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Relationship between major dietary patterns and metabolic syndrome among individuals with impaired glucose tolerance

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Objective: Dietary habits have been associated with the prevalence of the metabolic syndrome and limited data are available in this field for individuals with impaired glucose tolerance. This study focused on the association between major dietary patterns and prevalence of the metabolic syndrome in individuals with impaired glucose tolerance.
Methods: This cross-sectional study was done in 425 subjects 35 to 55 y of age. Dietary data were collected using a food-frequency questionnaire. Blood pressure, waist circumference, glucose, triacylglycerols, and high-density lipoprotein cholesterol were measured and metabolic syndrome was defined based on Adult Treatment Panel III guidelines.
Results: Five major dietary patterns were found: a western pattern (high in sweets, butter, soda, mayonnaise, sugar, cookies, tail of a lamb, hydrogenated fat, and eggs), a prudent pattern (high in fish, peas, honey, nuts, juice, dry fruits, vegetable oil, liver and organic meat, and coconuts and low in hydrogenated fat and non-leafy vegetables), a vegetarian pattern (high in potatoes, legumes, fruits rich in vitamin C, rice, green leafy vegetables, and fruits rich in vitamin A), a high-fat dairy pattern (high in high-fat yogurt and high-fat milk and low in low-fat yogurt, peas, and bread), and a chicken and plant pattern (high in chicken, fruits rich in vitamin A, green leafy vegetables, and mayonnaise and low in beef, liver, and organic meat). After adjusting for confounding variables, the western pattern was associated with greater odds of having increased triacylglycerol (odds ratio 1.76, 95% confidence interval 1.01–3.07) and blood pressure (odds ratio 2.62, 95% confidence interval 1.32–5.23). The prudent pattern was positively associated with a prevalence of low high-density lipoprotein cholesterol levels (odds ratio 0.55, 95% confidence interval 0.31–0.96). The vegetarian dietary pattern was inversely associated with a risk of an abnormal fasting blood glucose level (odds ratio 2.26, 95% confidence interval 1.25–4.06).
Conclusion: Major dietary patterns were significantly associated with the risk of metabolic syndrome.

Introduction

The metabolic syndrome, a constellation of inter-related risk factors for cardiovascular disease and type 2 diabetes mellitus, has become a major public health concern against the backdrop of increasing rates of obesity [1,2]. The presence of metabolic syndrome in children and adults represents a high-risk state that conveys an increased risk of metabolic disease [3,4]. The rate of metabolic syndrome in developing countries is high. In Isfahan, Iran, 29.7% of the adult population with a family history of diabetes is affected [5]. Diet has been suggested as a possible risk factor for metabolic syndrome [6,7]. Previous studies have mostly considered diet in terms of food groups (e.g., fruit and vegetables) or its content of single nutrients (e.g., dietary fat or fiber) or single foods [8,9]. However, given the complexity of human diets, the high correlations between intakes of various nutrients or food items, and the many nutrient-to-nutrient biochemical interactions, results describing the effects of

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consumption levels of single nutrients or foods on a given health outcome maybe spurious [10]. Therefore, a measurement of the overall pattern of dietary intake may have a greater potential for being associated with health outcomes than any single component [11]. In addition, an epidemiological nutrient approach is not directly related to dietary recommendation, because individuals ultimately determine nutrient intake largely by their choice of different foods [12] and the intake of one food or nutrient is often correlated with the intake of another or with other lifestyle factors, which may have a relation to the risk status of the individual. Although the role of individual dietary components has been a focus of considerable research, foods are consumed in many complex combinations. Therefore, dietary pattern analysis, which reflects the complexity of dietary intake, has recently received greater attention from nutritional epidemiologists [13–15]. Few studies have assessed dietary patterns in relation to the metabolic syndrome in individuals with impaired glucose tolerance (IGT). This study aimed to identify dietary patterns and to examine the association between dietary patterns and the metabolic syndrome in an adult population with IGT in Isfahan, Iran.

Materials and methods

Participants

This cross-sectional study was done in the framework of the Isfahan Diabetes Prevention Study, a population-based prospective cohort (n = 2800) in the second largest city in Iran. Baseline examinations in this cohort were conducted from 2003 to 2008. Men and women 35 to 55 y of age who were first-degree relatives of patients with type 2 diabetes were invited to participate in the study. In addition to being first-degree relatives of patients with type 2 diabetes, having no history of diabetes and not taking medications were inclusion criteria in this cohort. Subjects with following criteria were excluded: those with missing data (n = 7), those who were diagnosed with diabetes (fasting plasma glucose ≥126 mg/dl and 2 hour post prandial (hpp) ≥200 mg/dl, n = 13), and those whose blood glucose levels were in the normal range (fasting plasma glucose ≤100 mg/dl and 2 hpp ≤140 mg/dl, n = 30). Subjects with normal levels were excluded from the present analysis because dietary data were available only for individuals with IGT. This exclusion left 425 subjects with IGT for the present analysis. All participants gave informed written consent. The study protocol was approved by the research council of the Endocrine Research Center of Isfahan University of Medical Science, Isfahan, Iran.

Assessment of dietary intake

Dietary intake was assessed by the use of a pretested food-frequency questionnaire (FFQ) containing 39 food items. A trained dietitian administered the entire questionnaire. Participants were asked how often they had consumed each food item or food group over the previous 3 mo. Subjects responded in three frequency consumption categories: daily (core food), weekly (secondary core food), or monthly (peripheral food).

Assessment of other variables

Weight was measured with a Seca scale and recorded to the nearest 100 g. Height was measured with a Seca stadiometer while the subjects were in a standing position with their shoulders in normal position. Body mass index was computed as weight (kilograms) divided by height (meters) squared. Waist circumference was measured to the narrowest level between the lowest rib and the iliac crest and hip circumference was measured at the maximum level over light clothing with the use of an outstretched tape measure [16]. Measurements were recorded to the nearest 0.1 cm and waist-to-hip ratio (WHR) was calculated.

Blood samples were drawn from 07:30 to 09:30 h, after a 12-h fast, to determine serum lipids and whole blood glucose levels. Blood glucose, serum triacylglycerol, cholesterol, and high-density lipoprotein (HDL) levels were determined using an enzymatic method. OGT testing was done using 75 g of glucose. The analysis of samples was performed with an autoanalyzer (BT3000, Rome, Italy) using commercial kits (Chem. Enzyme, Tehran, Iran). Serum total cholesterol and triacylglycerol levels were measured by enzymatic reagents (Chem. Enzyme) adapted to the Selecta autoanalyzer. HDL cholesterol levels were measured using available commercial kits (Pars Azmoon, Tehran, Iran). Low-density lipoprotein cholesterol levels were calculated from the values of serum triacylglycerols, total cholesterol, and HDL cholesterol according to the Friedewald formula: low-density lipoprotein cholesterol = total cholesterol − HDL cholesterol − (triacylglycerols/5) [17]. Interassay coefficients of variations were 1.25 for triacylglycerols, 1.2 for cholesterol, and 1.25 for glucose. The corresponding intra-assay coefficients of variations were 1.97, 1.6, and 2.2, respectively.

Participants were made to rest for 15 min before their blood pressure was measured. A qualified physician then measured the blood pressure of a seated subject twice with a standard mercury sphygmomanometer, and thereafter the mean of two measurements was considered the participant's blood pressure. Systolic blood pressure was defined as the appearance of the first sound (Korotkoff phase 1), and the diastolic blood pressure was defined as the disappearance of the sound (Korotkoff phase 5) during deflation of the cuff at a decrement rate of 2 to 3 mm/s of the mercury column [18]. Data on physical activity were obtained by using participants' responses to a simple question: How much time do you exercise in a week? We categorized the responses to this question as never, <3 h/wk, and ≥3 h/wk.

Definition of the metabolic syndrome

The metabolic syndrome was defined according to Adult Treatment Panel III criteria; a diagnosis were established if at least three of the following five features were present: plasma glucose ≥110 mg/dL, systolic and diastolic blood pressures ≥135/85 mmHg, serum triacylglycerol level ≥150 mg/dl, HDL <40 mg/dl in men and <50 in women, waist circumference >88 cm in women and >102 cm in men [19].

Statistical analysis

To identify major dietary patterns based on the 39 food items, we used principal component analysis with orthogonal rotation. Factors with Eigen values ≥1.5 were defined as major dietary patterns. Factor scores of dietary patterns for each subject were calculated by summing intakes of foods weighed by their factor loading. Then we categorized participants by tertiles of dietary pattern scores. We used one-way analysis of variance with Tukey's post hoc comparisons for continuous variables and chi-square tests for categorical variables to identify significant differences across tertile categories of dietary pattern scores. We also calculated multivariate-adjusted (age, sex, physical activity, and education) means for components of the metabolic syndrome. Analysis of covariance with Bonferroni's correction was used to compare these means. To determine the association of dietary patterns with metabolic syndrome, we used multivariable logistic regression. All regression models were controlled for age (continuous), gender, physical activity (without activity, <3 h/wk, and >3 h/wk), and education (illiterate, less than high school degree, high school degree, and graduate degree). The first tertile of dietary pattern scores was considered a reference. For all analyses, SPSS 13 (SPSS, Inc., Chicago, IL, USA) was used and $P < 0.05$ was considered statistically significant.

Results

Five major dietary patterns were found by the use of factor analysis: a western pattern (high in sweets, butter, soda, mayonnaise, sugar, cookies, tail of lamb, hydrogenated fat, and eggs), a prudent pattern (high in fish, peas, honey, nuts, juice, dry fruits, non-hydrogenated vegetable oil, liver and organic meat, and coconuts and low in hydrogenated fat and non-leafy vegetables), a vegetarian pattern (high in potatoes, legumes, fruits rich in vitamin C, rice, green leafy vegetables, and fruits rich in vitamin A), a high-fat dairy pattern (high in high-fat yogurt and high-fat milk and low in low-fat yogurt, peas, and bread), and a chicken and plant pattern (high in chicken, fruits rich in vitamin A, green leafy vegetables, and mayonnaise and low in beef, liver, and organic meat). In total these dietary patterns explained 26.4% 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 with IGT across tertiles of major dietary patterns are presented in Table 2. Those in the top tertile of the western pattern were older (45.2 ± 6.00 versus 42.3 ± 6.1 y, $P < 0.001$), more likely to be female (91% versus 79%, $P < 0.05$), and centrally obese (55% versus 37%, $P < 0.01$) compared with those in the lowest tertile. The distribution of

Table 1
Factor loadings for five major dietary patterns*

Food groups	Food patterns				
	Western	Prudent	Chicken and plants	Vegetarian	High-fat dairy
Sweets	0.600	—	—	—	—
Butter	0.597	—	—	—	—
Soda	0.532	—	—	—	—
Mayonnaise	0.456	—	0.344	—	—
Sugar	0.449	—	—	0.333	—
Cookies	0.444	—	—	0.209	—
Tail	0.347	—	—	—	—
Hydrogenated fat	0.330	−0.328	—	—	—
Egg	0.291	—	—	—	—
Macaroni	0.253	—	—	—	—
Vegetable oil	−0.251	0.361	—	—	—
Liver and organic meat	0.236	0.342	−0.207	—	—
Coconut	0.225	0.301	—	—	—
Mutton	0.222	—	—	—	—
Juice	0.222	0.381	—	—	—
Bread	—	—	—	—	−0.200
Rice	—	—	—	0.513	—
Legume	—	—	—	0.549	—
Potato	—	—	—	0.591	—
Peas	—	0.502	—	—	−0.203
Barley	—	0.284	—	—	—
Beef	—	—	−0.350	—	—
Chicken	—	—	0.650	—	—
Fish	—	0.561	—	—	—
Cheese	—	—	—	—	−0.200
Low-fat milk	—	—	—	0.200	—
High-fat milk	—	—	—	—	0.628
Low-fat yogurt	—	—	—	—	−0.632
High-fat yogurt	—	—	—	—	0.639
Green leafy vegetables	—	—	0.379	0.464	—
Non-leafy vegetables	—	−0.303	—	0.205	—
Fruits rich in vitamin C†	—	—	—	0.516	—
Fruits rich in vitamin A‡	—	—	0.397	0.275	—
Other fruits	—	—	—	—	0.257
Dry fruits	—	0.363	—	—	—
Nuts	—	0.413	—	—	—
Candy	—	—	0.335	—	—
Honey	—	0.427	—	—	—
Tea	—	—	0.407	—	—
Percentage of variance explained	6.8	5.3	5.1	5.0	4.2

* Values <0.20 were excluded for simplicity.
† Strawberry, lime, groupe fruit, and citrus fruits.
‡ Cantaloupes and apricots.

participants with regard to education ($P < 0.01$) and physical activity ($P < 0.05$) was significantly different across tertiles of the prudent pattern. No significant difference was seen across tertiles of the other food patterns.

Multivariate-adjusted means of biochemical and anthropometric measurements across tertiles of the major dietary patterns are listed in Table 3. After adjustment for potential confounders, significant higher plasma glucose was seen in the upper tertile of the vegetarian pattern compared with that in the lowest tertile. Compared with those in the lowest tertile of the high fat dairy pattern, those in top tertile had lower WHR before ($P < 0.01$) and after ($P < 0.01$) controlling for confounding variables. A significant higher serum triacylglycerol level was seen in the upper tertile of the chicken and plants pattern compared with that in the lowest tertile. No significant associations were seen between other food patterns and metabolic variables before or after adjusting for confounders.

Odds ratios for features of the metabolic syndrome across tertiles of major dietary pattern score are presented in Table 4. Those in the top tertile of the western pattern had greater odds of abdominal obesity (odds ratio 2.00, 95% confidence interval 1.24–3.22) in a crude model. This association was not significant after taking the confounding variables into account. The western pattern was associated with greater odds of increased serum triacylglycerol (1.76, 1.01–3.07) and high blood pressure (2.62, 1.32–5.23) only after adjusting for confounding variables. The vegetarian pattern was associated with greater odds of abnormal plasma glucose (2.26, 1.25–4.06) for crude model 1. Other dietary patterns were not associated with features of the metabolic syndrome.

The western pattern was associated with an increased risk of the metabolic syndrome before (2.06, 1.25–3.4) and after (2.32, 1.27–4.21; Table 5) adjustment for confounders.

Discussion

In this study using principal components analysis in a sample of 425 adults, five major dietary patterns were derived. Some, but not all, of these dietary patterns were associated with an increasing risk of the metabolic syndrome. To our knowledge, limited data are available discussing the associations between food patterns and metabolic syndrome in subjects with IGT. Our study is among the first investigations in Middle Eastern countries to look for such association in individuals with IGT.

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

	Tertiles of western pattern		P^*	Tertiles of prudent pattern		P	Tertiles of vegetarian pattern		P	Tertiles of high-fat dairy pattern		P	Tertiles of chicken and plants pattern		P
	1 (Lowest)	3 (Highest)		1 (Lowest)	3 (Highest)		1 (Lowest)	3 (Highest)		1 (Lowest)	3 (Highest)		1 (Lowest)	3 (Highest)	
Age (y)†	42.3 ± 6.1	45.2 ± 6.00	<0.001	43.5 ± 6.1	44.5 ± 6.5	0.389	44.6 ± 6.8	43.7 ± 6.2	0.413	43.5 ± 5.9	43.5 ± 6.2	0.192	43.2 ± 6.1	44.2 ± 6.2	0.352
Men (%)	21	9	0.025	18	11	0.105	14	13	0.165	18	11	0.117	16	17	0.805
Education (%)			0.961			0.00			0.651			0.864			0.536
Illiterate	4	4		3	6		6	3		6	5		3	6	
Less than high school	59	59		46	74		59	60		58	58		62	57	
High school	24	23		31	13		23	23		22	23		25	22	
Graduate	13	14		20	7		11	13		13	14		11	15	
Physical activity			0.071			0.046			0.294			0.739			0.908
<3 h/wk	73	62		54	70		66	65		63	68		65	62	
3 h/wk	23	23		29	21		24	27		26	23		25	25	
>3 h/wk	4	15		17	9		10	8		11	9		10	13	
General obesity (%)‡	38	51	0.141	48	44	0.704	45	49	0.405	40	49	0.484	40	45	0.730
Central obesity (%)§	37	55	0.007	47	46	0.349	55	52	0.441	44	43	0.936	57	53	0.801

* Analysis of variance for continuous variables and chi-squares test for categorical variables.
† Data are mean ± SD.
‡ Body mass index ≥ 30 kg/m^2.
§ Waist circumferences ≥ 88 cm for women and ≥ 102 cm for men.

The patterns extracted in our study were similar to those found in previous studies in Iranian healthy adult populations. Esmaillzadeh and Azadbakht [20,21] found three major dietary patterns in Tehrani female teachers. They labeled the dietary patterns as western, healthy, and traditional Iranian dietary patterns. Their western and healthy dietary patterns were similar to those obtained in the present study in foods loaded in these dietary patterns and factor loadings. However, it must be taken into account that dietary patterns are comparable only if the food groups and the factor loadings relating to their magnitudes are similar. Because the patterns are extracted from the data obtained in the studied population, it is not expected that the results would be reproduced in populations with different food habits. Dietary patterns other than the prudent and western patterns extracted in the present study are unique patterns obtained for the first time in an Iranian population. This different pattern might be explained by the different dietary culture of the Isfahani population compared with the Tehrani population. Another explanation is the existence of IGT in the population of the present study, which might encourage them to follow healthy diets.

Positive significant associations were observed in the western pattern dominated by sweets, soda, and butter and serum triacylglycerol levels, blood pressure, and the metabolic syndrome. The prudent dietary pattern was associated with increased HDL levels. The vegetarian dietary pattern was positively related to plasma glucose. Dietary pattern analysis has emerged as a complementary approach to examine diet–disease relations [22,23]. In food pattern analysis, decreasing the number of dietary variables to obtain eating patterns is more interpretable by nutritionists and can be easily understood by the general population. Patterns seem more predictive of disease risk than individual foods or nutrients. In this approach, the problem of colinearity among nutrients and synergistic effects of foods and nutrients has been resolved. In the present study, the western pattern (characterized by high intake of sugar and hydrogenated fat and low intake of fruits, vegetables, and milk) [24] was associated with high blood pressure, high serum triacylglycerol levels, abdominal obesity [25], and the metabolic syndrome [26]. Our western pattern was the same as a dietary pattern labeled western or unhealthy in previous studies [27–29]. This pattern is comparable to the western pattern reported by Lutsey et al. [30] and Osler et al. [10] and to some extent similar to the western pattern found in a cross-sectional study in Iranian women [3]. Even the associations we reached are similar to previous findings. Lutsey et al. [30] found a positive association between the western dietary pattern and the risk of metabolic syndrome. Wirfält et al. [31] reported that high consumption of cake and low intake of fruit and vegetable increased the risk of abdominal obesity and hypertension. In a study by Kim et al. [3], although no significant association was found with the metabolic syndrome, the prevalence of abdominal obesity was highest in the western cluster. A similar association was reported by Lutsey et al. [30], Olser et al. [10], and Esmaillzadeh et al. [29]. Food components of the western pattern such as greater intakes of hydrogenated fat and simple sugars and low intakes of dietary fiber might account for the positive association of this dietary pattern and the metabolic syndrome. Previous studies have reported that greater intake of frying oils or hydrogenated fats might be responsible for the increased prevalence of insulin resistance and the metabolic syndrome [32], even in Iranians [6,33]. This is also the case for diets with a high glycemic load, the main characteristic of which is greater consumption of simple sugars

Table 3
Multivariate adjusted means of metabolic variable across tertiles of major dietary pattern scores*

	Western pattern		P†	Prudent pattern		P	Vegetarian pattern		P	High-fat dairy pattern		P	Chicken and plant pattern		P
	1	3		1	3		1	3		1	3		1	3	
Waist circumference															
Crude	89.34 ± 7.7	90.57 ± 11.53	0.4	90.07 ± 8.89	90.21 ± 8.69	0.3	89.64 ± 11.4	89.7 ± 8.44	0.9	90.34 ± 9.34	88.29 ± 10.54	0.1	89.88 ± 9.22	89.85 ± 11.06	0.8
Adjusted	89.72 ± 7.58	90.17 ± 11.42	0.3	89.72 ± 7.58	90.25 ± 8.58	0.1	89.99 ± 11.65	89.82 ± 8.15	0.8	90.41+ ± 9.52	88.48 ± 10.77	0.3	90.18 ± 9.08	89.79 ± 11.37	0.9
Plasma glucose															
Crude	100.44 ± 12.76	102.94 ± 11.12	0.1	102.7 ± 11.53	100.92 ± 11.69	0.3	100.53 ± 11.61	103.33 ± 11.39	0.1	102.24 ± 12.34	103.17 ± 10.27	0.1	102.19 ± 11.79	101.72 ± 11.77	0.9
Adjusted	102.35 ± 12.1	103.32 ± 10.83	0.8	103.28 ± 10.67	101.33 ± 11.15	0.2	101 ± 11.59	104.57 ± 11.49	0.04	103.11 ± 11.57	103.92 ± 9.61	0.1	102.99 ± 11.15	102.6 ± 11.27	0.9
Serum triacylglycerol															
Crude	162.55 ± 114.31	178.57 ± 95.98	0.1	169.15 ± 82.4	174.05 ± 95.88	0.5	191.71 ± 132.4	162.76 ± 90.4	0.06	167.61 ± 195.93	174.25 ± 116.26	0.3	152.8 ± 75.32	183.41 ± 98.64	0.006
Adjusted	168 ± 124.84	183.46 ± 99.32	0.1	176.22 ± 83.54	178.23 ± 95.43	0.8	196.18 ± 134.61	164.19 ± 87.65	0.06	169.23 ± 193.18	179.75 ± 123.68	0.2	157.69 ± 78.82	187.81 ± 96.51	0.01
Cholesterol															
Crude	197.91 ± 45.2	207.71 ± 39.87	0.06	200.37 ± 43.69	207.71 ± 39.87	0.6	202.27 ± 42.04	197.15 ± 38.75	0.4	202.16 ± 41.52	203.28 ± 44.08	0.5	194.13 ± 40.38	205.98 ± 44.68	0.04
Adjusted	202.08 ± 47.17	207.31 ± 39.17	0.4	203.41 ± 43.22	207.31 ± 39.17	0.9	202.42 ± 41.08	198.5 ± 40.04	0.1	202.37 ± 42.48	204.88 ± 45.22	0.8	197.54 ± 40.3	207.4 ± 45.15	0.2
High-density lipoprotein															
Crude	46.02 ± 11.79	46.39 ± 11.41	0.9	44.77 ± 10.74	46.39 ± 11.41	0.2	46.23 ± 11.99	46.18 ± 11.92	0.09	46.03 ± 11.27	47.02 ± 11.6	0.4	46.71 ± 11.03	46.23 ± 11.86	0.7
Adjusted	47.71 ± 11.94	46.44 ± 11.55	0.3	45.07 ± 10.67	46.44 ± 11.55	0.05	46.95 ± 12.52	46.89 ± 12.3	0.9	46.71 ± 11.59	47.72 ± 11.88	0.6	47.23 ± 10.88	46.88 ± 12.52	0.8
Systolic BP															
Crude	11.45 ± 1.63	11.69 ± 1.71	0.4	11.4 ± 1.74	11.75 ± 1.75	0.2	11.58 ± 1.56	11.46 ± 1.59	0.6	11.5 ± 1.52	11.38 ± 1.63	0.06	11.49 ± 1.78	11.61 ± 1.71	0.7
Adjusted	11.32 ± 1.65	11.68 ± 1.7	0.2	11.46 ± 1.81	11.69 ± 1.79	0.9	11.59 ± 1.56	11.44 ± 1.63	0.7	11.46 ± 1.55	11.38 ± 1.59	0.1	11.55 ± 1.82	11.64 ± 1.74	0.8
Diastolic BP															
Crude	7.44 ± 1.25	7.49 ± 1.32	0.9	7.44 ± 1.34	7.62 ± 1.35	0.1	7.5 ± 1.27	7.4 ± 1.29	0.8	7.39 ± 1.23	7.38 ± 1.24	0.3	7.49 ± 1.26	7.39 ± 1.28	0.7
Adjusted	7.23 ± 1.22	7.44 ± 1.35	0.2	7.45 ± 1.41	7.43 ± 1.3	0.3	7.45 ± 1.25	7.22 ± 1.24	0.4	7.28 ± 1.21	7.31 ± 1.22	0.3	7.49 ± 1.33	7.31 ± 1.25	0.4
WHR															
Crude	0.83 ± 0.06	0.82 ± 0.08	0.1	0.83 ± 0.06	0.82 ± 0.05	0.5	0.82 ± 0.09	0.81 ± 0.05	0.3	0.83 ± 0.06	0.8 ± 0.08	0.001	0.83 ± 0.05	0.82 ± 0.09	0.4
Adjusted	0.83 ± 0.06	0.82 ± 0.09	0.2	0.83 ± 0.06	0.82 ± 0.05	0.2	0.82 ± 0.09	0.81 ± 0.05	0.5	0.83 ± 0.06	0.8 ± 0.09	0.007	0.83 ± 0.05	0.82 ± 0.09	0.5

BP, blood pressure; WHR, waist-to-hip ratio

* Adjusted for sex, age, education, and physical activity. Data are presented as mean ± SD.

† *P* values obtained from analysis of variance.

Table 4
Multivariate-adjusted odds ratios (95% confidence intervals) for components of the metabolic syndrome across tertiles of major dietary patterns scores in subjects with impaired glucose tolerance*

	Western pattern		P	Prudent pattern		P	Vegetarian pattern		P	High-fat dairy pattern		P	Chicken and plant pattern		P
	1	3		1	3		1	3		1	3		1	3	
Abdominal adiposity															
Crude	1	2.00 (1.24–3.22)	0.004	1	1.01 (0.63–1.62)	0.9	1	1.13 (0.71–1.81)	0.58	1	0.97 (0.6–1.55)	0.9	1	1.14 (0.71–1.82)	0.58
Adjusted†	1	1.71 (0.97–3.03)	0.06	1	0.74 (0.42–1.32)	0.3	1	1.11 (0.64–1.91)	0.7	1	0.94 (0.54–1.62)	0.8	1	1.18 (0.68–2.04)	0.5
High serum triacylglycerol															
Crude	1	1.53 (0.95–2.45)	0.07	1	1.04 (0.65–1.66)	0.8	1	0.72 (0.45–1.15)	0.17	1	1.53 (0.95–2.46)	0.07	1	1.65 (1.03–2.64)	0.03
Adjusted	1	1.76 (1.01–3.07)	0.04	1	0.78 (0.45–1.35)	0.3	1	0.72 (0.43–1.23)	0.2	1	1.65 (0.97–2.81)	0.06	1	1.65 (0.97–2.8)	0.06
High blood pressure															
Crude	1	1.59 (0.94–2.71)	0.17	1	1.85 (1.09–3.12)	0.02	1	1.02 (0.6–1.76)	0.9	1	0.96 (0.55–1.66)	0.8	1	1.19 (0.69–2.03)	0.52
Adjusted	1	2.62 (1.32–5.23)	0.006	1	1.29 (0.69–2.41)	0.4	1	0.97 (0.51–1.82)	0.9	1	0.99 (0.52–1.89)	0.98	1	1.09 (0.59–2.00)	0.7
High plasma glucose															
Crude	1	1 (0.59–1.69)	1	1	0.85 (0.49–1.45)	0.56	1	2.22 (1.29–3.83)	0.004	1	0.75 (0.44–1.27)	0.28	1	0.85 (0.51–1.44)	0.57
Adjusted	1	0.81 (0.44–1.47)	0.49	1	0.73 (0.39–1.37)	0.34	1	2.26 (1.25–4.06)	0.006	1	0.78 (0.43–1.38)	0.39	1	0.89 (0.51–1.58)	0.7
Low high-density lipoprotein															
Crude	1	0.97 (0.6–1.56)	0.9	1	0.72 (0.45–1.17)	0.19	1	1.28 (0.79–2.06)	0.3	1	1.12 (0.69–1.81)	0.62	1	0.98 (0.61–1.57)	0.9
Adjusted	1	1.16 (0.67–2.00)	0.59	1	0.55 (0.31–0.96)	0.03	1	1.19 (0.7–2.02)	0.51	1	1.22 (0.72–2.07)	0.4	1	0.9 (0.53–1.52)	0.7

* Components of the metabolic syndrome were defined as abdominal adiposity (waist circumference >88 cm), low serum high-density lipoprotein cholesterol (<50 mg/dL), high serum triacylglycerol (≥150 mg/dL), elevated blood pressure (≥130/85 mmHg), and abnormal glucose homeostasis (fasting plasma glucose ≥110 mg/dL).
† Adjusted for sex, age, and physical activity.

and lower intakes of dietary fiber. The mechanisms by which hydrogenated fats and simple sugars increase the risk of the metabolic syndrome have been argued by several investigators. We observed a significant positive association between the prudent dietary pattern and high HDL cholesterol. The low saturated fat content and the seafood protein source of this diet might be important factors involved in these findings [34,35]. A significant positive association between a vegetarian dietary pattern high in rice, legumes, potatoes, fruits, and vegetables and elevated plasma glucose levels has been documented [36]. Healthy foods of this dietary pattern such as fruits and vegetables have been reported to be protectively associated with the metabolic syndrome; the pattern's unhealthy constituents such as rice and potato adversely affect metabolic risk factors, as indicated in previous investigations. High loading factors of refined grains (rice and potato) in this dietary pattern might explain the positive association of this dietary pattern with increased plasma glucose levels [37,38].

One might argue that some of the findings in the present study are counterintuitive. For example, glucose values were higher in the upper tertile of the vegetarian pattern than in the lower tertile, and the lower tertile of the high-fat dairy group had a higher WHR than the higher tertile. However, some points must be taken into account. Higher fasting plasma levels in individuals in the top tertile of the vegetarian dietary pattern might be explained by high loading factors of high glycemic index fruits containing vitamin C (e.g., watermelon) and greater loading of this dietary pattern by potato and refined grains (e.g., rice). Finding a higher WHR in individuals in the lowest tertile of the high-fat dairy pattern might be explained by a lower intake of calcium in this group. Calcium intake has recently been shown to be negatively associated with body waist and fat distribution. Another concern that might be questioned is the sample size of the present study. It has been recommended that in studies of dietary pattern analysis (by the use of factor analysis), the sample must have more than 200 people given the number of variables entering factor analysis. Another recommendation is that for each variable entering factor analysis, the investigators must have 10 people. Therefore, for the 39 variables we entered into the factor analysis, 390 people are required for the sample. However, the present study included 425 people. It must be taken into account that some published studies on dietary patterns have used very small samples.

This study has some limitations, mainly the cross-sectional design, which makes the inference of causality difficult. We used data from a short FFQ, which did not list all usual foods eaten in the studied population. Thus, the exact dietary intakes might be different from what we reached. Energy intake was not controlled for in our analysis due to the use of a qualitative FFQ. We were unable to separate refined from whole grain in our dietary pattern analysis because these had not been separately questioned in our FFQ. Our findings suggest that consumption of

Table 5
Multivariate-adjusted odds ratios (95% confidence intervals) for the metabolic syndrome across tertiles of five major dietary patterns scores in subjects with impaired glucose tolerance

	Western pattern		P	Prudent pattern		P	Vegetarian pattern		P	High-fat dairy pattern		P	Chicken and plants pattern		P
	1	3		1	3		1	3		1	3		1	3	
Metabolic syndrome*	1	2.06 (1.25–3.4)	0.004	1	1.05 (0.64–1.7)	0.8	1	1.44 (0.88–2.35)	0.1	1	1.24 (0.76–2.04)	0.3	1	1.08 (0.66–1.78)	0.7
Model 1†	1	2.32 (1.27–4.21)	0.006	1	0.58 (0.32–1.04)	0.06	1	1.36 (0.78–2.38)	0.27	1	1.25 (0.71–2.29)	0.4	1	1.05 (0.6–1.84)	0.84

* Defined as the presence of at least three of the following components: abdominal adiposity (waist circumference >88 cm), low serum high-density lipoprotein cholesterol (<50 mg/dL), high serum triacylglycerol (≥150 mg/dL), elevated blood pressure (≥130/85 mmHg), and abnormal glucose homeostasis (fasting plasma glucose ≥110 mg/dL).
† Adjusted for sex, age, education, and physical activity.

a western dietary pattern promotes the risk of the metabolic syndrome. Factors can markedly influence dietary intakes such as differences in culture, ethnicity, religion, availability of specific foods, and economic development, among others. Therefore, further studies are required to identify major dietary patterns across the country and search for their possible associations with chronic diseases.

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