Association of energy adjusts nutrient-rich foods on mental health among obese and overweight women: a cross-sectional study

Zahra Salehi1 · Farideh Shiraseb1 · Dorsa Hosseininasab2 · Niloufar Rasaei1 · Shahin Jamili3 · Khadijeh Mirzaei1,4

Abstract

Purpose Mental health and obesity have a bilateral relationship with each other. No study has been done on the association between mental health and the ENRF9.3 index so far. Therefore, for the first time, the present study investigated the relationship between the ENRF9.3 index and mental health in overweight and obese women.

Methods In the current cross-sectional study, 124 overweight and obese women were selected. Food intakes in the last year were collected with 147 items semi-quantitative food frequency questionnaire. Then, the ENRF9.3 index score was calculated for all individuals. Mental health was assessed with 21-item Depression Anxiety Stress Scales (DASS) questionnaire.

Results In the present study, the total DASS score was marginally significant \((P = 0.05)\), however, after the adjustment, it became insignificant \((P > 0.05)\). After adjusting confounders stress also became significant \((P = 0.04)\). No significant relationship was observed between depression and anxiety, even after adjustment \((P > 0.05)\).

Conclusion The present study showed that a nutritious diet is not associated with overall mental health score, among subgroups of the DASS total score. The relationship was seen only for the stress subgroup.

Level of evidence Level III: Evidence obtained from cohort or case-control analytic studies.

Keywords ENRF9.3 index · Mental health · Obesity · Stress · Anxiety · Depression
Introduction

Obesity is increasing rapidly worldwide and has doubled since 1980. The World Health Organization (WHO) estimates that by 2025, one in five adults will be obese [1, 2]. In Iran, the prevalence of a combination of obesity and overweight may be more than 76% in some areas [2]. Obesity is more common in women (39.5%) than men (14.5%) [3]. The interactive effect of positive energy balance, and metabolic, genetic, environmental, and psychological factors may play a decisive role in the etiology of obesity [4, 5]. Progressive weight gain can cause a range of comorbidities such as dyslipidemia, hypertension, cardiovascular disease, and certain types of cancer [6]. The risk of mental illness in individuals with obesity has been documented to range between 30 and 70% [7]. Some evidence has indicated that the relationship between weight and mental illness is dose-dependent, higher BMI increases the susceptibility to an incident of psychiatric disorder and reverses [8, 9].

The common psychological disorders including depression and anxiety have a considerable contribution to the global burden of disease, accounting for 7.4% of all healthy years of life lost [10]. Among the Iranian population, 21% of adults are affected by mental disorders [11]. The complex interactions of social, environmental, and biological factors are contributing to psychological disorders [12]. Diet has been considered a modifiable factor that plays a key role [13]. Healthy diets such as the Japanese diet or Mediterranean diet, are inversely associated with depression risk [14] while a pro-inflammatory diet increases the risk of adverse mental health consequences [15] such as high-fat meals could intensify stress [16].

Diet quality, which encompasses adequacy or sufficiency, moderation, diversity, and balance or equilibrium of nutrient and food intakes, is also critical to mental health [10]. One of the nutrient quality models is the nutrient-rich food (NRF) index [17]. Unlike the quality of the general diet index and similar to the healthy eating index (HEI), the NRF index, unlike the quality of the general diet index, similar to healthy eating index (HEI), has been tested and validated [18, 19]. The NRF 9.3 index is based on 9 nutrients that are encouraged, and 3 nutrients that are restricted [20]. The association between the NRF index, all-cause mortality, the incident of cardiovascular diseases [21], various anthropometric measurements [22], and malnutrition in children [17], have been assessed. No study has been performed on the association of nutrient-rich food on mental health among obese and overweight women, therefore the current study has been designed to determine this association.

Methods and materials

Study population

A cross-sectional study was conducted on 124 healthy obese and overweight women who were referred to health centers in Tehran, Iran recruited by the multi-stage cluster random sampling method. Finally, 20 clusters were selected, because different socio-economic statuses were also considered. Before the study, all participants signed informed written consent. The sample entry criteria were BMI 25–34.9 kg/m² and the age between 18 and 48 years old. Also, exclusion criteria were: pregnancy, lactation, menstruation, any acute or chronic infections, use of any medications, smoking, alcohol consumption, dieting or weight loss over the last year, and calorie intake between 800 and 4200 kcal per day. The current study was approved by the Medical Research Ethics Committee of TUMS (IR.TUMS.MEDICINE.REC.1399.165).

Anthropometric measures

The weight of the participants was measured using a digital scale (Seca725 GmbH& Co., Hamburg, Germany) and a precision of 0.1 kg without heavy clothing and shoes, and their height was measured by a rigid meter with a standing gauge, without shoes and hairpins with a precision of 0.5 cm. The BMI was then calculated from the formula “weight divided by the square of the height”. The waist circumference (WC) was determined at the narrowest point between the lower ribs and the iliac crest, with light clothing and with a tape measure without putting pressure on the body, with an accuracy of about 0.5 cm. To measure the waist to hip ratio (WHR), WC was divided by hip circumference (HC), WHR was calculated by dividing WC by height.

Dietary intake assessment

Normal daily intakes were measured using the 147 items food frequency questionnaire (FFQ) which was previously validated and reliable and contains a list of standard-sized foods Iranians typically use [23]. Participants were asked to report each food item over the past year and these amounts were first converted to daily intakes and then to grams using household scales [24]. Dietary intakes were analyzed using Nutritionist 4 (version 7.0; N-Squared Computing, Salem, OR).
ENRF index calculation

The NRF Index offers a valid measure of the nutrient density of a person’s diet [25, 26]. This index has two parts: the nutrient-rich (NR) sector, which is based on a changed number of useful nutrients and limiting nutrients (LIM) sector. The NRF9.3 score is based on the sum of the percentages of reference daily values (DVs) of 9 beneficial nutrient proteins, dietary fiber, vitamin A, vitamin C, vitamin E, calcium, magnesium, iron, and potassium [19]. The daily reference values, shown in Table 1, are based on FDA standards [27, 28], in which the selection of nutrients to persuasion, conforms to the FDA explanation of healthy foods [29], minus the entirety of the percentage of maximum suggested values for the 3 nutrients that are limited [19]. By the residual method, all the components mentioned are adjusted with energy. ENRF9.3 index is assessed as follows:

First, ENRF 9.3 algorithms based on the Dronovsky method score all foods eaten by each individual [30], this results in an ENRF9.3 score (per 100 kcal) for each food item, meaning a food score of ENRF9.3 (Table 2) [17]. Therefore, participants with a higher ENRF index score have a healthier dietary pattern than individuals with a lower ENRF index score.

Mental health assessment

The mental status of the subjects was assessed using a validated questionnaire with 21 questions (DASS-21) [31]. This questionnaire measures the mood states of depression, stress, and anxiety. Each state has 7 items that are rated in a range of 4 points. Participants were asked by a trained dietitian to indicate how much each item was correct about them during the last week. A higher score indicates more severe mental distress. For the stress subgroup, the range of 15–18 is considered mild, 19–25 moderate, 26–33 severe, and ≤34 very severe. Mild depression was 10–13, moderate was 14–20, severe was 21–27, and very severe was 28. Mild, moderate, severe, and very severe anxiety were also considered 8–9, 10–14, 15–19, and ≥20, respectively.

Other variables

To evaluate physical activity during the last 7 days, the valid and reliable Persian version of the International Physical Activity Questionnaire (IPAQ) was used [32]. Then the activity was converted into a daily metabolic equivalent (MET-min per week). Researchers received demographic characteristics by questionnaire.

| Table 1 | Daily reference values and maximum recommended nutrient values based on the 2000-kcal diet⁴ |
|---------|------------------------------------------------------------------------------------------|
| Nutrient | RDV | MRV |
| Fiber (g) | 25 | – |
| Protein (g) | 50 | – |
| Vitamin A (IU) | 5000 | – |
| Vitamin C (mg) | 60 | – |
| Vitamin E [IU (mg)] | 30(20) | – |
| Iron (mg) | 18 | – |
| Calcium (mg) | 1000 | – |
| Potassium (mg) | 3500 | – |
| Magnesium (mg) | 400 | – |
| Saturated fat (g) | – | 20 |
| Sodium (mg) | – | 2400 |
| Sugars, added (g) | – | 50 |

⁴RDV Reference daily value, MRV Maximum recommended value

| Table 2 | Algorithms for ENRF index score and the NRn and LIM sub scores, computed per 100 kcal |
|---------|-------------------------------------------------------------------------------------|
| Model   | Algorithm                                      | Reference value | Explanation                                                                 |
| NRn_100kcal | \[ \sum 1 - n \cdot (\text{nutrient}_i/\text{DV}_i) / \text{ED} \times 100 \] | 100 kcal        | Nutrient$_i$ = nutrient content in 100g edible quota                        |
|                  |                                                   |                  | DV$_i$ = daily values for nutrient $i$ (Table 1)                             |
|                  |                                                   |                  | $n$ = number of nutrients                                                    |
|                  |                                                   |                  | ED = energy density                                                         |
| LIM_100kcal | \[ \sum 1 - 3 \cdot (L_i/\text{MRV}_i) / \text{ED} \times 100 \] | 100 kcal        | $L_i$ = Limiter nutrient content per 100 g of the oral share of food         |
|                  |                                                   |                  | $i$ = 1 to 3                                                                |
|                  |                                                   |                  | ED = Energy density                                                         |
| compound models, NRF | NRn_100 kcal LIM_100 kcal | 100 kcal        | Discrepancy between sums                                                    |

MRV Maximum recommended value, NRF Nutrient rich food, LIM Limited nutrient score
Statistical analysis

Analyzes were performed on 124 women. Kolmogorov–Smirnov method was used to assess the normality of the population. Quantitative variables across the ENRF 9.3 tertiles were shown as mean ± standard deviations (SDs), and discrete variables were also expressed in numbers and percentages. Analysis of variance (ANOVA) was used for quantitative variables and Chi-square test for qualitative ones. Confounders such as age, BMI, physical activity, and energy intake were adjusted by analysis of covariance (ANCOVA). The Bonferroni method was used for posthoc analyses. Multi-nominal logistic regression was used to compute odds ratio (OR) and 95% CIs, for the assessment association of the total DASS and its subgroups scores with the ENRF index. There was a significant difference when it was $P \leq 0.05$. Data were analyzed using IBM SPSS version 25.0 (SPSS, Chicago, IL, USA).

Results

Study population characteristics

In the current cross-sectional study, 124 individuals were eligible for entering the study. The mean (± SD) age, BMI, and WHR of individuals were $35.19 \pm 8.28$ (years) $30.48 \pm 4.22$ (kg/m²), and $0.81 \pm 0.07$, respectively. $20\%$ ($n = 25$) of participants were married. $1\%$ ($n = 2$) of study population were illiterate and $60\%$ ($n = 75$) of women owned—a house and $54\%$ ($n = 68$) of them took supplements. The percentage of depression in participants was $44.4\%$. The stress percentage was $53.2$ and $55.6\%$ of the study population had Anxiety.

Association between quantitative and qualitative variables among ENRF9.3 index quartiles

All participants were categorized based on the ENRF9.3 and divided into quartiles group. Table 3 demonstrates the general characteristics of subjects and quantitative and qualitative of the study participants across quartiles of ENRF9.3. Subjects with the highest ENRF9.3 index scores were older, even after controlling for confounders ($P < 0.05$). Participants with a high ENRF9.3 score had significantly lower HC and WHR after adjusting for age, BMI, and physical activity ($P = 0.04$ and $P = 0.05$, respectively). Participants who had more adherence to ENRF9.3 scores were single and homeowners ($P < 0.05$). Physical activity means in the highest quartiles was more than in the lowest quartiles, which was significant at first ($P = 0.05$), but after adjustment showed marginal significance ($P = 0.06$). Regarding other variables related to general characteristics in ENRF9.3 quartiles, there was not a significant difference ($P > 0.05$) (Table 3).

The association of ENRF9.3 index components, micronutrient, macronutrient, and food groups across the ENRF9.3 index score quartiles

The association of food items consumed across the ENRF9.3 index quartiles is shown in Table 4. Participants who were in the first quartile of the ENRF9.3 index had lower intakes of vitamin A ($P < 0.001$), Potassium ($P = 0.03$), and calcium ($P = 0.05$) and higher intakes of vitamin E ($P = 0.01$). There was no significant difference for other dietary intakes ($P > 0.05$). After adjusting for energy intake, a significant relationship has been seen in protein intake, and magnesium among the ENRF9.3 quartiles, so that their mean was higher in the upper quartile, but the others remained insignificant ($P > 0.05$). Among food groups in the crude model, vegetables, milk and milk products, low-fat dairy, vegetable oil, meat and poultry, processed meat, tea and coffee intake were higher in the highest quartile of ENRF9.3 score, which were also significant ($P < 0.05$). However, no significant association was observed for the other food groups ($P > 0.05$). After controlling energy intake, a lower mean of zinc ($P = 0.01$), niacin ($P = 0.002$), beta carotene, riboflavin, pyridoxine, folate, biotin, and copper ($P < 0.001$) consumption, and significantly higher MUFA ($P < 0.001$), PUFA, and linoleic ($P = 0.002$) consumption, were observed at the highest ENFR9.3 quartile relative to the lowest, while there was no significant difference for other dietary intakes ($P > 0.05$).

DASS total score and its subgroups among quartiles of the ENRF9.3 index score

In Table 5, the DASS total score and its subgroups among ENRF9.3 index score quartiles were assessed, so that the mean of total DASS score was lower in higher quartiles, there was a significant relationship ($P = 0.05$), but among the 3 models of DASS score that were adjusted, significance was observed only for model 3 (when the adjustment was performed for all variables in models 1 and 2, plus education, consumption of dietary linolenic acid and BMI), which according to Bonferroni analysis, this significant difference was observed between the means of quartile 1 and 4. All the three-components of mental health and total DASS score, except anxiety in Model 3, were lower in the top quartile. The stress of individuals, in the crude model, was marginally significant ($P = 0.06$), which became significant after controlling the confounders in models 2 and 3 ($P = 0.04$),
and according to Bonferroni analysis, there was a significant difference between the means of quartile 2 and 4. Depression, after adjustment for all variables (Model 3), was able to become significant \( (P = 0.02) \), but for anxiety, after adjustment, no significant difference was observed \( (P > 0.05) \).

**Associations between total DASS score and its subgroups with ENRF9.3 score**

The odds ratio (OR) and its 95%CI of total DASS score and its subgroups with ENRF9.3 score were represented in Table 6. In the crude model, the relation between only the mild depression subgroup and ENRF9.3 was significant \( (OR = 0.97; 95\% \text{ CI} 0.94 \text{ to } 1; P = 0.05) \) and showed a 0.03% decrease with increasing ENRF9.3 quartiles, however, there was no association between mild depression index with ENRF9.3 in the adjusted model \( (OR = 0.98; 95\% \text{ CI} = 0.95\text{ to } 1.01; P = 0.3) \). After controlling the confounders by multinomial logistic regression analysis, mild, severe, and extremely severe stress became significant \( (P \leq 0.05) \), and very severe depression also found marginal significance \( (P = 0.06) \). Significance for anxiety was not observed at all in the present study \( (P > 0.05) \).
Table 4  ENRFC9.3 index score and its components, food groups, macronutrients, and micronutrients among quartiles (Q) categories of ENRFC9.3 index

| Variables                        | Quartiles (Q) of ENRFC9.3 index | p-valuea |
|----------------------------------|----------------------------------|----------|
|                                  | Q1      | Q2      | Q3      | Q4      |          |
| Mean ± SD                        |         |         |         |         |          |
| NRFRFC9.3 index score            | 55.25 ± 1.95 | 69.17 ± 2.02 | 81.15 ± 2.02 | 106.94 ± 2.08 | <0.001   |
| Model 1                          | 55.27 ± 1.95 | 69.03 ± 2.02 | 81.40 ± 2.03 | 106.81 ± 2.09 | <0.001   |
| NRF9 index score                 | 81.88 ± 1.09 | 89.80 ± 1.12 | 94.22 ± 1.12 | 102.10 ± 1.16 | <0.001   |
| Model 1                          | 81.88 ± 1.09 | 89.82 ± 1.13 | 94.19 ± 1.13 | 102.12 ± 1.17 | <0.001   |
| NRF9 index components            |         |         |         |         |          |
| Protein (g/100 kcal)             | 82.50 ± 4.32 | 86.38 ± 4.46 | 97.52 ± 4.46 | 86.72 ± 4.61 | 0.1      |
| Model 1                          | 82.17 ± 2.63 | 88.95 ± 2.72 | 93.07 ± 2.73 | 89.11 ± 2.81 | 0.03     |
| Total fiber (g/100 kcal)         | 49.35 ± 3.04 | 45.67 ± 3.14 | 44.37 ± 3.14 | 43.16 ± 3.25 | 0.5      |
| Model 1                          | 49.18 ± 2.49 | 46.99 ± 2.57 | 42.08 ± 2.59 | 44.39 ± 2.66 | 0.2      |
| Vitamin A (IU)                   | 1848.23 ± 188.95 | 2426.35 ± 194.95 | 3066.26 ± 194.95 | 2405.74 ± 201.56 | <0.001   |
| Model 1                          | 1839.54 ± 167.38 | 2492.77 ± 173.06 | 2951.30 ± 173.81 | 2467.52 ± 178.86 | <0.001   |
| Vitamin C (mg)                   | 192.67 ± 23.28 | 178.45 ± 24.02 | 198.59 ± 24.02 | 160.15 ± 24.84 | 0.6      |
| Model 1                          | 191.76 ± 21.43 | 185.40 ± 22.16 | 186.55 ± 22.25 | 166.62 ± 22.90 | 0.8      |
| Vitamin E (mg)                   | 24.52 ± 1.86 | 17.84 ± 1.92 | 18.27 ± 1.92 | 16.17 ± 1.98 | 0.01     |
| Model 1                          | 17.47 ± 1.81 | 18.19 ± 1.87 | 24.66 ± 1.88 | 16.50 ± 1.93 | 0.01     |
| Calcium (mg)                     | 1041.58 ± 65.90 | 1166.68 ± 67.99 | 1303.10 ± 67.99 | 1209.16 ± 70.30 | 0.05     |
| Model 1                          | 1037.02 ± 46.59 | 1201.60 ± 48.17 | 1242.65 ± 48.38 | 1241.65 ± 49.78 | 0.007    |
| Magnesium (mg)                   | 437.88 ± 22.18 | 422.99 ± 22.89 | 495.53 ± 22.89 | 461.57 ± 23.66 | 0.1      |
| Model 1                          | 436.09 ± 12.39 | 435.76 ± 12.81 | 471.71 ± 12.87 | 474.37 ± 13.24 | 0.04     |
| Potassium (mg)                   | 3702.33 ± 249.10 | 4039.57 ± 257.01 | 4694.69 ± 257.01 | 4405.30 ± 265.72 | 0.03     |
| Model 1                          | 3683.47 ± 157.74 | 4183.84 ± 163.09 | 4444.96 ± 163.80 | 4539.50 ± 168.55 | 0.001    |
| Iron (mg)                        | 19.17 ± 0.87 | 18.43 ± 0.90 | 19.77 ± 0.90 | 17.03 ± 0.93 | 0.4      |
| Model 1                          | 19.19 ± 0.48 | 18.97 ± 0.49 | 18.83 ± 0.50 | 18.21 ± 0.51 | 0.6      |
| LIM3 index score                 | 21.19 ± 0.58 | 18.14 ± 0.60 | 18.84 ± 0.60 | 16.34 ± 0.62 | <0.001   |
| Model 1                          | 16.19 ± 0.58 | 18.15 ± 0.60 | 18.83 ± 0.60 | 21.35 ± 0.62 | <0.001   |
| LIM3 index components            |         |         |         |         |          |
| Sodium (mg)                      | 4328.65 ± 239.30 | 4221.80 ± 246.90 | 4578.50 ± 246.90 | 4262.16 ± 255.27 | 0.7      |
| Model 1                          | 4314.85 ± 193.86 | 4327.32 ± 200.45 | 4395.84 ± 201.31 | 4360.31 ± 207.16 | 0.9      |
| Saturated fat (g)                | 27.34 ± 1.91 | 27.38 ± 1.97 | 31.82 ± 1.97 | 28.64 ± 2.04 | 0.3      |
| Model 1                          | 27.20 ± 1.28 | 28.45 ± 1.32 | 29.97 ± 1.33 | 29.63 ± 1.37 | 0.4      |
| Add sugar (g)                    | 15.20 ± 2.86 | 15.07 ± 2.95 | 21.66 ± 2.95 | 17.01 ± 3.05 | 0.3      |
| Model 1                          | 15.12 ± 2.76 | 15.66 ± 2.85 | 20.63 ± 2.86 | 17.56 ± 2.95 | 0.5      |
| Food groups                      |         |         |         |         |          |
| Grain                            |         |         |         |         |          |
| Whole grains (g)                 | 518.93 ± 38.34 | 478.23 ± 38.98 | 500.23 ± 38.98 | 513.70 ± 38.34 | 0.8      |
| Model 2                          | 473.82 ± 41.68 | 450.44 ± 44.00 | 484.68 ± 42.19 | 544.47 ± 43.19 | 0.4      |
| Refined grains (g)               | 425.45 ± 38.11 | 390.77 ± 38.74 | 404.76 ± 38.74 | 434.65 ± 38.11 | 0.8      |
| Model 2                          | 380.06 ± 41.86 | 365.78 ± 44.19 | 392.82 ± 42.37 | 455.72 ± 43.37 | 0.4      |
| Vegetables (g)                   | 271.96 ± 35.80 | 380.24 ± 36.39 | 504.51 ± 36.39 | 413.84 ± 35.80 | <0.001   |
| Model 2                          | 313.07 ± 41.86 | 388.62 ± 44.19 | 493.23 ± 42.38 | 408.47 ± 43.38 | 0.03     |
| Fruits (g)                       | 441.41 ± 57.40 | 488.57 ± 58.35 | 555.71 ± 58.35 | 528.49 ± 57.40 | 0.5      |
| Model 2                          | 450.40 ± 58.33 | 446.09 ± 61.58 | 528.71 ± 59.05 | 493.31 ± 60.44 | 0.7      |
| Variables                        | Quartiles (Q) of ENRF9.3 index | p-value<sup>a</sup> |
|---------------------------------|--------------------------------|---------------------|
|                                 | Q1               | Q2               | Q3               | Q4               |
| **Mean ± SD**                   |                  |                  |                  |                  |
| **Legumes(g)**                  |                  |                  |                  |                  |
| Crude                           | 55.76 ± 7.04     | 57.48 ± 7.26     | 57.30 ± 7.26     | 45.88 ± 7.51     | 0.8                |
| Model 2                         | 60.02 ± 7.88     | 52.54 ± 8.31     | 52.01 ± 7.97     | 50.28 ± 8.16     | 0.8                |
| **Nut and seeds(g)**            |                  |                  |                  |                  |
| Crude                           | 11.56 ± 2.63     | 12.54 ± 2.71     | 12.68 ± 2.71     | 14.97 ± 2.81     | 0.9                |
| Model 2                         | 13.39 ± 3.20     | 11.91 ± 3.38     | 11.20 ± 3.24     | 17.00 ± 3.31     | 0.6                |
| **Milk and milk products(g)**   |                  |                  |                  |                  |
| Crude                           | 243.62 ± 36.72   | 364.83 ± 37.33   | 427.77 ± 37.33   | 410.05 ± 36.72   | 0.003              |
| Model 2                         | 271.83 ± 42.64   | 320.41 ± 45.02   | 448.17 ± 43.17   | 428.08 ± 44.19   | 0.01               |
| **Low-fat dairy(g)**            |                  |                  |                  |                  |
| Crude                           | 191.03 ± 32.14   | 289.06 ± 32.68   | 324.11 ± 32.68   | 300.96 ± 32.14   | 0.02               |
| Model 2                         | 207.79 ± 37.48   | 266.73 ± 39.57   | 327.20 ± 37.94   | 318.36 ± 38.84   | 0.1                |
| **Fats and oils(g)**            |                  |                  |                  |                  |
| Crude                           | 49.13 ± 4.91     | 36.52 ± 4.99     | 35.87 ± 4.99     | 34.61 ± 4.91     | 0.1                |
| Model 2                         | 49.95 ± 5.44     | 33.24 ± 5.74     | 34.37 ± 5.51     | 39.83 ± 5.64     | 0.1                |
| **Vegetable oil(g)**            |                  |                  |                  |                  |
| Crude                           | 39.26 ± 4.51     | 24.86 ± 4.58     | 23.14 ± 4.58     | 23.71 ± 4.51     | 0.03               |
| Model 2                         | 40.95 ± 4.98     | 23.97 ± 5.26     | 22.05 ± 5.04     | 28.40 ± 5.16     | 0.04               |
| **Eggs(g)**                     |                  |                  |                  |                  |
| Crude                           | 18.80 ± 2.68     | 18.78 ± 2.72     | 23.41 ± 2.72     | 21.68 ± 2.68     | 0.5                |
| Model 2                         | 17.83 ± 2.96     | 17.74 ± 3.13     | 22.90 ± 3.00     | 23.95 ± 3.07     | 0.3                |
| **Meat and poultry(g)**         |                  |                  |                  |                  |
| Crude                           | 45.60 ± 6.70     | 56.03 ± 6.81     | 76.20 ± 6.81     | 55.69 ± 6.70     | 0.01               |
| Model 2                         | 45.42 ± 7.84     | 53.37 ± 8.28     | 77.31 ± 7.94     | 61.26 ± 8.13     | 0.04               |
| **Processed meat(g)**           |                  |                  |                  |                  |
| Crude                           | 22.70 ± 3.96     | 23.89 ± 4.03     | 40.42 ± 4.03     | 22.29 ± 3.96     | 0.004              |
| Model 2                         | 20.50 ± 4.34     | 21.20 ± 4.58     | 41.63 ± 4.39     | 22.55 ± 4.50     | 0.003              |
| **Fish and seafood(g)**         |                  |                  |                  |                  |
| Crude                           | 7.93 ± 1.95      | 9.51 ± 1.98      | 10.88 ± 1.98     | 11.88 ± 1.95     | 0.5                |
| Model 2                         | 7.77 ± 2.32      | 9.04 ± 2.45      | 11.34 ± 2.35     | 14.14 ± 2.41     | 0.2                |
| **Sugar, sweets, and beverage(g)**|            |                  |                  |                  |
| Crude                           | 21.54 ± 9.09     | 25.96 ± 9.24     | 42.10 ± 9.24     | 15.91 ± 9.09     | 0.2                |
| Model 2                         | 22.42 ± 10.92    | 25.15 ± 11.53    | 47.73 ± 11.06    | 16.98 ± 11.32    | 0.2                |
| **Tea and coffee**              |                  |                  |                  |                  |
| Crude                           | 349.79 ± 65.77   | 443.89 ± 66.86   | 699.77 ± 66.86   | 1196.88 ± 65.77  | <0.001             |
| Model 2                         | 431.99 ± 70.79   | 422.93 ± 74.73   | 657.96 ± 71.66   | 1200.67 ± 73.35  | <0.001             |
| **Dietary intake**              |                  |                  |                  |                  |
| Energy (kcal)                   | 2703.25 ± 593.05 | 2579.63 ± 717.49 | 2822.42 ± 673.68 | 2568.83 ± 740.52 | 0.4                |
| Energy from fat(%)              | 28.34 ± 1.06     | 31.63 ± 1.06     | 34.99 ± 1.07     | 37.28 ± 1.06     | <0.001             |
| Energy from protein(%)          | 14.09 ± 0.39     | 13.51 ± 0.39     | 13.56 ± 0.39     | 12.13 ± 0.39     | 0.005              |
| Energy from carbohydrate(%)    | 61.06 ± 1.02     | 57.86 ± 1.02     | 53.90 ± 1.03     | 52.74 ± 1.02     | <0.001             |
| Zinc (mg)                       | 13.57 ± 0.36     | 13.49 ± 0.36     | 12.59 ± 0.37     | 12.12 ± 0.36     | 0.01               |
| Copper (mg)                     | 2.23 ± 0.05      | 2.06 ± 0.05      | 1.84 ± 0.05      | 1.69 ± 0.05      | <0.001             |
| Selenium (mcg)                  | 124.43 ± 4.41    | 130.25 ± 4.41    | 124.00 ± 4.48    | 120.23 ± 4.41    | 0.4                |
| Beta carotene (Mg)              | 6658.55 ± 382.16 | 5442.31 ± 382.34 | 4122.67 ± 388.21 | 3258.33 ± 381.95 | <0.001             |
| Thiamin (mg)                    | 2.23 ± 0.06      | 2.18 ± 0.06      | 2.12 ± 0.06      | 2.02 ± 0.06      | 0.1                |
| Niacin (mg)                      | 26.59 ± 0.80     | 25.43 ± 0.80     | 25.38 ± 0.81     | 22.25 ± 0.80     | 0.002              |
Discussion

In the present study, the mental health subgroups, such as stress, anxiety, and depression, before and after adjustment for the confounders, had lower means in the upper ENRF quartiles, but significance was observed only for the stress subgroup after controlling the confounders.

Diet plays an important role in improving or advancing mental illness. In line with a current study concerning depression and anxiety, Lizanne JS. Schweren et al. [33] in a cohort study showed that diet is unlikely to prevent depression and anxiety in the community in the long run, and Murakami et al. also in their systematic review, found no association between dietary variables and depressive symptoms [34]. However, against these studies, Poorrezaeiana and colleagues [35, 36] in two cross-sectional studies found an inverse relationship between anxiety and depression with dietary diversity score as the healthy eating index in women, because dietary diversity is positively associated with dietary micronutrients and negatively correlated with micronutrient deficiencies intake [37], and the relationship between the consumption of processed foods, commercial baked goods, fast foods, and sweets, with an increased risk of depression, due to the high content of saturated fats, trans-fatty acids, added sugar and refined carbohydrates and low content of fiber and nutrients, has been seen in observational studies [38]. Gibson-Smith et al. [39] found that the quality of the diet was poorer in people with anxiety disorders and depression. Another opposed study has shown, that people who received a Mediterranean diet for 3 months had better scores on depression and overall mental health scores than those who did not, due to improvements in the quality of their diet [40].

Deficiency in some B and C vitamins and iron has been linked to psychological symptoms [41], and many of the nutrients are effective against depression [42, 43]. In this context, Lisa and colleagues reported that folate, B12, iron, selenium, and zinc deficiency are more common in depressed people [44]. Because vitamin D affects brain structure, neuronal differentiation, binding, dopamine pathways, neurotransmitters, brain calcium homeostasis, inflammatory markers, nerve growth factor synthesis, and the response of the hypothalamic-pituitary-adrenocortical axis to threat, zinc is important for energy metabolism, macronutrient stabilization, regulation of protein synthesis, neuronal progenitor cell activity, neurotransmitters, neutrophils, and antioxidants, iron is needed for energy production, phospholipid metabolism, myelination and the synthesis of neurotransmitters and DNA [45], calcium works by activating tryptophan hydroxylase and synthesizing serotonin [46] and omega-3 fatty acid has anti-inflammatory or neuroendocrine modulating effects [47]. Folate-derived coenzymes, B12 and B6, are also involved in the synthesis and metabolism of dopamine and serotonin. Besides, vitamins B6 and B12, as

| Table 4 (continued) | Quartiles (Q) of ENRF9.3 index | p-value<sup>a</sup> |
|---------------------|-------------------------------|-------------------|
|                     | Q1 | Q2   | Q3   | Q4   |       |
| Mean ± SD           |    |      |      |      |       |
| Riboflavin (mg)     | 2.55 ± 0.09 | 2.30 ± 0.09 | 2.12 ± 0.09 | 1.90 ± 0.09 | <0.001 |
| Pyridoxine (mg)     | 2.38 ± 0.06 | 2.15 ± 0.06 | 2.04 ± 0.06 | 1.82 ± 0.06 | <0.001 |
| Cobalamin (mcg)     | 4.57 ± 0.35 | 4.48 ± 0.35 | 4.25 ± 0.35 | 3.83 ± 0.35 | 0.4 |
| Folate (mcg)        | 665.15 ± 16.62 | 625.14 ± 16.63 | 601.74 ± 16.89 | 553.40 ± 16.61 | <0.001 |
| Biotin (mg)         | 45.97 ± 1.67 | 38.68 ± 1.67 | 34.56 ± 1.70 | 29.18 ± 1.67 | <0.001 |
| MUFA (g)            | 28.10 ± 1.55 | 30.19 ± 1.55 | 36.28 ± 1.57 | 38.24 ± 1.54 | <0.001 |
| PUFA (g)            | 18.07 ± 1.46 | 19.16 ± 1.46 | 24.47 ± 1.48 | 24.21 ± 1.46 | 0.002 |
| Linoleic acid (mg)  | 15.39 ± 1.45 | 16.61 ± 1.45 | 21.77 ± 1.47 | 21.71 ± 1.45 | 0.002 |
| Linolenic acid (mg) | 1.08 ± 0.10 | 1.23 ± 0.10 | 1.23 ± 0.10 | 1.44 ± 0.10 | 0.1 |
| EPA (mg)            | 0.03 ± 0.006 | 0.02 ± 0.006 | 0.02 ± 0.006 | 0.02 ± 0.006 | 0.7 |
| DHA (mg)            | 0.10 ± 0.01 | 0.09 ± 0.01 | 0.08 ± 0.01 | 0.08 ± 0.01 | 0.7 |
| Caffeine (mg)       | 125.89 ± 16.53 | 143.91 ± 16.54 | 116.81 ± 16.79 | 172.21 ± 16.52 | 0.08 |

NRF9.3, nutrient-rich food, NRF9 nutrient-rich, LM3 nutrients to limit, MUFA monounsaturated fatty acids, PUFA polyunsaturated fatty acids, EPA Eicosapentaenoic acid, DHA Docosahexaenoic acid

NRF9.3 components model 1 are mean ± standard error, adjust for energy. Food groups model 2 are mean ± standard error, adjust for age, BMI, physical activity, obtained from the analysis of covariance (ANCOVA). Macronutrient and micronutrient are mean ± standard error, adjust for energy intake, obtained from the analysis of covariance. Other variables are mean ± standard deviation, one-way analysis of variance was used for comparison of all variables among quartile of NRF9.3 score

<sup>a</sup>P-values result from the ANOVA test for the crude model and analysis of covariance test (ANCOVA) for the adjusted model.
a cofactor, convert homocysteine and inadequate levels of these vitamins can lead to the accumulation of homocysteine and reduced monoamine synthesis in the brain, which may play a vital role in mental health etiology [48]. Therefore, perhaps the reason for a not meaningful association between anxiety and depression in the present study can be related to a significant reduction in B vitamins and zinc, and the meaninglessness of nutrients such as vitamin D, omega 3, iron, and vitamin C in quartiles of ENRF index score.

In the present study, among all of the food groups, vegetables, dairy, meat and poultry, tea and coffee were significant across ENRF quartiles. Micronutrients in vegetables like B group vitamins and their metabolites [49–51] and the others such as vitamin C [52], calcium [53], and zinc [54], which regulate brain pathways [55]. Green leafy vegetables are proper sources of magnesium and insufficient magnesium can cause headaches and fatigue and exacerbate the effects of stress [56]. In the current study, magnesium intake also increased with increasing ENRF quartile, which can be one of the reasons for a significant stress reduction; because magnesium is the main cofactor in the synthesis of neurotransmitters and adrenaline and is participated in neuronal cell metabolism [57]. It was seen that low serum magnesium concentrations, in response to stress, increase the release of stress-related hormones, including cortisol, adrenocorticotropic hormone, and catecholamines [58, 59], which affects their access to the brain and creates a vicious cycle of reduced stress resistance and further magnesium depletion [60, 61]. In addition to the vegetables, in the study of Laugero et al. [62] stress was also associated with lower protein intake, because of the amino acid tryptophan in meat, which can play a momentous role in relieving mood, satiety, and sleep regulation by converting to serotonin that could help mental health [63]. A positive relationship between dairy consumption, and some cognitive and psychological health measures, has been found in the study by Crichton et al. [64] result in the present study has shown calcium was higher at the top of the ENRF quartile since milk and other dairy products account for more than half of the dietary calcium intake in most parts of the world [65], their stress-relieving properties can also be attributed to more calcium intake. People with higher HEI scores are more likely to eat nutritious foods [66] and when replacing junk food with fresh, high-fiber plant-based foods, they will consume few nutrients that are essential for healthy metabolism and provide significant stress protection [67]. Vitamin B is used as a cofactor for adrenaline synthesis in stress response, and it is also used to

| Variables | Model | Quartiles (Q) categories of NRF9.3 index | P-value |
|-----------|-------|----------------------------------------|---------|
|           |       | Q1          | Q2          | Q3          | Q4          |
| DASS-21 total Score | Crude | 43.35±3.76 | 34.25±4.27 | 35.61±4.27 | 25.90±5.07 | 0.05 |
|           | 1     | 40.40±4.30 | 34.98±4.53 | 34.67±4.51 | 33.68±4.63 | 0.07 |
|           | 2     | 41.47±4.86 | 30.13±5.15 | 35.53±5.01 | 33.96±5.23 | 0.08 |
|           | 3     | 39.14±4.98 | 34.71±4.54 | 34.42±5.57 | 23.07±6.6b | 0.04 |
| DASS-21 depression subscale Score | Crude | 12.40±1.52 | 9.61±1.73 | 11.09±1.73 | 6.90±2.05 | 0.1 |
|           | 1     | 11.48±1.72 | 10.25±1.81 | 10.43±1.80 | 9.29±1.83 | 0.8 |
|           | 2     | 11.87±1.99 | 7.85±2.11 | 11.14±2.05 | 9.29±2.14 | 0.4 |
|           | 3     | 12.5±2.03  | 12.67±1.8a | 9.86±2.27 | 7.36±2.6b | 0.02 |
| DASS-21 anxiety subscale Score | Crude | 11.80±1.19 | 8.90±1.35 | 9.16±1.35 | 7.27±1.60 | 0.1 |
|           | 1     | 11.48±1.35 | 8.98±1.42 | 9.06±1.41 | 8.74±1.45 | 0.4 |
|           | 2     | 11.45±1.50 | 7.47±1.59 | 9.27±1.55 | 8.19±1.62 | 0.3 |
|           | 3     | 7.46±1.55  | 9.62±1.41 | 9.89±1.73 | 10.07±2.02 | 0.66 |
| DASS-21 stress Subscale Score | Crude | 19.15±1.64 | 15.74±1.87 | 15.35±1.87 | 11.72±2.21 | 0.06 |
|           | 1     | 17.43±1.87 | 15.74±1.97 | 15.17±1.96 | 15.65±2.01 | 0.4 |
|           | 2     | 18.14±2.08 | 14.81±2.21 | 15.10±2.15 | 16.48±2.24 | 0.04 |
|           | 3     | 15.17±2.1  | 17.4±1.92 | 16.66±2.35 | 13.63±2.79 | 0.04 |

DASS Depression anxiety stress score, NRF Nutrient-rich food

a mean±SE

Model 1: adjusted for age and energy intake; model 2: more adjusted for marital status, housing ownership, job status, family size, supplement intake, physical activity, and economic status; model 3: more adjusted for education, consumption of dietary linolenic acid and BMI

b Association quartile 1 and 4.

c Association quartile 2 and 4.

P-values result from the ANOVA test for the crude model and analysis of covariance test (ANCOVA) for the adjusted model
synthesize neurotransmitters such as serotonin and dopamine that affect stress [68, 69].

**Strength and limits**

The present study is the first study that investigates the relationship between ENRF index score and mental health. However, there were some limitations, including the cross-sectional design of the study, which makes it impossible to report a causal relationship using the FFQ questionnaire to assess food intake, which depends on a person’s memory, and restricting the gender of the study population, that decreased generalizability.

**Conclusion**

In the current study, there was no significant relationship between the overall DASS score, anxiety, and depression with the ENRF index score. There was a significant relationship between stress and ENRF. More studies are needed especially with a prospective and clinical trial plan, to confirm the results.

**What is already known on this subject?**

Although the role of nutrients in improving mental health is well known, no study to date has used the ENRF index to examine this association.

**What your study adds?**

The findings of this study may provide guidance for the use of nutrient-rich foods for improving mental health. Therefore, the findings might have important research implications.

Table 6: Relationship of DASS-21 scale and subscales with an NRF9.3 index score

| Variable                  | Crude model | Adjust model* |
|---------------------------|-------------|---------------|
|                           | OR  | 0.95% CI | P-value | OR  | 0.95% CI | P-value |
| **Mental health**         |     |          |         |     |          |         |
| **DASS-21 stress subscale** |     |          |         |     |          |         |
| Normalª                   | –   | –        | –       | –   | –        | –       |
| Mild                      | 0.97| 0.94–1.00| 0.09    | 0.98| 0.91–1.00| 0.05    |
| Moderate                  | 1.00| 0.98–1.02| 0.6     | 0.99| 0.92–1.07| 0.84    |
| Severe                    | 1.01| 0.98–1.03| 0.3     | 0.95| 0.87–0.94| 0.02    |
| Extremely severe          | 0.97| 0.94–1.01| 0.2     | 0.96| 0.85–0.90| 0.04    |
| **DASS-21 depression subscale** |     |          |         |     |          |         |
| Normalª                   | –   | –        | –       | –   | –        | –       |
| Mild                      | 0.97| 0.94–1.00| 0.05    | 0.98| 0.91–1.06| 0.77    |
| Moderate                  | 0.98| 0.96–1.01| 0.3     | 0.98| 0.91–1.05| 0.64    |
| Severe                    | 1.00| 0.97–1.03| 0.5     | 0.99| 0.82–0.88| 0.03    |
| Extremely severe          | 0.99| 0.96–1.02| 0.6     | 0.97| 0.89–0.92| 0.06    |
| **DASS-21 anxiety subscale** |     |          |         |     |          |         |
| Normalª                   | –   | –        | –       | –   | –        | –       |
| Mild                      | 1.01| 0.98–1.03| 0.3     | 0.98| 0.9–1.07 | 0.71    |
| Moderate                  | 1.00| 0.98–1.02| 0.6     | 1.00| 0.92–1.07| 0.99    |
| Severe                    | 0.99| 0.96–1.02| 0.7     | 0.98| 0.9–1.08 | 0.79    |
| Extremely severe          | 0.99| 0.97–1.02| 0.7     | 1.06| 0.97–1.16| 0.14    |

**DASS depression anxiety stress score, NRF nutrient-rich food**

ªAs a reference group, 

ªmild stress (15–18), moderate stress (19–25), severe stress (26–33), extremely severe stress (≥34) 

ªMild depression (10–13), moderate depression (14–20), severe depression (21–27), extremely severe depression (≥28) 

ªMild anxiety (8–9), moderate anxiety (10–14), severe anxiety (15–19), extremely severe anxiety (≥20) 

P-value result from multinominal logistic regression test

Adjusted for age, energy intake, marital status, housing ownership, job status, family size, supplement intake, PA, economic status, education, consumption of dietary linolenic acid and BMI
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Declarations

Competing interest The authors have no relevant financial or non-financial interests to disclose.

Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval Approval was obtained from the ethics committee of Tehran University of Medical Sciences [Grant number 1400-3-212-57017].

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent to publish Patients signed informed consent regarding publishing their data.

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