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Exploring the relationship between dietary patterns and health-related quality of life among Iranian adult population: Tehran lipid and glucose study

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Abstract

Background The current study aims to investigate the association between dietary patterns and health-related quality of life (HRQoL) in a large Iranian adult population.

Methods This cross-sectional study was conducted using the Tehran Lipid and Glucose Study (TLGS) data. Data from 5711 adults (53.0% female) collected by trained interviewers were analyzed. For assessments of dietary intakes and HRQoL, the 147-item semi-quantitative Food Frequency Questionnaire (FFQ) and Short-Form 12-Item Health Survey version 2 (SF-12v2) were used, respectively. The physical component summary (PCS) and mental component summary (MCS) scores of HRQoL were calculated using the appropriate scoring algorithms. Dietary patterns were identified using factor analysis. General linear models were used to assess the association between dietary patterns and HRQoL scores.

Results Two dietary patterns, labeled as healthy and western, were identified. In men, the median (interquartile range (IQR)) of PCS and MCS were 51.4 (47.2–55.0) and 52.2 (44.2–58.2), respectively. For women, the median (IQR) of PCS and MCS were 48.9 (42.6–53.7) and 47.7 (39.6–55.2), respectively. Significant increasing trends in MCS scores were observed in both men and women across tertiles of healthy dietary pattern. For PCS scores, a significant increasing trend was noted only in women. The Western dietary pattern was not significantly associated with either PCS or MCS in women. However, in men, a significant decreasing trend in MCS scores was observed across tertiles of the Western dietary pattern.

Conclusions The present study suggests a more beneficial effect of healthy dietary pattern on women's HRQoL. On the other hand, in men, the healthy dietary pattern is positively associated with the mental dimension of HRQoL, whereas the Western dietary pattern is negatively linked to the mental dimension of HRQoL.

Keywords Health-related quality of life, Physical component summary, Mental component summary, Dietary patterns

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Introduction

In the past few decades, following increased lifespan and the rising trend of mental and physical chronic diseases, the health-related quality of life (HRQoL) assessment and promotion has become popular in medicine and public healthcare systems [1]. The World Health Organization (WHO) has acknowledged the HRQoL as a term to characterize an individual's perception of their physical, emotional, and social well-being about their health condition [2]. In other words, the HRQoL is a multidimensional concept that goes beyond clinical measures of disease and can provide a comprehensive understanding of an individual's daily life, health status, functioning, and needs [3].

Several investigations have shown that various factors can impact HRQoL, including dietary habits [4, 5], environmental conditions [6], lifestyle factors like smoking [7], physical activity [8], and economic status [9]. Of these, dietary habits are recognized as the most crucial modifiable factors affecting overall HRQoL and its subscales [10, 11]. Dietary patterns are defined as the quantities, proportions, diversity, or combination of different foods, drinks, and nutrients in the diets, as well as the frequency with which they are habitually consumed [12]. As dietary patterns are highly affected by cultural and social norms, personal preferences, and food accessibility, using the empirically derived approach allows for identifying culture- and context-specific dietary patterns [13, 14]. Dietary patterns represent a wide picture of food components and nutrient interactions and reflect a comprehensive and realistic assessment of the diet-disease relationship, and their findings are easily translated into clinical and public health recommendations [15, 16].

In recent decades, dietary patterns attracted much attention in HRQoL-related studies [17, 18]. In this regard, several studies have investigated the relationship between HRQoL and dietary patterns in the general population or the context of chronic diseases such as obesity, diabetes, and cardiovascular disease [13, 18–20]. The most commonly reported dietary patterns in the nutrition literature are “Prudent”, “Healthy”, and “Western” patterns [18]. A healthy dietary pattern is mainly characterized by higher intakes of nutrient-dense and whole foods like vegetables, fruits, legumes, whole grains, low-fat or nonfat dairy, lean meats and poultry, seafood, nuts, and unsaturated vegetable oils. It is lower in red and processed meats, sugar-sweetened foods and beverages, and refined grains [21]. In contrast, the Western dietary pattern is characterized by high intakes of pre-packaged foods, refined grains, red meat, processed meat, high-sugar drinks, candy, sweets, fried foods, conventionally raised animal products, high-fat dairy products, and high-fructose products [22].

The studies were mainly conducted in developed countries, and the majority of them have been limited to the cross-sectional study design [18, 23]. Although it is well established that there is a significant association between healthy and unhealthy diets and the development of diseases, as well as psychological factors, cognitive function, and immune function, studies examining the relationship between dietary patterns and HRQoL have yielded inconsistent results [18, 24, 25]. To the best of our knowledge, among all of the studies that have specifically explored the relationship between dietary patterns and HRQoL in Iran, one study was carried out among patients with type 2 diabetes [19], one among subjects with multiple sclerosis [26], one in overweight or obese women [27], and one performed among apparently healthy adolescents [13]. Hence, the association between dietary patterns and HRQoL was not investigated among the Iranian adult population.

The HRQoL is deeply entangled with sociocultural context, therefore the findings of previous studies cannot be generalized to culturally diverse communities [13]. Iran is a Middle Eastern country with an accelerated nutrition transition from traditional/healthy dietary patterns toward modern/unhealthy patterns and is witnessing a simultaneous substantial rise in the incidence and burden of non-communicable diseases, particularly among the adult population [28, 29]. Hence, identifying dietary patterns that are associated with adults' HRQoL may have major implications for their current as well as future overall health. Therefore, the present study for the first time aimed to examine the potential sex-specific associations between dietary patterns and HRQoL among a large Iranian adult population.

Materials and methods

Study design and population

This study was conducted in the framework of the Tehran Lipid and Glucose Study (TLGS), which is the first large population-based cohort in Iran. The TLGS was conducted in District 13 of Tehran (the capital city of Iran), which is considered a representative sample of the overall Tehranian population. To recruit participants, a cluster random sampling method was used to select three healthcare centers from the 20 existing centers. Subsequently, all families within these centers were randomly recruited and family members were invited to participate. The baseline assessment of the TLGS involved 15,005 individuals aged ≥ 3 years. The TLGS has two main periods: The first period was executed between February 1999 and August 2001. The second period includes six follow-up phases which have been conducted from 2002 to 2021, triennially. For more detailed information about the TLGS protocol and data collection process, comprehensive publications are available [30, 31].

This cross-sectional study utilized data from the sixth phase of the TLGS which spanned from 2016 to 2018. Initially, a total of 7,721 adult participants aged ≥ 18 years completed dietary assessments. Subsequently, participants with underreporting and overreporting of dietary intakes, as well as those with daily energy intake < 500 and > 4200 Kcal per day, were excluded ($n = 247$). From the remaining 7,474 participants, 5,711 individuals who had complete data on HRQoL, biochemical and anthropometric measures, and medical history information were selected for the current analysis.

Information on demographic data (age, sex, marital status, level of education, and occupation status), dietary intakes, physical activity, smoking habits, HRQoL, and history of chronic diseases were collected by trained interviewers.

The ethics committee of the Research Institute for Endocrine Sciences (RIES), Shahid Beheshti University of Medical Sciences approved the study and all participants signed written informed consents.

Dietary assessment

Data on dietary intakes were collected using the 147-item semi-quantitative food frequency questionnaire (FFQ) which is a valid and reliable tool for assessments of dietary intakes [32]. The participants reported the frequency of consumption of each food item on a daily, weekly, or monthly basis. Afterward, portion sizes were converted to grams. The Iranian food composition table (FCT) was used to calculate the energy, macro- and micro-nutrient content of food items [33].

Assessment of physical activity

Data on physical activity was collected using the Iranian version of the Modifiable Activity Questionnaire (MAQ) [34]. Previous findings confirmed the validity and reliability of the Iranian version of the MAQ [35]. Total physical activity was calculated as the sum of occupational and leisure time activities and expressed in MET-hr/wk.

Assessment of health-related quality of life

Assessment of HRQoL conducted by a generic measure of perceived health status entitled the Short-Form 12-Item Health Survey version 2 (SF-12v2). This scale has 12 items and eight subscales including physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health. Each subscale score ranges between 0 and 100 and a higher score indicates a better HRQoL. The physical component summary (PCS) and mental component summary (MCS) scores of HRQoL were calculated using the appropriate scoring algorithms. The findings of a previous study among the Iranian population confirmed the

validity and reliability of the Iranian version of SF-12v2 [36].

Anthropometric measurements

Weight was measured without shoes and with light clothing using digital scales and was recorded to the nearest 100 g. Height was measured in standing position, without shoes, and while the shoulders were in a normal position. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m^2).

Definitions

Obesity was defined as having a $BMI \geq 30$ kg/m^2 . Type 2 diabetes was defined as fasting blood sugar $FBS \geq 126$ mg/dl or 2-hour post-load glucose ≥ 200 mg/dl or taking medication for diagnosed diabetes [37]. Chronic kidney disease (CKD) was defined as structural or functional kidney damage or Glomerular filtration rate (GFR) < 60 ml/min/ $1.73 m^2$ present for more than three months according to the kidney disease outcome quality initiative guidelines [38]. Cardiovascular diseases (CVD) were defined as any measures of coronary heart disease (CHD) events in the past 18 years plus stroke or cerebrovascular events. CHD events are defined as cases of (1) definite myocardial infarction diagnosed by ECG and biomarkers, (2) probable myocardial infarction (positive ECG findings plus cardiac symptoms or signs but biomarkers showing negative or equivocal results), (3) unstable angina pectoris (new cardiac symptoms or changing symptom patterns and positive ECG findings with normal biomarkers), (4) angiographic-proven CHD, and (5) CHD death [39].

Statistical analysis

To identify dietary patterns, dietary data were categorized into 25 groups, based on food and nutrient composition similarity as follows: red meat, organ meats, processed meats, poultry, low-fat dairy products, high-fat dairy products, fruits, dried fruit, legumes, whole grains, refined grains, nuts and seeds, yellow vegetables, tomatoes, green leafy vegetables, allium vegetables, other vegetables, starchy vegetables, fruit juice, hydrogenated vegetable oils, vegetable oils, salty snacks, egg, sugar-sweetened beverages, sugar, sweets and chocolate (Table 1). Principle component analysis (PCA) was used to identify dietary patterns based on eigenvalues > 1 , scree plot, and factor interpretability. To assist interpretation, factors were rotated with the varimax procedure (Table 2). Each dietary pattern was labeled by a descriptive name after the most important factor loading as “healthy dietary pattern” and “Western dietary pattern”.

The normality of the distribution of variables was assessed by the Histogram and the Kolmogorov-Smirnov test. All variables had a normal distribution.

Table 1 Food grouping used in dietary patterns analyses

Food Groups	Food items
Red meat	Beef, lamb
Organ meats	brain, tongue, feet and head, liver, kidney, heart
Processed meats	Sausages, Hamburger
Poultry	chicken
Low-fat dairy products	Skim or low-fat milk, low-fat yogurt
High-fat dairy products	High-fat milk, high-fat yogurt, cream yogurt, cheeses
Fruits	Apple, pears, peaches, nectarine, plums, apricots, strawberries, cherry, sour cherry, banana, grape, orange, grapefruit, kiwi, tangerine, lemons, persimmons, pomegranates, fresh figs, dates, grapes, watermelon, melon, cantaloupe, orange, persimmon, pineapple, cranberry
Dried fruit	Dried figs, dried dates, dried mulberries, raisins, and other dried fruit
Legumes	Lentil, bean, chickpea, broad bean, soybean, mung bean, split peas
Whole grains	Whole and dark bread (Barbari, Sangak, Toftoon), cooked barley, bulgur,
Refined grains	White bread (Lavash), baguette, rice, pasta, wheat flour, noodles, cooked angel hair pasta
Nuts and seeds	Peanut, almond, walnut, pistachio, hazelnut, Sunflower seed, pumpkin seeds, watermelon seeds
Yellow vegetables	Raw carrots, cooked carrots
Tomatoes	Tomatoes, tomato sauce, tomato pasta
Green leafy vegetables	Mixed vegetables, celery, lettuce, spinach, cabbage, kale, cauliflowers
Allium vegetables	Onion, garlic
Other vegetables	Eggplant, green beans, green pepper, turnip, cucumber, zucchini, mushroom,
Starchy vegetables	Green peas, corn, squash, green lima bean, pumpkin, boiled potatoes, mashed potatoes
Fruit juice	Apple juice, orange juice, cantaloupe juice, and other fruit juice
Hydrogenated vegetable oils	Hydrogenated vegetable oils
Vegetable oils	Sunflower oil, corn oil, canola oil, soybean oils
Salty snack	Potato chips, puff, crackers
Egg	Egg
Sugar-sweetened beverages	sugar-sweetened carbonated soft drinks, sugar-sweetened synthetic fruit juice
Sugar, sweets, and chocolate	Cakes, chocolates, pastries, biscuits, Iranian confectionaries (Gaz, Sohan, and Noghl), crème caramel, candies, cubed sugar

Characteristics of participants were expressed as mean $\pm$ standard error (SE) for continuous variables and percentages for categorical variables. General linear models were used to estimate the mean (95% confidence interval) for MCS and PCS scores and their components across the tertiles of dietary patterns. Mean (95% confidence interval) for MCS and PCS scores and their components were also estimated according to sex. If there was a significant difference in the MCS and PCS values between the tertiles, a post-hoc test with the Bonferroni method was used. Multiple linear regression analysis was used to test for linear trends between Western and Healthy dietary patterns scores and MCS and PCS scores.

Confounding factors were selected based on prior studies on this topic and variables that exhibited significant differences across tertiles of dietary patterns ($P < 0.05$), such as age, sex, energy intake, BMI, occupation status, educational level, marital status, physical activity levels, and chronic diseases, were considered as potential confounding factors.

To correct for multiple testing, false discovery rate q -values were computed from P values using the Benjamini-Hochberg procedure [40]. All statistical analyses were performed in SPSS version 20.0 (SPSS Inc., Chicago,

IL, USA), and P -values less than 0.05 were considered statistically significant.

Results

5711 participants, ranging in age from 18 to 88 years, took part in the current study. The mean (SD) of BMI was 27.6 ± 4.8 kg/m². The median (interquartile range (IQR)) of PCS and MCS in men were 51.4 (47.2–55.0) and 52.2 (44.2–58.2), respectively. In women, the median (IQR) of PCS and MCS were 48.9 (42.6–53.7) and 47.7 (39.6–55.2), respectively.

Using PCA, two predominant dietary patterns were identified: healthy dietary pattern (high in other vegetables, tomatoes, green leafy vegetables, yellow vegetables, allium vegetables, fruits, low-fat dairy products, legumes, dried fruits, vegetable oils, and fruit juice), and Western dietary pattern (high in red meat, refined grains, processed meats, sugar, sweets and chocolate, high-fat dairy products, salty snacks, organ meats, eggs, sugar-sweetened beverages, poultry, starchy vegetables) (Table 2).

Baseline characteristics of participants across the tertiles of dietary patterns are reported in Table 3. Participants in the third tertile of Western and healthy dietary patterns were older, mostly women, married, had higher

Table 2 Factor-loading matrix for dietary patterns

	Healthy dietary pattern	Western dietary pattern
Other vegetables	0.65	0.07
Tomatoes	0.63	0.09
Green leafy vegetables	0.61	0.11
Yellow vegetables	0.55	0.04
Allium vegetables	0.51	0.02
Fruits	0.43	0.19
Low-fat dairy products	0.37	0.02
legumes	0.36	0.23
Dried fruits	0.32	0.01
Vegetable oils	0.29	0.10
Fruit juice	0.29	0.18
Red Meat	0.06	0.47
Refined grains	0.11	0.44
Processed meats	0.09	0.43
Sugar, sweets, and chocolate	0.03	0.43
High-fat dairy products	0.01	0.42
Salty snacks	0.04	0.42
Organ meats	0.01	0.39
Eggs	0.16	0.37
Sugar-sweetened beverages	0.03	0.37
Poultry	0.15	0.32
Starchy vegetables	0.12	0.31
Hydrogenated vegetable oils	0.02	0.18
Whole grains	0.07	0.13
Nuts and seeds	0.25	0.21

BMI, were obese, and had a significantly higher intake of total energy, and carbohydrates. Individuals in the highest quartile of healthy dietary pattern showed a higher percentage of employment, while those in the highest quartile of western dietary pattern were more likely to be unemployed.

Subjects with higher Western dietary pattern scores consumed more protein, fat, SFA, MUFA, PUFA, and cholesterol, fruit juice, dried fruit, legumes, nuts, and seeds, refined grains, red meat, processed meat, poultry, eggs, starchy vegetables, vegetable oils, hydrogenated vegetable oils, sugar-sweetened beverages, salty snack, and less fiber, fruit, low-fat dairy products, green leafy vegetables, yellow vegetables, and allium vegetables, other vegetables.

However, the intake of fat, saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA), PUFA, and cholesterol, protein, refined grains, eggs, decreased and the intake of energy, carbohydrates, fiber, fruits, fruit juice, dried fruits, legumes, nuts and seeds, low-fat dairy products, poultry, tomatoes, green leafy vegetables, yellow vegetables, allium vegetables, other vegetables, vegetable oils, increased across the tertile of healthy dietary pattern.

The prevalence of cardiovascular disease, type 2 diabetes, and chronic kidney disease increased across tertiles of Western dietary patterns. In terms of socioeconomic factors, participants with high adherence to healthy dietary patterns were more educated and more employed, while adherence to Western dietary patterns was associated with less employment.

The association between dietary patterns and HRQoL scores is presented in Table 4. In model 1, an increasing trend in all subscale scores of HRQoL was observed across tertiles of healthy dietary pattern. These associations remained significant after further adjustment for marital status, education level, occupation status, physical activity, smoking status, and chronic disease in model 2. However, no significant associations were observed for HRQoL subscale scores across tertiles of Western dietary pattern.

The results of sex-specific analysis are shown in Fig. 1. The findings show significant increasing trends in the MCS scores in both men ($P=0.031$) and women ($P<0.001$) and in the PCS scores only in women ($P=0.002$) across tertiles of healthy dietary pattern. Furthermore, in men, a significant decreasing trend was observed in the MSC scores across tertiles of the Western dietary pattern.

Discussion

This study aimed to explore the association between dietary patterns and HRQoL among the Iranian adult population. Our findings indicated that there were significant associations between Healthy dietary pattern and mental and physical aspects of HRQoL and their subscales, however, the Western dietary pattern was not significantly associated with HRQoL. Moreover, the sex-specific analysis indicated that in women Healthy dietary pattern was significantly associated with both physical and mental dimensions of HRQoL. While, in men, significant associations were observed for both Healthy and Western dietary patterns and were limited to the mental dimension of HRQoL. However, the cross-sectional nature of the current study limits its ability to conclude causality between dietary patterns and health outcomes.

Previous studies have consistently demonstrated the role of nutrition and certain dietary habits on health [18, 19]. Accordingly, consistent with our results, the benefits of healthy dietary habits including healthy and prudent dietary patterns, Mediterranean Diet, and Dietary Approaches to Stop Hypertension (DASH) on the mental and physical perception of health have been frequently described in many epidemiological studies [13, 18, 41–45]. The findings of recent studies in Iran indicated that higher adherence to a healthy dietary pattern is associated with better HRQoL among apparently healthy adolescents [13], patients with multiple sclerosis [46], and

Table 3 Characteristics of participants across tertiles of dietary patterns

	Western dietary pattern				Healthy dietary pattern			
	T1	T2	T3	Pvalue	T1	T2	T3	Pvalue
Participants, n	1904	1903	1904		1904	1902	1905	
Age (y)	42.6±0.3	45.1±0.3	46.1±0.3	< 0.001	42.6±0.3	45.0±0.3	46.2±0.3	< 0.001
Female, n (%)	894 (47.0)	1046 (55.0)	1084 (56.9)	< 0.001	893 (46.9)	1009 (53.0)	1122 (58.9)	< 0.001
Married, n (%)	1397 (73.4)	1479 (77.8)	1462 (76.7)	< 0.001	1401 (73.6)	1449 (76.2)	1488 (78.1)	0.002
Academic degrees, n (%)	600 (31.5)	591 (31.1)	546 (28.7)	0.120	549 (28.8)	564 (29.6)	624 (32.8)	0.020
Occupation status, employed, n (%)	1011 (53.2)	844 (44.4)	740 (38.9)	< 0.001	762 (40.0)	827 (43.5)	1006 (52.8)	< 0.001
Employment status, employed, n (%)	1011 (53.2)	844 (44.4)	740 (38.9)	< 0.001	762 (40.0)	827 (43.5)	1006 (52.8)	< 0.001
BMI (kg/m ²)	27.3±0.1	27.7±0.1	28.0±0.1	< 0.001	27.2±0.1	27.5±0.1	28.2±0.1	< 0.001
Obese, n (%)	484 (25.5)	534 (28.2)	579 (30.6)	0.002	469 (24.7)	527 (27.9)	601 (31.7)	< 0.001
Cardiovascular disease, n (%)	119 (6.3)	116 (6.1)	162 (8.5)	0.005	126 (6.6)	128 (6.7)	143 (7.5)	0.497
Diabetes, n (%)	172 (9.0)	229 (12.0)	253 (13.2)	< 0.001	210 (11.0)	217 (11.4)	227 (11.9)	0.686
Chronic kidney disease, n (%)	352 (18.5)	424 (22.3)	458 (24.1)	0.001	381 (20.0)	446 (23.4)	407 (21.3)	0.137
Smoker, n (%)	205 (10.8)	235 (12.4)	347 (18.2)	< 0.001	338 (17.8)	234 (12.3)	215 (11.3)	< 0.001
Physical activity (MET hour/week)	32.7±1.1	32.3±1.1	35.2±1.1	0.134	32.8±1.1	32.1±1.1	35.4±1.1	0.091
Total energy (Kcal/d)	2000±14.8	2179±14.8	2531±14.8	< 0.001	2074±15.3	2241±15.4	2394±15.3	< 0.001
Carbohydrate (% of total energy)	58.2±0.1	59.0±0.1	61.4±0.1	< 0.001	58.8±0.1	59.7±0.1	60.1±0.1	< 0.001
Protein (% of total energy)	14.9±0.1	15.6±0.1	15.2±0.1	< 0.001	15.6±0.1	15.1±0.1	15.0±0.1	< 0.001
Fat (% of total energy)	28.2±0.1	29.4±0.1	29.6±0.1	< 0.001	29.3±0.1	29.1±0.1	28.8±0.1	0.024
SFA (% of total energy)	8.7±0.1	9.5±0.1	9.4±0.1	< 0.001	9.3±0.1	9.1±0.1	9.0±0.1	0.003
MUFA (% of total energy)	9.3±0.1	9.9±0.1	10.0±0.1	< 0.001	9.9±0.1	9.8±0.1	9.7±0.1	0.021
PUFA (% of total energy)	5.7±0.1	5.9±0.1	6.2±0.1	< 0.001	5.9±0.1	5.8±0.1	5.4±0.1	0.712
Total fiber (g/d)	41.4±0.4	41.8±0.4	36.1±0.4	< 0.001	39.8±0.4	43.1±0.4	46.3±0.4	< 0.001
Cholesterol (g/d)	203±2.8	223±2.8	239±2.8	< 0.001	235±2.8	220±2.8	210±2.8	< 0.001
Fruits (g/d)	436±6.3	393±6.3	260±6.3	< 0.001	135±4.2	295±4.2	659±4.2	< 0.001
Fruit juice (g/d)	20.8±1.1	25.1±1.1	23.1±1.0	0.018	11.9±1.0	18.9±1.0	38.1±1.0	0.001
Dried fruit (g/d)	2.0±0.2	3.1±0.2	3.7±0.2	0.038	2.0±0.2	3.7±0.2	7.1±0.2	< 0.001
legumes (g/d)	44.3±0.9	45.1±0.6	46.2±0.9	0.304	39.2±0.8	45.0±0.8	51.4±0.8	< 0.001
Nuts and seeds (g/d)	8.3±0.4	10.8±0.4	11.3±0.4	< 0.001	7.1±0.4	9.7±0.4	13.5±0.4	< 0.001
Whole grains (g/d)	145±2.6	146±2.6	150±2.6	0.340	144±2.6	145±2.6	152±2.6	0.064
Refined grains (g/d)	276±3.5	269±3.5	282±3.5	0.035	302±3.5	270±3.5	256±3.5	< 0.001
Low-fat dairy products (g/d)	219±4.2	255±4.2	180±4.2	0.004	217±4.4	264±4.4	273±4.4	< 0.001
High-fat dairy products (g/d)	96.7±2.8	97.2±2.8	100±2.8	0.532	95.6±2.8	96.0±2.8	103±2.8	0.105
Red meat (g/d)	14.0±0.4	15.0±0.4	16.9±0.4	< 0.001	14.1±0.4	15.3±0.4	14.5±0.4	0.065
Processed meat (g/d)	4.7±0.2	4.2±0.2	8.7±0.2	< 0.001	4.3±0.2	4.1±0.2	4.3±0.2	0.671
Poultry (g/d)	26.4±0.7	29.6±0.7	31.4±0.7	< 0.001	27.3±0.7	28.6±0.7	31.6±0.7	< 0.001
Eggs (g/d)	16.0±0.4	17.8±0.4	18.9±0.4	< 0.001	18.6±0.4	17.9±0.4	16.3±0.4	< 0.001
Vegetables (g/day)	256±4.1	256±4.1	316±4.1	< 0.001	199±3.5	291±3.5	325±3.5	< 0.001
Other vegetables (g/d)	90.7±1.6	80.6±1.6	69.4±1.6	< 0.001	85.2±1.6	77.3±1.6	105.2±1.6	< 0.001
vegetable oils (g/d)	6.6±0.1	7.3±0.1	8.4±0.1	< 0.001	6.7±0.1	7.5±0.1	8.1±0.1	< 0.001
hydrogenated vegetable oils (g/d)	8.1±0.3	9.1±0.3	14.8±0.3	0.003	7.7±0.3	8.0±0.3	8.3±0.3	0.296
Sugar-sweetened beverages (g/d)	18.7±0.5	23.8±0.5	28.7±0.5	< 0.001	18.4±0.5	18.5±0.5	18.3±0.5	0.372
Salty snacks (g/d)	6.7±0.3	5.9±0.3	9.1±0.3	0.048	6.5±0.3	5.8±0.3	6.4±0.3	0.157

n, number; BMI, body mass index; MET, Metabolic Equivalent; SFA, saturated fatty acid; MUFA, mono-unsaturated fatty acid, PUFA, polyunsaturated fatty acid

Values are mean ± SEM unless otherwise listed

type 2 diabetes. In addition, the findings derived from developed countries including Spain [47–50], the USA [51], and Australia [51] revealed that healthy dietary patterns were related to better mental and physical quality of life in one or more subscales. However, the results of three studies in France [52], Italy [53], and Spain [49]

showed no association between healthy dietary patterns and HRQoL.

In terms of the Western dietary pattern, two systematic review and meta-analysis studies, contrary to our findings, have shown the deleterious effects of unhealthy eating habits on HRQoL [51, 54, 55]. A systematic review by Vajdi et al. showed that unhealthy dietary patterns

Table 4 Multivariate adjusted mean (95% CI) for health-related quality of life scores across tertiles of healthy and Western dietary patterns

Patterns	Model 1				Q value	Model 2				Q value
	T1	T2	T3	P for trend		T1	T2	T3	P for trend	
Healthy dietary pattern										
Physical function	83.6 (82.7 to 84.8)	86.0 (84.9 to 87.0) ^a	86.1 (85.0 to 87.1) ^a	0.004	0.009	83.8 (82.8 to 84.9)	85.9 (84.9 to 87.0) ^a	86.0 (84.9 to 87.1) ^a	0.006	0.013
Role emotional	73.4 (72.3 to 74.4)	76.2 (75.1 to 77.1) ^a	77.5 (76.4 to 78.6) ^a	<0.001	0.003	73.4 (72.4 to 74.4)	76.1 (75.1 to 77.1) ^a	77.4 (76.4 to 78.5) ^a	<0.001	0.003
Role physical	79.1 (78.1 to 80.1)	80.9 (80.0 to 81.9) ^a	82.6 (81.6 to 83.6) ^{a, b}	<0.001	0.003	79.1 (78.1 to 80.1)	80.9 (80.0 to 81.9) ^a	82.6 (81.6 to 83.6) ^{a, b}	<0.001	0.003
Bodily pain	78.1 (77.1 to 79.2)	79.7 (78.7 to 80.7)	80.9 (79.9 to 82.0) ^a	0.002	0.005	78.1 (77.1 to 79.2)	79.6 (78.6 to 80.7)	80.9 (79.9 to 82.1) ^a	0.002	0.005
General Health	47.1 (46.1 to 48.1)	49.7 (48.8 to 50.7) ^a	50.4 (49.4 to 51.4) ^a	<0.001	0.003	47.2 (46.2 to 48.2)	49.7 (48.7 to 50.6) ^a	50.4 (49.4 to 51.4) ^a	<0.001	0.003
Vitality	62.0 (60.8 to 63.1)	65.8 (64.7 to 66.9) ^a	67.5 (66.3 to 68.6) ^{a, b}	<0.001	0.003	62.1 (60.9 to 63.2)	65.8 (64.7 to 66.9) ^a	67.4 (66.2 to 68.5) ^{a, b}	<0.001	0.003
Social functioning	79.7 (78.6 to 80.9)	83.5 (82.3 to 84.6) ^a	83.3 (82.1 to 84.6) ^a	<0.001	0.003	79.8 (78.6 to 80.9)	83.4 (82.3 to 84.6) ^a	83.2 (82.1 to 84.4) ^a	<0.001	0.003
Mental health	68.0 (67.0 to 69.0)	71.1 (70.2 to 72.1) ^a	72.4 (71.4 to 73.4) ^a	<0.001	0.003	68.1 (67.1 to 69.1)	71.1 (70.2 to 72.1) ^a	72.4 (71.3 to 73.4) ^a	<0.001	0.003
MCS	47.3 (46.8 to 47.8)	49.0 (48.5 to 49.4) ^a	49.5 (49.0 to 50.0) ^a	<0.001	0.003	47.3 (46.8 to 47.8)	49.0 (48.5 to 49.4) ^a	49.5 (49.0 to 50.0) ^a	<0.001	0.003
PCS	48.4 (48.1 to 48.8)	48.9 (48.6 to 49.3)	49.2 (48.8 to 49.5)	0.019	0.038	48.4 (48.1 to 48.8)	48.9 (48.6 to 49.3)	49.2 (48.8 to 49.5) ^a	0.023	0.046
Western dietary pattern										
Physical function	85.6 (84.5 to 86.6)	84.6 (83.6 to 84.7)	85.6 (84.6 to 86.6)	0.343	0.527	85.6 (84.5 to 86.6)	84.6 (83.6 to 85.7)	85.5 (84.5 to 86.6)	0.367	0.564
Role emotional	75.5 (74.4 to 76.5)	75.7 (74.7 to 76.7)	75.9 (74.8 to 76.9)	0.860	0.947	75.4 (74.4 to 76.5)	75.6 (74.6 to 76.6)	75.8 (74.8 to 76.9)	0.861	0.906
Role physical	81.1 (80.2 to 82.1)	80.1 (79.2 to 81.1)	81.4 (80.4 to 82.3)	0.159	0.265	81.1 (80.2 to 82.1)	80.1 (79.2 to 81.1)	81.3 (80.4 to 82.3)	0.158	0.263
Bodily pain	79.3 (78.3 to 80.4)	79.8 (78.7 to 80.8)	79.7 (78.7 to 80.7)	0.841	0.947	79.3 (78.3 to 80.4)	79.7 (78.7 to 80.8)	79.7 (78.6 to 80.7)	0.848	0.906
General Health	49.0 (48.0 to 50.0)	49.2 (48.2 to 50.1)	49.0 (48.1 to 50.0)	0.972	0.972	49.1 (48.1 to 50.0)	49.1 (48.1 to 50.1)	49.1 (48.1 to 50.1)	0.998	0.998
Vitality	65.4 (64.2 to 66.5)	64.8 (63.6 to 65.9)	65.1 (64.0 to 66.3)	0.751	0.947	65.4 (64.2 to 66.5)	64.7 (63.6 to 65.8)	65.1 (64.0 to 66.3)	0.728	0.906
Social functioning	82.5 (81.4 to 83.6)	81.0 (79.9 to 82.2)	82.9 (81.8 to 84.1)	0.049	0.089	82.5 (81.4 to 83.7)	81.0 (79.9 to 82.1)	82.9 (81.8 to 84.1)	0.043	0.078
Mental health	70.6 (69.6 to 71.6)	70.3 (69.4 to 71.3)	70.6 (69.6 to 71.6)	0.900	0.947	70.6 (69.7 to 71.6)	70.3 (69.3 to 71.3)	70.6 (69.6 to 71.6)	0.860	0.906
MCS	48.6 (48.1 to 49.1)	48.5 (48.0 to 48.9)	48.7 (48.2 to 49.2)	0.816	0.947	48.6 (48.1 to 49.1)	48.5 (48.0 to 48.9)	48.7 (48.2 to 49.2)	0.774	0.906
PCS	48.9 (48.5 to 49.2)	48.7 (48.4 to 49.0)	48.9 (48.6 to 49.3)	0.617	0.881	48.9 (48.5 to 49.2)	48.7 (48.4 to 49.0)	48.9 (48.6 to 49.3)	0.613	0.875

Model 1 was adjusted for age, sex, BMI, energy intake

Model 2 further adjusted for marital status, education level, occupation status, physical activity levels, smoking status

General linear models were used to estimate the mean (95% confidence interval) for MCS and PCS scores and their components across the tertiles of dietary patterns

Multiple linear regression analysis was used to test for linear trends between Western and Healthy dietary patterns scores and MCS and PCS scores

^a Significantly different from T1 (Bonferroni pairwise comparisons in the general linear model) $P < 0.05$ ^b Significantly different from T2 (Bonferroni pairwise comparisons in the general linear model) $P < 0.05$

and Western dietary patterns are associated with lower scores of HRQOL [18]. Furthermore, the consumption of fast food, sweets, carbonated beverages, and salty snacks was linked to a lower quality of life in children and

adolescents in another meta-analysis [56]. It is important to note that significant heterogeneities were observed in earlier research included in these meta-analyses [18, 42]. Evidence from perspective in Europe has shown a

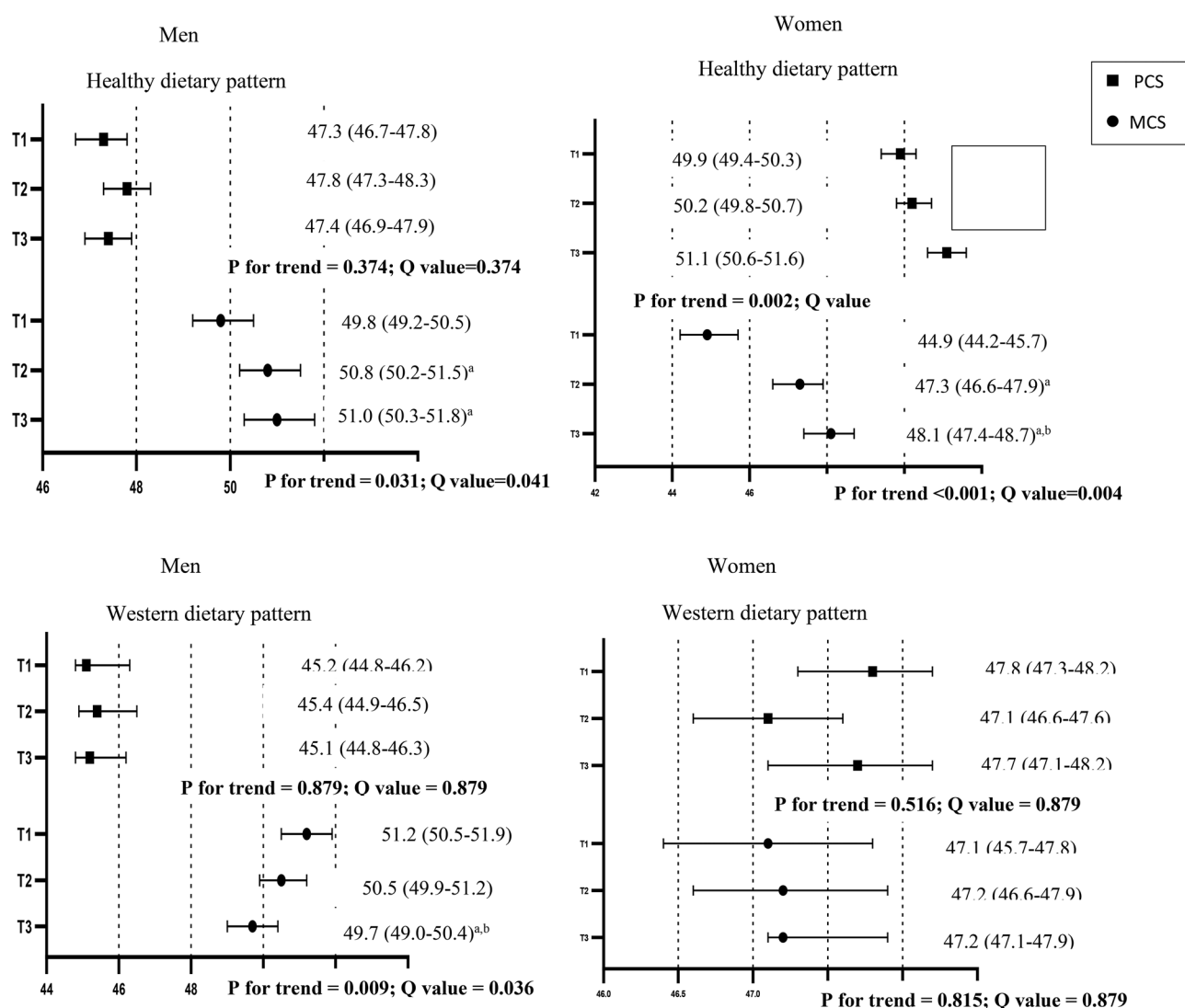


Fig. 1 Multivariable mean (95% confidence interval) of the association between Healthy and Western dietary patterns, physical component summary (PCS), and mental component summary (MCS) scores, stratified by sex. Data were adjusted for age, sex, BMI, energy intake, smoking status, physical activity levels, marital status, education level, occupation status, and chronic diseases

harmful association between unhealthy dietary patterns and HRQoL [57, 58]. The 4-year Follow-up SUN Project study in Spain demonstrated a significant inverse dose-response association between adherence to the Western dietary pattern - characterized by high consumption of fast food, red and processed meats, high-fat dairy products, processed foods, refined grains, eggs, commercial bakery goods, and sauces- and PCS and MCS score and its subscales [57]. In another population-based 12-year longitudinal study involving Australian adults aged 60 years and older, higher intakes of red meat protein, processed animal protein, and other animal protein, were associated with detrimental changes in MCS and PCS score [58]. However, in a cross-sectional study involving a sample of Italian participants enrolled in the Moli-sani Project, no significant association was observed between

unhealthy dietary pattern including eggs and sweets pattern and meat and pasta pattern, and PCS and MCS scores [59]. Furthermore, in a randomized control trial, the consumption of a high-protein diet including 160 g/d of lean red meat improved the PCS score but did not affect MCS during the 4-month intervention period in elderly women [60]. In another clinical trial, no changes in HRQoL single scales or component summaries were found after consumption of high consumption of animal protein during the intervention period among healthy men [61] and patients with chronic inflammatory diseases [62]. It should be noted that previous prospective studies have reported an inverse association between a Western dietary pattern and HRQoL [57, 58]. However, cross-sectional studies and clinical trials showed conflicting results, with most of them not observing any

significant association [59–62]. In the current study, we also did not find a relationship between Western diet and quality of life. This lack of association could be attributed to the cross-sectional nature of our study. It is worth noting that in studies where an association was observed between the Western dietary pattern and HRQoL [57, 58], the consumption of unhealthy food items was notably higher compared to studies that did not find any association. For instance, the consumption of ultra-processed food in the Sun project and Moli-sani Study were 29.7 [63] and 42% [64] of total energy, respectively, surpassing the intake levels in studies that did not show an association [60–62, 65]. These findings suggest that high long-term consumption of unhealthy foods may have detrimental effects on quality of life. Consequently, further prospective studies with extended follow-up periods are needed to clarify the association between dietary patterns and HRQoL.

Our findings demonstrated that regardless of gender, those with higher adherence to healthy dietary patterns were more likely to have better HRQoL than those with lower adherence. The beneficial effect of the healthy dietary pattern could be largely explained by its specific characteristics in terms of the components and nutrients. The food constituents of the healthy dietary pattern identified in this study similar to those typically reported in similar studies are rich in fruits, vegetables, legumes, and low-fat dairy and poor in refined grains, processed meat, sweetened foods, and salty snacks [66, 67]. Hence, it had a high content of essential micronutrients namely fiber, polyphenols, water-soluble vitamins, magnesium, and potassium, and a low content of sodium, cholesterol, saturated- and trans fatty acids [13, 68]. Therefore, these characteristics through several possible biological pathways such as reducing oxidative damage and inflammation, modulation of the immune system, and gut microbiota could lead to better metabolic control and physical health [69]. Regarding the mental quality of life, several studies have reported that healthy dietary patterns by some biological mechanisms were associated with a better mental perception of health. One possibility is that the healthy dietary pattern by its beneficial long-chain fatty acids plays an important role in the dynamic structure and fluidity of neural membranes and beneficial influences on serotonin transport [70]. On the other hand, B vitamins and folate are involved in several methylation reactions, such as those related to the synthesis of serotonin and other monoamine neurotransmitters. In addition, the anti-inflammatory effect of healthy food items may have an essential role in mediating the link between diet, cognitive function, and mental health disorders such as depression and anxiety [20, 55, 56].

The current study found that, regardless of gender, the Western dietary pattern did not affect the physical

and mental perception of health. The lack of association could be partially attributed to a possible tendency towards unhealthy foods as a way to feel better or to cope with negative emotions [71, 72]. Numerous studies have shown that there is a complex interplay between psychosocial factors and eating behaviors, such that stress triggers the release of hormones such as cortisol and neuropeptide Y, which can increase cravings for comfort foods [73, 74]. Although it is well-documented that unhealthy food just provides a temporary sense of relief, and results in a negative mood and more stress in the long term [75]. In addition, our findings indicated higher adherence to the Western dietary pattern was significantly associated with greater improvement in social functioning, as a subscale of mental HRQoL. Social functioning which typically includes items that assess the person's ability to interact with others, participate in social activities, and maintain relationships is highly affected by daily stress, social norms, and peer pressures [76]. Hence, it could be expected that consuming the Western dietary pattern by temporary alleviation of stress leads to improving the person's social activities and roles. Regarding the physical HRQoL, the lack of association could be explained by the refusal of Western dietary pattern consumers to express their physical discomfort due to the public's negative attitude towards unhealthy foods [71, 72]. As low-quality food habits as unhealthy conscious habits are often criticized by community members, Western dietary pattern consumers may complain less about physical discomforts that may be attributed to unhealthy eating because they avoid being judged.

As gender was frequently considered an important variable of the association between dietary pattern and HRQoL [73], this study analyzed the data by considering the gender differences of the participants. In this regard, our findings illustrated a sex-specific association between healthy dietary pattern and HRQoL, such that in women, the healthy dietary pattern was positively associated with both physical and mental HRQoL, however, it was exclusively limited to the mental HRQoL in male participants. This finding implies the greater beneficial effect of following a healthy dietary pattern on women compared to men. These differences could be partially attributed to the interplay of hormonal influences, biological needs, attitudes, behavioral and lifestyle differences, as well as culturally specific dietary habits. Men generally have higher levels of testosterone compared to the higher levels of estrogen and progesterone in women. These hormonal differences can influence metabolic rate, body composition, appetite, food preferences, and nutrient needs differently, which may lead to differences in how men and women respond to the same healthy dietary pattern [77, 78]. In addition, women have different nutritional needs than men due to their unique biology. Therefore,

consuming a healthy dietary pattern that meets their specific nutrient needs like iron and folate can be particularly important for women's health [75]. Moreover, several studies have noted that women generally were more likely to follow dietary guidelines and make healthy food choices [73]. Although such behavioral differences may seem small, they can have a great impact on women's health in the long term by influencing dietary patterns [55]. Hence, sticking to a healthy dietary pattern as a greater concern in women may have a stronger effect on women's perception of health. Additionally, cultural beliefs could differently influence food preferences, portion sizes, and the perceived acceptability of certain foods between men and women even among people who belong to the same culture [79]. On the other hand, the lack of association between physical HRQoL and healthy dietary pattern in men could be related to the gender differences in the reporting of physical symptoms such that numerous studies have indicated men generally had less sensitivity to bodily symptoms such that less concerned about their physical conditions or fewer complaints of their physical problems [80, 81].

Regarding the sex-specific differences between Western dietary patterns and HRQoL, our findings revealed that it was only related to mental HRQoL in men, such that higher adherence to the Western dietary pattern was associated with a greater decline in their mental HRQoL. The deleterious effects of Western dietary pattern on mental HRQoL could be explained by its specific harmful components which are high in SFA and trans-fatty acids, refined sugars, and red and processed meats. In addition, the Western dietary pattern by inducing chronic inflammation and oxidative stress, gut microbiome alteration, and blood sugar imbalances could impair the brain's ability to produce and regulate neurotransmitters such as serotonin and dopamine, which are important for mood and emotional regulation [20, 82]. In addition, the Western dietary pattern is associated with nutrient deficiencies, which can affect brain cognitive function and lead to mood swings, and psychological problems [83]. The susceptibility of men to the negative effect of Western dietary pattern on mental HRQoL could be attributed to their gender-specific differences in hormonal factors and coping styles. The studies showed that a Western dietary pattern may disrupt testosterone regulation and lead to greater negative impacts on mental HRQoL in men [84]. In addition, psychosocial factors, such as stress, social support, and coping strategies, can influence how people respond to their food intake. Since men are more likely than women to engage in unhealthy coping strategies, the negative effects of an unhealthy diet on their mental health are likely to be greater [85]. Furthermore, as men and women have different nutrient needs, Western

dietary pattern may affect men's nutrient needs differently than women's [83].

This study has both strengths and limitations. As a large population-based study that was conducted in a middle-income community in the Middle East and North Africa (MENA), the current study for the first time provided a unique opportunity to determine the effect of two different dietary patterns on HRQoL among adult population. However, the cross-sectional design of the current study is a limitation in establishing cause-and-effect relationships, allowing us only to assess the short-term effect of dietary patterns on HRQoL. Furthermore, the majority of studies investigating the association between HRQoL and dietary patterns have been conducted in Europe, where dietary practices and quality of life may differ from those in the Middle East and North Africa (MENA) region. Considering the variations in cultural heritage, culinary traditions, socioeconomic status, and dietary contexts across different regions and countries, alongside the diverse values, beliefs, and attitudes towards health, well-being, and quality of life among various cultures, as well as the importance of social relationships, family ties, and community support in influencing an individual's well-being and quality of life, it is important to approach the generalizability of the results to other communities with caution. Moreover, because of the strict ban on alcohol consumption in Iran and the lack of a direct and official method to assess its use, we were unable to incorporate measures of alcohol consumption in our questionnaires.

Conclusions

The current study indicated healthy and Western dietary patterns were differently related to the HRQoL, while healthy dietary pattern was associated with better mental and physical aspects of HRQoL, no association was found between Western dietary pattern and HRQoL. The present study indicates the more beneficial effect of the healthy dietary pattern on women's HRQoL and also reveals the stronger effect of dietary patterns on the mental aspects of HRQoL among men. Current results can contribute to promoting the knowledge for developing evidence-based public health strategies to promote future planning in healthy-eating programs.

Abbreviations

HRQoL	Health-related quality of life
WHO	World health organization
TLGS	Tehran lipid and glucose study
NCDs	Non-communicable diseases
FCT	Food composition table
MAQ	Modifiable activity questionnaire
SF-12v2	Short-form 12-item health survey version 2
PCS	Physical component summary
MCS	Mental component summary
BMI	Body mass index
GFR	Glomerular filtration rate
CVD	Cardiovascular diseases

CHD	Coronary heart disease
PCA	Principle component analysis
SE	Standard error
IQR	Interquartile range
SFA	Saturated fatty acids
MUFA	Mono-unsaturated fatty acids
DASH	Dietary approaches to stop hypertension
MENA	Middle east and north africa

Acknowledgements

We express our appreciation to the participants of this study for their collaboration.

Author contributions

S.H.N. and M.N. conceptualized and designed the study. S.H.N., F.H.E., and S.J.F. analyzed and interpreted the data; S.H.N., M.N., P.M., P.P., E.E., and F.A. drafted the initial manuscript; P.M., P.A. and S.H.N. supervised the project; all authors have read and approved the final version of the manuscript.

Funding

This work was supported by Shahid Beheshti University of Medical Sciences, Tehran, Iran.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due institution's policy but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the ethics committee of the Research Institute for Endocrine Sciences (RIES), Shahid Beheshti University of Medical Sciences. Written informed consent was acquired from participants prior to their inclusion in the study. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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Received: 10 October 2023 / Accepted: 29 May 2025

Published online: 09 June 2025

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