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Dietary Patterns Defined a Posteriori or a Priori in Relation to Obesity Indices in Iranian Women

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ABSTRACT

Background: Obesity is a multifactorial chronic disease that develops from multiple interactions between various factors. This study investigated the associations between dietary patterns defined a posteriori or a priori and obesity indices in a sample of Iranian women.

Methods: Totally, 267 women aged 30-50 years participated in this cross-sectional study. Obesity indices of body mass index (BMI) and waist circumference (WC) were determined. Dietary intakes were evaluated with a 168-item food frequency questionnaire. Dietary patterns were a posteriori or a priori by performing factor analysis and by assessing participants' adherence to dietary approaches to stop hypertension (DASH) diet, respectively.

Results: After controlling potential confounders in the analysis of covariance models, multivariable adjusted means of BMI and WC of subjects in the highest quintile of the DASH pattern score defined a priori were significantly lower than those in the lowest quintile (for BMI: mean difference -2.9 kg/m^2, p=0.003; and for WC: mean difference -5.4 cm, p=0.009). Similar results were observed in case of the healthy pattern score defined a posteriori (BMI: mean difference -3.7 kg/m^2, p=0.003; WC: mean difference -6.5 cm, p=0.002). Multivariable adjusted means of BMI and WC of subjects in the highest quintile of the unhealthy pattern score defined a posteriori, were significantly higher than those in the lowest quintile (BMI: mean difference 3.9 kg/m^2, p=0.001; WC: mean difference 8.2 cm, p=0.001).

Conclusion: These findings indicated significant associations between dietary patterns defined a posteriori or a priori and obesity indices in Iranian women.

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Introduction

Obesity is a multifactorial chronic disease that develops from multiple interactions between genetic, physiologic, metabolic, socio-economic, and lifestyle factors (1, 2). It is a serious public health concern in nearly all developed countries (3), and its prevalence is rapidly escalating in developing populations such as Iran, particularly among women (4, 5). In Iran, the prevalence of general obesity (body mass index≥30 kg/m^2) and central obesity (waist circumference≥88 cm) among adult women is substantial, and it is estimated to be as high as 31% and 54%, respectively (6). These conditions are usually associated with increased rates of type 2 diabetes mellitus, stroke, certain types of cancer, and cardiovascular diseases (1, 3). However, as far as the etiology and management of obesity are concerned, our current knowledge is still incomplete, but it seems that lifestyle factors, especially diet, play important roles in these respects (2).

Thus far, the most common approach to assessing the relationship between diet and obesity has been based on evaluating a single food or a few foods and nutrients. However, addressing the complex role of diet in the etiology of obesity by this traditional approach has some limitations (7). To address these limitations, studying dietary patterns (overall diet) has been recently proposed as an alternative approach to examine diet–disease associations (7). Dietary patterns can be defined either a posteriori, by applying multivariate statistical techniques like cluster analysis or factor analysis on dietary intake data obtained from specific study populations, or a priori, through the use of dietary indices or food consumption models such as diet quality index, healthy eating index, Mediterranean diet, and dietary approaches to stop hypertension (DASH) diet (7, 8). In brief, a dietary pattern approach could resolve our concerns about confounding factors and interactions among foods and nutrients (7), and enable us to provide public health messages that are more well-defined and easier to follow compared to recommendations that stem from individual foods and nutrients (9).

Despite its prominence, the association of dietary patterns defined a priori or a posteriori and obesity is not yet well clarified. This is in line with the findings of a systematic literature review by Togo *et al.* (10), which indicated that it is difficult to identify consistent associations between obesity or obesity indices and dietary patterns, derived from dietary indices, cluster analysis, or factor analysis. Furthermore, few studies in the Middle Eastern populations such as Iran have assessed the association of dietary patterns defined a priori (11, 12) or a posteriori (13-17) with obesity among women. Addressing this association is of great importance due to the unique characteristics of the Middle Eastern diet and the rapid nutrition transition from traditional diets into Western-style diets taking place in this region (4, 18, 19), and also because unlike most western populations, the prevalence of general and central obesity among Middle-Eastern women is higher than that among men (5, 20).

Since the posteriori approaches (e.g., factor analysis) produce dietary patterns on the basis of available empirical data without a priori hypothesis, they might not necessarily represent optimal dietary patterns. Moreover, one must evaluate whether the patterns generated appropriately fit into the commonly recognized eating habits of the target population, as these patterns are produced simply based on eating behaviors. On the other hand, dietary pattern analysis based on the a priori approaches (e.g., dietary indices) is limited by current knowledge and understanding of the diet-disease association (7). However, it might be reasonable to hypothesize that simultaneous use of both the posteriori and the a priori methods for identification of dietary patterns in the studies analyzing the relationships between diet and health outcomes, such as obesity, could provide us with better and clearer understanding of the underlying associations. Therefore, using a sample of Iranian women, we aimed to investigate, for the first time in the Middle East, the associations between dietary patterns defined a posteriori or a priori and obesity indices.

Materials and Methods

This cross-sectional study was carried out among a sample of adult women aged 30–50 years, selected by a stratified random sampling method from women's health clubs in Tehran, Iran. A total of 400 women were invited to participate in the present study and 371 women agreed to do so (the participation rate was 92.8%). After excluding subjects who were pregnant, lactating, or menopausal (n=13); with a diagnosed condition or disease that could influence nutritional status or obesity indices (n=18); taking medications (n=11); following weight-management diets (n=33); smokers (n=5); with more than 70 blank items on the food frequency questionnaire (FFQ; n=11); and those who reported a total energy intake outside the range of 0.8-4.8 Mcal/d (3.3-20.1 MJ/d; n=13), 267 women (mean age 38.3 y) remained for the current analysis. Notably, none of these women reported any history of alcohol consumption.

The ethics board of the National Nutrition and Food Technology Research Institute (WHO Collaborating

Center) of Shahid Behehshti University of Medical Sciences reviewed and approved the study protocol, and verbal informed consents were witnessed and formally recorded from participants prior to their inclusion in the study. All procedures followed were in accordance with the Helsinki Declaration of 1964 and all subsequent revisions (21). As validated (22), semi-quantitative 168-item FFQ was used for assessing subject's usual dietary intake during the past 12 months. After calculating the daily intake of each food item, a manual for household measures (23) was used to convert it to daily grams of intake. Energy content of foods was computed using the United States Department of Agriculture (USDA) food composition data included in the Nutritionist 4 software (First Databank; Hearst, San Bruno, CA, USA) and the Iranian food composition table (24).

Participant's weight (to the nearest 0.1 kg) and height (to the nearest 0.1 cm) were measured by digital scales (Seca 881, Germany) and a stadiometer (Seca 214, Germany), respectively, while they were wearing minimal clothing and no shoes. Body mass index (BMI), as an index for general obesity, was calculated as weight in kilograms divided by height in meters squared. Subject's waist circumference (WC), as a marker for central obesity, was measured to the nearest 0.1 cm by an unstretched tape measure at the end of a normal expiration, over light clothing and without any pressure to body surface, at the narrowest point between the lowest rib and the iliac crest. Subject's physical activity was measured with a validated physical activity questionnaire and reported as MET-hours per day (MET-h/d) (25). Data on age (y) and education (<12 y, ≥12 y), as a measure of socio-economic status, were obtained via general questionnaires. A well-trained dietitian performed all anthropometric measurements and administered all questionnaires through face-to-face interviews.

In the present study, dietary patterns were defined a priori or a posteriori by assessing participants' adherence to the DASH diet and by performing the principal component factor analysis (PCFA), respectively (26). According to the Fung *et al.*'s method (27), we calculated a DASH pattern score for each subject based on her intake of foods and nutrients commonly emphasized or minimized in the DASH diet, with a focus on 8 major components: higher intake of fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains, and lower intake of sodium, sweetened beverages, and red or processed meats (28). To do so, subjects were initially classified according to the quintile categories of their intake of these 8 components. In case of fruits, vegetables, nuts and legumes, low-fat dairy products, and whole grains, the scores of 1, 2, 3, 4, and 5 were assigned to those in the first (lowest), second, third, fourth, and fifth (highest) quintiles, respectively. On the other hand, for sodium, sweetened beverages, and red or processed meats, the exact opposite of this scoring system was used. The 8 component scores were then added up to construct the overall DASH pattern score for each subject, which ranged from 8 to 40. The higher the overall DASH pattern score of a subject, the more her adherence to the DASH diet.

To perform the PCFA, the 168 food items were initially categorized into 25 predefined food groups (Table 1). Detailed information on the food grouping procedure is available elsewhere (29, 30). The PCFA with orthogonal transformation (26) was then applied to derive major dietary patterns (factors) based on a set of 25 predefined food groups. In brief, out of the 9 factors extracted by the PCFA, we decided to retain the first 2 major factors for current analysis based on the following criteria: natural interpretability, eigenvalue >1, and Cattell's scree test (26). These factors were labeled as "unhealthy" and "healthy", respectively, according to the earlier literature (31) and also based on our interpretation of the data. Factor scores for each dietary pattern and each subject were then calculated by summing the intake frequency of each food group weighted by factor loadings (i.e., the correlation coefficients which relate food groups to each of the identified dietary patterns) (26).

The a priori and a posteriori defined dietary pattern scores were categorized into 5 groups according to the quintiles. The Chi-square test and the One-way analysis of variance were used for comparison of categorical and continuous variables among quintiles of each dietary pattern score, respectively. Multivariable adjusted means of the obesity indices were computed for and compared among quintiles of each dietary pattern score using the analysis of covariance (ANCOVA) models adjusted for age, physical activity, energy intake, and education as potential confounders. Pairwise differences in the means of the obesity indices between highest (Q5) and lowest (Q1) quintiles of each dietary pattern score were assessed by the Bonferroni post-hoc test to adequately adjust for multiple comparisons. The statistical package for social sciences software, version 21 (IBM, Armonk, NY, USA) was used to perform all analyses, considering a two-sided p-value of <0.05 as statistically significant.

Results

Table 1 presents the factor-loading matrix for the unhealthy and healthy dietary patterns defined a posteriori using the PCFA. The unhealthy pattern was characterized by high intake of refined grains,

Table 1: Factor loading matrix for the dietary patterns defined a posteriori using factor analysis.[a,b]

Food groups	Food items	Dietary patterns	
		Unhealthy	Healthy
Refined grains	Lavash bread, baguette bread, rice, pasta, others	0.617	0.018
Red or processed meats	Beef and veal, lamb, minced meat, sausage, deli meat, hamburger	0.598	0.065
French fries	French fries	0.589	0.003
Mayonnaise	Mayonnaise	0.531	0.051
Salt	Salt	0.481	-0.136
Potatoes	Potatoes	0.430	0.177
Sweets and desserts	Cookies, cakes, muffins, pies, chocolates, honey, jam, sugar cubes, sugar, candies, sweet Tahini, others	0.413	0.390
Sweetened beverages	Sweetened beverages	0.384	0.038
Snacks	Biscuits, corn puffs, crackers, potato chips, others	0.330	0.266
High-fat dairy products	High-fat milk, high-fat yogurt, cream cheese, cream, dairy fat, ice cream, others	0.323	0.251
Vegetable oils	Vegetable oils (except for olive oils)	0.309	0.183
Hydrogenated fats	Hydrogenated vegetable oils, solid fats (animal origin), animal butter, margarine	0.303	0.160
Eggs	Eggs	0.299	0.246
Whole grains	Dark breads (e.g., Barbari, Sangak, Taftun), bran breads, others	0.293	0.125
Fruits	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, others	0.073	0.678
Vegetables	Cauliflower, carrot, tomato and its products, spinach, lettuce, cucumber, eggplant, onion, greens, green bean, green pea, squash, mushroom, pepper, corn, garlic, turnip, others	0.264	0.621
Low-fat dairy products	Low-fat milk, skim milk, low-fat yogurt, cheese, Kashk, yogurt drink, others	-0.150	0.514
Nuts	Almonds, peanut, walnut, pistachio, hazelnut, seeds, others	0.100	0.485
Fish	All fish types	-0.025	0.478
Legumes	Lentils, split pea, beans, chick pea, fava bean, soy, others	0.319	0.419
Tea and coffee	Tea and coffee	0.144	0.414
Olive	Olives, olive oils	-0.009	0.345
Organ meats	Heart, kidney, liver, tongue, brain, offal, rennet	0.170	0.343
Pickles	Pickles, sauerkraut	0.331	0.342
Poultry	Chicken	0.210	0.327

[a]Factor loadings for the food groups included in each dietary pattern are presented in bold; [b]The unhealthy and healthy dietary patterns explained 16.932% and 6.870% of the whole variance in dietary intakes, respectively.

red or processed meats, French fries, mayonnaise, salt, potatoes, sweets and desserts, sweetened beverages, snacks, high-fat dairy products, vegetable oils, and hydrogenated fats. The healthy pattern, on the other hand, was high in fruits, vegetables, low-fat dairy products, nuts, fish, legumes, tea and coffee, olive, organ meats, pickles, and poultry. Overall, these two posteriori defined dietary patterns explained 23.80% of the whole variance in dietary intakes. With respect to the DASH dietary pattern defined a priori, the overall adherence of subjects was moderate, as indicated by a mean DASH pattern score of 24.00±4.50.

Table 2 and 3 demonstrate the characteristics of study participants and the multivariable adjusted means of the obesity indices by quintiles of dietary pattern scores defined a posteriori or a priori, respectively. As shown in Table 3, after controlling for potential confounders in the ANCOVA models, multivariable adjusted means of the BMI and WC of subjects in the highest quintile of the DASH pattern score defined a priori were significantly lower than those in the lowest quintile (for BMI: mean difference -2.9 kg/m^2, p=0.003; and for WC: mean difference -5.4 cm, p=0.009). Similar results were observed in case of the healthy pattern score defined a posteriori (for BMI: mean difference -3.7 kg/m^2, p<0.001; and for WC: mean difference -6.5 cm, p=0.002). By contrast, multivariable adjusted means of the BMI and WC of subjects in the highest quintile of the unhealthy pattern score defined a posteriori were significantly higher than those in the lowest quintile

Table 2: Characteristics of study participants by quintiles of dietary pattern scores defined a posteriori or a priori.[a,b]

Characteristics	All (n=267)	Dietary patterns defined a posteriori[c]						Dietary patterns defined a priori[d]		
		The unhealthy pattern score			The healthy pattern score			The DASH pattern score		
		Q1 (n=53)	Q3 (n=53)	Q5 (n=53)	Q1 (n=53)	Q3 (n=53)	Q5 (n=53)	Q1 (n=53)	Q3 (n=53)	Q5 (n=53)
Age (y)	38.3±6.1	37.5±6.2	38.2±5.8	38.7±6.1	38.3±5.8	37.6±5.7	39.7±7.1	37.3±6.0	37.5±6.1	40.2±6.3
Physical activity (MET-h/d)	36.0±6.5	35.5±5.1	37.3±7.5	35.5±7.0	35.0±5.6	35.3±6.2	38.0±8.4	35.8±5.6	35.5±6.1	37.3±7.8
Energy intake (Mcal/d)	2.5±0.9	1.7±0.5	2.3±0.6	3.5±0.8**	1.8±0.5	2.4±0.7	3.3±0.8**	1.9±0.6	2.5±0.9	2.9±0.9**
Education (≥12 y)	146 (54.7)	34 (64.2)	30 (56.6)	26 (49.1)	21 (39.6)	30 (56.6)	28 (52.8)	28 (52.8)	36 (67.9)	24 (45.3)
Weight (kg)	68.5±10.5	65.6±9.8	68.6±10.2	71.2±11.7**	71.1±11.6	68.2±11.1	66.3±10.0	70.0±11.0	70.2±9.8	66.6±9.7
Height (cm)	161.8±5.4	163.0±5.5	162.0±4.9	160.5±5.2	161.6±4.6	161.9±4.4	161.4±4.4	161.3±5.2	162.9±5.4	162.2±5.1
BMI (kg/m^2)	26.2±4.0	24.7±3.6	26.1±3.4	27.6±4.2**	27.2±4.2	26.0±4.0	25.5±3.9*	26.9±4.1	26.5±3.8	25.4±3.8
WC (cm)	85.7±8.1	83.0±6.6	85.6±6.5	89.2±8.9**	87.4±7.9	84.9±7.4	84.7±8.6*	87.1±8.2	86.4±6.9	84.4±8.3

DASH: Dietary approaches to stop hypertension; MET: Metabolic equivalent; BMI: Body mass index; WC: Waist circumference.
[a]Data are presented as mean±standard deviation or *n* (%); [b]The Chi-Square test and the one-way analysis of variance were used for comparison of categorical and continuous variables among quintiles of each dietary pattern score, respectively; [c]Dietary patterns were defined a posteriori using factor analysis; [d]Dietary patterns were defined a priori by assessing participants' adherence to the DASH diet. $^{*}p<0.05$; $^{**}p\leq0.01$.

Table 3: Multivariable adjusted means of the obesity indices by quintiles of dietary pattern scores defined a posteriori or a priori (*N*=267).[a,b,c,d]

Obesity indices	Dietary patterns defined a posteriori[e]								Dietary patterns defined a priori			
	The unhealthy pattern score			Pairwise difference [Q5-Q1]	The healthy pattern score			Pairwise difference [Q5-Q1]	The DASH pattern score			Pairwise difference [Q5-Q1]
	Q1 (n=53)	Q3 (n=53)	Q5 (n=53)		Q1 (n=53)	Q3 (n=53)	Q5 (n=53)		Q1 (n=53)	Q3 (n=53)	Q5 (n=53)	
BMI (kg/m^2)	24.4 [23.3-25.5]	26.0 [25.0-27.0]	28.3* [27.0-29.6]	3.9* [1.1; 6.7]	27.9 [26.8-28.9]	26.3 [25.3-27.2]	24.2* [23.0-25.3]	-3.7* [-6.2; -1.3]	27.4 [26.4-28.5]	26.8 [25.8-27.8]	24.6* [23.5-25.6]	-2.9* [-5.1; -0.7]
WC (cm)	82.3 [80.0-84.6]	85.4 [83.3-87.5]	90.5* [87.9-93.1]	8.2* [2.5; 13.9]	88.7 [86.5-90.9]	85.4 [83.4-87.5]	82.2* [79.9-84.5]	-6.5* [-11.5; -1.5]	88.2 [86.0-90.4]	86.9 [84.9-89.0]	82.8* [80.7-85.0]	-5.4* [-9.9; -0.8]

DASH: Dietary approaches to stop hypertension; BMI: Body mass index; WC: Waist circumference. [a]Data are presented as mean [95% confidence intervals]; [b]Multivariable adjusted means of the obesity indices were computed for and compared among quintiles of each dietary pattern score using the analysis of covariance (ANCOVA); [c]Age, physical activity, energy intake, and education were included as covariates in all ANCOVA models; [d]Pairwise differences in the means of the obesity indices between highest (Q5) and lowest (Q1) quintiles of each dietary pattern score were examined by the Bonferroni post-hoc test; [e]Dietary patterns were defined a posteriori using factor analysis; [f]Dietary patterns were defined a priori by assessing participants' adherence to the DASH diet. $^{*}p<0.01$

(for BMI: mean difference 3.9 kg/m^2, p=0.001; and for WC: mean difference 8.2 cm, p=0.001).

Discussion

To our knowledge, this is the first study in the Middle East to simultaneously assess the associations between dietary patterns defined a posteriori or a priori and obesity indices. The findings suggested inverse associations of obesity indices (i.e., BMI and WC) with the DASH dietary pattern defined a priori and the healthy dietary pattern defined a posteriori in a sample of Iranian women. In addition, the results of the present study indicated positive relationship between the unhealthy dietary pattern defined a posteriori and obesity indices.

Although there is a considerable body of evidence from randomized controlled trials regarding the beneficial effects of the DASH diet on various health outcomes and especially on cardiovascular diseases, only few observational studies to date have examined the link between adherence to this diet, as assessed by DASH pattern score, and obesity. In this respect, our findings were in line with those of the 2 previous studies in the Middle East by Saneei *et al.* (12) and Barak *et al.* (11), in which, using the same method for constructing the DASH pattern score, significant inverse associations were observed between the DASH pattern score and obesity indices (i.e., WC and/or BMI) among Iranian female nurses. Moreover, our findings replicated those of The SEARCH for Diabetes in Youth Study, in which the greater adherence to the DASH diet, as assessed by the DASH pattern score, was inversely associated with BMI *Z* score in 320 youth with type 2 diabetes mellitus (32).

With respect to the a posteriori defined dietary patterns, our findings were consistent with those reported in previous studies in adult women. In fact, the healthy pattern in our research was similar to the "healthy patterns" previously identified among Iranian women in the study of Esmaillzadeh and Azadbakht (13) and the study of Rezazadeh and Rashidkhani (14), which were inversely associated with risk of having general and central obesity. Furthermore, the "healthy pattern" found in the study of Newby *et al.* (33) and the "vegetables/fruits pattern" emerged in the study of Boggs *et al.* (34) also resembled our healthy pattern and both were negatively associated with BMI and/or WC. On the other hand, our unhealthy pattern replicated the "Western" and "unhealthy" patterns found in the study of Esmaillzadeh and Azadbakht (13) and the study of Rezazadeh and Rashidkhani (14), respectively, which had direct relationships with risk of having general and central obesity among adult Iranian women. In addition, the "Western patterns" identified in the study of Cunha *et al.* (35) and the study of Naja *et al.* (16) were also similar to our unhealthy pattern, and both had positive associations with BMI and WC.

The inverse relationships of obesity indices with the DASH pattern defined a priori and the healthy pattern defined a posteriori in this study might be due to some of the common characteristics of these patterns, including high intake of foods with low content of fat, low density of energy, and low glycemic index (GI). Higher intake of low-fat foods reduces the energy density of diet, and subsequently prevents the development of energy imbalance, which is known as the main cause of obesity (36). In addition, low-fat diets are often associated with greater satiety because they usually have a higher content of complex carbohydrate (36). Moreover, higher consumption of foods with low GI may contribute to the prevention of obesity (37), as they promote satiety, lower postprandial insulin secretion, increase insulin sensitivity, inhibit the synthesis of fats, and enhance fat oxidation (38, 39). The positive associations of the unhealthy pattern defined a posteriori with obesity indices in our study, on the other hand, could be justified by higher intakes of energy-dense foods with low density of nutrients, high content of fat, and high GI in this pattern. It seems that higher intake of these foods might cause a state of insulin resistance in central nervous system, which in turn results in leptin resistance and promotes the pleasurable or "hedonic" responses to foods (40). Furthermore, greater consumption of high-fat foods leads to obesity through increasing the energy density of the diet and enhancing passive overconsumption of energy (36). Additionally, faster digestion and absorption and higher insulin responses after consumption of high-GI meals affects appetite and energy partitioning in a way that, over the long term, may promote body fat gain (38, 39).

Despite the strengths of the present work, such as using both a posteriori and a priori methods for identifying dietary patterns and the relatively high participation rate of more than 92%, some study limitations need to be considered. First, due to the cross-sectional design of this research, no causal relationship could be inferred between our dietary patterns and obesity indices. Second, as the sample size was relatively small, we were not able to appropriately perform any subgroup analysis. Third, due to the nature of our study population, the findings cannot be generalized to men. Fourth, although the ANCOVA models were controlled for a number of potential confounding variables, the possibility of residual confounding bias due to unknown or unmeasured confounders could not be entirely ruled out. Fifth, as discussed earlier, both a posteriori and a priori methods for defining dietary-patterns have some inherent limitations (7), which are worth noting.

Conclusion

In conclusion, the results of this research suggested that greater adherence to the DASH dietary pattern defined a priori and following a healthy dietary pattern (high in fruits, vegetables, low-fat dairy products, nuts, fish, legumes, tea and coffee, olive, organ meats, pickles, and poultry) defined a posteriori were both inversely associated with obesity indices (i.e., BMI and WC) among Iranian women, while there were positive relationships between these markers of obesity and an unhealthy dietary pattern (high in refined grains, red or processed meats, French fries, mayonnaise, salt, potatoes, sweets and desserts, sweetened beverages, snacks, high-fat dairy products, vegetable oils, and hydrogenated fats) defined a posteriori. Overall, these findings support the idea that proper food selection (i.e., following an appropriate dietary pattern) is important for the prevention of obesity. However, additional prospective studies of sufficient methodological quality are needed to further confirm these findings.

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Conflict of Interest

None declared.

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