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Major dietary patterns and bone mineral density in postmenopausal Iranian women

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A B S T R A C T

Background: As the global elderly population increases, the prevalence of osteoporosis and the incidence of osteoporosis-related fractures are becoming a major social and medical concern in both developed and developing countries. Therefore, the objective of the present study was to examine association dietary pattern and bone health in postmenopausal women.

Methods: In this study, 254 postmenopausal women aged 46 to 78 years were examined. Body composition measured by Body Composition Analyzer Physical activity using the short form of International Physical Activity Questionnaire (IPAQ) was performed. Bone mineral density was measured by DEXA method. Major dietary patterns were determined using factor analysis on 27 foods groups using a valid and reliable 147-item semi-quantitative food frequency questionnaire (FFQ). The major dietary patterns were identified by Principal Component Analysis (PCA) method.

Results: Three dietary patterns including the Mediterranean, Traditional and unhealthy patterns were identified. These three dietary patterns explained 30.45 % of total variance in dietary intakes. Our results showed that higher adherence score to a " Mediterranean " dietary pattern was positively associated with Z score L2_L4 lumbar spine ($p > 0.05$). Furthermore, logistic regression results showed that Mediterranean dietary pattern reduces the risk of osteopenia/ osteoporosis (OR = 0.75, 95%CI: 0.58 - 0.96). However, Traditional (OR = 0.97, 95%CI: 0.76 -1.24) and Unhealthy (OR = 1.19, 95%CI: 0.93 -1.52) dietary patterns had no association with risk of osteopenia/ osteoporosis.

Conclusion: It seems Mediterranean dietary pattern has a protective association against the risk of osteopenia/ osteoporosis in postmenopausal women.

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Introduction

Osteoporosis has been termed "silent disease" as it progresses without symptoms until a fracture occurs. The fractures caused by osteoporosis have a great impact on public health since they are often associated with increased morbidity, mortality, reduced quality of life, long hospital stays and high economic cost [1]. Consequently, cost-effective intervention policies must be urgently identified in an attempt to minimize the impact of fractures [2]. Postmenopauasl osteoporosis, resulting from estrogen deficiency, is the most common type of osteoporosis. Estrogen deficiency results in an increase in bone turnover owing to effects on all types of bone cells [3]. Moreover, osteoporosis has been associated with other risk factors specifically age [4], physical activity[5], obesity [6], stress [7], alcoholism [8] , smoking habit [9], genetic variants [10] and dietary pattern [11].

Dietary patterns allow investigators to examine the whole diet, and assess whether individual nutrients known to be associated with certain diseases are present or absent in those diets, and hence draw associations between dietary habits and diseases[12, 13]. The use of a dietary pattern approach to evaluating the association between diet and bone health warrants further studies, considering the wide variability in diets among different countries [14-18]. Previous studies suggest that Mediterranean diet as healthy dietary pattern, can be beneficial for bone mineral density [19]. The dietary pattern rich in Monounsaturated to saturated fatty acid, Antioxidant (polyphenols and carotenoids), non-antioxidant (phytosterols) bioactive compounds and dietary fiber may have a significant role in health [20, 21]. The intake of these compounds is strongly linked with the high consumption of fruits, vegetables, and unrefined cereals [20]. In other hand, inverse association between BMD and dietary patterns with high loadings for sweet foods [14], alcohol [22], red meat [23], saturated fat [24], salt intake [25], processed foods [26] were previously shown by nutritional studies. Therefore, the objective of the present study was to examine association dietary pattern and bone health in postmenopausal women.

Methods and Materials

Study population

This cross-sectional study was performed from July 2015 to December 2015 in Shariati Hospital in Tehran on 254 postmenopausal women (aged 46-78 years). The study was approved by the local committee of ethics at Tehran University of Medical Sciences (No.:1394-06-30-803). The study participants were chosen according to our defined inclusion criteria, postmenopausal women, an absence of any acute or chronic inflammatory disease, no history of hypertension, no alcohol or drug abuse, and not being smoker. Accordingly, individuals who had the history of any condition affecting inflammatory markers such as known cardiovascular disease, thyroid diseases, malignancies, current smoking, diabetes mellitus, sustained hypertension, heart failure, acute or chronic infections, and hepatic or renal diseases were excluded from the study. All participants were provided with a written informed consent before taking part in the study.

Weight and height were measured while participants were wearing lightweight clothing and no shoes. Weight was measured with digital scales (Seca 803, Germany) and was recorded to

Table 1. Study population characteristics

	Min	Max	Mean	SD
Age(years)	46	78	57.8	6.14
Age of menopause(years)	35	59	48.75	4.28
Height(cm)	141.6	173	154.82	11.58
Weight(kg)	42.30	158	70.63	13.87
BMI(kg/m2)	17.50	41	28.6	4.43
Waist circumference (cm)	72	150	105.51	9.41
Hip circumference (cm)	61	151	89.79	12.26
Fat percentage %	10.8	58.30	27.10	7.79
FFM	10.10	70.10	42.09	6.92
MET	High PA	Medium PA	Low PA	
N	90	126	32	
P (%)	34.1%	47.7%	12.1%	

BMI, Body mass index; FFM, Fat free mass, PA, Physical activity

Table 2. Food groups used in the factor analysis and factor loadings for each of the identified dietary patterns

		Dietary pattern		
Food group	**Food items**	Mediterranean	Traditional	Unhealthy
Whole Grain	Dark breads(sangak), Corn and Cob	0.388*	-	-
Legumes	Lentils, beans, chickpeas, faba beans, mung beans, split peas and soy	0.352	-	0.387
Refined grain	Lavash bread, baguette bread, rice, pasta, noodle and noodles soup, taftoon bread, barbari bread	-	0.283	0.349
Red Meat	Beef and veal, lamb, minced meat	0.314	-	-
Processed Meats	Sausage, deli meat, hamburger	-	0.591	-
White meat	Chicken and fish	0.310	-	-
Eggs	Eggs	-	0.389	-
Organ meats	Heart, kidney, liver, tongue, brain, offal, rennet		0.505	
Low-fat dairy products	Low-fat milk, skim milk, low-fat yogurt, cheese, Kashk, yogurt drink, others	0.558	-	-
High-fat dairy products	High-fat milk, high-fat yogurt, cream cheese, cream, dairy fat, ice cream, others	-	-	0.501
Hydrogenated fats	Hydrogenated vegetable oils, solid fats (animal origin), animal butter, margarine	-	-	0.761
Vegetable oils	Vegetable oils	-	0.326	-
Olive	Olive oil and green olives	0.725		
Sweets and desserts	Cookies, cakes, muffins, pies, chocolates, honey, jam, sugar cubes, sugar, candies, sweet Tahini, others	-	0.490	-
Nuts	Almonds, peanut, walnut, pistachio, hazelnut, seeds and others	0.608	-	-
Dried Fruit	Dried berries and dried figs	0.568	-	-
Fruit	Melon, watermelon, honeydew melon, plums, prunes, apples, cherries, sour cherries, peaches, nectarine, pear, fig, date, grapes, kiwi, pomegranate, strawberry, banana, persimmon, berry, pineapple and others	0.681	-	-
Vegetables	Cauliflower, carrot, tomato and its products, spinach, lettuce, cucumber, eggplant, onion, greens, green bean, green pea, squash, mushroom, pepper, corn, garlic, turnip, others	0.743	-	-
Fruit juices	lemon juice, apple juice, water melon and orange juice	0.311	-	-
Pickles	Pickles, salted cucumbers	-	-	0.422
Snacks	Biscuits, corn puffs, crackers, potato chips, others	-	0.478	-
Soft drinks	Soft drinks	-		-
Tea and coffee	Tea and coffee	-	0.420	-
Condiments	Turmeric, pepper, others	-	0.326	-
Salt	Salt	-	-	0.25
Potatoes	Potatoes	-	0.307	0.300
Tomato	Tomato, red sauce, tomato paste	-	-	-
Explained variance (%)		14.30	10.18	5.96

* Factor loadings of < 0.25 have been removed to simplify the table

the nearest 0.1 kg. Height was measured with a stadiometer (Seca 206 portable stadiometer) and was recorded to the nearest 0.1 cm. Waist and hip circumferences were measured by using non-elastic tape measure with an accuracy of 0.5 cm.

Complete body composition analysis

The researchers assessed the body composition of all cases with the use of BODY COMPOSITION ANALYZER BC-418MA - Tanita (United Kingdom) by strictly following

Table 3. Associations among Mediterranean Pattern , demographic factors and bone health factors of postmenopausal women

Mediterranean Pattern	**Q1**	**Q2**	**Q3**	**Q4**	***P* ***	***P*****
Age(years)	57.68± 6.34	56.81±6.02	57.86±6.02	67.68±6.34	-	-
Height(cm)	154.71±6.10	155.03±8.45	154.29±16.12	155.24±13.77	0.96	0.71
Weight(kg)	71.82±11.14	69.01±11.63	71.47±16.60	70.22±15.45	0.64	0.66
BMI(kg/m2)	29.98±4.41	28.36±4.40	28.69±4.39	27.37±4.23	0.008	<0.001
Waist circumference (cm)	92±10.46	90.20±14.06	90.09±13.11	86.88±10.72	0.11	0.09
Hip circumference (cm)	106.79±7.77	104.39±9.87	106.74±11.22	104.11±8.27	0.19	0.004
Fat percentage %	37.65±6.89	36.37±6.21	37.46±5.93	36.49±5.68	0.53	0.35
FFM	42.64±7.03	42.35±5.81	42.43±7.91	40.92±6.81	0.47	0.60
Fat Mass	28.53±8.32	26.30±7.76	27.87±7.73	25.68±7.12	0.12	0.01
Visceral Fat	9.53±2.51	8.83±2.58	8.93±2.36	8.9±2.41	0.33	0.003
Total Hip BMD	0.91±0.13	0.90±0.11	0.95±0.19	0.92±0.10	0.15	0.56
Total Hip T score	-0.64±1.0	-0.83±0.96	-0.54±1.07	-0.58±0.87	0.40	0.65
Total Hip Z score	-0.09±1.02	-0.11±0.92	-0.98±1.02	-0.98±1.02	0.49	0.28
L2_L4 BMD	1.01±0.18	1.02±0.15	1.04±0.16	1.05±0.15	0.32	0.08
L2_L4 T score	-1.51±1.39	-1.50±1.16	-1.10±1.34	-1.13±1.35	0.14	0.08
L2_L4 Z score	-0.65±1.32	-0.62±1.28	-0.28±1.22	-0.17±1.23	0.07	0.02
MET	1430.7±227.4¥	1022.1±148.07¥	1894.7±295.64¥	2241.5±141.75¥	0.01	0.02

Q: Quartile; BMI, Body mass index; FFM, Fat free mass; BMD, Bone mineral density.
* P-Value for ANCOVA test
** P-Value for ANCOVA test after adjustment for Age, Age of menopause Weight, Physical activity, Calorie intake
¥ Standard error

the techniques, procedure and precaution of the manufacturer's protocol [27]. The device calculates body-fat percentage, fat mass, and fat-free mass and predicts muscle mass on the basis of data obtained by Dual Energy X-ray Absorptiometry (DXA) using Bioelectrical Impedance Analysis (BIA).

Major dietary pattern measurement

Dietary intake was assessed using a valid and reliable [28] 147-item semi-quantitative food frequency questionnaire (FFQ) to assess the usual food intake of individuals during the 12 months before the examination. The consumption frequency of each food item on a daily, weekly or monthly basis was converted to daily intakes; portion sizes were then converted to grams, using household measures. Food items in the food frequency questionnaire were classified in 27 food groups (Table 2).

Physical activity assessment

The physical activity level was assessed by International Physical Activity Questionnaire (IPAQ) short form that is an instrument designed primarily for population surveillance activity among adults [29]. The validity and reliability of this questionnaire have been well established [30]. This questionnaire measures the specific types of activity that are waking, moderate-intensity and vigorous-intensity activity during the last 7 days. We assessed the duration per day (in minutes) and frequency (days) per week of waking, moderate-intensity and vigorous-intensity activity. In data analysis of physical activity, the volume of activity was computed by weighting each type of activity by its energy requirements defined in metabolic equivalents (MET) to yields a score in MET-minutes that is multiples of the resting metabolic rates.

Bone mineral density measurement

BMD was measured by DXA using Lunar DPX-MD device (Lunar Corporation, Madison, Wisconsin, 53713. USA). The DXA device was calibrated daily and weekly by using appropriated phantoms methods. To assess BMD, second to fourth lumbar spine and from the femur bone (neck, trochanter and the whole femur), bone density was calculated based on gr/cm^2. Osteoporosis and osteopenia were defined by World Health Organization (WHO) criteria. Participants with T-scores between -1 SD and -2.5 SD are diagnosed with osteopenia and are considered at high risk for osteoporosis. Participants with T-scores lower than -2.5 SD are diagnosed with osteoporosis.

Results

Study population characteristics

The mean age, age at menopause, height, weight and BMI of the study participants were 57.8 (SD ±6.14) years, 48.75(SD ± 4.28) years, 154.82 (SD ±11.58) cm, 70.63 (SD± 13.87) kg and 28.61 (SD ±4.43) kg/m^2 respectively (Table 1). The participants were 95 healthy subjects, 114 patients with osteopenia ,45 patients with lumber osteoporosis and in hip 153, 95, 6 were healthy, osteopenia and osteoporosis respectively. As shown in the Figure 1, postmenopausal women in level of physical activity were, 41.7% (N=106) sedentary, 45.6% (N=116) moderate activity and 12.7% (N=32) intensive activity.

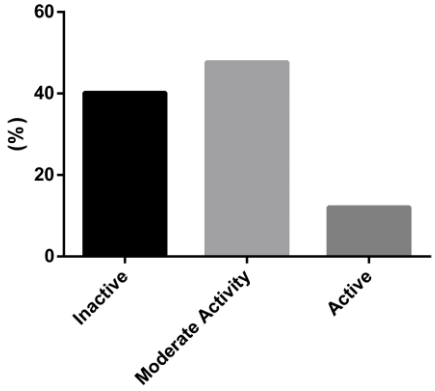

Fig. 1. Levels of physical activity in postmenopausal women

Dietary pattern

Factor analysis revealed 3 main dietary patterns for the population under study; food groups and factor loadings for those with absolute values of ≥0.25 are presented in Table 2. Dietary intake of food groups adjusted for total calorie intake. Factor 1, identified as a Mediterranean dietary pattern, was characterized by high intakes of vegetables, fruits, olive, nuts, dried fruit, fruit juices, whole grain, legumes, white meat, low-fat dairy products and red meat whereas factor 2, the Traditional dietary pattern, was typified by greater consumption of organ meats, processed meats, eggs, refined grain, vegetable oils, tea and coffee, condiments, potatoes snacks, sweets and desserts. Moreover, factor 3, identified as an Unhealthy dietary pattern, was recognized by high intakes of hydrogenated fats, high-fat dairy products, refined grain, legumes, pickles, salt and potatoes.

Highest quartile of the Mediterranean dietary pattern after adjustment for age, age of menopause weight, physical activity, calorie intake were positive associated with reduced BMI (*P*=0.001>), hip circumference (*P*=0.004), Fat Mass (*P*=0.01) and Visceral Fat (*P*=0.003).

Table 5. Associations among Unhealthy Pattern , demographic factors and bone health factors of postmenopausal women

Unhealthy Pattern	**Q1**	**Q2**	**Q3**	**Q4**	***P****	***P*** **
Age(years)	57.27± 5.99	58.59±6.22	56.75±5.58	57.74±6.71	-	-
Height(cm)	155.48±12.17	152.37±13.15	155.77±13.36	155.63±5.9	0.27	0.56
Weight(kg)	70.69±14.40	67.41±12.18	72.80±17.15	71.61±10.61	0.13	0.25
BMI(kg/m2)	29.18±3.97	28.33±4.73	28.45±4.74	29.47±4.23	0.33	0.07
Waist circumference (cm)	87.86±10.72	88.52±10.57	90.94±16.04	91.85±10.60	0.18	0.10
Hip circumference (cm)	106.79±7.77	104.39±9.87	106.74±11.22	104.11±8.27	0.19	0.004
Fat percentage %	37.12±5.72	36.90±5.93	36.10±7.13	37.83±6.04	0.47	0.65
FFM	41.92±7.38	41.66±5.45	42.04±8.62	42.74±5.92	0.83	0.93
Fat Mass	26.09±7.13	26.50±8.92	27.34±7.88	28.49±7.03	0.30	0.13
Visceral Fat	8.83±2.28	9.12±2.71	8.84±2.47	9.4±2.41	0.51	0.13
Total Hip BMD	0.93±0.15	0.91±0.12	0.93±0.12	0.92±0.16	0.89	0.41
Total Hip T score	-0.64±1.0	-0.54±0.95	-0.07±0.87	-0.18±0.79	0.75	0.21
Total Hip Z score	-0.04±0.93	-0.11±0.92	-0.98±1.02	-0.98±1.02	0.48	0.14
L2_L4 BMD	1.39±0.15	1.09±0.18	1.05±0.15	1.02±0.17	0.54	0.12
L2_L4 T score	-1.33±1.27	-1.41±1.40	-1.10±1.31	-1.40±1.29	0.50	0.29
L2_L4 Z score	-0.38±1.22	-0.34±1.38	-0.39±1.30	-0.61±1.21	0.64	0.20
MET	1543.3±231.5¥	1544.5±293.8¥	1681.1±269.4¥	1818.4±340.8¥	0.87	0.45

Q: Quartile; BMI, Body mass index; FFM, Fat free mass; BMD, Bone mineral density.
* P-value for ANCOVA test
** P-value for ANCOVA test after adjustment for age, age of menopause weight, physical activity, calorie intake
¥ Standard error

Table 6. The associations of dietary pattern scores and risk of osteopenia/ osteoporosis using logistic regression

	Crude Models	Adjusted Models*
Major dietary patterns	**OR(95%CI)**	**OR(95%CI)**
Mediterranean	0.84(0.67 to 1.05)	**0.75(0.58 to 0.96)**
Traditional	0.93(0.74 to 1.17)	0.97(0.76 to 1.24)
Unhealthy	1.10(0.88 to 1.38)	1.19(0.93 to 1.52)

* Adjusted for age, BMI, physical activity, calorie intake
OR: Odds Ratio, CI: Confidence Interval

Postmenopausal women in the highest quartile of Mediterranean dietary pattern scores had higher L2_L4 Z-score in lumbar spine (P=0.02) than those in the lowest quartile. However, there was no significant adherence to the Mediterranean dietary pattern on hip bone health among the quartiles (P>0.05) (Table 3). Consumption of Traditional and Unhealthy dietary patterns after adjustment for age, age of menopause weight, physical activity, calorie intake were not associated with demography, body composition and bone characteristics(P>0.05) (4 and 5 Tables). Furthermore, logistic regression results showed that Mediterranean dietary pattern after adjustmen for age, BMI, physical activity, calorie intake reduces the risk of osteopenia/ osteoporosis (OR = 0.75, 95%CI: 0.58 -0.96). However, Traditional (OR = 0.97, 95%CI: 0.76 - 1.24) and Unhealthy (OR = 1.19, 95%CI: 0.93 - 1.52) dietary patterns were no association with risk of osteopenia/ osteoporosis (Table 6).

Discussion

This cross-sectional study demonstrated that dietary patterns can associate with the bone health in postmenopausal women. We identified three dietary patterns, Mediterranean dietary pattern, Traditional dietary pattern and Unhealthy dietary pattern. We found that the Mediterranean dietary pattern was related to several factors, including body composition and lumbar L_2L_4–Z-score. In addition, Mediterranean dietary pattern reduces the risk of osteopenia/ osteoporosis Although, we did not find any consistent relationship between Traditional and Unhealthy dietary pattern with body composition and bone health after adjustment for age, age of menopause weight, physical activity, calorie intake in postmenopausal women.

Our findings showed that the prevalence of osteoporosis in lumber and hip were 17.7 % and 2.4 % respectively in postmenopausal women. The prevalence of osteoporosis in lumber spine was in agreement with previous studies in Iran [31, 32]. But in hip prevalence of osteoporosis is lower than these studies. This results may be due to lower age of participant rather than previous studies.

Our results demonstrated that individual with higher adherence to the Mediterranean dietary pattern had positive significant relationship on lumbar Z-score. But, adherence to the Mediterranean dietary pattern in women had no significant associations with total hip BMD, total hip t-score and z-score. This association has been hypothesized to be caused by the effects of small number of women with hip osteoporosis. In hip site, may similar bone mineral density in participants led to the Mediterranean diet miss its association with bone parameter.

Furthermore, logistic regression results showed that Mediterranean dietary pattern, has a protective association against the risk of osteopenia/ osteoporosis in postmenopausal women. Mediterranean diet rich in several components, such as calcium, potassium, vitamin D, vitamin K, B vitamins, vitamin C, vitamin A and carotenoids, phytoestrogens and non-digestible oligosaccharides [33-35] . These components through their effect on calcium absorption or their involvement in the bone remodeling sequence could improve bone health. Furthermore, Mediterranean dietary pattern was characterized by high intakes of olive oil. Previous Studies suggested that olive oil phenols by modulating the proliferative capacity and cell maturation of osteoblasts by increasing alkaline phosphatase activity, depositing calcium ions in the extracellular matrix [36] and inhibition of inflammatory cytokine [37] can be beneficial in preventing the loss of bone mass. In addition, Mediterranean dietary pattern rich in plant-derived estrogens, especially soy phytoestrogens. These phytoestrogens may be useful for preventing bone loss caused by estrogen deficiency in females [38].

In this study, observed that the inverse relationship between the higher adherence to the Mediterranean dietary pattern with BMI, hip circumference, fat mass and visceral fat after

adjustment for age, age of menopause, weight, physical activity, calorie intake. These in agreement with previous research demonstrating inverse associations between the high consumption of vegetables, fruits, whole grain, nuts and olive oil in Mediterranean dietary pattern with obesity [39-43]. This relationship may be due to the specific characteristics Mediterranean dietary pattern, including rich in fiber [44] and calcium [45], low energy density, low glycemic load, high water content[40] and higher levels of plasma antioxidant capacity[43].

In conclusion, the Mediterranean dietary pattern (consisting of vegetables, fruits, olive, nuts, dried fruit, fruit juices, whole grain, legumes, white meat and low-fat dairy products) are associated with lower BMI and improve Z-score in L_2L_4 lumbar spine. The traditional (high in organ meats, processed meats, eggs, refined grain, vegetable oils, tea and coffee, condiments, potatoes snacks, sweets and desserts) and Unhealthy (hydrogenated fats, high-fat dairy products, refined grain, legumes, pickles, salt and potatoes) dietary patterns were not associated with bone health characteristics and body composition parameters in postmenopausal Iranian women. Moreover, investigating the associations of dietary pattern scores and risk of osteopenia/ osteoporosis revealed that Mediterranean dietary pattern in the prevention of the risk of osteoporosis in postmenopausal women is beneficial.

Strenghs and Limitations

All assessments were performed using validated tools and questionnaires. This study compared with previous similar studies, had used the new FFQ questionnaire. The main limitations of the present study were the relatively small number of participants in the same-sex sample and also small number of postmenopausal women with hip osteoporosis.

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Conflict of interest

There are no competing financial interests in relation to current study.

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