507.

[DOI: 10.18502/jnfs.v9i3.16159]

physical, cognitive, and behavioural symptoms" (Aucoin *et al.*, 2021). The prevalence of anxiety has been estimated about 4% (301.4 million people) worldwide (Collaborators, 2022). Moreover, previous epidemiological studies have indicated that approximately 15.6% of Iranian population are suffering from symptoms of this mental ailment (Hajebi *et al.*, 2018). In the absence of timely treatment, anxiety would be accompanied by reduced functioning along with higher burden of social costs (Gallagher *et al.*, 2023, O'Connor *et al.*, 2023), enhanced suicide risks (Moitra *et al.*, 2021), chronic illnesses such as cardiovascular disease (CVD) (Kyrou *et al.*, 2017), diabetes (Smith *et al.*, 2013), gastrointestinal system impairment (Mayer *et al.*, 2001), elevated body inflammation level (Olafiranye *et al.*, 2011), body weight imbalance, and altered eating behavior (Braden *et al.*, 2023). The bidirectional association between dietary food intake and psychological disorders has been investigated extensively (Bakhtiyari *et al.*, 2013, Weng *et al.*, 2012). In 2019, a study by Sadeghi (Sadeghi *et al.*, 2021) reported a negative connection between imitation level of the Mediterranean dietary pattern and the odds of anxiety, depression, and stress status. Similarly, a reduced risk of psychological disorders was detected regarding the higher adherence to a "low-fat diet" in both genders (Le Port *et al.*, 2012). However, the adverse effect of a "western diet" on anxiety score has been suggested in Norwegian adults (Jacka *et al.*, 2011). In addition, high intakes of chocolate and confectionery, butter, high-fat cheese, added sugars, together with poor consumption of dietary fiber, have all been documented to have links with the elevated risk of anxiety indicators (Chen *et al.*, 2023). Hence, the potential effects of diet as a lifestyle modifiable factor on mental well-being and cognitive function will justify the necessity of research in this scientific field (Saha *et al.*, 2023).

On the other hand, it has also been proposed that there is a mutual connection between the features of overweight/obesity and psychological ailments (Godina-Flores *et al.*, 2023). A growing body of evidence revealed that overweight/obesity status is associated with a multitude of structural and functional alterations in central nervous system which is strikingly comparable to the symptoms observed in mental health disorders. The aforementioned modifications include region-specific elevations in proliferation of cells, hampered neuronal connection, and responsiveness (Opel *et al.*, 2021). Furthermore, it has been documented that excessive accumulation of fat in the body can result in several physiological and psychological health issues including diabetes, CVD, impaired mobility due to lower physical activity (PA), and reduced self-esteem and body satisfaction, all of which may be involved in anxiety state and decrease quality of life (Moradi *et al.*, 2021, Riquelme *et al.*, 2021, Taylor Jr *et al.*, 2014). Moreover, it has been suggested that a cycle of psychological concerns, hopelessness, overeating, and lack of exercise may boost the severity of obesity (Fulton *et al.*, 2022).

While earlier investigations have shown the separate bidirectional relations between dietary food intake, overweight/obesity, and anxiety, whether there is an interaction between these variables regarding anxiety is still unclear. Therefore, the present study aims to investigate the possible interaction between major DPs and overweight/obesity in relation to the odds of anxiety among Iranian population.

Materials and Methods

Study participants

The present cross-sectional study was conducted on the baseline data of 9962 individuals, aged 20-70, who were enrolled in two large cohort investigations in Yazd, Iran (Yazd Health Study (YaHS) and Taghzieh Mardom Yazd (TAMYZ)). The YaHS-TAMYZ study's methodology is covered in detail in another publication (Mirzaei *et al.*, 2018). The exclusion criteria were not answering to more than 70 FFQ items (n=850), incomprehensible intake of energy (<800 kcal/d or >6000 kcal/d) (n=864), missing body mass index (BMI) data (n=202) and BMI ≤ 18.49 (n=351), pregnancy (n=104), medication treatment for psychological disorders (n=91), and having an

[DOI: 10.18502/jnfs.v9i3.16159]

established history of chronic diseases including cardiovascular disease, diabetes, and cancer (n=1719).

Dietary intake assessment

All the data regarding the participants' dietary intake were gathered by skilled interviewers via an Iranian validated food frequency questionnaire (FFQ) (Zimorovat *et al.*, 2022) . Subjects were asked to indicate: a) the typical frequency of their consumption of each food item over the previous year by selecting an appropriate response from a list of ten alternatives ranging from "never or less than once per month" to "10 or more times per day", and b) a general portion size for each food item according to five options of Iranians' typical serving sizes. All the research participants completed an extra multiple-choice questionnaire addressing the consumption frequency of the specific supplements (i.e., vitamin D, calcium, iron, folic acid, fish oil (or omega-3), and multivitamin-minerals). Then, the total collected information was converted to g/day by Iranian household measures (Ghaffarpour *et al.*, 1999). Then, the United States Department of Agriculture food composition database was used to assess energy and nutrient intakes (Bodner-Montville *et al.*, 2006). In order to analyze the study DPs, all food items were subsequently merged into 31 food groups, which were determined based on similarities in their nutritional profiles and culinary applications (**Table 1**).

Table 1. Food grouping used for factor analysis in the YaHS-TAMYZ studies.

Food groups	Food items
Red meat	Lamb, beef, kebab
Processed meat	Sausages, hamburgers
Organ meat	Beef liver, Lamb organ (tongue, tripe, head and trotters, brain, foot, abomasum)
Fish	Fish
Canned fish	Canned fish
Poultry	Chicken with skin, chicken without skin, chicken with or without skin (liver, heart, gizzard)
Eggs	Eggs
Solid fats	Butter, margarine, hydrogenated fats, animal fats
Dairy products	milk, yogurt, cheese, curd, icecream, flavored milk, chocolate milk, coffee milk, honey milk, cream
Fruits	pears, apricots, cherries, apples, grapes, bananas, cantaloupe, melons, watermelon, kiwi, Strawberries, peaches, mulberries, plums, persimmons, pomegranates, figs, dates, greengages, sour cherries, pineapples, citrus fruits (oranges, tangerines, grapefruits, lemons), all types of canned fruit (canned pineapple, other canned fruits), all types of natural fruit juices (apple juice, orange juice, grapefruit juice, cantaloupe juice, other fruit juices)
Dried fruits	dried figs, dried mulberries, raisins, dried plums, dried apricots, dried peaches, other dried fruits
Vegetables	cucumbers, cabbage, cauliflower, brussels sprouts, kale, carrots (row or boiled), squash, spinach, lettuce, mixed vegetables (raw or cooked), eggplants, celery, kohlrabi, green peas, green beans, turnips, corn, mushrooms, onions, beets, beet roots, artichokes, bell peppers, pepper, tomatoes, tomato paste
Legumes	beans, peas, lima beans, broad beans, lentils, soy, split peas, mung beans
Potatoes	Potatoes
French fries	French fries
Whole grains	Iranian dark bread (sangak, taftoon, barbari), local bread (korno, tanoori), wheat germ, oatmeal, barley, bulgur, whole grain biscuit (saghe talaee)
Refined grains	White bread (lavash, baguettes), noodles, pasta, rice, biscuits and wafers
Pizza	Pizza
Snacks	Potato chips, corn puffs
Nuts	Peanuts, almonds, pistachios, hazelnuts, walnuts, sunflower, pumpkin and watermelon seeds
Mayonnaise	Mayonnaise sauce
Olive	Olives, olive oil
Vegetable oils	Vegetable oils (except for olive oil)

[DOI: 10.18502/jnfs.v9i3.16159]

Total sugars	Jam, honey, sugars, candies, syrup, nabat (an Iranian confectionery made of sugar and served by tea), noql (an iranian confectionery), pashmak, chocolates, cookies, cakes, confections, traditional sweets (komaj sen, poshtzik, pirashki, qottab, baqlava, loz, haji badam, nan berenj, sohan, yazdi cake), ardeh (liquid sesame), homemade halva, halva shekari (a sweet breakfast food in Iran), cream caramel, homemade cake
Condiments	Pomegranate paste, other sauces and pastes
Broth	Broth
Soft drinks	Soft drinks, non-alcoholic beer, all types of artificial fruit juices
Yoghurt drink	Doogh
Salt	Salt
Pickles	Pickles
Hot drinks	Coffee, Tea

Anxiety score assessment

The symptoms of anxiety disorder were evaluated using a validated DASS-21 questionnaire (Samani and Joukar, 2007), with a range of responses from 0 (did not relate to me at all – never) to 3 (exactly represented my experience over the last week), in which the total higher scores revealed an upper severity of anxiety state. Based on the calculated scores, participants were assigned to one of the five main classifications as: "no illness", "mild", "moderate", "severe", and "extremely severe" (Shams-Rad *et al.*, 2022). Eventually, participants were categorized into two groups of a) "no or mild anxiety symptoms" and b) "moderate, severe, and extremely severe anxiety symptoms".

BMI measurement

Body weight was assessed via a body analyzer (Omron BF511, Omron Inc. Nagoya, Japan) with an accuracy of 0.1 kg with minimum clothes and no shoes. Height was measured without shoes by a non-stretchable tape fixed on the wall to the nearest 0.5 cm. At last, the BMI was calculated as weight (kg) divided by the square of height (m^2). Then, participants were divided into two categories of a) 18.5≤BMI<25 (indicated the normal body weight status), and b) BMI≥25 (specified for overweight/obesity status) (James *et al.*, 2002).

Assessment of other study variables

Additional information was achieved by face to face interview regarding variables including age, sex, PA [expressed as metabolic equivalent minutes per week (MET*min/wk)] (Moghaddam *et al.*, 2012), job, education, smoking, marital status, homeownership state, established history of chronic diseases (including high cholesterol levels, hypertension, asthma, Alzheimer's disease, thyroid dysfunction, osteoporosis, lung disease, arthritis, hepatitis, renal failure, kidney stone, fatty liver, epilepsy, chronic headache, rheumatic arthritis, psychiatric disorder, and multiple sclerosis), and average period of watching television, and mobile use per day.

Ethical considerations

In order to participate in both YaHS and TAMYZ studies, all the individuals signed a written consent form. The procedure of the present investigation was approved by the ethics committee of Baqiyatallah Universityof Medical Sciences, Tehran, Iran (IR.BMSU.BAQ.REC.1401.012).

Data analysis

The study's DPs were identified using principal component analysis (PCA) with varimax rotation. Major DPs' selection was done based on eigenvalues (>1), scree plots, and factor interpretability (Kim and Mueller, 1978). According to the level of adherence to each of the study's DPs, the participants were categorized into tertile, in which the lowest tertile (T1) had the lowest imitation of the DP, and individuals in the highest tertile (T3) had the highest adherence to the DP.

Normal distribution of the data was measured by histogram and Kolmogorov–Smirnov tests. Analysis of variance (ANOVA) was carried out to compare continuous variables [reported as mean ± standard deviation (SD)] such as anxiety score, body weight, BMI, cell phone use (min/day), watching television and movie (min/day) and PA

[DOI: 10.18502/jnfs.v9i3.16159]

across tertiles of imitation level regarding the study DPs. The chi-square test was performed in order to compare categorical variables including age group, sex, marital status, education, job status, smoking status, homeownership, and chronic disease across the levels of adherence to dietary food patterns. ANCOVA with Bonferroni correction was also employed to compare age, sex, and energy standardized dietary food groups and nutrients intakes between tertiles of DPs' adherence levels.

A multivariable adjusted binary logistic regression test was carried out to examine the interaction between the tertiles of major derived DPs and BMI on the odds of anxiety. Total procedure of analyses was adjusted for sex, age, the status of house ownership education, and smoking, occupation, financial situation, total energy intake, PA, and the duration of mobile phone use and TV/movie watching. Statistical analysis was done using SPSS software (Statistical Package for the Social Sciences, version 22.0, SPSS Inc, Chicago, Illinois, USA). All the differences were considered statistically significant at P-value ≤ 0.05.

Results

In total, 5781 participants (2938 males and 2843 females) met the eligibility criteria of the present investigation.

Dietary patterns of the study

Four major DPs of the study were identified as "sugar and fat", "fruits and vegetables", "western", and "high animal protein". Totally, 23.17% of the variation in food intakes was explained by these DPs. All the food groups and their loading factors for each DP are presented in **Table 2**. The "sugar and fat" DP was characterized by high intake of sugars, snacks, soft drinks, nuts, broth, condiments, and mayonnaise (explained 8.32 % of the total variation). The "fruits and vegetables" DP was rich in dried fruits, olive, fruits, vegetables and dairy products intake (which accounted for 5.45% of the overall variation). The "western" DP was defined by high intake of potatoes, French fries, red meat and refined grains (accounted for 4.71% of the total variation). The "high animal protein" DP was highly loaded by fish, processed meat, organ meat and canned fish (accounted for 4.67% of the overall variation).

Table 2. Loading factor for foods and food groups based on major DPs derived from principal component analysis[a].

Variables	Factor 1 "sugar and fat diet"	Factor 2 "fruits and vegetables"	Factor 3 "Western diet"	Factor 4 "High animal protein diet"
Total sugars	0.714	-	-	-
Snacks	0.610	-	-	-
Soft drinks	0.598	-	-	-
Nuts	0.595	-	-	-
Broth	0.586	-	-	-
Condiments	0.446	-	-	-
Mayonnaise	0.414	-	-	-
Dried fruits	-	0.597	-	-
Olive	-	0.594	-	-
Fruits	-	0.570	-	-
Vegetables	-	0.418	-	-
Dairy products	-	0.410	-	-
Potatoes	-	-	0.659	-
French fries	-	-	0.535	-
Red meat	-	-	0.525	-
Refined grains	-	-	0.508	-
Fish	-	-	-	0.637
Processed meat	-	-	-	0.606
Organ meat	-	-	-	0.476
Canned fish	-	-	-	0.390

[DOI: 10.18502/jnfs.v9i3.16159]

Hot drinks	-	-	-	-
Salt	-	-	-	-
Vegetable oils	-	-	-	-
Legumes	-	-	-	-
Solid fats	-	-	-	-
pickles	-	-	-	-
Yoghurt drink	-	-	-	-
Pizza	-	-	-	-
Eggs	-	-	-	-
Poultry	-	-	-	-
Whole grain	-	-	-	-
Total variation explained (%)	**8.32**	**5.45**	**4.71**	**4.67**

[a] Loading factors lower than 0.3 are not shown for better interpretation of the study's major DPs.

Baseline characteristics

The baseline characteristics of the study participants are shown in **Table 3**. Participants in top tertile of the "sugar and fat" DP were more likely to be young men, with higher education level and cell phone use and poor PA (P<0.05). Those people with the highest imitation to the fruits and vegetables' DP were related to the higher level of phone use and education and lower anxiety score (P<0.05). Participants with the highest adherence to the "western" DP were young and married who had a higher anxiety and education level along with lower BMI and an established chronic disease history (P<0.05). The highest tertile of the "high animal protein" DP was accompanied by higher PA and a lower level of cell phone use and education (P<0.05).

Consumption of the macronutrients

According to the imitation level of the study's DPs, age, sex, and energy adjusted for macronutrients' are compared in **Table 4**. In comparison with the subjects in the lowest tertile of the "sugar and fat" DP, those in the top tertile consumed significantly higher amounts of total energy, and fat (P<0.05), along with lower protein, and carbohydrate (P<0.05). Furthermore, subjects with the highest imitation of the "fruits and vegetables" DP had significantly greater intake of total energy, and protein (P<0.05) and lower intake of total fat (P<0.05) compared with those in the lowest tertile of this DP. Moreover, greater adherence to "western" DP was accompanied by higher consumption of total energy and protein (P<0.05) along with less ingested carbohydrate and fat (P<0.05) in comparison with the lowest tertile. In addition, compared to the lowest imitation of "high animal protein" DP, the top adherence level was related to the higher consumption of total energy, protein, and carbohydrate (P<0.05), together with less intake of total fat (P<0.05).

Interaction detections

The interaction between the study DPs, BMI status, and the odds of anxiety state have been presented in **Tables 5**.

[DOI: 10.18502/jnfs.v9i3.16159]

Table 3. Baseline characteristics of the participants.

Variables	Sugar and fat diet adherence			Fruits and vegetables adherence			Western diet adherence			High animal protein diet adherence		
	Low Tertile 1	High Tertile 3	P-value[b]	Low Tertile 1	High Tertile 3	P-value[b]	Low Tertile 1	High Tertile 3	P-value[b]	Low Tertile 1	High Tertile 3	P-value[b]
Weight (kg)	73.3±13.4[a]	73.9±14.4	0.056	72.8±14.2	73.9±14.2	0.075	73.0±14.0	73.4±14.3	0.541	73.3±14.0	73.3±14.0	0.998
BMI (kg/m^2)	27.2±4.8	27.1±5.0	0.221	27.0±5.0	27.1±4.8	0.755	27.4±4.9	26.8±4.9	0.001	27.0±4.8	27.0±4.8	0.437
Physical activity (MET*min/wk)	859.7±905	942.3±948.1	0.020	920.3±938.5	930.2±939.9	0.076	864.6±917.3	925.5±927.3	0.059	880.9±913.6	949.7±949	0.040
Cell phone use (min/day)	23.8±50.5	30.8±55.7	<0.001	25.4±52.8	31.2±57.6	<0.001	25.2±51.6	28.4±55.9	0.144	29.5±55.8	27.3±53.5	0.021
WTM (min/day)	229.5±156.3	229±148.8	0.312	232.7±153.6	225.1±149.2	0.136	227.6±150.4	224.5±156.8	0.604	224.6±153.9	230.8±149.9	0.415
Anxiety (score)	2.9±3.6	2.7±3.4	0.289	3.1±3.7	2.7±3.4	0.001	2.8±3.6	3±3.6	0.002	2.9±3.5	2.7±3.6	0.243
Sex (male)	944(49)[d]	1040(54)	0.005	958(49.7)	992(51.5)	0.659	902(46.8)	1039(53.9)	<0.001	954(49.5)	1010(52.4)	0.441
Age (year)			<0.001			0.171			<0.001			0.001
20-29	378(19.6)	474(24.6)		422(21.9)	460(23.9)		372(19.3)	478(24.8)		437(22.7)	455(23.6)	
30-39	420(21.8)	495(25.7)		455(23.6)	460(23.9)		387(20.1)	505(26.2)		414(25.1)	474(24.6)	
40-49	470(24.4)	449(23.3)		453(23.5)	449(23.3)		470(24.4)	422(21.9)		441(22.9)	435(22.6)	
50-59	372(19.3)	283(14.7)		331(17.2)	339(17.6)		362(18.8)	322(16.7)		312(16.2)	324(16.8)	
60-69	287(14.9)	225(11.7)		255(13.8)	218(11.3)		335(17.4)	200(10.4)		252(13.1)	262(11.6)	
Education (high school diploma and graduate degree)	607(31.5)	638(33.1)	<0.001	586(30.4)	674(35.0)	<0.001	601(31.2)	649(33.7)	<0.001	661(34.3)	622(32.3)	0.001
Job status			0.004			0.042			0.003			0.023
Unemployed	356(18.5)	387(20.1)		405(21.0)	333(17.3)		383(19.9)	356(18.5)		366(19.0)	337(17.5)	
Employee	965(50.1)	834(43.5)		912(47.4)	908(47.1)		960(49.8)	884(45.9)		942(48.9)	896(46.5)	
Manual worker	65(3.4)	79(4.1)		73(3.8)	67(3.5)		54(2.8)	65(3.4)		62(3.2)	83(4.3)	
Self-employed	539(28.0)	622(32.3)		536(27.8)	618(32.1)		530(27.)5	620(32.2)		557(28.9)	611(31.7)	
Married	1630(84.6)	1619(84.0)	0.058	1626(84.4)	1609(83.5)	0.083	1646(85.4)	1624(84.3)	0.002	1617(83.9)	1632(84.7)	0.758
Currently smoker	216(11.2)	195(10.1)	0.844	216(11.2)	187(9.7)	0.277	191(9.9)	206(10.7)	0.651	206(10.7)	206(10.7)	0.933
Homeowner	1516(78.7)	1455(75.5)	0.002	1420(73.7)	1528(79.3)	0.003	1482(76.9)	1449(75.2)	0.141	1441(74.8)	1470(76.3)	<0.001
Chronic disease (Yes)[c]	782(40.6)	740(38.4)	0.173	732(38.0)	751(39.0)	0.506	821(42.6)	680(35.3)	<0.001	759(39.4)	719(37.3)	0.185

[a]: Mean ± SD; [b]: ANOVA for quantitative variables and chi-square for qualitative variable; [c]: Chronic disease: including high cholesterol levels, hypertension, asthma, Alzheimer's disease, thyroid dysfunction, osteoporosis, lung disease, arthritis, hepatitis, renal failure, kidney stone, fatty liver, epilepsy, chronic headache, rheumatic arthritis, psychiatric disorder, and multiple sclerosis
MET: metabolic equivalent; [d]: n(%); BMI: body mass index; PA: physical activity; BMI: Body mass index; WTM: Watching television and movies..

[DOI: 10.18502/jnfs.v9i3.16159]

Table 4. Comparison of age, sex, and energy adjusted for dietary macronutrients' intake across the imitation level of DPs.

Variables	Sugar and fat diet adherence			Fruits and vegetables adherence			Western diet adherence			High animal protein diet adherence		
	Low Tertile 1	High Tertile 3	P-value[b]	Low Tertile 1	High Tertile 3	P-value[b]	Low Tertile 1	High Tertile 3	P-value[b]	Low Tertile 1	High Tertile 3	P-value[b]
Total energy (Kcal/day)	2217.5±22.7[a]	3654.8±22.8	<0.001	2418.0±24.5	3464.7±24.4	<0.001	2599.5±25.9	3186.3±26.2	<0.001	2671.4±24.9	3362.7±24.9	<0.001
Total protein (g/day)	118.0±0.8	95.9±0.9	<0.001	103.9±0.8	117.0±0.8	<0.001	107.6±0.8	116.8±0.8	<0.001	108.2±0.8	116.1±0.8	<0.001
Total carbohydrate (g/day)	395.2±1.9	389.6±2.1	<0.001	388.9±1.9	387.6±1.9	0.903	393.9±1.8	377.7±1.9	<0.001	374.1±1.8	396.1±1.9	<0.001
Total fat (g/day)	95.1±0.7	119.2±0.8	<0.001	110.9±0.7	99.6±0.8	<0.001	108.3±0.7	101.8±0.8	<0.001	108.7±0.7	105.6±0.8	<0.001

[a]: Mean ± SD; [b]**:** Resulted from analysis of covariance (ANCOVA).

Table 5. Interaction between study DPs, BMI status, and the odds of anxiety state.

Variables	Sugar and fat diet				Fruits and vegetables				Western diet				High animal protein diet			
	Tertile 1[b]	Tertile 2[b]	Tertile 3[b]	P-int[c]	Tertile 1[b]	Tertile 2[b]	Tertile 3[b]	P-int[c]	Tertile 1[b]	Tertile 2[b]	Tertile 3[b]	P-int[c]	Tertile 1[b]	Tertile 2[b]	Tertile 3[b]	P-int[c]
Odds of anxiety state																
Body mass index				0.851				0.249				0.666				0.030
18.5-24.99	1	0.89 (0.6-1.3)[a]	0.83 (0.5-1.3)		1	1.07 (0.7-1.6)	0.97 (0.6-1.5)		1	0.74 (0.5-1.1)	1.03 (0.7-1.5)		1	1.36 (0.9-2.1)	1.15 (0.7-1.8)	
≥25	1.04 (0.7-1.5)	0.99 (0.6-1.6)	1.13 (0.7-1.9)		1.22 (0.9-1.7)	0.68 (0.4-1.1)	1 (0.6-1.7)		0.96 (0.7-1.4)	1.16 (0.7-1.9)	1.25 (0.8-2)		1.48 (1.01-2.2)	0.50 (0.3-0.8)	0.77 (0.5-1.3)	

[a]: Data are presented in odds ratio (95% CI); [b]: Adjusted for gender (category), age (category), house ownership status (category), education status (category), job status (category), smoking status (category), marital status (category), total energy intake (continuous), PA (continuous), duration of phone use (continuous) and watching television and movie (continuous); [c]: Binary Logistic Regression; BMI: Body mass index.

[DOI: 10.18502/jnfs.v9i3.16159]

It was observed that overweight/obesity was associated with higher chance of anxiety in participants with the lowest adherence to "high animal protein" DP (P= 0.041, OR= 1.48, 95% CI: 1.01-2.2). Besides, it was detected that subjects with higher imitation of the "high animal protein" DP and overweight/obesity status had significantly lower odds of anxiety compared to those with normal body weight and the lowest adherence to the diet (P for interaction=0.030).

Discussion

To the best of the authors' knowledge, findings of the current investigation were the first scientific effort regarding the effect of interaction between major DPs and overweight/obesity in relation to the chance of human anxiety, which revealed an inverse interaction between the highest imitation of the "high animal protein" DP and overweight/obesity regarding the risk of participants' anxiety.

Anxiety disorder as a mental illness can be common among overweight/obese individuals due to the shareable etiology factors including genetic issues, undesirable self-image, impaired sleep patterns, and altered dietary behaviors (Lindberg *et al.*, 2020, Reeves *et al.*, 2008). Moreover, mounting evidence suggests that an elevated BMI may play an important predictive role in heightening the risk of anxiety ailment by 30% (Gariepy *et al.*, 2010, Zhao *et al.*, 2009). Similarly, in other studies, researchers found that a rise in individuals' BMI was associated with an increase in the frequency of anxiety symptoms (Amiri and Behnezhad, 2019, Xie *et al.*, 2023). Earlier clinical findings among subjects suffering from obesity have proposed the chronic body inflammation induced by a poor nutritional lifestyle as the main deleterious reason for such adverse repercussions (Fulton *et al.*, 2022). It has also been documented that a systemic inflammation caused by fatty acid accumulation in body may have a substantial impact on the brain by actively moving cytokines across the brain and interfering with the metabolism of neurotransmitters like serotonin and dopamine (Adjibade *et al.*, 2017). In this regard, it has been demonstrated that people with anxiety disorder commonly consume low-quality diets rich in simple sugars and saturated fatty acids, but low in dietary proteins, fruits, and vegetables (Murphy and Mercer, 2013).

There is convincing evidence regarding the beneficial impacts of healthy dietary food intake on brain functioning and psychological well-being (Ljungberg *et al.*, 2020). Brain synaptic plasticity, cell membrane fluidity, and neurotransmitters production regulation are all among a number of underlying molecular mechanisms that may explain the connections between diet and mental health (Nabi *et al.*, 2012). In the current investigation, it was detected that "high animal protein" DP characterized by high intakes of fish, processed meat, organ meat, and canned fish may result in lower chance of anxiety in overweight/obese participants. Currently, the imitation of high-protein diets has become widespread in societies, particularly among obese adults, due to its established potential in promoting satiety and lowering food intake (de Souza *et al.*, 2023). Moreover, it has been reported that maintaining mental health may need an optimal diet rich in tryptophan, phenylalanine, and tyrosine amino acids owing to the brain's generation of vital neurotransmitters such as serotonin (Rao *et al.*, 2008). Likewise, in one study by Kofler (Kofler *et al.*, 2019) the researchers revealed that patients with depressive and anxiety symptoms had considerably lower levels of these amino acids in their brains, in comparison to healthy people. The positive association between serotonin deficit and anxiety behaviors had also been investigated in women (Narvaes and Martins de Almeida, 2014). A growing body of literature indicated that reduction of clinical indicators of anxiety was supported by modifications in the macronutrient composition, which included cutting back on refined carbohydrates and increasing dietary protein intake (Aucoin and Bhardwaj, 2016, Haghighatdoost *et al.*, 2016). Similarly, recent studies suggested anxiolytic properties of amino acids including lysine, arginine, beta-alanine, tryptophan, and tyrosine (Salehi-Abargouei *et al.*, 2019).

[DOI: 10.18502/jnfs.v9i3.16159]

The primary strength of the current study was that the authors evaluated a significant number of individuals and considered a variety of potential confounders while analyzing the data. Yet, the subsequent limitations should be taken into account; the study design was cross-sectional which made reaching inferences about the causal relationship possible. Furthermore, measurement error, misclassification, and recall bias were commonly encountered issues with FFQs. Besides, DASS-21 was a self-reported scale that could be useful for screening the severity of the psychological disorders, not an ideal option for diagnosis. Thus, future prospective cohort investigations are necessary in order to confirm the findings.

Conclusion

Findings revealed that the "high animal protein" DP may be inversely associated with the lower chance of anxiety in overweight/obesity individuals. Future prospective cohort investigations are required to confirm the results of this study.

Acknowledgements

The authors would like to thank YaHS-TAMYZ cohort study authorities for allowing the researchers to work on that dataset. Also, the authors would like to thank all the residents of Yazd region, Yazd, Iran, who willingly participated in the present study.

Conflict of interest

The authors declared no conflict of interests.

Authors' contributions

Parastouei K designed and conducted the study. Salehi-Abargouei A, Rahmati F were study advisor and revised the paper. Nadjarzadeh A and Mirzaei M were involved in practical work and data analysis. All the authors read and approved the final manuscript.

Funding

This study was approved by Health Research Centre, Life Style Institute, Baqiyatallah, University of Medical Sciences.

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[DOI: 10.18502/jnfs.v9i3.16159]