Red and white meat intake in relation to mental disorders in adults

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Abstract

Background The association between meat intake and mental disorders are less investigated and the findings are contradicting. We aimed to examine the association between meat intake and depression, anxiety and psychological distress in Iranian adults.

Methods This cross-sectional study included 3362 subjects with 18-55 years old. A dish-based 106-item semi-quantitative food frequency questionnaire (FFQ), Hospital Anxiety and Depression Scale (HADS), General Health Questionnaire (GHQ), all validated in Iranian population, were applied to collect data on meat intake, anxiety, depression and psychological distress, respectively.

Results The prevalence of depression, anxiety and psychological distress in the study population was 28.6, 13.6 and 22.6%, respectively. After considering potential confounders, individuals in top quartile of red meat intake had 43% increased risk of depression (OR=1.43; 95%CI: 1.09-1.89), compared to the first quartile. No significant relationship was observed between red meat intake and anxiety or psychological distress. White meat intake was not associated with mental disorders. Stratified analysis by gender showed that male participants in the highest quartile of red meat intake had 92% higher risk of depression (95%CI: 1.17-3.15). Red and white meat intake was not associated with mental disorders in women. In overweight or obese individuals, no association was found between red meat intake and mental disorders, while higher intake of white meat was significantly associated with lower odds of psychological distress (OR=0.64; 95%CI: 0.42-0.99) and marginally associated with lower risk of depression (OR= 0.68; 95%CI: 0.45-1.00). In normal weight participants, highest quartile of red meat intake associated with increased odds of depression (OR= 1.66; 95%CI: 1.14-2.42).

Conclusions We found that higher intake of red meat was associated with increased risk of depression, especially in males and normal weight participants. In overweight or obese subjects, white meat intake was inversely associated with psychological distress.

Introduction

Mental disorders are a growing public health concern (1). Anxiety and depression are two important mental disorders (2); 350 million people suffered by depression worldwide (3). The prevalence of anxiety and depression among Iranian general population is estimated about 42 and 37.2%, respectively (4–6). Previous studies reported that anxiety and depression increased the risk of several cardiovascular diseases and chronic disease including hemorrhagic stroke, myocardial infarction, diabetes, cancer and irritable bowel syndrome (7–10). The economic burden of depression in US was estimated to be 83.1 billion dollars in the year of 2000 and in Europe was estimated 118 billion dollars in 2004 (11, 12).

Anxiety and depression are multi-factorial illnesses (4, 13). Previous researches have shown that dietary intakes, as modifiable factors of lifestyle, had important effects on mental disorders (14–16). Red or processed meat intake has only rarely been investigated compared to other dietary intakes (17), whereas red or processed meat could elevate levels of pro-inflammatory cytokines and in this way would contribute to the development of mental disorders (8).

A recently published meta-analysis has investigated the relationship between meat consumption and depression, this analysis included three cross-sectional, three cohort and two case-control studies (17). Most of these included studies showed no significant association between highest versus lowest intake of meat and depression (18–23), while included cohort studies (23–25) were reported that meat consumption was associated with a 13% higher risk of depression (17). It is noteworthy that some cross-sectional studies reported increased risk of depression in those who eating meat rarely or less than once a week in comparison to moderate level of intake (18, 20), while higher intake of meat, compared to moderate consumption, was also associated with more prevalence of depression (20). Thus, findings in this regard are in contradiction and more studies are needed to shed a light on the association between meat intake and mental disease. Moreover, as far as we know, there is no research in this regard in Iranian population. So, the aim of this investigation was to evaluate the association between red and white meat intake and mental disorders in a large group of Iranian adults.

Material And Methods:

Participants: The data of this cross-sectional study was derived from the Study on the Epidemiology of Psychological-Alimentary Health and Nutrition (SEPAHAN), a cross sectional study administered in 2010, with two main goals of assessing the link of functional gastrointestinal disorders (FGIDs) and their symptoms with lifestyle and nutritional aspects, and also psychological features. The study carried out among the Iranian adults with the age of 18–55 years who worked in 50 health centers related to Isfahan University

of Medical Sciences (IUMS). In the first step, precise questionnaires on socio-demographic factors, dietary habits and dietary intakes were given to 10087 individuals, a group of 8691 subjects delivered the accomplished questionnaires (response rate: 86.16%). There was no considerable difference in features of those who returned the questionnaires and others who did not. In the second step, which was done one month later, a validated questionnaire on psychological distress and mental disorders was distributed among the study group (response rate: 64.64%). After integrating data from the two steps, complete information was obtained from 3846 participants. Data of some participants were not usable, because some of them did not complete questionnaires in step 1 or 2. Some others did not provide their identification code in one of steps. Some other individuals who did not provide data on the exposure, outcome or covariates, were also excluded. Moreover, participants with caloric intakes outside the range of 800–4200 kcal/day were excluded. Finally, data of 3362 adults were used for the present analysis.

Assessment of meat intakes

We used a validated dish-based 106-item semi-quantitative food frequency questionnaire (FFQ), designed for Iranian adults, to achieve red and white meat intake (26). This FFQ included five groups of dishes and foods; two of them -mixed dishes (cooked or canned, 29 items) and other food items (fast foods and other miscellaneous foods, 36 items)- were included meat intake of the participants. In brief, Participants were asked to report their frequency of dietary intakes of foods and mixed dishes over the last year, with nine various responses from “never or less than once a month” to “12 or more times per day”. Then, the daily grams of each food item were calculated using the household measures. An Iranian-validated version of Nutritionist IV software was used to achieve the daily average nutrient intakes for each subject (27). In this study, red meat consumption was calculated by summing up the intake of red meat (beef, veal, mutton, lamb), processed meat (sausages, hamburgers, hot dogs) and visceral meats (lamb's liver, kidney, heart). White meat consumption included all kinds of fish, chicken and poultry.

Assessment of outcomes: To assess the anxiety and depression, we used Hospital Anxiety and Depression Scale (HADS) which was validated in Iranian population (28). HADS is a short and efficient questionnaire to assess psychological disorders and to determine the scale of the symptoms of anxiety disorders and depression. It includes 14 items and composes of two sections: anxiety and depression. Each item includes a four-degree scale (0-1-2-3), in the present study in both sections, anxiety and depression, the points of 0–7 were considered as ‘normal’ and the points of 8 or more were interpreted as having the psychological disorders (29). To define psychological distress, we used an Iranian-validated version of General Health Questionnaire (GHQ), a short and simple to use questionnaire that has 12 items with a four-level scale (less than usual, no more than usual, rather more than usual, or much more than usual). Responders were asked to report whether they recently have a specific symptom of psychological distress. In the current study, the bimodal scoring method with the score of 0-0-1-1 was applied and provided scores ranging from 0 to 12. Scoring of 4 or more, were defined as high levels of psychological distress. Lower scores represented low levels of psychological distress in individuals (30).

Assessment of confounders: To obtain data on age, gender, education, marital status, smoking status, family size, socio-economic status (SES), diabetes, anti-depressants medication and dietary supplement use, a self-administered questionnaire was applied. Anthropometric information (including height and weight) was collected by using a validated self-reported questionnaire (31). Body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in meters. Participants were divided into two groups according to their BMI: normal weight (< 25 Kg/m²), overweight or obese (≥ 25 Kg/m²). General Practice Physical Activity Questionnaire (GPPAQ), a valid simple four-level physical activity index, was used to estimate the activity levels of participants (29).

Statistical methods

First we obtained energy-adjusted amounts of red and white meat intake through residual method. Then, participants were classified based on energy-adjusted quartiles of red and white meat intake. One-way ANOVA was used to compare of continuous variables across different categories of red and white meat intake. Chi-square test was applied to examine the distribution of categorical variables across different categories of red and white meat intake. Analysis of Covariance (ANCOVA) with Bonferroni correction was used to report the mean intake of nutrients and food groups after adjustment of age, gender and energy intakes. Logistic regression was used to assess the relationship between red and white meat intakes and psychological disorders. The relationships were first examined in crude model. Then, adjustment was done for the confounder variables, including age (years), gender (male/female) and energy intake (kcal/days) in model 1. More adjustments were made for physical activity (≥ 1 h/week/< 1 h/week), smoking (current smokers/ ex-smokers/non-smokers), marital status (single/married), socioeconomic status [consist of educational level (> diploma/≤ diploma), family size (> 4/≤ 4 members), house ownership (yes/no)], self-reported diabetes (yes/no), use of anti-depressants medications (yes/no) and dietary supplements (yes/no) in model 2. Dietary intakes (including intake of fat, dairy, nuts, soy and legumes, grains, fruit, vegetables and n – 3 fatty acids) were also considered in Model 3. BMI was added to adjustments in the last

model. To determine the trend of odds ratios across different levels of red and white meat intakes, we considered the quartiles of meat as an ordinal variable. The participants in the first category of meat intake were considered as the reference category in all models. The analyses were also conducted separately by gender and BMI status. Statistical Package for Social Sciences (SPSS Inc., version 18.0, Chicago, IL) was used for all analyses and P values less than 0.05 were considered statistically significant.

Results

The mean age and weight of study participants were respectively 36.29 ± 7.87 (SD) years and 68.65 ± 13.18 kg. The prevalence of depression, anxiety and psychological distress in the study population was 28.6, 13.6 and 22.6%, respectively. General characteristics of study participants across quartiles of energy-adjusted red and white meat intake are provided in Table 1. Subjects in highest quartile of red meat intake had higher weight (69.75 ± 14.25 vs. 68.33 ± 12.61 , $P = 0.02$), physical activity (16.00 vs. 11.20%, $P = 0.03$) and were less likely to be women (52 vs. 58.5%, $P < 0.001$), educated (54.30 vs. 66.70%, $P < 0.001$) and more likely to be homeowners (59 vs. 56.70%, $P = 0.02$), compared with those in lowest quartile. Individuals in top category of white meat intake had higher weight (69.93 ± 13.13 vs. 68.84 ± 13.04 , $P < 0.001$) and physical activity (33 vs. 24.40%, $P < 0.001$), were less likely to be women (50.80 vs. 54.60%, $P < 0.001$), married (78.80 vs. 80.20%, $P = 0.01$) in compared with those in the bottom category. There were no significant differences in other demographic characteristics of participants across quartiles of red and white meat intake.

Table 1
General characteristics of study participants across quartiles of energy-adjusted red and white meat intake¹

	Quartiles of energy-adjusted red meat intake					Quartiles of energy-adjusted white meat intake				
	Q1	Q2	Q3	Q4	p ²	Q1	Q2	Q3	Q4	p ²
Age (years)	36.29 ± 7.74	36.07 ± 7.77	35.94 ± 7.73	36.87 ± 8.23	0.11	36.59 ± 7.84	36.14 ± 7.66	35.74 ± 7.51	36.72 ± 8.44	0.07
Weight (kg)	68.33 ± 12.61	67.80 ± 12.51	68.71 ± 13.23	69.75 ± 14.25	0.02	68.84 ± 13.04	67.70 ± 13.09	68.15 ± 13.39	69.93 ± 13.13	< 0.001
BMI(kg/m ²)	24.85 ± 3.69	24.82 ± 3.80	24.92 ± 3.94	25.03 ± 3.86	0.70	24.85 ± 3.82	24.86 ± 3.75	24.92 ± 3.84	24.99 ± 3.88	0.88
Female (%)	58.50	62.10	60.50	52.00	< 0.001	54.60	63.30	64.30	50.80	< 0.001
Married (%)	79.90	81.20	82.80	82.90	0.60	80.20	84.80	82.90	78.80	0.01
Education (%) (> diploma)	66.70	66.30	60.30	54.30	< 0.001	57.90	61.10	64.40	60.60	0.11
Family size (%) (> 4)	12.90	12.60	10.70	14.60	0.12	15.60	11.10	11.30	12.90	0.02
House possession (%)	56.70	57.00	60.40	59.00	0.02	56.50	57.20	60.00	59.30	0.23
Diabetes (%)	1.80	1.00	2.10	2.30	0.17	1.70	1.80	1.10	2.60	0.12
Anti-psychotic medications ³ (%)	5.00	4.80	6.50	6.00	0.35	6.70	5.70	5.10	4.80	0.34
Dietary supplement use ⁴ (%)	31.00	31.20	29.00	28.90	0.63	27.60	33.20	32.80	26.40	< 0.001
Smokers (%)	12.90	13.30	12.70	16.30	0.11	13.00	11.70	14.40	16.20	0.05
Physically active (%) (≥ 1 h/week)	11.20	12.40	13.20	16.00	0.03	12.90	10.10	12.40	17.40	< 0.001
Obese ⁵ (%)	63.70	44.20	45.50	45.70	0.80	45.70	44.50	44.80	44.20	0.93
¹ All values are means ± standard deviation (SD), unless indicated.										
² Obtained from ANOVA for continuous variables and chi-square test for categorical variables.										
³ Anti-psychotic medications include nortriptyline, amitriptyline or imipramine, fluoxetine, citalopram, fluvoxamine and sertraline.										
⁴ Dietary supplements include iron, calcium, vitamins and other dietary supplements.										
⁵ BMI ≥ 25										

Dietary intakes of selected nutrients and food groups of study participants across quartiles of energy-adjusted red and white meat intake are shown in Table 2. In highest quartile of red meat intake in compared with lowest quartile, we observed lower intake of energy, carbohydrates, vitamin B₁, iron, whole grains, refined grains and fruits, but higher intake of proteins, fats, omega-3 fatty acids, vitamin B₆, vitamin E, vegetables, nuts, soy and legumes. Individuals with the highest intake of white meat had higher consumption of proteins, fats, omega-3 fatty acids, vitamin B₆, vitamin C, vitamin E, vegetables, nuts, soy and legumes and significantly lower intake of energy, carbohydrates, dietary fiber, vitamin B₁, iron, whole grains and refined grains in compared with the lowest quartile.

Table 2

Dietary intakes of selected nutrients and food groups of study participants across quartiles of energy-adjusted red and white meat intake¹

	Quartiles of red meat intake					Quartiles of white meat intake				
	Q1	Q2	Q3	Q4	P ²	Q1	Q2	Q3	Q4	P ²
Energy (kcal/d)	2641.32 ± 28.50	2134.87 ± 28.81	2189.80 ± 28.80	2561.03 ± 29.00	< 0.001	2730.88 ± 28.32	2172.32 ± 28.12	2102.78 ± 28.38	2531.62 ± 28.80	< 0.001
Nutrients										
Proteins (% of energy)	13.80 ± 0.08	14.28 ± 0.08	15.17 ± 0.08	16.11 ± 0.08	< 0.001	13.36 ± 0.7	13.98 ± 0.7	15.05 ± 0.7	17.01 ± 0.7	< 0.001
Fats (% of energy)	32.75 ± 0.20	35.87 ± 0.20	39.03 ± 0.20	42.50 ± 0.20	< 0.001	34.26 ± 0.22	36.65 ± 0.22	38.34 ± 0.22	40.86 ± 0.22	< 0.001
Carbohydrates (% of energy)	54.83 ± 0.23	51.35 ± 23	47.29 ± 0.23	42.94 ± 234	< 0.001	53.91 ± 0.25	50.92 ± 0.25	48.10 ± 0.25	43.48 ± 0.25	< 0.001
Dietary fiber (g/d)	22.72 ± 0.21	22.72 ± 0.21	22.63 ± 0.21	22.40 ± 0.21	0.65	23.74 ± 0.21	22.83 ± 0.21	22.41 ± 0.21	21.46 ± 0.21	< 0.001
Omega-3 fatty acids (g/d)	1.69 ± 0.03	1.72 ± 0.03	1.76 ± 0.03	1.82 ± 0.03	< 0.001	1.53 ± 0.03	1.67 ± 0.03	1.78 ± 0.03	2.00 ± 0.03	< 0.001
Vitamin B1 (mg/d)	2.23 ± 0.02	1.90 ± 0.02	1.76 ± 0.02	1.50 ± 0.02	< 0.001	2.14 ± 0.02	1.87 ± 0.02	1.79 ± 0.02	1.59 ± 0.02	< 0.001
Vitamin B6 (mg/d)	1.68 ± 0.01	1.90 ± 0.01	2.05 ± 0.01	2.31 ± 0.01	< 0.001	1.81 ± 0.01	1.94 ± 0.01	2.01 ± 0.01	2.18 ± 0.01	< 0.001
Iron (mg/d)	18.57 ± 0.12	17.73 ± 0.12	17.38 ± 0.12	16.77 ± 0.12	< 0.001	18.80 ± 0.12	17.67 ± 0.12	17.39 ± 0.12	16.57 ± 0.12	< 0.001
Vitamin C (mg/d)	100.18 ± 1.89	103.83 ± 1.91	103.30 ± 1.90	99.62 ± 1.91	0.31	97.30 ± 1.92	101.07 ± 1.88	101.31 ± 1.91	107.43 ± 1.91	< 0.001
Vitamin E (mg/d)	16.31 ± 0.17	20.35 ± 0.17	22.74 ± 0.17	26.55 ± 0.17	< 0.001	19.10 ± 0.21	21.17 ± 0.21	22.04 ± 0.21	23.55 ± 0.21	< 0.001
Food groups (g/d)										
Whole grains	54.48 ± 2.74	47.12 ± 2.77	41.02 ± 2.75	27.27 ± 2.77	< 0.001	47.54 ± 2.81	47.11 ± 2.75	40.99 ± 2.79	34.33 ± 2.80	< 0.001
Refined grains	446.76 ± 5.85	402.46 ± 5.90	380.41 ± 5.87	340.23 ± 5.91	< 0.001	451.64 ± 5.93	401.54 ± 5.80	381.24 ± 5.89	335.19 ± 5.91	< 0.001
Fruit	337.08 ± 8.28	339.67 ± 8.36	311.22 ± 8.32	282.47 ± 8.37	< 0.001	318.52 ± 8.48	318.3 ± 8.29	315.80 ± 8.43	318.58 ± 8.46	0.96
Vegetables	215.96 ± 4.24	228.75 ± 4.28	248.04 ± 4.26	265.14 ± 4.28	< 0.001	224.04 ± 4.36	238.85 ± 4.26	242.00 ± 4.33	252.67 ± 4.35	< 0.001
Nuts, soy and legumes	44.35 ± 1.28	56.08 ± 1.30	60.03 ± 1.29	68.90 ± 1.30	< 0.001	51.91 ± 1.34	57.54 ± 1.31	57.76 ± 1.33	61.91 ± 1.34	< 0.001
High fat dairy	14.39 ± 0.63	14.42 ± 0.64	14.53 ± 0.63	15.52 ± 0.64	0.54	14.43 ± 0.64	15.11 ± 0.63	15.18 ± 0.64	14.10 ± 0.64	0.59
¹ All values are means ± standard error (SE), energy intake is adjusted for age and gender; all other values are adjusted for age, gender and energy intake.										
² Obtained from ANCOVA										

The prevalence of depression, anxiety and high psychological distress in study participants across different energy-adjusted quartiles of red and white meat intake in whole population is shown in Fig. 1. Higher prevalence of depression (32.6 vs. 25.2%, P = 0.01) was

observed among individuals in top quartile of red meat intake in compared with bottom quartile. There was no significant difference across quartiles of intake in anxiety and psychological distress. No significant differences were found in prevalence of mental disorders between different levels of white meat intakes.

Multivariable-adjusted odds ratios and 95% confidence intervals (CI) for depression, anxiety and psychological distress across quartiles of energy-adjusted red and white meat intake in whole population are presented in Table 3. The risk of depression among individuals in top quartile of red meat intake was 43% more than those were in first quartile (OR = 1.43; 95%CI: 1.16–1.78). The association was remained significant even after controlling for all potential confounders including BMI (OR = 1.43; 95%CI: 1.09–1.89). No significant relationship was observed between red meat intakes and anxiety or psychological distress. Similarly, white meat intake did not associate with depression, anxiety and psychological distress in both crude and adjusted models.

Table 3

Multivariable-adjusted odds ratios and 95% confidence intervals for depression, anxiety and psychological distress across quartiles of energy-adjusted red and white meat intake in whole population¹

	Quartiles of red meat intake					Quartiles of white meat intake				
	Q1	Q2	Q3	Q4	P trend	Q1	Q2	Q3	Q4	P trend
Depression										
Crude	1.00	1.17(0.94–1.45)	1.18(0.95–1.46)	1.43(1.16–1.78)	< 0.001	1.00	0.93(0.75–1.15)	1.08(0.87–1.33)	0.92(0.74–1.14)	0.77
Model 1	1.00	1.13(0.89–1.44)	1.17(0.92–1.49)	1.50(1.19–1.89)	0.01	1.00	0.86(0.68–1.09)	1.00(0.79–1.26)	0.87(0.69–1.10)	0.47
Model 2	1.00	1.19(0.92–1.52)	1.18(0.92–1.52)	1.47(1.16–1.88)	< 0.001	1.00	0.96(0.75–1.23)	1.18(0.92–1.51)	0.93(0.72–1.19)	0.96
Model 3	1.00	1.20(0.93–1.55)	1.19(0.92–1.55)	1.48(1.13–1.94)	0.01	1.00	0.95(0.74–1.23)	1.16(0.90–1.50)	0.91(0.70–1.18)	0.85
Model 4	1.00	1.19(0.92–1.53)	1.18(0.91–1.53)	1.46(1.11–1.91)	0.01	1.00	0.96(0.75–1.24)	1.19(0.92–1.53)	0.94(0.72–1.23)	0.90
Model 5	1.00	1.15(0.88–1.50)	1.13(0.87–1.48)	1.43(1.09–1.89)	0.02	1.00	0.95(0.73–1.23)	1.16(0.89–1.51)	0.89(0.68–1.17)	0.79
Anxiety										
Crude	1.00	1.19(0.90–1.58)	0.93(0.69–1.25)	1.23(0.93–1.63)	0.38	1.00	1.10(0.83–1.46)	1.13(0.85–1.50)	0.94(0.70–1.25)	0.73
Model 1	1.00	1.06(0.78–1.44)	0.85(0.62–1.17)	1.24(0.92–1.67)	0.38	1.00	0.95(0.70–1.29)	1.00(0.74–1.36)	0.83(0.61–1.14)	0.36
Model 2	1.00	1.07(0.78–1.48)	0.80(0.57–1.12)	1.13(0.82–1.55)	0.87	1.00	1.06(0.77–1.47)	1.18(0.85–1.64)	0.91(0.65–1.27)	0.76
Model 3	1.00	1.13(0.81–1.58)	0.87(0.62–1.24)	1.27(0.89–1.81)	0.45	1.00	1.11(0.80–1.55)	1.26(0.90–1.76)	0.99(0.69–1.41)	0.85
Model 4	1.00	1.13(0.81–1.57)	0.87(0.61–1.23)	1.25(0.88–1.79)	0.49	1.00	1.12(0.81–1.56)	1.28(0.91–1.79)	1.02(0.71–1.46)	0.73
Model 5	1.00	1.10(0.78–1.54)	0.89(0.62–1.28)	1.27(0.89–1.83)	0.39	1.00	1.11(0.79–1.55)	1.23(0.87–1.74)	0.96(0.67–1.40)	0.97
Psychological distress										
Crude	1.00	1.01(0.80–1.26)	0.97(0.77–1.22)	0.99(0.79–1.25)	0.88	1.00	0.97(0.78–1.22)	1.02(0.81–1.28)	0.83(0.66–1.04)	0.17
Model 1	1.00	1.00(0.78–1.28)	0.97(0.76–1.24)	1.04(0.81–1.32)	0.85	1.00	0.88(0.69–1.13)	0.96(0.75–1.22)	0.80(0.62–1.03)	0.15
Model 2	1.00	1.02(0.79–1.33)	1.00(0.77–1.29)	1.03(0.79–1.33)	0.91	1.00	0.96(0.74–1.25)	1.12(0.86–1.46)	0.88(0.68–1.15)	0.60

¹Model 1: Adjusted for age, gender and energy intake.

Model 2: Further adjustment for physical activity, smoking, marital status, education, socioeconomic status (SES), diabetes, intake of Anti-psychotic medications and dietary supplements.

Model 3: Additional controlling for dietary intakes of high fat dairy, nuts, soy and legumes, grains, fruit and vegetables.

Model 4: More adjustment for n-3 fatty acids.

Model 5: Further adjusted for BMI.

	Quartiles of red meat intake					Quartiles of white meat intake				
	Q1	Q2	Q3	Q4	P trend	Q1	Q2	Q3	Q4	P trend
Model 3	1.00	1.03(0.79–1.35)	1.00(0.76–1.31)	1.01(0.76–1.34)	0.98	1.00	0.97(0.75–1.27)	1.13(0.86–1.48)	0.89(0.67–1.18)	0.69
Model 4	1.00	1.03(0.79–1.35)	1.00(0.76–1.31)	1.00(0.75–1.34)	0.95	1.00	0.97(0.75–1.27)	1.13(0.86–1.48)	0.90(0.68–1.19)	0.73
Model 5	1.00	1.01(0.76–1.32)	1.02(0.77–1.34)	1.03(0.77–1.38)	0.84	1.00	0.93(0.71–1.22)	1.14(0.87–1.51)	0.87(0.65–1.17)	0.71
¹ Model 1: Adjusted for age, gender and energy intake.										
Model 2: Further adjustment for physical activity, smoking, marital status, education, socioeconomic status (SES), diabetes, intake of Anti-psychotic medications and dietary supplements.										
Model 3: Additional controlling for dietary intakes of high fat dairy, nuts, soy and legumes, grains, fruit and vegetables.										
Model 4: More adjustment for n-3 fatty acids.										
Model 5: Further adjusted for BMI.										

Multivariable-adjusted odds ratios and 95% confidence intervals for depression, anxiety and psychological distress across quartiles of energy-adjusted red and white meat intake in men and women are provided in Table 4 and Table 5, respectively. In male participants, highest quartile of red meat intake had higher odds of depression (OR = 1.75; 95%CI: 1.23–2.51) in compared with lowest quartile, in crude model. After controlling for potential confounders this association was strengthened (OR = 1.92; 95%CI: 1.17–3.15). Either in crude or in the adjusted models, no significant associations were observed between different levels of red meat intake and odds of anxiety and psychological distress among male participants. In case of white meat intake, after adjustment for confounding variables, men in third quartile of intake had higher risk of depression (OR = 1.64; 95%CI:1.02–2.63) and psychological distress (OR = 2.02; 95%CI: 1.20–3.39), compared to the first quartile.

Table 4

Multivariable-adjusted odds ratios and 95% confidence intervals for depression, anxiety and psychological distress across quartiles of energy-adjusted red and white meat intake in men¹

	Quartiles of red meat intake					Quartiles of white meat intake				
	Q1	Q2	Q3	Q4	P trend	Q1	Q2	Q3	Q4	P trend
Depression										
Crude	1.00	1.15(0.77–1.72)	1.08(0.73–1.60)	1.75(1.23–2.51)	< 0.001	1.00	0.71(0.48–1.05)	1.16(0.80–1.66)	0.93(0.66–1.31)	0.77
Model 1	1.00	1.31(0.83–2.05)	1.17(0.74–1.84)	1.79(1.20–2.66)	0.01	1.00	0.79(0.50–1.24)	1.46(0.96–2.22)	0.98(0.66–1.44)	0.53
Model 2	1.00	1.37(0.85–2.19)	1.15(0.71–1.84)	1.82(1.20–2.77)	0.01	1.00	0.84(0.52–1.34)	1.53(0.99–2.38)	0.97(0.65–1.46)	0.58
Model 3	1.00	1.46(0.89–2.38)	1.26(0.76–2.09)	2.01(1.24–3.26)	0.01	1.00	0.82(0.51–1.33)	1.49(0.95–2.34)	0.91(0.58–1.43)	0.77
Model 4	1.00	1.43(0.88–2.33)	1.26(0.76–2.09)	1.97(1.22–3.20)	0.01	1.00	0.86(0.53–1.39)	1.59(1.01–2.52)	1.02(0.65–1.62)	0.42
Model 5	1.00	1.43(0.86–2.36)	1.12(0.66–1.88)	1.92(1.17–3.15)	0.03	1.00	0.88(0.54–1.46)	1.64(1.02–2.63)	1.05(0.65–1.68)	0.40
Anxiety										
Crude	1.00	1.30(0.76–2.24)	0.76(0.42–1.39)	1.28(0.76–2.14)	0.68	1.00	0.76(0.43–1.34)	1.13(0.67–1.91)	0.95(0.58–1.57)	0.86
Model 1	1.00	1.58(0.86–2.93)	0.70(0.34–1.43)	1.22(0.68–2.19)	0.96	1.00	0.75(0.38–1.49)	1.29(0.70–2.38)	0.95(0.53–1.68)	0.81
Model 2	1.00	1.51(0.79–2.89)	0.59(0.28–1.24)	1.10(0.59–2.03)	0.64	1.00	0.83(0.41–1.66)	1.25(0.66–2.38)	0.86(0.47–1.57)	0.86
Model 3	1.00	1.84(0.93–3.64)	0.88(0.39–1.97)	1.73(0.83–3.61)	0.38	1.00	0.98(0.47–2.02)	1.41(0.72–2.77)	1.01(0.51–1.98)	0.78
Model 4	1.00	1.83(0.93–3.62)	0.88(0.39–1.96)	1.72(0.83–3.58)	0.38	1.00	0.99(0.48–2.04)	1.43(0.73–2.82)	1.03(0.52–2.04)	0.73
Model 5	1.00	1.80(0.89–3.63)	0.89(0.39–2.02)	1.62(0.75–3.48)	0.51	1.00	1.05(0.50–2.19)	1.43(0.71–2.90)	1.06(0.52–2.15)	0.70
Psychological distress										
Crude	1.00	0.89(0.59–1.35)	1.02(0.68–1.52)	1.00(0.68–1.46)	0.85	1.00	0.99(0.66–1.49)	1.28(0.87–1.91)	0.96(0.66–1.41)	0.89
Model 1	1.00	1.01(0.64–1.61)	1.05(0.67–1.65)	1.03(0.68–1.56)	0.88	1.00	0.96(0.60–1.54)	1.49(0.95–2.34)	0.97(0.64–1.47)	0.72
Model 2	1.00	1.03(0.63–1.68)	1.06(0.66–1.71)	1.08(0.69–1.68)	0.72	1.00	1.11(0.68–1.82)	1.65(1.02–2.65)	1.02(0.65–1.59)	0.62

¹Model 1: Adjusted for age and energy intake.

Model 2: Further adjustment for physical activity, smoking, marital status, education, socioeconomic status (SES), diabetes, intake of Anti-psychotic medications and dietary supplements.

Model 3: Additional controlling for dietary intakes of high fat dairy, nuts, soy and legumes, grains, fruit and vegetables.

Model 4: More adjustment for n-3 fatty acids.

Model 5: Further adjusted for BMI.

	Quartiles of red meat intake					Quartiles of white meat intake				
	Q1	Q2	Q3	Q4	P	Q1	Q2	Q3	Q4	P
					trend					trend
Model 3	1.00	1.10(0.66–1.83)	1.19(0.72–2.00)	1.20(0.71–2.01)	0.47	1.00	1.18(0.71–1.96)	1.73(1.05–2.84)	1.09(0.67–1.79)	0.45
Model 4	1.00	1.09(0.65–1.81)	1.20(0.72–2.00)	1.18(0.71–1.98)	0.49	1.00	1.22(0.73–2.04)	1.82(1.11–3.00)	1.19(0.72–1.95)	0.29
Model 5	1.00	1.14(0.68–1.94)	1.13(0.66–1.93)	1.18(0.69–2.02)	0.58	1.00	1.16(0.67–2.00)	2.02(1.20–3.39)	1.33(0.79–2.24)	0.11
¹ Model 1: Adjusted for age and energy intake.										
Model 2: Further adjustment for physical activity, smoking, marital status, education, socioeconomic status (SES), diabetes, intake of Anti-psychotic medications and dietary supplements.										
Model 3: Additional controlling for dietary intakes of high fat dairy, nuts, soy and legumes, grains, fruit and vegetables.										
Model 4: More adjustment for n-3 fatty acids.										
Model 5: Further adjusted for BMI.										

Table 5

Multivariable-adjusted odds ratios and 95% confidence intervals for depression, anxiety and psychological distress across quartiles of energy-adjusted red and white meat intake in women¹

	Quartiles of red meat intake					Quartiles white meat intake				
	Q1	Q2	Q3	Q4	P trend	Q1	Q2	Q3	Q4	P trend
Depression										
Crude	1.00	1.13(0.87–1.47)	1.21(0.92–1.57)	1.36(1.04–1.79)	0.02	1.00	0.96(0.74–1.25)	0.96(0.74–1.25)	0.95(0.72–1.25)	0.72
Model 1	1.00	1.07(0.81–1.42)	1.17(0.89–1.56)	1.37(1.03–1.82)	0.02	1.00	0.87(0.66–1.16)	0.84(0.63–1.12)	0.80(0.59–1.07)	0.13
Model 2	1.00	1.12(0.83–1.51)	1.21(0.90–1.62)	1.38(1.02–1.86)	0.04	1.00	1.01(0.75–1.37)	1.06(0.78–1.43)	0.89(0.65–1.23)	0.58
Model 3	1.00	1.11(0.82–1.51)	1.18(0.87–1.61)	1.33(0.95–1.86)	0.09	1.00	1.00(0.74–1.36)	1.04(0.76–1.42)	0.88(0.63–1.23)	0.55
Model 4	1.00	1.11(0.81–1.50)	1.17(0.86–1.60)	1.31(0.94–1.83)	0.11	1.00	1.00(0.74–1.36)	1.05(0.77–1.44)	0.90(0.65–1.26)	0.64
Model 5	1.00	1.05(0.77–1.44)	1.16(0.84–1.59)	1.31(0.93–1.84)	0.11	1.00	0.96(0.70–1.31)	1.01(0.73–1.39)	0.82(0.58–1.15)	0.32
Anxiety										
Crude	1.00	1.11(0.79–1.55)	0.97(0.69–1.37)	1.31(0.93–1.84)	0.23	1.00	1.15(0.82–1.60)	1.04(0.74–1.45)	0.97(0.68–1.39)	0.73
Model 1	1.00	0.94(0.66–1.34)	0.89(0.62–1.27)	1.27(0.89–1.79)	0.26	1.00	1.00(0.70–1.41)	0.92(0.65–1.31)	0.77(0.53–1.12)	0.15
Model 2	1.00	0.95(0.65–1.38)	0.85(0.58–1.25)	1.19(0.82–1.73)	0.50	1.00	1.16(0.80–1.70)	1.17(0.79–1.71)	0.91(0.61–1.38)	0.69
Model 3	1.00	0.096(0.65–1.41)	0.86(0.58–1.29)	1.21(0.80–1.83)	0.51	1.00	1.19(0.81–1.75)	1.21(0.82–1.80)	0.96(0.63–1.48)	0.90
Model 4	1.00	0.95(0.65–1.40)	0.86(0.57–1.27)	1.19(0.78–1.80)	0.57	1.00	1.20(0.82–1.76)	1.23(0.83–1.82)	0.99(0.64–1.53)	0.99
Model 5	1.00	0.92(0.62–1.37)	0.89(0.59–1.34)	1.25(0.82–1.91)	0.35	1.00	1.15(0.78–1.70)	1.17(0.78–1.75)	0.92(0.59–1.44)	0.77
Psychological distress										
Crude	1.00	1.03(0.78–1.35)	0.93(0.70–1.24)	1.05(0.79–1.41)	0.92	1.00	0.88(0.67–1.16)	0.84(0.63–1.11)	0.78(0.58–1.06)	0.10
Model 1	1.00	0.99(0.74–1.33)	0.95(0.70–1.27)	1.05(0.78–1.42)	0.86	1.00	0.83(0.62–1.12)	0.79(0.58–1.6)	0.71(0.52–0.97)	0.03
Model 2	1.00	1.01(0.74–1.37)	0.97(0.71–1.32)	1.02(0.74–1.40)	0.99	1.00	0.91(0.66–1.24)	0.94(0.69–1.30)	0.80(0.57–1.11)	0.24

¹Model 1: Adjusted for age and energy intake.

Model 2: Further adjustment for physical activity, smoking, marital status, education, socioeconomic status (SES), diabetes, intake of Anti-psychotic medications and dietary supplements.

Model 3: Additional controlling for dietary intakes of high fat dairy, nuts, soy and legumes, grains, fruit and vegetables.

Model 4: More adjustment for n-3 fatty acids.

Model 5: Further adjusted for BMI.

	Quartiles of red meat intake					Quartiles white meat intake				
	Q1	Q2	Q3	Q4	P trend	Q1	Q2	Q3	Q4	P trend
Model 3	1.00	1.00(0.73–1.37)	0.94(0.68–1.30)	0.97(0.68–1.38)	0.76	1.00	0.90(0.66–1.24)	0.94(0.68–1.30)	0.80(0.56–1.13)	0.27
Model 4	1.00	1.00(0.73–1.37)	0.94(0.68–1.30)	0.98(0.69–1.39)	0.80	1.00	0.90(0.66–1.24)	0.93(0.68–1.30)	0.79(0.56–1.12)	0.24
Model 5	1.00	0.95(0.68–1.31)	0.99(0.71–1.38)	1.02(0.71–1.46)	0.86	1.00	0.86(0.62–1.19)	0.92(0.66–1.28)	0.73(0.51–1.04)	0.14
¹ Model 1: Adjusted for age and energy intake.										
Model 2: Further adjustment for physical activity, smoking, marital status, education, socioeconomic status (SES), diabetes, intake of Anti-psychotic medications and dietary supplements.										
Model 3: Additional controlling for dietary intakes of high fat dairy, nuts, soy and legumes, grains, fruit and vegetables.										
Model 4: More adjustment for n-3 fatty acids.										
Model 5: Further adjusted for BMI.										

Among female participants, those in highest quartile of red meat intake had higher odds of depression (OR = 1.36; 95%CI: 1.04–1.79) in crude model. However, after additional controlling for dietary intakes, omega-3 fatty acids and BMI, no statistically significant association was seen. Crude and multivariable-adjusted models did not show significant association between different levels of red meat intake and odds of anxiety and psychological distress in women. Moreover, no significant associations were found between different amount of white meat intakes and mental disorders after considering all potential confounders.

Multivariable-adjusted odds ratios and 95% confidence intervals for psychological disorders across quartiles of energy-adjusted red and white meat intake in overweight or obese participants (BMI $\geq$ 25 kg/m²) and normal-weight participants (BMI < 25 kg/m²) are presented in Table 6 and Table 7, respectively. After adjustment for confounding variables, no association was found between red meat intake and mental disorders in overweight or obese individuals. However, higher intake of white meat was significantly associated with lower odds of psychological distress (OR = 0.64; 95%CI: 0.42–0.99) and marginally associated with lower risk of depression (OR = 0.68; 95%CI: 0.45–1.00), compared to lower intake.

Table 6

Multivariable-adjusted odds ratios and 95% confidence intervals for depression, anxiety and psychological distress across quartiles of energy-adjusted red and white meat intake in overweight or obese participants (BMI $\geq$ 25 kg/m²)¹

	Quartiles of red meat intake					Quartiles of white meat intake				
	Q1	Q2	Q3	Q4	P trend	Q1	Q2	Q3	Q4	P trend
Depression										
Crude	1.00	1.07(0.77–1.50)	1.29(0.93–1.79)	1.43(1.04–1.97)	0.02	1.00	0.92(0.67–1.26)	0.95(0.69–1.30)	0.7(0.56–1.07)	0.16
Model 1	1.00	1.00(0.70–1.43)	1.19(0.84–1.69)	1.41(1.00–1.99)	0.03	1.00	0.86(0.61–1.21)	0.94(0.66–1.33)	0.68(0.48–0.97)	0.07
Model 2	1.00	1.01(0.69–1.47)	1.19(0.82–1.72)	1.41(0.98–2.02)	0.04	1.00	0.98(0.68–1.41)	1.13(0.78–1.63)	0.73(0.51–1.06)	0.20
Model 3	1.00	0.99(0.67–1.45)	1.14(0.78–1.68)	1.31(0.88–1.95)	0.13	1.00	0.96(0.66–1.38)	1.05(0.72–1.53)	0.64(0.44–0.95)	0.06
Model 4	1.00	0.98(0.67–1.44)	1.13(0.77–1.65)	1.27(0.86–1.90)	0.18	1.00	0.97(0.67–1.40)	1.08(0.74–1.57)	0.68(0.45–1.00)	0.11
Anxiety										
Crude	1.00	1.18(0.77–1.80)	0.98(0.64–1.52)	1.39(0.92–2.09)	0.21	1.00	0.92(0.61–1.38)	1.06(0.71–1.58)	0.75(0.49–1.14)	0.31
Model 1	1.00	0.93(0.58–1.48)	0.83(0.52–1.32)	1.39(0.90–2.15)	0.19	1.00	0.79(0.51–1.23)	0.90(0.58–1.40)	0.64(0.40–1.02)	0.12
Model 2	1.00	0.88(0.54–1.44)	0.76(0.46–1.26)	1.31(0.82–2.09)	0.33	1.00	0.93(0.58–1.49)	1.14(0.71–1.83)	0.67(0.40–1.11)	0.26
Model 3	1.00	0.96(0.58–1.58)	0.88(0.52–1.48)	1.65(0.98–2.78)	0.09	1.00	0.95(0.59–1.54)	1.17(0.72–1.90)	0.69(0.40–1.17)	0.34
Model 4	1.00	0.96(0.58–1.58)	0.86(0.51–1.45)	1.61(0.96–2.71)	0.11	1.00	0.96(0.59–1.57)	1.21(0.74–1.97)	0.73(0.42–1.24)	0.47
Psychological distress										
Crude	1.00	0.73(0.51–1.03)	0.87(0.62–1.21)	0.85(0.60–1.19)	0.55	1.00	0.90(0.64–1.25)	0.85(0.60–1.19)	0.66(0.46–0.94)	0.02
Model 1	1.00	0.75(0.52–1.09)	0.86(0.60–1.24)	0.84(0.59–1.21)	0.50	1.00	0.84(0.58–1.20)	0.87(0.60–1.25)	0.61(0.42–0.89)	0.02
Model 2	1.00	0.77(0.52–1.14)	0.91(0.62–1.34)	0.88(0.60–1.29)	0.70	1.00	0.95(0.64–1.40)	1.09(0.74–1.62)	0.68(0.46–1.02)	0.14
Model 3	1.00	0.78(0.52–1.16)	0.89(0.60–1.33)	0.82(0.54–1.26)	0.50	1.00	0.97(0.65–1.44)	1.07(0.72–1.61)	0.66(0.43–1.01)	0.11
Model 4	1.00	0.78(0.52–1.16)	0.90(0.60–1.34)	0.83(0.54–1.27)	0.52	1.00	0.96(0.65–1.43)	1.06(0.71–1.59)	0.64(0.42–0.99)	0.09
¹ Model 1: Adjusted for age, gender and energy intake.										
Model 2: Further adjustment for physical activity, smoking, marital status, education, socioeconomic status (SES), diabetes, intake of Anti-psychotic medications and dietary supplements.										
Model 3: Additional controlling for dietary intakes of high fat dairy, nuts, soy and legumes, grains, fruit and vegetables.										
Model 4: More adjustment for n-3 fatty acids.										

Table 7

Multivariable-adjusted odds ratios and 95% confidence intervals for depression, anxiety and psychological distress across quartiles of energy-adjusted red and white meat intake in normal-weight participants (BMI < 25 kg/m²)¹

	Quartiles of red meat intake					Quartiles of white meat intake				
	Q1	Q2	Q3	Q4	P trend	Q1	Q2	Q3	Q4	P trend
Depression										
Crude	1.00	1.24(0.93–1.66)	1.08(0.81–1.46)	1.44(1.08–1.92)	0.04	1.00	0.94(0.70–1.26)	1.20(0.90–1.60)	1.06(0.79–1.41)	0.37
Model 1	1.00	1.25(0.91–1.72)	1.15(0.83–1.59)	1.57(1.15–2.15)	0.01	1.00	0.88(0.63–1.21)	1.06(0.77–1.46)	1.06(0.77–1.45)	0.46
Model 2	1.00	1.33(0.95–1.87)	1.18(0.84–1.66)	1.55(1.11–2.16)	0.03	1.00	0.97(0.69–1.36)	1.23(0.87–1.73)	1.11(0.79–1.55)	0.30
Model 3	1.00	1.41(0.99–2.00)	1.25(0.87–1.80)	1.67(1.15–2.44)	0.02	1.00	0.98(0.69–1.40)	1.27(0.89–1.82)	1.17(0.81–1.68)	0.20
Model 4	1.00	1.40(0.99–2.00)	1.24(0.87–1.79)	1.66(1.14–2.42)	0.03	1.00	0.99(0.70–1.41)	1.29(0.91–1.85)	1.20(0.83–1.74)	0.15
Anxiety										
Crude	1.00	1.20(0.82–1.75)	0.89(0.60–1.33)	1.10(0.75–1.62)	0.99	1.00	1.31(0.88–1.93)	1.21(0.81–1.80)	1.15(0.77–1.72)	0.62
Model 1	1.00	1.19(0.79–1.79)	0.88(0.57–1.35)	1.09(0.72–1.66)	0.95	1.00	1.16(0.76–1.78)	1.14(0.74–1.75)	1.07(0.69–1.65)	0.83
Model 2	1.00	1.22(0.79–1.89)	0.83(0.52–1.30)	0.96(0.62–1.50)	0.46	1.00	1.23(0.78–1.94)	1.24(0.78–1.97)	1.14(0.72–1.81)	0.60
Model 3	1.00	1.23(0.79–1.95)	0.83(0.51–1.35)	0.94(0.57–1.55)	0.43	1.00	1.32(0.82–2.11)	1.36(0.84–2.20)	1.31(0.80–2.16)	0.32
Model 4	1.00	1.24(0.79–1.96)	0.84(0.51–1.36)	0.95(0.57–1.56)	0.44	1.00	1.32(0.82–2.11)	1.36(0.84–2.20)	1.31(0.79–2.17)	0.32
Psychological distress										
Crude	1.00	1.28(0.95–1.73)	1.07(0.78–1.46)	1.13(0.83–1.54)	0.72	1.00	1.04(0.77–1.42)	1.18(0.87–1.60)	0.99(0.73–1.35)	0.85
Model 1	1.00	1.25(0.89–1.74)	1.08(0.77–1.51)	1.23(0.88–1.71)	0.38	1.00	0.93(0.66–1.30)	1.04(0.74–1.47)	1.00(0.71–1.39)	0.82
Model 2	1.00	1.28(0.90–1.82)	1.07(0.75–1.53)	1.17(0.82–1.65)	0.63	1.00	0.97(0.68–1.38)	1.13(0.79–1.62)	1.04(0.73–1.48)	0.63
Model 3	1.00	1.32(0.92–1.89)	1.10(0.76–1.60)	1.19(0.80–1.76)	0.64	1.00	0.98(0.68–1.41)	1.16(0.80–1.68)	1.07(0.74–1.57)	0.51
Model 4	1.00	1.32(0.92–1.89)	1.10(0.76–1.60)	1.18(0.80–1.75)	0.66	1.00	0.98(0.68–1.42)	1.18(0.81–1.70)	1.10(0.75–1.61)	0.44
¹ Model 1: Adjusted for age, gender and energy intake.										
Model 2: Further adjustment for physical activity, smoking, marital status, education, socioeconomic status (SES), diabetes, intake of Anti-psychotic medications and dietary supplements.										
Model 3: Additional controlling for dietary intakes of high fat dairy, nuts, soy and legumes, grains, fruit and vegetables.										
Model 4: More adjustment for n-3 fatty acids.										
Legend to figures:										

In normal weight participants, highest quartiles of red meat intake associated with higher odds of depression in both crude (OR = 1.44; 95%CI: 1.08–1.92) and fully adjusted model (OR = 1.66; 95%CI: 1.14–2.42). No significant relationship was observed between white meat intake and mental disorders in normal weight subjects.

Discussion

This cross-sectional study showed a significant positive association between red meat intake and the risk of depression in Iranian adults. This association was seen among male participants, even after adjustment for all potential confounders. But there was no relationship in females, after considering confounding factors. Also, in normal weight participants a significant direct association was observed between red meat intake and the odds of depression. While, analysis in overweight or obese subjects showed that white meat intake had an inverse association with odds of psychological distress and marginally inverse association with depression risk. To our knowledge, this study was one of the first investigations in the Middle East which evaluated the relationship between meat intake and mental disorders.

Considering the high prevalence of mental disorders especially depression all over the world, and high consumption of red meat on the other hand, our findings of the present study could be a dietary approach to prevent some mental disorders and subsequent costs to societies and governments. Therefore, recommendation to decrease red meat intake, especially in men and even normal weight individuals, along with replacing the consumption of white meat, particularly in overweight or obese individuals, could be efficient to reduce depression and psychological distress.

Previous studies have shown inconsistent results on relationship between depression and meat consumption. Two prospective cohort studies indicated a significant association between meat or processed meat consumption (but not fish intake) and depression (24, 32). Whitehall II, another cohort study conducted on 3486 participants, showed that high adherence to "processed food dietary pattern" including processed meat was associated with an increased odds of depression (33). Similarly, a pilot randomized controlled trial have suggested that restriction of meat, fish, and poultry consumption could improve mental state (34). Zhou et al in a cross-sectional study indicated that weekly meat intake was positively correlated with depression symptoms (20). In contrast, a cross-sectional study among 11,473 Chinese participants revealed consumption of meat (including fresh and salted meat and fish) less than once a week was significantly associated with increased risk of depression, compared with once a week or more meat intake (35). This effect might be due to family low income, insufficient consumption of fish, or perhaps anemia caused by low meat intake (36). A prospective cohort study with multistage random sampling, has also found no significant relationship between meat or processed meat intake and depressive symptoms in elders (25). These inconsistencies could be due to different study designs, different populations, different tools and scales to measure variables.

Previous studies revealed that women were more susceptible to mental disorders; however, we found that red meat intake is related to depression in men, but not in women. This finding might be because of estrogens that have neuronal protective effects (37). In addition, our analyses showed significantly higher red meat intake in males than females (84.7 vs. 74.4 gr/d, $P < 0.001$) that could be the reason. Also, another possible reason might be healthier dietary intake of women than men (38).

Although previous studies have shown that the prevalence of depression in overweight or obese individuals was higher than in normal weight subjects (39), our findings showed a direct relationship between red meat intake and depression in normal-weight subjects and no relationship in the overweight or obese participants. Furthermore, in overweight or obese subjects, white meat intake showed an inverse association with psychological distress, while there was no linkage in normal-weight individuals. Some compensatory mechanisms might exist in overweight or obese individuals that coping with the harmful effects of meat on the path to depression. In the case of white meat intake, the current study was conducted in one of the central provinces of Iran, where is far from the sea and fish was less likely to be consumed by the study population than chicken and poultry; this point might affect our findings. So, we made adjustment for omega-3 intakes in the analysis. However, the results were still unexplained and further investigations are needed.

Previous findings showed low grade inflammatory status in depression and anxiety disorders (40–43). Inflammation plays a potential role in the etiology of depression (44), on the other hand it has indicated that red meat intake could elevate levels of pro-inflammatory cytokines such as CRP, TNF- α , and IL-6 (45). Unfortunately, in the current study, it was not possible to evaluate inflammatory and oxidative biomarkers. Although the involved biochemical pathways are not fully known, some studies blamed total fat and fat types of meat for this condition (17, 46). Diets rich in SFA or total fats could increase free radical production and elevate oxidative stress and inflammation (47–49). Pro-inflammatory cytokines may disrupt neurotransmitter metabolism pathways, reduce plasma tryptophan

level, and prevent Brain-Derived-Neurotrophic-Factor (BDNF) expression (50, 51). BDNF is a peptide critical for optimal neuronal function which has been indicated to be decreased in depression (52, 53). Also, endothelium is involved in synthesis and secretion of BDNF; therefore, endothelial dysfunction leading to disturb cell signaling cascades (54). It was suggested that diets high in meat, fish and poultry increases the risk of inflammation and depression due to n-6 to n-3 fatty acid ratio (55). Plasma concentrations of tryptophan, an essential amino acid to produce serotonin, and large neutral amino acids (LNAA) could be another mechanism which may be involved in depression (56). Brain concentrations of tryptophan depend on plasma concentrations of both tryptophan and LNAA, which competes with tryptophan to cross over the blood-brain barrier. (57). Some studies have shown a higher reduction in plasma tryptophan than plasma LNAA after consumption of a meal rich in proteins or proteins plus fats such as meat (58).

The strengths of the present study were collecting data from a large population of Iranian adults and using validated questionnaires to evaluate psychological disorders, physical activity and dietary intakes. Effects of several potential confounders were also taken into account. However, several limitations need to be considered when interpreting our findings. Due to the cross-sectional design of the study, we did not have possibility to have causal relationship between meat intake and mental disorders. Large prospective cohort studies are necessary to distinguish a causal relationship. Utilization of self-administered FFQ could inevitably lead to errors due to fixed list of foods and portion sizes and its dependency on memory. Different types of red and white meat were not specifically investigated. We could not measure biomarkers of inflammation and oxidative status. Also, it was not possible to assess body resources of micronutrient, such as vitamin D, B₆, B₁₂, folate and zinc, which might involve in mental disorders (59–62). In addition, the study population consisted of a medical university non-academic staff, including crews, employees and managers, although the socio-economic status of the study population was representative of general Iranian population, generalization the findings to other populations should be made cautiously.

Conclusions

We found that higher intake of red meat was associated with increased risk of depression, especially in males. In overweight or obese subjects, white meat intake was inversely associated with psychological distress. Red meat intake was related to increased odds of depression in normal weight participants. Therefore, conscious and controlled consumption of red meat could be one of the dietary strategies to prevent mental disorders. Further prospective studies are needed to confirm these findings.

Declarations

Ethical Approval and Consent to participate: All participants provided informed written consent. The study was ethically approved by the Research Council of Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran (IUMS).

Consent for publication: Each author acknowledges he/she has participated in the work in a substantive way and is prepared to take public responsibility for the work.

Availability of supporting data: Supporting data for this investigation can be available by contacting the supervisor of the research (AE).

Competing interests: None of the authors declared potential personal or financial conflicts of interest.

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Authors' contributions: SK, AHK, PS, HA, AE and PA contributed in conception, design, data collection, data interpretation, manuscript drafting, approval of the final version of the manuscript, and agreed for all aspects of the work.

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Figures

Figure 2

The prevalence of depression, anxiety and high psychological distress in study participants across different energy-adjusted quartiles of red and white meat intake in whole population.