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Association of Pro-Healthy Diet Index and Non-Healthy Diet Index with Body Composition: Baseline Results from Cohort Study

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ABSTRACT

Background: Various dietary patterns have different effects on the body composition of adults. This study investigated the association of pro-healthy diet index (PHDI) and non-healthy diet index (NHDI) with body composition in employees of Shiraz University of Medical Sciences, Shiraz, Iran.

Methods: This cross-sectional study was performed on baseline data from the Cohort Study of Employees of Shiraz University of Medical Sciences, Shiraz, Iran. Out of 4550 participants, 3380 were included in this study. Body composition was obtained from cohort database. PHDI and NHDI were calculated by a 113-item food frequency questionnaire. The association of PHDI and NHDI with body composition was assessed depending on the type of variable using regression methods along with the adjustment of confounders.

Results: There was a positive association between PHDI and body fat mass (coef.=1.04; CI: 0.22-1.86), fat free mass (coef.=1.17; CI: 0.27-2.07), skeletal muscle mass (coef.=0.71; CI: 0.19-1.23), fat free mass index (coef.=0.33; CI: 0.04-0.67), fat mass index (coef.=0.31; CI: 0.01-0.61), and bone mineral content (coef.=0.07; CI: 0.02-0.12). However, PHDI was not related to body fat percent. There was no significant correlation between NHDI and body composition.

Conclusion: PHDI had a positive correlation with skeletal muscle mass, bone mineral content, body fat mass, fat free mass, fat free mass index, and fat mass index. Yet, no association was found between NHDI and body composition.

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Introduction

In recent decade, overweight and obesity were shown to have an increasing trend worldwide (1). According to the World Health Organization (WHO) report in 2016, the prevalence of obesity and overweight in adults (over 18 years) has been 13% and 39%, respectively and the prevalence of obesity is estimated to reach 44% by 2030 (2, 3).

In 2016, the prevalence of obesity and overweight in Iran has been 22.7% and 36.5%, respectively (4). Obesity can increase the risk of some chronic diseases such as cardiovascular and metabolic diseases, different types of cancer, sleep apnea, and mechanical dysfunction (5-8). In addition, considering that the control of obesity-related disorders requires a huge budget, the world would face a major health trouble in the near future (9). Many factors can cause obesity, including epigenetic, genetic, hormonal, biological, microbial, social, behavioral, cultural, and environmental factors which cause disturbance in the balance of received and consumed energy (2, 10).

Diet is one of the most important factors for preventing or controlling overweight and obesity (11, 12). Studying dietary patterns is the latest approach in the current nutritional epidemiology, as it can provide a more realistic picture of food consumption habits, and also the synergistic or antagonistic effects of foods and nutrients when they are consumed together in many diseases (13-15). Based on this approach, diet quality is assessed via indices that can evaluate a variety of healthy choices in basic food groups and the compliance of dietary patterns with dietary guidelines (16, 17). There are a large number of Diet Quality Indices (DQIs), among which we can refer to newer indices, including the PHDI and the NHDI, which provide us with more comprehensive information on dietary patterns. PHDI-10 is the sum of daily consumption (times/day) of 10 food groups with potentially useful products including whole meal bread, other whole grain cereal products (whole grain pasta, barley, oatmeal, thickly-ground barley), milk, fresh cheese, fermented dairy products, dishes with white meat, fish, fruit, vegetables, and legume seeds (16). The NHDI-14 consists of 14 food items that represent less healthy foods including white bread, other purified cereal products (plain pasta, white rice, finely-ground barley), fried foods, fast food, hard and processed cheeses, butter, lard, processed meat products (hot dogs, cold cuts, sausages), red meat dishes, sweets and confectionary, canned meat, sweetened carbonated or non-carbonated beverages, alcoholic beverages, and energy drinks (13).

In 2022, a cross-sectional study in Iran showed a significant correlation between the HEI-2015 score and percentage of muscle mass (PMM) and body fat (PBF) (18). A clinical trial in the United States in 2022 showed that changes in nutrient and food intake and diet quality on a low-fat vegan diet were associated with the changes in body composition in overweight adults (19). Hence, each person's body composition has a significant impact on their health and performance. As diet is one of the most important factors affecting body composition, if people's dietary patterns are modified, it can change body composition to its best condition (20). Therefore, the aim of this study was to assess the association between pro-healthy diet index and non-healthy diet index with body composition in an adult population.

Materials and Methods

The present study is a descriptive-analytical cross-sectional study that is a part of the cohort study of employees of Shiraz University of Medical Science, Shiraz, Iran. The nutritional information of 4550 participants was complete, while among them 1170 people were excluded due to the incomplete information. So the analysis was undertakene on 3380 participants. Demographic, anthropometric, nutritional and medical information, physical examinations, and collection of biological samples for laboratory testing were collected by trained experts at the start of the study. A 113-item Food Frequency Questionnaire (FFQ) was used to assess food intake (21). The Ethics Committee of Shiraz University of Medical Science reviewed and approved the study protocol (IR.SUMS.SCHEANUT.REC.1402.014).

The weight of people with minimal covering and without shoes was measured using a digital scale with an accuracy of 0.1 kg. Also, the height of the people was determined while standing next to the wall without shoes, and the shoulders, hips and backs of the legs were touching the wall. Then, the body mass index (BMI) was calculated for the participants by dividing the weight (in kilograms) by the square of the height (in square meters). The waist circumference was measured at the middle point between the last rib and the iliac crest from light clothing. The hip circumference was measured at the widest part of the hips using an inflexible tape measure, without any pressure on the body surface and with an accuracy of 0.1 cm. Arm circumference was assessed in the middle part of the arm between the elbow and the tip of the shoulder using the standard method. Arm muscle circumference (AMC) was evaluated as AMC ([cm]=arm circumference [cm]_(3.14×triceps skin fold thickness [cm]). The body composition information of the participants was obtained using body analyzer (BIA InBody, Model: 770; Biospace, Seoul, South Korea). Fat mass index (FMI) and fat free mass index (FFMI) were calculated via the equations of FMI [kg/]=fat mass/, FFMI [kg/]=fat-free mass/.

Participants filled out the questionnaire by face-to-face interview. This questionnaire had two types of questions including nutritional and medical parts. Medical data was divided to history of chronic diseases, consuming drugs, family history of diseases, individual habits (alcohol and tobacco consumption), physical examination and physical disabilities, fertility history (for women), oral health, and blood pressure measurement. A 113-item Willet format food frequency questionnaire was utilized for nutritional information. This questionnaire included a list of food with standard sizes that were commonly consumed by Iranians. The participants were asked to report the amount of consumption of each food item they consumed during the past year on a daily, weekly, monthly, and yearly basis. A standard portion size was designed using USDA for each item. Previous studies confirmed the validity and reliability of this questionnaire (21). Data about the physical activity of the participants was collected using the International Physical Activity Questionnaire (IPAQ). Based on the MET criterion defined for each activity and the number of days that activity was performed per week, a score was taken and then all activities were added together to determine the final score (hours/week). Finally, each participant's activity was classified into one of light, moderate, or intense activity categories.

Two diet quality scores were evaluated including PHDI-10 and NHDI-14. The scores were calculated by summing up the daily consumption of the selected food group (times/day). PHDI-10 included 10 food items that represented potentially beneficial food types of whole meal bread, other whole grain cereal products (whole grain pasta, barley, oatmeal, thickly-ground barley), milk, fresh cheese, fermented dairy products, dishes with white meat, fish, fruit, vegetables, and legume seeds. NHDI-14 included 14 groups of products with potentially detrimental effects on health including white bread, other purified cereal products (plain pasta, white rice, finely-ground barley), fried foods, fast food, hard and processed cheeses, butter, lard, processed meat products (hot dogs, cold cuts, sausages), red meat dishes, sweets and confectionary, canned meat, sweetened carbonated or non-carbonated beverages, alcoholic beverages, and energy drinks. In the present study, lard, energy drinks, and alcoholic beverages were not reported. Because, in the food frequency questionnaire used in the cohort study, these items were not mentioned (due to lack of report or low consumption). Thus, NHDI included 11 items. For both indices, 0 to 2 points were assigned for each food group. Participants' food intake was categorized based on the tertiles of PHDI and NHDI. 0, 1, and 2 points were considered for the first, second, and third tertiles, respectively. PHDI-10 index values were within the range of 0-20, and values of the NHDI-11 in the range of 0-22.

Data were analyzed by SPSS software (version 23, Chicago, IL, USA). Quantitative data were reported as mean and standard deviation, and qualitative data were presented as frequency and percentage. To check the normality of the data, the Kolmogorov-Smirnov test was used. Chi-square analysis, independent sample t-test, ANOVA and their non-parametric equivalents (for skewed data) were employed for data analysis in order to check the percentage, mean and median. To examine the relationship of all indicators, depending on the type of variable, linear regression was applied along with the adjustment of confounders, so that confounders could be controlled more correctly. Results with p values less than 0.05 were considered significant.

Results

Data of 3380 participants were included in the final analysis. The baseline characteristics of the study participants were demonstrated in Table 1. The median of participants' age was 44 years old (95%CI: 44.51-44.98). Female individuals (55.2%) were more than male ones (44.8%). The study population's median of BMI was 26.38 (kg/m^2) (95%CI: 26.62-26.90). The highest percentage of people had moderate wealth index (34.3%). The other baseline information was shown in Table 1.

The nutrient intake of the study participants across the tertiles of PHDI and NHDI were illustrated in Table 2. Higher tertiles of PHDI had significantly higher intake of energy, protein, carbohydrate, fat, total fiber, cholesterol, saturated fatty acid (SFA), mono unsaturated fatty acid (MUFA), poly unsaturated fatty acid (PUFA), iron, magnesium, zinc, calcium, phosphorus, selenium, and vitamins E, B1, B2, B3, B6, B9, B12, and C ($p<0.001$ for all) in comparison with the lower tertiles. Also, nutrient intake of participants in the higher tertiles of NHDI was significantly higher than the lower ones, regarding energy, protein, carbohydrate, fat, total fiber, cholesterol, SFA, MUFA, PUFA, iron, magnesium, zinc, calcium, phosphorus, selenium, and vitamins E, B1, B2, B3, B6, B9, B12, and C intakes ($p<0.001$ for all, Table 2).

The association between PHDI and body composition in two crude and adjusted models were demonstrated in Table 3. In the third tertile, PHDI had a positive significant correlation with body fat mass (coef.=1.79; CI: 1.06-2.52), fat free mass (coef.=2.62; CI: 1.61-3.62), skeletal muscle mass (coef.=1.56; CI: 0.97-2.15), fat free mass index (coef.=0.56; CI: 0.38-0.92), fat mass index (coef.=0.50; CI: 0.21-0.78), AMC (coef.=0.76; CI: 0.38-1.14), arm circumference (coef.=0.98; CI: 0.53-1.44), visceral fat area (coef.=7.17; CI: 3.32-11.02), and bone mineral content (coef.=0.15; CI:

Table 1: The baseline characteristics of the study participants.

Variable	Median	IQR	95% Confidence interval	
			Low	Up
Age (year)	44.00	10.00	44.51	44.98
Physical activity (MET/per week)	2822.25	5766.00	4710.15	5077.99
Weight (kg)	71.70	18.00	72.71	73.68
Height (cm)	164.30	14.00	164.73	165.39
BMI (kg/m^2)	26.38	4.89	26.62	26.90
WC (cm)	93.50	12.72	93.80	94.51
HC (cm)	102.00	9.50	102.28	102.80
Body fat percent (%)	34.30	12.10	32.92	33.56
Body fat mass (kg)	23.80	10.30	24.14	24.75
Fat free mass (kg)	45.70	16.50	46.84	47.68
Skeletal muscle mass (kg)	25.00	10.10	25.85	26.34
Fat free mass index	17.20	3.40	17.04	17.27
Fat mass index	8.80	4.30	8.97	9.21
AMC (cm)	27.30	4.10	26.83	27.15
Arm circumference (cm)	32.30	4.40	31.72	32.11
Bone mineral content	2.61	0.81	2.66	2.71
Visceral fat area (cm)	115.05	63.93	117.02	120.23
Categorical variables	Frequency		Percent	
Gender				
Male	1515		44.8	
Female	1865		55.2	
Cigarette smoking				
Yes	320		9.5	
No	3057		90.5	
Hookah use				
Yes	387		11.5	
No	2985		88.4	
Opium use				
Yes	47		1.4	
No	3330		98.6	
Alcohol use				
Yes	144		4.3	
No	3233		95.7	
Educational level				
Diploma and less than diploma	275		8.1	
Higher than diploma	3105		91.9	
Marital status				
Single	482		14.3	
Married	2898		85.7	
Medication and supplementation use				
Yes	1930		57.1	
No	1450		42.9	
Wealth index				
Low	1107		32.8	
Moderate	1158		34.3	
High	1112		32.9	

kg: Kilogram; cm: Centimeter; BMI: Body mass index; MET: Metabolic equivalent of task; WC: Waist circumference; HC: Hip circumference; AMC: Arm muscle circumference. Quantitative values are reported as median (IQR) and qualitative data are reported as frequency (percent).

0.09-0.20) in comparison to the first tertile, in the crude model. This positive significant relationship was also seen in the adjusted models: body fat mass (coef.=1.04; CI: 0.22-1.86), fat free mass (coef.=1.17; CI: 0.27-2.07), skeletal muscle mass (coef.=0.71; CI: 0.19-1.23), fat free mass index (coef.=0.33; CI: 0.04-0.67), fat mass index (coef.=0.31; CI: 0.01-0.61) and bone mineral content (coef.=0.07; CI: 0.02-0.12)). In the second tertile, PHDI was significantly and positively associated with bone mineral content (coef.=0.09; CI: 0.04-0.15), skeletal muscle mass (coef.=0.90; CI: 0.28-1.51), and fat free mass (coef.=1.50; CI: 0.46-2.54) of participants compared with tertile 1, in the crude model. Yet, there was not any significant correlation between PHDI and body fat percent.

Table 2: The nutrient intake of the study participants across the tertiles of PHDI and NHDI.

Variable*	Tertile 1 PHDI Median (IQR)	Tertile 2 PHDI Median (IQR)	Tertile 3 PHDI Median (IQR)	*P* value#
Energy (kcal/day)	1722.86 (607)	2042.95 (698)	2417.41 (822)	<0.001
Protein (g/day)	56.52 (20.54)	68.93 (22.90)	85.31 (30.01)	<0.001
Carbohydrate (g/day)	273.52 (117.32)	323.13 (125.19)	373.59 (144.89)	<0.001
Fat (g/day)	46.28 (20.70)	56.59 (21.83)	68.03 (27.38)	<0.001
Total fiber (g/day)	16.69 (6.61)	21.83 (7.89)	28.17 (10.47)	<0.001
Cholesterol (mg/day)	200.49 (122.82)	243.40 (128.69)	292.58 (155.03)	<0.001
SFA (g/day)	12.73 (5.52)	16.27 (6.57)	20.09 (8.55)	<0.001
MUFA (g/day)	13.49 (7.08)	16.47 (7.76)	20.19 (9.53)	<0.001
PUFA (g/day)	13.08 (8.05)	15.16 (8.13)	17.64 (8.93)	<0.001
Iron (mg/day)	12.98 (5.05)	15.77 (6.00)	18.80 (7.15)	<0.001
Magnesium (mg/day)	197.56 (69.62)	258.76 (78.53)	322.57 (111.04)	<0.001
Zinc (mg/day)	5.89 (2.14)	7.47 (2.35)	9.39 (3.33)	<0.001
Calcium (mg/day)	554.85 (200.22)	745.12 (235.70)	963.97 (351.51)	<0.001
Phosphorus (mg/day)	742.07 (255.73)	968.65 (279.11)	1246.02 (435.90)	<0.001
Selenium (mg/day)	0.07 (0.03)	0.08 (0.04)	0.10 (0.04)	<0.001
Vitamin E (mg/day)	3.06 (1.93)	4.00 (2.33)	4.90 (2.75)	<0.001
Vitamin B_1 (mg/day)	1.71 (0.70)	2.01 (0.77)	2.32 (0.86)	<0.001
Vitamin B_2 (mg/day)	1.23 (0.43)	1.61 (0.49)	2.03 (0.70)	<0.001
Vitamin B_3 (mg/day)	16.85 (7.70)	19.56 (8.12)	22.72 (9.29)	<0.001
Vitamin B_6 (mg/day)	1.20 (0.44)	1.59 (0.49)	2.03 (0.68)	<0.001
Vitamin B_9 (mg/day)	244.44 (100.30)	331.48 (128.97)	423.20 (178.08)	<0.001
Vitamin B_{12} (mcg/day)	2.59 (1.77)	3.51 (2.10)	4.69 (3.06)	<0.001
Vitamin C (mcg/day)	117.01 (69.67)	167.48 (93.86)	222.48 (113.07)	<0.001
Variable*	**Tertile 1 NHDI Median (IQR)**	**Tertile 2 NHDI Median (IQR)**	**Tertile 3 NHDI Median (IQR)**	***P* value#**
Energy (kcal/day)	1715.87 (603)	2048.32 (669)	2449.98 (879)	<0.001
Protein (g/day)	58.76 (21.35)	70.05 (22.95)	83.99 (32.72)	<0.001
Carbohydrate (g/day)	273.19 (109.08)	322.42 (116.82)	378.38 (145.11)	<0.001
Fat (g/day)	47.55 (20.30)	55.41 (21.85)	69.12 (29.30)	<0.001
Total fiber (g/day)	20.33 (10.64)	21.64 (9.72)	24.04 (11.39)	<0.001
Cholesterol (mg/day)	200.27 (106.82)	244.71 (127.31)	297.13 (147.38)	<0.001
SFA (g/day)	13.60 (6.17)	16.01 (6.69)	19.80 (8.66)	<0.001
MUFA (g/day)	13.85 (7.15)	16.03 (7.56)	20.44 (9.90)	<0.001
PUFA (g/day)	12.78 (7.01)	14.82 (7.55)	18.61 (9.56)	<0.001
Iron (mg/day)	13.30 (5.32)	15.73 (5.73)	18.80 (7.31)	<0/001
Magnesium (mg/day)	227.81 (97.58)	253.24 (96.63)	297.29 (121.12)	<0.001
Zinc (mg/day)	6.44 (2.56)	7.40 (2.50)	8.95 (3.51)	<0.001
Calcium (mg/day)	663.64 (323.44)	729.60 (332.58)	843.12 (353.92)	<0.001
Phosphorus (mg/day)	844.76 (369.63)	953.99 (355.72)	1141.04 (462.16)	<0.001
Selenium (mg/day)	0.07 (0.03)	0.08 (0.03)	0.10 (0.04)	<0.001
Vitamin E (mg/day)	3.30 (1.92)	3.92 (2.36)	5.05 (3.08)	<0.001
Vitamin B_1 (mg/day)	1.70 (0.65)	2.02 (0.71)	2.34 (0.89)	<0.001
Vitamin B_2 (mg/day)	1.40 (0.62)	1.58 (0.59)	1.87 (0.79)	<0.001
Vitamin B_3 (mg/day)	16.15 (6.21)	19.73 (6.83)	23.82 (9.49)	<0.001
Vitamin B_6 (mg/day)	1.40 (0.67)	1.57 (0.64)	1.81 (0.76)	<0.001
Vitamin B_9 (mg/day)	295.63 (160.93)	324.08 (153.78)	373.15 (182.88)	<0.001
Vitamin B_{12} (mcg/day)	2.80 (1.97)	3.50 (2.47)	4.49 (3.16)	<0.001
Vitamin C (mcg/day)	157.24 (117.08)	163.69 (109.60)	177.28 (109.50)	<0.001

g: Gram; mg: Milligram; mcg: Microgram; SFA: Saturated fatty acid; MUFA: Mono unsaturated fatty acid; PUFA: Poly unsaturated fatty acid. *Values were reported as median (IQR) for continuous variables. #Using Kruskal-wallis test for abnormal continuous variables. Significant values were shown in bold (*P* values less than 0.05 were considered significant).

Table 3: The association between PHDI with body composition in two crude and adjusted models.

Variable	Tertile 1			Tertile 2			Tertile 3		
	Coef.	95% Confidence interval		Coef.	95% Confidence interval		Coef.	95% Confidence interval	
		Low	Up		Low	Up		Low	Up
Body fat percent (%)									
Crude	Ref.	-	-	-0.23	-1.02	0.55	0.39	-0.37	1.15
Adjusted*	Ref.	-	-	-0.25	-0.89	0.38	0.25	-0.43	0.94
Body fat mass (kg)									
Crude	Ref.	-	-	0.65	-0.10	1.40	1.79	1.06	2.52
Adjusted*	Ref.	-	-	0.26	-0.50	1.02	1.04	0.22	1.86
Fat free mass (kg)									
Crude	Ref.	-	-	1.50	0.46	2.54	2.62	1.61	3.62
Adjusted*	Ref.	-	-	0.57	-0.26	1.41	1.17	0.27	2.07
Skeletal muscle mass (kg)									
Crude	Ref.	-	-	0.90	0.28	1.51	1.56	0.97	2.15
Adjusted*	Ref.	-	-	0.35	-0.12	0.83	0.71	0.19	1.23
Fat free mass index									
Crude	Ref.	-	-	0.26	-0.006	0.54	0.56	0.38	0.92
Adjusted*	Ref.	-	-	0.07	-0.18	0.34	0.33	0.04	0.61
Fat mass index									
Crude	Ref.	-	-	0.06	-0.22	0.36	0.50	0.21	0.78
Adjusted	Ref.	-	-	-0.01	-0.28	0.26	0.31	0.01	0.61
AMC (cm)									
Crude	Ref.	-	-	0.23	-0.15	0.63	0.76	0.38	1.14
Adjusted*	Ref.	-	-	-0.01	-0.40	0.38	0.32	-0.10	0.74
Arm circumference (cm)									
Crude	Ref.	-	-	0.28	-0.18	0.75	0.98	0.53	1.44
Adjusted*	Ref.	-	-	0.002	-0.48	0.49	0.47	-0.04	1.00
Bone mineral content									
Crude	Ref.	-	-	0.09	0.04	0.15	0.15	0.09	0.20
Adjusted*	Ref.	-	-	0.04	-0.01	0.09	0.07	0.02	0.12
Visceral fat area (cm)									
Crude	Ref.	-	-	1.97	-2.01	5.95	7.17	3.32	11.02
Adjusted*	Ref.	-	-	0.33	-3.53	4.19	3.75	-0.39	7.90

kg: Kilogram; cm: Centimeter; AMC: Arm muscle circumference obtained by linear regression. These values were Beta coefficient (95%CIs). p values less than 0.05 were considered significant. *Adjusted for age, gender, physical activity, cigarette smoking, opium use, alcohol use, education level, wealth index and energy intake.

The association between NHDI and body composition in two crude and adjusted models were presented in Table 4. In the crude model, in tertile 2, a negative significant correlation was observed between NHDI and fat percent (coef.=2.11; CI: _2.90-_1.32), body fat mass (coef.=_0.77; CI: _1.54-_0.003), fat mass index (coef.=_0.62; CI: _0.92-_0.32), and visceral fat area (coef.=_6.53; CI: _10.57-_2.48) in comparison to tertile 1. Also, in the last tertile, NHDI was significantly and inversely related to body fat percent (coef.=_3.74; CI: _4.48-_3.00), body fat mass (coef.=_0.89; CI: _1.60-_0.17), fat mass index (coef.=_0.97; CI: _1.25-_0.69), and visceral fat area (coef.=_9.24; CI: _13.00-_5.48) compared with the first tertile, in crude models. NHDI had a positive significant correlation with fat free mass (coef.=3.25; CI: 2.22-4.28), skeletal muscle mass (coef.=2.00; CI: 1.39-2.61), fat free mass index (coef.=0.53; CI: 0.26-0.81), AMC (coef.=0.63; CI: 0.23-1.03), and bone mineral content (coef.=0.16; CI: 0.10-0.22) in the second tertile in comparison to the first one, in the crude model. Also, in tertile 3, NHDI had a positive significant correlation with fat free mass (coef.=6.41; CI: 5.45-7.37), skeletal muscle mass (coef.=3.93; CI: 3.36-4.50), fat free mass index (coef.=1.06; CI: 0.80-1.32), AMC (coef.=0.82; CI: 0.37-1.27), arm circumference (coef.=0.82; CI: 0.37-1.27), and bone mineral content (coef.=0.32; CI: 0.27-0.38) compared with tertile 1, in the crude model. However, in the adjusted model, NHDI was not associated with different components of body composition.

Discussion

Dietary choices have a significant impact on anthropometric parameters and body composition of people in the society (22, 23). In the current

Table 4: The association between NHDI with body composition in two crude and adjusted models.

Variable	Tertile 1			Tertile 2			Tertile 3		
	Coef.	95% Confidence interval		Coef.	95% Confidence interval		Coef.	95% Confidence interval	
		Low	Up		Low	Up		Low	Up
Body fat percent (%)									
Crude	Ref.	-	-	-2.11	-2.90	-1.32	-3.74	-4.48	-3.00
Adjusted*	Ref.	-	-	-0.07	-0.72	0.57	0.07	-0.60	0.76
Body fat mass (kg)									
Crude	Ref.	-	-	-0.77	-1.54	-0.003	-0.89	-1.60	-0.17
Adjusted*	Ref.	-	-	-0.32	-1.09	0.44	-0.16	-0.97	0.64
Fat free mass (kg)									
Crude	Ref.	-	-	3.25	2.22	4.28	6.41	5.45	7.37
Adjusted*	Ref.	-	-	-0.09	-0.94	0.75	-0.05	-0.94	0.83
Skeletal muscle mass (kg)									
Crude	Ref.	-	-	2.00	1.39	2.61	3.93	3.36	4.50
Adjusted*	Ref.	-	-	-0.03	-0.52	0.44	-0.01	-0.52	0.49
Fat free mass index									
Crude	Ref.	-	-	0.53	0.26	0.81	1.06	0.80	1.32
Adjusted*	Ref.	-	-	-0.04	-0.30	0.22	-0.08	-0.37	0.19
Fat mass index									
Crude	Ref.	-	-	-0.62	-0.92	-0.32	-0.97	-1.25	-0.69
Adjusted*	Ref.	-	-	-0.13	-0.41	0.14	-0.10	-0.39	0.19
AMC (cm)									
Crude	Ref.	-	-	0.63	0.23	1.03	1.20	0.83	1.57
Adjusted*	Ref.	-	-	0.02	-0.36	0.42	-0.03	-0.45	0.38
Arm circumference (cm)									
Crude	Ref.	-	-	0.40	-0.07	0.88	0.82	0.37	1.27
Adjusted*	Ref.	-	-	-0.007	-0.50	0.48	-0.06	-0.58	0.46
Bone mineral content									
Crude	Ref.	-	-	0.16	0.10	0.22	0.32	0.27	0.38
Adjusted*	Ref.	-	-	-0.005	-0.05	0.04	-0.009	-0.05	0.05
Visceral fat area (cm)									
Crude	Ref.	-	-	-6.53	-10.57	-2.48	-9.24	-13.00	-5.48
Adjusted*	Ref.	-	-	-1.60	-5.49	2.29	-0.43	-4.54	3.67

kg: Kilogram; cm: Centimeter; AMC: Arm muscle circumference. Obtained by linear regression. These values were Beta coefficient (95%CIs). Significant values were shown in bold (*P* values less than 0.05 were considered significant). *Adjusted for age, gender, physical activity, cigarette smoking, opium use, alcohol use, education level, wealth index and energy intake.

study, pro-healthy diet index was significantly and positively related to skeletal muscle mass, bone mineral content, body fat mass, fat free mass, fat free mass index, and fat mass index. No significant association was observed between PHDI and body fat percent. Moreover, adherence to non-healthy diet index had no correlation with various factors of body composition. The present study showed a positive association between PHDI and body fat mass and fat mass index. However, contrary to the result of the present study, Lombardo and colleagues revealed that Mediterranean diet (MD) could cause a significant loss in fat mass in menopausal women (24) . A study by Li *et al.* (25) revealed that participants following a Mediterranean-like diet had lower FMI. Further, MD had an inverse relationship with fat mass in a study by Moradi and colleagues (26). The contradiction between the results of the current study and other studies could be possibly due to the fact that the participants in the higher tertiles of PHDI received a higher amount of energy, fat, and carbohydrates, which could possibly affect their fat mass and fat mass index to be higher.

In addition, in the present study, there was no significant relationship between PHDI and body fat percent (BF%). Also, Landry and colleagues showed that the HEI-2015 had no association with BF% (27) that was in accordance with the results of the present study. Moreover, no association was found between HEI with fat percent in AL-Rubaye and colleagues' study (28). However, a study by Zagarins *et al.* (29) revealed that healthy diet indices like Alternate Healthy Eating Index 2010, Healthy Plant-Based Diet

Index, and alternate MD were significantly correlated with BF%. The reason for these differences could be possibly due to the difference in the sample size, population, design of the studies, or differences in the indices used in evaluating diet quality as well.

As another finding of the present study, PHDI was significantly and positively related to skeletal muscle mass, bone mineral content, fat-free mass, and fat-free mass index. Also, these results were in line with another study by Li and colleagues which revealed that adherence to a Mediterranean-like diet was associated with higher FFM and FFMI (25). Additionally, Pooyan *et al.* (30) showed that healthy dietary pattern could be associated with FFM, bone mineral content, and skeletal muscle mass. MD was positively associated with bone mineral content in children (31). In the study by Bento *et al.* (32), the DASH diet was associated with improved bone mineral status. The current finding was in accordance with all of the aforementioned studies. The reason for such results could be possibly attributed to the higher intake of soluble and insoluble fiber, protein, PUFA, magnesium, calcium, iron, and vitamin C in pro-healthy diet index group which according to the previous studies are associated with higher skeletal muscle mass, bone mineral content, and fat free mass, (26, 32, 33). Moreover, PHDI contains vitamin D, which is important for maintaining skeletal muscle mass and muscle function (33). Further, fruits and vegetables are included in PHDI that contain minerals (such as magnesium, calcium and potassium), vitamins such as K and C, antioxidants such as polyphenols, phytochemicals (such as plant estrogens), and oligosaccharides that could affect calcium absorption or their involvement in the process of bone regeneration and in this way, it can improve the status of bones (34, 35). The fish consumed in this food index contains vitamin D, calcium, and omega-3. Omega-3 probably affects bone health by reducing bone loss and suppressing osteoclast activity (32).

As another finding of the current study, NHDI was not related to any factors of body composition. Yet, adherence to a non-healthy diet like Western dietary pattern was positively associated with FMI (25). Saghafi-Asl *et al.* found that Western dietary patterns had positive association with FM (36). In addition, adherence to NHDI did not have any significant association with different factors of body composition in the present study. However, another study showed that unhealthy dietary pattern was related to lower FFMI (37). The difference can be due to the differences in the characteristics of the studied populations, sample size, data analysis methods, and nutritional indicators. On the other hand, the reason for not observing the negative effects of NHDI on body composition indices could be possibly related to the moderating effects of higher consumption of fiber and B group vitamins (effective on energy metabolism) in the higher tertiles of the index.

The present study had some limitations. One possible limitation of the present study was its cross-sectional design, so that no causal relationship could be confirmed. Second, because of the probability of risk of recall bias when using FFQ, estimating the participants' real intake was impossible. Due to the special population of the study as the medical staffs, the results could not be used for or generalized to other populations and should be interpreted with caution. On the other hand, the present study had some strength as well. Data were extracted from the employees' health cohort of Shiraz University of Medical Sciences with a large sample size. Validated questionnaires were used. In addition, adjustment was performed for controlling several significant confounding variables.

Conclusion

The present study showed that PHDI had a significant positive correlation with skeletal muscle mass, bone mineral content, body fat mass, fat free mass, fat free mass index, and fat mass index. However, there was no association between NHDI and different factors of body composition. Due to the special situation of the study population as the health staffs, the current results should be interpreted with caution. More researches in various populations with longer follow-ups are needed to confirm these findings.

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Authors' Contribution

ND, ZS, and SJM have made substantial contributions to the conception and design of the work; ND helped in the acquisition of the data, MN and ZS helped in the analysis and interpretation of data; ND, MN, and ZS have drafted the work and all authors reviewed and substantively revised the final manuscript.

Conflict of Interest

None declared.

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