Original Communication

Cardiorespiratory fitness is positively associated with both healthy and western dietary pattern in Iranian middle-aged

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Abstract: *Background*: The association between dietary patterns and cardiorespiratory fitness (CRF) is not well established. *Objective*: We sought to investigate association between a posteriori dietary pattern and CRF in middle-aged adults. *Design*: Adults (n = 276), aged 20–74 years, who were residents of Tehran, Iran were recruited. Diet was assessed by using a validated 168-item semi-quantitative food frequency questionnaire. Principal component analysis was used to derive dietary patterns. Socio-economic status, anthropometric measures, body composition, and blood pressure were recorded. CRF was assessed by using a graded exercise treadmill test. Analysis of variance and linear regression models were used to discern the association between dietary patterns and CRF. *Results*: Higher scores of the healthy dietary pattern had no association with VO_{2max} ($p = 0.13$). After controlling for potential confounders, VO_{2max} was positively associated across tertiles of healthy dietary patterns ($p < 0.001$). Higher adherence to the "mixed" dietary pattern was inversely related to VO_{2max} ($p < 0.01$). After adjusting for confounders, the significant association disappeared ($p = 0.14$). Higher scores of the "Western" dietary pattern was not associated with VO_{2max} ($p = 0.06$). However, after controlling for potential confounders, VO_{2max} was positively associated with the "Western" dietary pattern ($p = 0.01$). A positive linear association between the "healthy" dietary pattern and CRF for the total sample ($R^2 = 0.02$; $p < 0.01$) were presented. *Conclusions*: Overall, our findings suggest that higher adherence to a "healthy" and "Western" dietary pattern was positively associated with CRF. However, further studies are required to examine and clarify the causal relationship between dietary patterns and CRF.

Keywords: Dietary patterns, cardiorespiratory fitness, principal components analysis, VO_{2max}, blood pressure, food groups

Introduction

Cardiorespiratory fitness (CRF) may be defined as the ability to provide the oxygen needed for muscles and other organs during continuous physical activity. Indeed, this ability relates to the functionality of the respiratory, cardiovascular, and muscular systems [1, 2]; although the cardiovascular system is regarded as the most integral part of the aforementioned systems for CRF [3].

CRF is associated with important consequences for adolescents and adults [4]; where low levels of CRF are associated with increased body fat mass and obesity [5–7], increased risk of cardiovascular disease (CVD) and its risk factors, including hypertension, hypercholesterolemia, hypertriglyceridemia [5, 6, 8], and the risk of diabetes [5, 9, 10]. Prospective studies have also shown that low CRF consistently increases the mortality rate. The main putative reason for mortality rate increases is the increased risk of cardiovascular diseases (CVD) [9, 11, 12]. Conversely, an increased level of CRF can help to reduce the risk of CVD [13].

The most important indicator for measuring CRF is the maximum rate of oxygen consumption (VO_{2max}), which is the highest volume of oxygen that a person can use in a maximal intensity exercise performance [14]. Aging is related to a decline in the capacity for power and strength development, a decrease in cardiorespiratory rate, and, ultimately, a reduction in functional capacity [3, 15, 16]. Nutrition represents another prominent factor which may have an effect on CRF. A diet with high consumption of fruits and

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vegetables elicits many benefits in certain cancers and the prevention of obesity and CVD [17]. However, few studies have been performed on the association between CRF and nutrient groups, or a single nutrient, in adults [18–23] and children [24–26]. Notwithstanding, it has been observed that CRF is positively associated with higher consumption of fruits, vegetables, bread, and dairy products [23–27], while a negative relationship has been reported with the consumption of sweetened beverages in adults and children [20–24]. It has previously been shown that CRF can be improved following intake of folate, vitamin C, vitamin A, calcium, and fiber [20]. However, despite these positive findings, other studies did not show any association between CRF and diet [25, 26]. In contrast to research on single nutrients and food groups, the study of dietary patterns facilitates the investigation of the cumulative effects of food on health or disease, while the effect of a single food or a nutrient may be negligible [28]. Usually, food intake may also be associated with the interference of unknown components of foods with known or unknown nutrients [29]; thus, for dietary analysis, consideration of the whole diet should be recommended but is not currently widely demonstrated in the literature [30]. Therefore, the aim of this study was to investigate the relationship between the major dietary patterns and CRF in adults.

Subjects and methods

Study design

This cross-sectional study was conducted on 270 adults (118 males and 152 females), aged between 18–75 years old, who lived in Tehran, Iran between February 2018 to December 2019. Participants were recruited using advertisement, distribution of flyers in common rooms, and information sessions held at residential facilities. The participants were selected based on the following inclusion criteria: age range of 18–75 years, no alcohol or drug abuse, whilst participants were excluded if they were; following special diets, such as weight loss and weight gain diets, adults with chronic diseases affecting the CRF such as CVD or coronary heart disease (CHD), individuals with kidney, liver and pulmonary diseases, and other diseases that affect the health of the cardiac and the respiratory system, pregnant and lactating women, people with any infectious or inflammatory disease, people who have restricted exercise conditions (including atopy, asthma, myocardial infarction, etc.), patients who were unable to walk, affected by arthritis, and other complications of limb and disability, or receiving any special medication or supplements (slimming medicine, hormone, sedative, etc.). All necessary explanations about the project were provided, and all participants signed a written informed consent prior to the start of the study. All procedures were conducted in accordance with the ethical standards of the Tehran University of Medical Sciences (Ethic Number: IR.TUMS.VCR.REC.1396.4085), who approved the protocol and informed consent form.

Exposures and outcomes

Dietary assessment

The dietary intake of participants was assessed using a valid and reliable semi-quantitative food frequency questionnaire (FFQ), which contained 168 food items which validated for an Iranian population [31]. The FFQ was administered by trained dietitians via face-to-face interviews, asking participants to report their frequency of consumption of each food item, during the past year, on a daily, weekly, or monthly basis. These reports were converted to daily intakes. Based on household measures, portion sizes of food consumed were calculated in grams per day to evaluate dietary nutrient intakes, and dietary intakes were analyzed using Nutritionist IV software modified for Iranian foods [32].

Dietary patterns

Principal component analysis with orthogonal transformation was used to identify major dietary patterns and factor loadings for each of the 25 food groups. Eigenvalues, the scree plot test, and interpretability were evaluated to retain factors (> 1.5) for further analysis (Figure 1). An absolute factor loading ≥ 0.3 was used to define a subset of at least 6 food groups in each factor. The identified factors were labeled on the basis of our interpretation of the data and based on previous studies that found similar dietary patterns in adults [33–35]. Factor scores for each pattern were obtained by summing intakes of food groups weighted by their factor loadings [36]. Each participant received a factor score for each identified pattern. Participants were then categorized based on tertiles of dietary pattern scores.

Anthropometric measures

Patient's height was measured, unshod, using a stadiometer (SECA, Hamburg, Germany). Bodyweight, body mass index (BMI), waist to hip ratio, waist circumference, and body composition were measured via body composition analyzer, following standard procedures (InBody 720, Biospace, Tokyo, Japan).

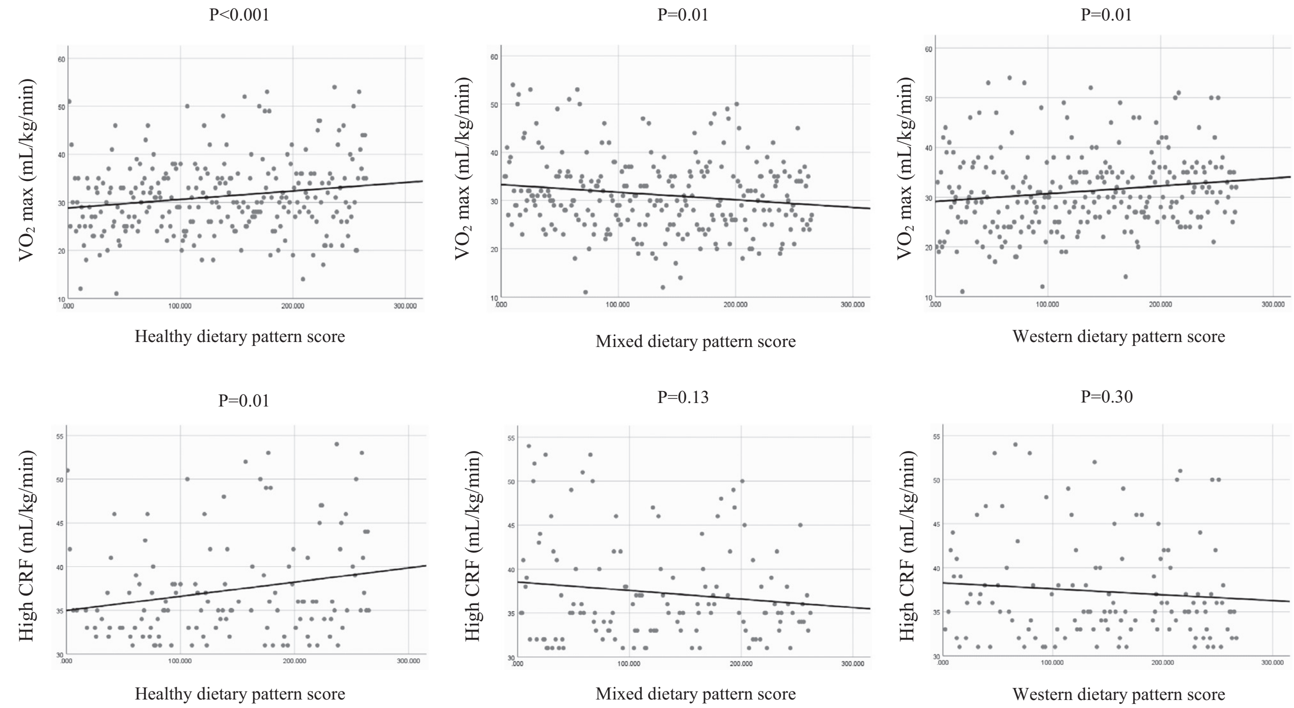

Figure 1. Association of major dietary patterns and VO_{2max}.

Blood pressure

Blood pressure was measured after an initial resting for 15 minutes while the patients were in seated position and arms. BP was measured twice with at least 30-second interval by a digital instrument (Beurer BP equipment, BC 08, digital, Germany). The average of 2 measurements was used in our analyses.

Cardiorespiratory fitness testing

After anthropometric measurement, the maximum rate of oxygen consumption (VO_{2max}) was measured using a treadmill and respiratory gas analyzer (Cortex Metabolizer 3B). Subjects were required to warm up for 5 minutes on the treadmill at a speed of 5 km/h, and then the Bruce test was conducted to determine VO_{2max}. After completing the Bruce test, the subjects walked at a speed of 4 km/h for 3 minutes and performed 5-to-10 minutes of stretching. The conditions for the end of the test were: the patient's heart rate reached more than 90% of their age-predicted (220 – age) maximum heart rate; a ratio of respiratory exchange ratio of up to 1.1, and oxygen intake reaching plateau, despite concomitant increases in exercise intensity [37]. Participants were additionally categorized into low and high CRF using the median of VO_{2max}.

Covariates

Participants completed a questionnaire designed to assess the participants' demographic including age, sex, education, marital status, lifestyle, smoking, and physical activity. Educational status was classified as illiterate, under diploma, diploma, and educated. Marital status was categorized into married or single. Lifestyle was quantified as living alone and co-habiting. Smoking was classified as non-smoker, former smoker, or current smoker. In addition, physical activity level was categorized into low, moderate, and high.

Statistical analysis

The normality of data was tested by Kolmogorov-Smirnov test. One-way analysis of variance (ANOVA) and chi-square tests were conducted to compare general characteristics across the tertiles. Analysis of covariance (ANCOVA) was used to adjust for age and energy intake. Multivariate adjusted means for anthropometric measures, body composition, and CRF were computed using general linear models, controlling for confounders. All statistical analyses were performed using the Statistical Package for the Social Sciences 25 (SPSS Inc., Chicago, IL). We considered $p < 0.05$ to represent statistical significance, *a* priori.

Results

The general characteristics of study participants are detailed in Table 1. Overall, there were 270 participants, where 56% were female and 44% male, with a mean age of 36.77 years. Males had higher body mass index, systolic blood pressure, diastolic blood pressure, and pulse pressure, compared to females. However, females were younger and less likely to be obese.

The food grouping used in the factor analysis and factor loading matrix for the identified dietary patterns are demonstrated in Table 2. Three major dietary patterns were identified by factor analysis and explained 30.271% of the total variance in dietary intakes. The first factor showed the highest factor loading for legumes, poultry, vegetables, fish, fruits, and egg, so this was labeled as the "healthy" pattern. The second factor demonstrated the highest factor loading for high-fat dairy products, pickles, mayonnaise, none refined cereals, vegetables, and vegetable oils, and was named the "mixed" pattern. The third factor showed the highest factor loading for refined cereals, red or processed meat, soft drinks, sweets and desserts, salty snacks, and French fries, and was labeled as the "Western" pattern.

Table 3 details the characteristics of study participants by tertiles of dietary pattern scores. There were significant differences in the mean age and distribution of sex across the tertiles of the dietary patterns, including "healthy", "mixed" and "Western" dietary patterns ($P < 0.001$ for all) scores Moreover, higher scores of these three dietary patterns contributed to the higher dietary energy intake ($P < 0.001$ for all).

Adherence to the "Western" dietary pattern showed that those in the highest tertile had higher intake of fat ($P = 0.01$) compared to the lowest tertile. In contrast, the consumption of protein ($P = 0.009$) and fiber ($P < 0.001$) decreased with an increasing "Western" dietary pattern. In tertiles of the 'mixed' dietary pattern, the intake of protein was lower in the subjects who were in the highest tertile in comparison to those who were in the lowest tertile ($P = 0.01$). In addition, the consumption of protein and fiber was greater in those with higher "healthy" dietary pattern scores ($P < 0.001$).

Multivariate adjusted means for VO_{2max}, heart rate, pulse pressure, SBP, and DBP across tertiles of major dietary patterns scores are shown in Table 4. Higher "healthy" dietary pattern scores had no significant association with VO_{2max} ($p = 0.13$), heart rate ($p = 0.62$), pulse pressure ($p = 0.43$), and DBP ($p = 0.22$). However, noticeable increases in SBP were observed across the tertiles of the "healthy" dietary pattern. After controlling for the potential confounders (age, sex, smoking, education, physical activity, BMI, and energy intake), changes in VO_{2max} across tertiles of the "healthy" dietary pattern were significant ($p < 0.001$). There was no significant relationship between higher scores of the "mixed" dietary pattern and heart rate ($p = 0.55$), pulse pressure ($p = 0.61$), and SBP ($p = 0.22$). Higher adherence to the "mixed" dietary pattern was also related to VO_{2max} ($p < 0.01$) and DBP ($p = 0.04$); although, after adjusting for confounders, there was no significant relationship. Higher scores of the "Western" dietary pattern was not associated with VO_{2max} ($p = 0.06$), heart rate ($p = 0.29$), pulse pressure ($p = 0.43$), SBP ($p = 0.24$), and DBP ($p = 0.59$). However, after controlling for potential covariates the association of western dietary pattern with VO_{2max} became significant (Table 4).

The linear associations between CRF and major dietary patterns are presented in Electronic Supplementary 1 (Figure E1). The association between the "healthy" and "western" dietary pattern with CRF for the total sample showed a positive linear association respectively ($R^2 = 0.02$; $p < 0.01$) ($R^2 = 0.02$, $p = 0.01$). Also, we found a negative linear association between "mixed" dietary pattern and CRF for the total sample. When we limited analyzes

Table 1. Characteristics of participants in the study

Characteristics	All	Men	Women
Age (year)	36.7 ± 13.1	38.0 ± 13.1	35.7 ± 13.2
Height (cm)	168 ± 9.96	176 ± 7.36	161 ± 6.34
Weight (kg)	72.7 ± 16.0	82.1 ± 14.5	65.5 ± 13.1
BMI (kg/m^2)	25.6 ± 4.6	26.3 ± 4.09	25.0 ± 5.01
FM (kg)	22.4 ± 9.38	20.6 ± 9.23	23.8 ± 9.31
FFM (kg)	50.1 ± 12.6	61.5 ± 9.13	41.3 ± 6.38
SBP (mmHg)	111 ± 19.1	116 ± 15.5	107 ± 20.6
DBP (mmHg)	70.6 ± 10.6	73.0 ± 9.46	68.7 ± 11.2
Pulse pressure (mmHg)	79.6 ± 10.9	77.5 ± 11.3	81.4 ± 10.3
Heart rate (BPM)	171 ± 20.0	171 ± 19.9	171 ± 20.2
Sex, n (%)	270	118 (44%)	152 (56%)
Physical activity* (n)			
Low	103	37	66
Moderate	111	45	56
High	55	36	19
Smoking (n)			
Not smoking	233	87	146
Lifestyle (n)			
Alone	24	17	7
With someone	245	101	144
Marriage (n)			
Married	143	64	79
Education (n)			
Educated	198	85	113

Notes. Values are based on mean ± standard deviation or reported percentage. BMI: Body mass index; FM: Fat mass; FFM: Fat free mass; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; CM: Centimeter; Kg: Kilogram; Kg/m^2: Kilogram per meter^2; mmHg: Millimeter of mercury; BPM: Beats per minute; n: Numbers. *Defined using METs were classified as very low (<600 MET-minutes/week), low (600–3000 MET-minutes/week), and moderate and high (>3000 MET-minutes/week).

Table 2. Factor loadings matrix for three dietary patterns identified from the food frequency questionnaire

		Dietary patterns		
Food groups	Food items	Healthy pattern	Mixed pattern	Western pattern
Refined cereals	*Lavash* bread, baguette bread, rice, pasta, others			0.456
Non refined cereals	Dark breads (e.g., *barbari*, *sangak*, *taftun*), bran breads, others		0.468	
Legumes	Lentils, split pea, beans, chick pea, fava bean, soy, others	0.623		
Red or processed meat	Beef and veal, lamb, minced meat, sausage, deli meat, hamburger			0.401
Vegetables	Cauliflower, carrot, tomato and its products, spinach, lettuce, cucumber, eggplant, onion, greens, green bean, green pea, squash, mushroom, pepper, corn, garlic, turnip, others	0.538	0.467	
Vegetable oils	Vegetable oils (except for olive oils)		0.428	
Poultry	Chicken	0.727		
Organ meats	Heart, kidney, liver, tongue, brain, offal, rennet			
Soft drinks	Soft drinks			0.699
Sweets and desserts	Cookies, cakes, biscuits, muffins, pies, chocolates, honey, jam, sugar cubes, sugar, candies, sweet tahini, others			0.469
Salt	Salt			
Mayonnaise	Mayonnaise		0.767	
Tea and coffee	Tea and coffee			0.313
Salty snacks	Corn puffs, crackers, potato chips, others			0.547
High fat dairy product	High-fat milk, high-fat yogurt, cream cheese, cream, dairy fat, ice cream, others		0.543	
French fries	French fries			0.621
Potatoes	Potatoes			
Fruits and fruits juices	Melon, watermelon, honeydew melon, plums, prunes, apples, cherries, sour cherries, peaches, nectarine, pear, fig, date, grapes, kiwi, pomegranate, strawberry, banana, persimmon, berry, pineapple, oranges, dried fruits, all juices, others	0.582		
Nuts	Almonds, peanut, walnut, pistachio, hazelnut, seeds, others	0.485		
Fish	All fish types	0.581		
Pickles	Pickles, sauerkraut		0.718	
Egg	Eggs	0.648		
Low fat dairy product	Low-fat milk, skim milk, low-fat yogurt, cheese, *Kashk*, yogurt drink, others	0.451		
Hydrogenated fats	Hydrogenated vegetable oils, solid fats (animal origin), animal butter, margarine			
Olive and olive oil	Olives, olive oils	0.453		

Notes. Food groups with absolute values < 0.30 are not shown for simplicity.

to those who had high CRF a linear association demonstrated only for "healthy" dietary pattern ($R^2 = 0.04$; $p = 0.01$).

Discussion

The purpose of this cross-sectional study was to characterize dietary patterns and to investigate their relationship with CRF in middle-aged men and women. We identified three major dietary patterns, including "healthy", "mixed", and "western" dietary patterns. The first pattern had the highest factor loading for low-fat dairy, vegetables, fish, and fruits, and was labeled as the "healthy" pattern. The second pattern demonstrated the highest factor loading for high fat dairy products, mayonnaise, and non-refined cereals, and was named as the "mixed" pattern. The third pattern showed the highest factor loading for refined cereals, red or processed meat, soft drinks, sweets, and desserts, and was thus categorized as the "Western" pattern. We found that higher adherence to "healthy" and "Western" dietary patterns was positively associated with CRF. Furthermore, we observed that adherence to the "mixed" dietary pattern had no significant relationship with CRF.

CRF is a modifiable factor that is related to CVD risk, metabolic syndrome, and body composition [17, 38, 39].

Table 3. Characteristics of study participants by tertiles (T) of dietary pattern scores

	Major dietary patterns			
	Western dietary pattern			
	T1	T2	T3	P*
Age (year)	41.7 ± 14.4	34.0 ± 11.6	34.0 ± 11.7	<0.001
BW (kg)	71.43 ± 14.00	71.73 ± 17.85	75.12 ± 16.16	0.23
BMI (kg/m^2)	26.08 ± 4.35	25.28 ± 5.35	25.47 ± 4.29	0.49
WC (cm)	88.96 ± 10.96	88.71 ± 14.26	91.17 ± 12.38	0.35
WHR	0.89 ± 0.06	0.89 ± 0.07	0.91 ± 0.06	0.11
FFM (kg)	48.50 ± 12.34	49. 36 ± 12.23	52.65 ± 13.18	0.07
FM (kg)	22.93 ± 8.97	22.44 ± 10.56	21.98 ± 8.70	0.80
Sex (M/F)	28/61	35/55	54/35	0.34
Diet composition				
Energy (kcal)	2093 ± 789	2122 ± 716	2960 ± 1092	<0.001
Carbohydrate (% of kcal)	58.4 ± 8.04	56.6 ± 7.52	56.1 ± 8.44	0.130
Fat (% of kcal)	28.0 ± 6.67	30.4 ± 7.56	31.2 ± 7.98	0.015
Protein (% of kcal)	16.1 ± 3.92	15.0 ± 2.97	14.6 ± 3.47	0.009
Fiber (g/1000 kcal)	7.90 ± 2.34	6.40 ± 1.55	6.23 ± 1.57	<0.001
	Mixed dietary pattern			
Age (year)	32.7 ± 11.6	36.6 ± 12.5	40.3 ± 14.0	<0.001
BW (kg)	72.61 ± 16.54	71.68 ± 16.08	73.99 ± 15.80	0.63
BMI (kg/m^2)	25.04 ± 4.12	25.53 ± 4.98	26.26 ± 4.87	0.21
WC (cm)	88.08 ± 12.17	88.94 ± 12.59	91.81 ± 12.91	0.11
WHR	0.89 ± 0.06	0.90 ± 0.06	0.91 ± 0.06	0.02
FFM (kg)	51.32 ± 15.03	49.31 ± 11.47	49.87 ± 11.21	0.55
FM (kg)	20.80 ± 8.17	22.44 ± 10.22	24.11 ± 9.56	0.06
Sex (M/F)	42/47	33/57	42/47	0.56
Energy (kcal)	2066 ± 944	2096 ± 461	3014 ± 1063	<0.001
Carbohydrate (% of kcal)	56.5 ± 8.52	57.2 ± 7.83	57.3 ± 7.82	0.762
Fat (% of kcal)	29.4 ± 7.56	30.0 ± 7.57	30.1 ± 7.48	0.788
Protein (% of kcal)	16.1 ± 4.49	14.9 ± 3.22	14.7 ± 2.43	0.017
Fiber (g/1000 kcal)	6.64 ± 2.01	6.97 ± 1.95	6.91 ± 2.03	0.509
	Healthy dietary pattern			
Age(year)	33.4 ± 12.1	35.4 ± 12.7	40.9 ± 13.4	<0.001
BW (kg)	69.24 ± 15.84	72.54 ± 16.49	76.49 ± 15.34	0.01
BMI (kg/m^2)	24.81 ± 4.38	25.42 ± 4.68	26.59 ± 4.85	0.03
WC (cm)	87.32 ± 12.20	89.45 ± 12.97	92.06 ± 12.34	0.04
WHR	0.89 ± 0.06	0.90 ± 0.06	0.91 ± 0.06	0.22
FFM (kg)	47.60 ± 12.47	50.17 ± 11.61	52.73 ± 13.48	0.02
FM (kg)	21.64 ± 8.12	22.34 ± 9.57	23.37 ± 10.46	0.47
Sex (M/F)	30/59	40/50	47/42	0.42
Energy (kcal)	2026 ± 995	2243 ± 638	2905 ± 999	<0.001
Carbohydrate (% of kcal)	57.9 ± 8.17	57.5 ± 7.39	55.6 ± 8.43	0.128
Fat (% of kcal)	30.3 ± 8.79	29.6 ± 7.14	29.7 ± 6.50	0.820
Protein (% of kcal)	13.6 ± 2.43	15.0 ± 2.59	17.1 ± 4.29	<0.001
Fiber (g/1000 kcal)	5.91 ± 1.44	6.63 ± 1.73	7.99 ± 2.17	<0.001

Notes. BMI: Body mass index; FM: Fat mass; FFM: Fat free mass; BW: Body weight; WC: Waist circumference; WHR: Waist to hip ratio; cm: Centimeter; Kg: Kilogram; Kg/m^2: Kilogram per meter^2; mmHg: Millimeter of mercury; BPM: Beats per minute; kcal: Kilocalorie; gr: Gram; M: Male; F: Female. *One-way analysis of variances. P value less than 0.05 was considered significant. Values are based on mean ± standard deviation.

The results of the past studies regarding the influence of diet on CRF are inconsistent [40, 41]. Many previous studies have been conducted to find an association between individual nutrients or food groups with CRF, however, have yielded equivocal findings [20, 21, 42]. The "healthy" dietary pattern is rich in fruits and vegetables and may elicit

Table 4. Multivariate adjusted means for CRF, Heart Rate, Pulse Pressure, SBP and DBP across tertiles (T) of major dietary patterns

	Tertiles of major dietary patterns					
	Healthy dietary pattern					
	T1	T2	T3	P	P_{Trend}	P_{ANCOVA}
VO_2 Max (mL/kg/min)	29.9 ± 6.91	31.7 ± 7.76	32.0 ± 8.44	0.13	0.06	0.01
Heart Rate (BPM)	170 ± 22.4	173 ± 20.3	170 ± 17.4	0.62	0.79	0.30
Pulse Pressure (mmHg)	80.2 ± 9.55	79.8 ± 11.5	78.9 ± 11.6	0.72	0.43	0.83
SBP (mmHg)	106 ± 26.9	110 ± 10.8	116 ± 14.5	<0.01	<0.001	0.22
DBP (mmHg)	69.9 ± 11.7	69.7 ± 10.4	72.2 ± 9.75	0.22	0.15	0.67
	Mixed dietary pattern					
	T1	T2	T3	P	P_{Trend}	P_{ANCOVA}
VO_2 Max (ml/kg/min)	33.2 ± 8.48	29.98 ± 7.16	30.4 ± 7.25	<0.01	0.01	0.14
Heart Rate (BPM)	173 ± 23.6	170.88 ± 17.96	169 ± 18.45	0.55	0.29	0.89
Pulse Pressure (mmHg)	78.7 ± 10.9	79.7 ± 11.1	80.4 ± 10.7	0.61	0.32	0.17
SBP (mmHg)	109 ± 18.6	110 ± 20.7	114 ± 17.8	0.22	0.09	0.93
DBP (mmHg)	69.7 ± 8.3	69.2 ± 12.3	72.9 ± 10.7	0.04	0.04	0.50
	Western dietary pattern					
	T1	T2	T3	P	P_{Trend}	P_{ANCOVA}
VO_2 Max (ml/kg/min)	30.0 ± 8.84	30.9 ± 7.49	32.7 ± 6.64	0.06	0.02	0.04
Heart Rate (BPM)	168 ± 19.7	173 ± 18.5	172 ± 21.9	0.29	0.29	0.89
Pulse Pressure (mmHg)	78.4 ± 11.5	80.2 ± 10.6	80.3 ± 10.6	0.43	0.24	0.90
SBP (mmHg)	114 ± 18.0	110 ± 19.7	109 ± 19.5	0.24	0.13	0.22
DBP (mmHg)	70.0 ± 13.1	70.2 ± 8.8	71.5 ± 9.8	0.59	0.35	0.30

Notes. Significant level was set at $p < 0.05$. Values are mean and SD. CRF: Cardiorespiratory fitness, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, $P_{ANCOVA=}$ Adjusted for age, sex, education status, smoking, physical activity level, body mass index and energy intake. P_{value} derived from one-way analysis of variances. ml/kg/min: Milliliter per kilogram per minute; BPM: Beats per minutes; mmHg: Millimeter mercury.

positive influences on CRF [24, 43]. Consistent with the present study, Anna Howe et al. [44] found a noticeable increase in CRF following a greater adherence to a healthy dietary pattern in adolescents. Furthermore, in a study performed by James M Shikany et al. [23], the fruit-vegetable pattern was positively associated with treadmill run duration in white women only.

The "Western" dietary pattern was defined by abundant consumption of soft drinks, salty snacks, and French fries. Saeedi et al. [45] reported contrasting findings to the present study, where the authors did not report any significant association between a snack-based pattern and CRF. Moreover, Brodney et al. [21] showed an inverse relationship between consumption of sweetened drinks and CRF. A recent systematic review and meta-analysis reported that a Western-style dietary pattern is associated with an increased risk of metabolic syndrome [46].

To understand the discordant findings of our study were those in the literature, we should consider that our study has some key differences with the other past papers. The first consideration regards the measurement of VO_{2max}. We used the Bruce et al test [37] to evaluate the CRF; however, most of other studies used the 20 m shuttle run test to assess CRF [47]. Secondly, higher intake of dairy products in our study could have influenced dietary patterning and CRF. For instance, in an observational study, participants who had higher intake of dairy products also had higher CRF [24]. The difference between M. Cuenca-Garcia et al. and the present study is that we divided the total dairy into low and high fat products, however, M. Cuenca-Garcia et al reported the association of total dairy products, which would influence any potential relationship; indeed, some previous studies have reported the beneficial effect of dairy consumption on body composition [48] and risk of metabolic syndrome [49]. Thirdly, the nature of factor analysis is inherently subjective, and thus, it is not inconceivable that opinions may differ depending on the researchers [30].

The mechanisms by which "healthy", "mixed", and "Western" dietary patterns may affect CRF are unclear. One purported mechanism is acid-base balance. In a clinical study that investigated the effect of diet composition on acid-base balance in adolescents, young adults, and elderly at rest and during exercise, reported that oxygen consumption could be increased by following a normal-protein diet with high amounts of vegetables and fruit [50]. In another study, alkalosis induced by bicarbonate could expedite the increases in oxygen consumption at the onset of high-intensity exercise [51]. However, associated acidosis diminished the capacity of hemoglobin to bind with oxygen, therein decreasing oxygen uptake [52].

Our study has several strengths and some limitations. First, and foremost, this is the first study, to the authors knowledge, to have investigated the association between dietary patterns with CRF in Iranian middle-aged adults. The wide range in the socioeconomic statuses included in the study enables better community representation. Another strength is that the effect of possible confounders was detected and controlled in our analyses. Furthermore, we used a validated FFQ for gathering dietary data which reflects the long-term nutritional intake of each person. The analysis of dietary patterns, as opposed to single nutrients, and their relationship to CRF also permitted the assessment of the interaction among components in the diet. However, as a limitation, we must acknowledge that the cross-sectional study design precludes the discernment of causal inferences. Additionally, the small sample size of the study prevents the detection of weak statistical relationships. Thus, we recommend that longitudinal and high-quality, randomized trials are needed to examine the causal relationships.

Conclusion

In conclusion, our findings suggest that higher adherence to a "healthy" and "Western" dietary pattern is positively associated with CRF. Further studies are necessitated in order to explore the causal relationship between dietary patterns and CRF.

Electronic supplementary material

The electronic supplementary material (ESM) is available with the online version of the article at https://doi.org/10.1024/0300-9831/a000685

ESM 1. Scree plot of 25 food groups according to eigenvalues (Figure E1)

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