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Concurrent association of dietary pattern and physical activity with sarcopenia in menopausal women

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ABSTRACT

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Objective: To examine concurrent association of dietary pattern and physical activity with sarcopenia in menopausal women.

Methods: In this cross-sectional study, 250 menopausal women aged 45-75 were studied. Dietary intakes were assessed with a validated 147-item food-frequency questionnaire, and dietary patterns were identified by a principal components analysis method. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ). Sarcopenia was defined, according to the European Working Group on Sarcopenia in Older People (EWGSOP) criteria, as the presence of low muscle mass plus low muscle performance, or low physical strength.

Results: Two major dietary patterns were identified: a prudent pattern (high in vegetable, vegetable oil, fish, dairy, legume, nut, animal protein and fruit), and a Western pattern (high in commercial beverage, hydrogenated fat, sugar, sweet-snack, potato, tea-coffee and refined grain). After adjusting for age, we found a significant interaction of the Western pattern with physical activity level in terms of the odds of sarcopenia (p-interaction = 0.01), which was higher in active than inactive subjects. However, there was no significant difference between inactive and active participants in the prudent pattern (p-interaction = 0.90).

Conclusion: physical activity and adherence to the Western dietary pattern is associated with higher odds of sarcopenia among menopausal women.

key words:
sarcopenia;
menopause;
dietary pattern;
physical activity.

Introduction

Age-related alterations in skeletal muscle health include a decline in muscle mass and function, known as sarcopenia [1]. This phenomenon is responsible for a higher risk of falls, disability, decreased quality of life, loss of independence, and increased mortality [2-4]. The loss of muscle mass and function with aging is associated with multiple factors including nutritional status, physical activity, and hormonal changes [5,6]. The menopause is associated with a decline in estrogen concentrations, which has negative effects on skeletal muscle [7].

Changes in lifestyle factors such as diet and exercise can be appropriate strategies for the prevention of sarcopenia [8]. Previous studies have mostly considered diet in terms of single foods, food groups (e.g., fruits, vegetables, and dairy), or single

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nutrients (e.g., dietary protein or vitamin D) [9,10]. However, given the complexity of human diets and biochemical interactions between nutrients, results describing the effects of consumption of single foods or nutrients on a given health outcome may be misleading [11], as the intake of one nutrient or food is often correlated with the intake of other nutrients or lifestyle factors the combination of which may influence the individuals' health status [12].

The present study aimed to identify dietary patterns and assess the association of dietary patterns and physical activity with sarcopenia in menopausal women. The results may improve the current understanding of the effect of diet and physical activity on sarcopenia and provide new insights into lifestyle interventions to prevent sarcopenia.

Materials and methods

Participants

A total of 250 menopausal women (aged 45-75 years) were enrolled in this cross-sectional study through random sampling in the fall of 2015. Menopause was defined as lack of menstruation for the past year. None of the participants had liver, heart, or kidney failure, chronic obstructive pulmonary disorder, cancer, diabetes, artificial limbs, or history of smoking and alcohol consumption. The study protocol was approved by the research council and ethics committee of Tehran University of Medical Sciences. All participants gave written informed consent.

Dietary assessment

Dietary intake was assessed by the use of a validated food-frequency questionnaire (FFQ) containing 147 food items with standard serving sizes [13]. A trained dietitian administered the questionnaire and the participants were asked to specify their frequency of intake for each food item on a daily, weekly, monthly, or yearly basis. The US Department of Agriculture (USDA) food composition table (FCT) was used to calculate dietary energy and nutrient intake using the Nutritionist IV software (version 3.5.2; 1994, N-Squared Computing, San Bruno, CA). However, for some traditional Iranian food items (e.g., traditional bread and dairy products such as kashk) that are not included in Nutritionist IV, the Iranian FCT was used [14].

Physical activity assessment

International Physical Activity Questionnaire (IPAQ) was used to assess the physical activity level. Following the instructions of the IPAQ [15], frequency and duration of physical activity were converted to metabolic equivalent of tasks (MET). Then, the subjects were categorized as either inactive (< 1000 MET-min/wk) or active (> 1000 MET-min/wk).

Definition of sarcopenia

The European Working Group on Sarcopenia in Older People (EWGSOP) suggested a practical definition and diagnostic criteria for sarcopenia, namely, the presence of both low muscle mass and function (performance or strength) [1]. Moreover, EWGSOP developed an algorithm for the diagnosis of sarcopenia based on easily available measurements such as muscle mass (assessed by bioelectrical impedance analysis [BIA] or dual X-ray absorptiometry), muscle strength (assessed by handgrip strength), and physical performance (assessed by Short Physical Performance Battery or gait speed).

Muscle mass assessment using BIA

Bioelectrical impedance (in ohms) was used to evaluate muscle mass. A Tanita BC-418 (Tanita Corporation, Tokyo, Japan) with an operating frequency of 50 kHz at 500 μA was used for this purpose. Muscle mass was estimated according to the following equation [16]:

$$\text{Skeletal muscle mass (kg)} = (\text{height}^2/R \times 0.401) + (\text{gender} \times 3.825) + (\text{age} \times -0.071) + 5.102$$

Where height is in centimeters; R is bioelectrical impedance in ohms; age is in years; and gender is equal to either 1 or 0 for males and females, respectively.

Skeletal muscle index (SMI) was calculated by dividing skeletal mass in kilogram by height squared. Using the cutoff points proposed in the EWGSOP consensus, women were classified as having severe sarcopenia (SMI: ≤ 5.75 kg/m^2), moderate sarcopenia (SMI: 5.76–6.75 kg/m^2), and normal muscle (SMI: ≥ 6.76 kg/m^2) [17,18].

Physical performance assessment using gait speed

Participants walked a 4-meter course at their usual pace. A walking speed of less than 0.8 m/s identified individuals with low physical performance [18].Timing began when participants started foot movement and stopped when a foot touched the ground after completely crossing the 4-meter mark.

Muscle strength measurement

Muscle strength was assessed using a squeeze bulb dynamometer (Rolyan c7489-02). Three trials were conducted with each hand and the sum of averaged readings for each hand was used in the analysis. Using the cutoff points proposed for different age-sex groups by Merkies et al. [19], we identified individuals with low levels of muscular strength.

Statistical analysis

To reduce the complexity of data, the initial 147 food items were categorized into 18 predefined food groups according to the similarity of their nutrient contents (e.g., dairy products, refined or whole grain, and fruits). Then, food groups and nutrients were energy-adjusted using the residual method because underreporting or overreporting of food items may result in an irrelevant increased variation. To identify major dietary patterns based on the 18 food groups, we used principal components analysis with varimax rotation. Factors with eigenvalues greater than 1.5 were extracted and then scree plots were used to identify the main dietary patterns. Factor scores for each subject and each dietary pattern were calculated by summing intakes of foods weighed by their factor loading. Factor scores were then categorized into tertiles (tertile 1 = low adherence to the pattern; tertile 3 = high adherence to the pattern).

We used chi-square tests for categorical variables and one-way analysis of variance (ANOVA) for continuous variables to identify significant differences across tertiles of dietary pattern scores. To determine the association of dietary patterns with sarcopenia across physical activity levels, we used multivariable logistic regression (all regression models were controlled for age). The first tertile of dietary pattern scores was considered as reference. Then, we examined the interactions between dietary patterns and categories of physical activity with sarcopenia. For all analyses, SPSS software version 16 (SPSS Inc., Chicago, IL, USA) was used, and $p < 0.05$ was considered statistically significant.

Table 1. Food groups used in the factor analysis and factor loadings for each of the identified dietary patterns.

Food groups	Food items	Prudent	Western
Vegetables	Leafy vegetables (raw and cooked), lettuce, celery, cucumber, green pea, spinach, bell pepper, mushroom, tomato, zucchini, eggplant, carrot (raw and cooked), garlic, onion (raw and fried), turnip, green chilies, green beans, cruciferous vegetables, pumpkin	.659	
Vegetable oil	All vegetable oils, olive oil	.642	
Fish	Fish, canned tuna	.632	
Dairy	High-fat milk, low-fat milk, chocolate milk, cheese, cream cheese, traditional ice cream, nontraditional ice cream, cream, kashk, high-fat yogurt, concentrated yogurt, plain yogurt, doogh (yogurt drink)	.607	
Legumes	Lentils, beans, chickpeas, cooked broad beans, soybean, mung beans, split peas	.479	.351
Nuts	Peanut, almond, walnut, pistachio, hazelnut, seeds	.460	
Animal protein	Red meat (beef or lamb), ground meat, poultry, eggs, organ meat (brain, tongue, feet, head, tripe, liver, kidney, and heart), and rennet	.405	.379
Fruits	Watermelon, honeydew melon, cantaloupe, Persian melon, pears, apricots, apples, cherries, sour cherries, peach, nectarine, greengages, fig, grapes, kiwi, grapefruit, orange, persimmon, tangerine, pomegranate, dates, plums, strawberry, banana, sweet lemon, lime, mulberry, dried fig, dried mulberry, dried fruits, raisins, juices (orange, apple, and honeydew), olives	.403	
Fast food	Hamburger, sausage, lunch meat, pizza	.333	.332
wholegrain	Dark bread (Barbari, Sangak, Taftoon), cooked barley or bulgur, Corns		
Commercial beverage	Soft drinks, commercial juices		.637
Hydrogenated fat	Hydrogenated vegetable oils, animal fats, butter, margarine, mayonnaise	-.217	.582
Sugar	Sugar, sugar cubes, candies, honey, Jams, gaz, sohan, halvah (arde), canned fruits		.553
Sweet -snack	Cakes, pastries, chocolates, halva (homemade), cookies, crackers, cheese puffs		.491
Potato	French fries, potato, potato chips	.244	.490
Tea-coffee	Tea, coffee		.389
Refined grain	White bread (lavash, baguette), cooked rice, pasta, cooked angel hair pasta, reshteh		.368
Condiments/Pickles	Ketchup, lime juice, spices, salt, salted pickles, pickled cucumber, other pickles		
Total variance explained (%)		16.23	11.27

Note: food groups with factor loadings ≥ 0.2 are shown

Results

Two major dietary patterns were found using factor analysis: a prudent pattern (high in vegetables, vegetable oil, fish, dairy, legumes, nuts, animal protein, and fruits), and a Western pattern (high in commercial beverage, hydrogenated fat, sugar, sweet snacks, potato, tea/coffee, and refined grains). In total, these dietary patterns explained 27.5% of the variations in dietary intake. Loading factors of foods or food groups across these major food patterns are presented in Table 1.

General characteristics of participants across tertiles of major dietary patterns are presented in Table 2. Those in the third tertile of the prudent pattern were older (58.7 vs 56.2 y, p = 0.02) and had lower weight (68.9 vs 73.3 kg, p = 0.02) and BMI (28.1 vs 30.5 kg/m^2, p < 0.01) compared with those in the first tertile. Mean handgrip strength (69.4 vs 65.9 kg, p = 0.03) and gait speed (1.03 vs 0.87 m/s, p < 0.01) were higher in the third tertile of the prudent pattern compared with the first tertile. There was no significant difference between the third and first tertiles of the prudent pattern in the mean muscle mass index. Gait speed was significantly lower among the participants in the third tertile of the Western pattern compared with the participants in the first tertile. No significant differences were seen in muscle mass index and handgrip strength across tertiles of the western pattern.

The association of each dietary pattern with sarcopenia and its components was evaluated within subgroups defined by physical activity levels (Table 3). Subgroup analyses revealed that physical activity changed the association between the Western pattern and sarcopenia (p-interaction = 0.01). The Western pattern was positively associated with the odds of sarcopenia in active women (T3 compared with T1: OR = 5.90; 95% CI = 1.48, 23.49; p-trend = 0.01), but not in inactive women (p-trend = 0.24). The interactive effect of the western pattern and physical activity on the odds of abnormal components of the sarcopenia was not statistically significant.

Also, the effect of interaction of the prudent pattern with physical activity on sarcopenia and its components was not statistically significant. The third tertile of the prudent pattern was associated with a lower likelihood of abnormal muscle strength and abnormal muscle performance in both active and inactive women.

Table 2. Characteristics of the study participants across tertiles of dietary patterns

Parameters	Prudent pattern				Western pattern			
	T3 (n = 83)	T2 (n = 84)	T1(n = 83)	P[a]	T3 (n = 83)	T2 (n = 84)	T1(n = 83)	P[a]
Age, y[b]	56.2 ± 6.3	58.1 ± 5.9	58.7 ± 6.3	0.02	57.8 ± 5.8	57.5 ± 6.2	57.6 ± 6.7	0.93
Weight, kg[b]	73.3 ± 11.6	70.0 ± 9.5	68.9 ± 10.4	0.02	71.3 ± 10.0	68.9 ± 10.7	72.0 ± 11.1	0.15
Height, cm[b]	154.9 ± 5.8	156.3 ± 6.5	155.9 ± 6.3	0.31	156.5 ± 6.4	155.3 ± 5.9	155.4 ± 6.3	0.41
Body mass index[b], kg/m^2	30.5 ± 4.2	28.9 ± 4.0	28.1 ± 3.8	< 0.01	29.2 ± 4.1	28.6 ± 4.2	29.7 ± 4.0	0.17
Physical activity, MET-min/wk	1666	1960	2181	0.29	2153	1942	1713	0.40
Muscle mass index,[b,c] kg/m^2	7.0 ± 0.7	6.9 ± 0.7	6.7 ± 0.7	0.22	6.8 ± 0.7	6.8 ± 0.7	6.9 ± 0.7	0.73
Hand grip strength, kPa[b,c]	65.9 ± 12.5	68.1 ± 13.5	69.4 ± 12.4	0.03	69.2 ± 12.2	68.9 ± 12.6	65.3 ± 13.4	0.72
Gait speed, m/s[b,c]	0.87 ± 0.15	0.94 ± 0.19	1.03 ± 0.19	< 0.01	1.00 ± 0.19	0.95 ± 0.18	0.90 ± 0.18	<0.01

[a] *Analysis of variance for continuous variables.*
[b] *Data are mean ± SD.*
[c] *Adjusted for age.*

Table 3. Age-adjusted odds ratios (95% confidence interval) for the sarcopenia across tertiles of dietary pattern scores in menopausal women

Parameters	Prudent pattern					Western pattern				
	T1 (n = 83)	T2 (n = 84)	T3 (n = 83)	p-trend	p-interaction	T1 (n = 83)	T2 (n = 84)	T3 (n = 83)	p-trend	p-interaction
Abnormal muscle mass					0.77					0.05
Inactive (n = 124)	1	1.36 (0.57-3.24)	1.83 (0.73-4.55)	0.19		1	0.57 (0.23-1.42)	0.37 (0.15-0.92)	0.03	
Active (n = 126)	1	1.02 (0.39-2.67)	1.96 (0.79-4.87)	0.12		1	1.52(0.62-3.73)	1.30 (0.51-3.30)	0.55	
Abnormal muscle strength					0.30					0.76
Inactive (n = 124)	1	0.30 (0.12-0.75)	0.23 (0.09-0.62)	<0.01		1	0.99 (0.39-2.52)	2.95 (1.17-7.45)	0.02	
Active (n = 126)	1	0.48 (0.19-1.19)	0.39 (0.16-0.97)	0.04		1	1.39 (0.57-3.36)	2.31 (0.93-5.72)	0.07	
Abnormal muscle performance					0.70					0.09
Inactive (n = 124)	1	0.28 (0.09-0.84)	0.15 (0.03-0.59)	<0.01		1	0.66 (0.20-2.16)	1.21 (0.42-3.44)	0.66	
Active (n = 126)	1	1.59 (0.55-4.58)	0.07 (0.01-0.39)	<0.01		1	3.69 (1.00-13.53)	5.81 (1.59-21.17)	<0.01	
Sarcopenia					0.90					0.01
Inactive (n = 124)	1	0.42 (0.14-1.20)	0.63 (0.23-1.76)	0.32		1	0.29 (0.09-0.91)	0.62 (0.24-1.62)	.24	
Active (n = 126)	1	0.69 (0.23-2.00)	0.43 (0.14-1.30)	0.13		1	4.79 (1.21-18.93)	5.90 (1.48-23.49)	.01	

Discussion

In this study, using principal components analysis in a sample of 250 menopausal women, two major dietary patterns were derived: the prudent and the Western pattern. In stratified analysis, we found a significant interaction of the western pattern with physical activity such that the odds of sarcopenia was higher in active women than those who were inactive, but there was no significant difference in the odds of sarcopenia between inactive and active participants using the prudent pattern. Also, we did not find any significant interaction between dietary pattern and physical activity with respect to abnormal muscle mass, abnormal muscle strength, or abnormal muscle performance.

Previous studies were focused on the association of sarcopenia with either dietary patterns or physical activity. However, in fact, nutrition and exercise are strongly interrelated with each other. Our study is the first study to evaluate the concurrent association of dietary pattern and physical activity with the odds of sarcopenia.

We observed an increased odds of sarcopenia among active participants using the western dietary pattern. Although there is no doubt that exercise has beneficial effects at any age, senescent muscle seems to be more vulnerable to oxidative stress during exercise due to the age-related biochemical and ultrastructural changes that facilitate reactive oxygen species (ROS) formation [20-22]. Because of low consumption of fruits and vegetables in the West, active individuals may have a compromised ROS defense [23], leading to a greater susceptibility to muscle damage compared with inactive ones. Furthermore, consuming a diet rich in vegetables and fruits that produce alkaline products probably could prevent protein degradation in muscle [24-26].

Some studies have also shown the effectiveness of macronutrient and micronutrient for sarcopenia. Nevertheless, we must consider the appropriate concomitant energy intake [27]. Exercise (both aerobic and resistance) in combination with adequate energy and protein intake is a strategic factor of the prevention and management of sarcopenia [28]. In a systematic review, Weinheimer et al [29] surveyed the efficacy of exercise and energy restriction on fat-free mass loss and showed that exercise alone had a more protective effect on fat-free mass than exercise plus energy restriction. Evidence indicates that regular physical activity alongside optimal dietary protein intake and adequate vitamin D, calcium, and antioxidant nutrients intake may make an important contribution to avenues for prevention of age-related deterioration of musculoskeletal health [30,31].

We also investigated the association between components of sarcopenia (muscle mass, strength, and performance) and dietary patterns by physical activity categories. We noticed an unexpected decrease in muscle mass abnormality among inactive women in the Western pattern, which may be because of high consumption of tea and coffee in this dietary pattern [32-35].

The concurrent association of physical activity and the prudent with sarcopenia and its components was not significant. However, this dietary pattern decreased significantly the odds of abnormality in muscle strength and performance among both inactive and active women. Several studies have suggested that a healthy diet can prevent age-related loss of skeletal muscle function (muscle strength and muscle performance) [36-41].

The strengths of our study are that sarcopenia was defined based on EWGSOP criteria. We used a validated FFQ, and this is the first study to examine the interaction between physical activity and dietary pattern in relation to sarcopenia.

The study also has several limitations. The cross-sectional nature of the study limits the interpretation of the results. Although the FFQ is a standard instrument in nutritional epidemiology to assess long-term dietary intake, estimates of food intake from an FFQ are not precise, and there is always a possibility of measurement error. Physical activity level captured using IPAQ over the previous week may not reflect the actual physical activity level of the participants. And finally, stratified results must be interpreted with caution due to smaller sample sizes when analyzing by both dietary pattern and physical activity.

In conclusion, the prudent pattern could reduce the loss of muscle function with age for menopausal women. When models were stratified by physical activity, the Western dietary pattern was associated with higher odds of sarcopenia in active women. These results provide interesting insights about developing and planning future dietary intervention trials in combination with exercise for the prevention of sarcopenia.

Conflict of interest

The authors declare no potential conflict of interest with respect to the research, authorship, or publication of this article.

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