Original Article

A Cross-sectional Study on Food Patterns and Adiposity among Individuals with Abnormal Glucose Homeostasis

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Abstract

Background: Dietary habits play an important role in the prevention of chronic disease; however, few studies have assessed the major dietary patterns in Middle Eastern countries. This study identifies major dietary patterns among Iranian people with abnormal glucose homeostasis.

Methods: This cross-sectional study was conducted at the Diabetes Research Center, Isfahan, Iran among 425 subjects with abnormal glucose homeostasis. Patients were of ages 35 – 55 years and had family histories of diabetes. We assessed dietary intake by the use of a food frequency questionnaire (FFQ) that contained 39 food items. General obesity was defined as a BMI ≥ 30 kg/m^2 and central obesity was defined as waist circumference (WC) ≥ 88 in women and WC ≥ 102 in men.

Results: Five major dietary patterns were revealed by factor analysis: 'western', 'healthy', 'vegetarian', 'high-fat dairy', and 'chicken and plants'. Those in the top tertile of the 'western pattern' had greater odds for general (OR = 1.73; 95% CI = 1.07 – 2.78) and central obesity (OR = 2, 95% CI = 1.24 – 3.22), however these associations were not significant after adjustment for confounding variables. The 'high-fat dairy pattern' was associated with greater odds of general obesity only after adjusting for confounding variables (OR = 1.73; 95%CI = 1.01 – 2.96).

Conclusion: The dietary pattern characterized by high intake of hydrogenated fat and sugar was shown to be positively associated with a risk of general and central obesity, however further prospective studies are required to confirm our findings.

Keywords: Central obesity, diet, factor analysis, general obesity

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Introduction

Obesity is a major worldwide epidemic that affects more than 400 million people.[1] A recent World Health Organization (WHO) report has placed obesity as a major risk factor for a wide range of non-communicable diseases (NCDs).[2] 'Healthy People 2010' has identified obesity as one of the 10 leading health indicators in the U.S.[3] Obesity has increased more than 20% in the past decade in the U.S. and more than one-half of U.S. adults are overweight or obese.[4] WHO has warned that obesity affects developing countries which have adopted a Western lifestyle.[2,5] The prevalence of overweight or obesity in Iran, as one of the Middle Eastern countries, is 42.8% in men and 57% in women (BMI ≥ 25) in which 11.1% of men and 25.2% of women are obese (BMI ≥ 30).[6]

Obesity is a multi-factorial disorder with genetic, physical activity and diet playing an important role in its prevalence.[7,8] Despite considerable research, the nutritional etiology of obesity remains controversial.[9–11] Studies on the effect of single nutrients on weight status are limited because food is consumed, not in an isolated form, but as part of a dietary pattern.[4,8] Neither nutrients nor single food intake adequately describe dietary behaviors, but rather a pattern of dietary intake appears to be an important precursor of chronic disease and health.[7,9]

In the dietary pattern approach, various foods are combined into composite variables to create a dietary variable that resembles actual eating behaviors.[4,10] Dietary patterns may differ across ethnicities, educational groups, cultures and gender.[4,9] Most studies on dietary patterns have been conducted in Western countries but little work has been performed in Middle Eastern countries.[9,11] Due to the escalating rate of obesity and unique characteristics of Iranian dietary patterns [rice and bread as staple foods served with kabab (meat), stew and legumes], it is interesting to see which dietary patterns exist in this population. Although previous studies have used factor analysis to show meaningful dietary patterns among Iranians, all were limited to healthy women. It is unclear if an interpretable dietary pattern will be extracted among people with abnormal glucose homeostasis. Individuals with this condition might alter their dietary intakes and therefore, their dietary patterns might differ from those of healthy people. It is not clear if the use of statistical methods such as factor analysis in this population would result in meaningful dietary patterns. Although posteriori methods of dietary pattern identification have widely been used in the literature, data on the applicability of these methods to a population with abnormal glucose homeostasis are scarce. The purpose of this study is to identify major dietary patterns among Iranian people with abnormal glucose homeostasis and to explore the relation of these patterns with different types of obesity.

Materials and Methods

Participants

This cross-sectional study was conducted within the framework

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Table 1. Factor loadings for five major dietary patterns[1]

	Food patterns				
	Western pattern	Healthy pattern	Vegetarian Pattern	High-fat dairy patern	Chicken and, plants pattern
Sweet	0.600	-	-	-	-
Butter	0.597	-	-	-	-
Soda	0.532	-	-	-	-
Mayonnaise	0.456	-	-	-	0.344
Sugar	0.449	-	0.333	-	-
Cookies	0.444	-	0.209	-	-
Tallow	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	-	-	0.464	-	0.379
Non leafy vegetables	-	-0.303	0.205	-	-
fruits Rich inVit C [2]	-	-	0.516	-	-
fruits Richin Vit A [3]	-	-	0.275	-	0.397
Other fruits	-	-	-	0.257	-
Dry fruits	-	0.363	-	-	-
Nuts	-	0.413	-	-	-
Candy	-	-	-	-	0.335
Honey	-	0.427	-	-	-
Tea	-	-	-	-	0.407
Percent of variance explained	6.8	5.3	5.0	4.2	5.1

1 = Values < 0.20 were excluded for simplicity; 2 = Strawberry, Lime, Grope fruit, Citrus fruits; 3 = Cantaloupes and apricot.

of the Isfahan Diabetes Prevention Program (IDPP). During 2003 to 2006, subjects with family histories of diabetes (≥ 1 first-degree relative with a diagnosis of diabetes after age 30 years) were selected. A total of 475 subjects (ages: 35 – 55 years) participated in the study. Subjects with the following criteria were excluded: missing relevant data (n = 7), those diagnosed with diabetes (Fasting Plasma Glucose (FPG) ≥ 126 and 2-hour postprandial glucose ≥ 200; n = 13), and those with normal blood glucose levels (FPG ≤ 100 and 2hp.p ≤ 140; n = 30). There were 425 subjects diagnosed with abnormal glucose homeostasis for the current analysis. All participants gave informed written consent. The protocol of the study was approved by the Research Council of the Endocrine and Metabolism Research Center (EMRC) of Isfahan University of Medical Science, Isfahan, Iran.

Assessment of dietary intake

Dietary intake was assessed by the use of a pre-tested food frequency questionnaire (FFQ) that contained 39 food items or food groups. All foods were allocated to 1 of 39 individual food groups. A trained dietitian administered the questionnaire. Participants were asked how often they consumed each food item or food group over the last three months. Subjects responded in three frequency consumption categories of daily (core food), weekly (secondary core food) or monthly (peripheral food) basis.

Assessments and other variables

Weight was measured with the use of a Seca scale and recorded to the nearest 100 g. Height was measured with a Seca studiometer while subjects were standing with their shoulders positioned normally. BMI was calculated as the weight in kilograms divided by the height in meters squared. Waist circumference (WC) was measured at 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. Measurements were recorded to the nearest 0.1 cm and waist-to-hip ratio (WHR) was calculated. Abdominal obesity was defined as WC ≥ 88 in women and WC ≥ 102 in men. General obesity was defined as a BMI ≥ 30 kg/m^2. Covariate information regarding age, sex, education, and leisure-time activity was obtained. For physical activity, we asked participants the following question: 'How long do you participate in leisure-time activities?' Subjects responded in three categories of: less than 3 hr/wk, 3 hr/wk, more than 3 hr/wk. Educational qualifications were classified as illiterate, less than high school, high school and graduate.

Statistical methods

We used principal component analysis with orthogonal rotation to determine major dietary patterns. Factors were preselected to determine which set of factors meaningfully described distinct food patterns. Those factors with eigenvalues ≥ 1.5 were chosen as major dietary patterns. The factor score was then calculated for each subject by summing the intakes of food groups, weighted by their factor loadings. Factors were labeled based on their major food components. For further analyses, factor scores were categorized as tertiles. One-way ANOVA was used to compare continuous variables, whereas the chi-square test compared categorical variables, across tertiles. General linear model was performed to compute multivariate adjusted means for anthropometric measures controlling for age (continuous), sex (categorical), education (categorical), and physical activity (categorical).

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

	Tertiles of 'Western pattern'		P^1	Tertiles of 'Healthy 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[2]	45.2±6.00	<0.001	43.5±6.1	44.5±6.5	0.38	44.5±6.8	43.7±6.2	0.41	43.5±5.9	43.5±6.2	0.19	43.2 ± 6.1	44.2±6.2	0.35
Male (%)	21	9	0.02	18	11	0.10	14	13	0.16	18	11	0.11	16	17	0.80
Education (%)	---	---	0.96	---	---	0.001	---	---	0.65	---	---	0.86	---	---	0.53
Illiterate	4	4	---	3	6	---	6	3	---	6	5		3	6	---
Under 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	---	---	0.07	---	---	0.04	---	---	0.29	---	---	0.73	---	---	0.90
$< 3_{hr/wk}$	73	62	---	54	70	---	66	65	---	63	68	---	65	62	---
$= 3_{hr/wk}$	23	23	---	29	21	---	24	27	---	26	23	---	25	25	---
$> 3_{hr/wk}$	4	15	---	17	9	---	10	8	---	11	9	---	10	13	---
General obesity[3] %	38	51	0.07	48	44	0.35	45	49	0.14	40	49	0.29	40	45	0.45
Central obesity[4] %	37	54	0.009	46	46	0.29	44	47	0.41	43	43	0.93	43	46	0.81

1 = ANOVA for continuous variables and chi-squares test for categorical variables; 2 = Data are mean ± SD unless indicated; 3= BMI ^{3}30; 4 = Waist circumference ^{3}88 cm for women and ^{3}102cm for men.

Multivariable logistic regression models were used to obtain adjusted odds ratios. All regression models were controlled for age (continuous), sex (categorical), education (categorical) and physical activity (categorical). The first tertile of a dietary pattern score was treated as a reference. All analyses were performed with SPSS software (version 13; SPSS Inc., Chicago IL) and $P < 0.05$ was considered significant.

Results

There were five major dietary patterns revealed by the use of factor analysis: 'western' (high in sweets, butter, soda, mayonnaise, sugar, cookies, tallow, hydrogenated fat, and eggs); 'healthy' (mostly consisted of fish, peas, honey, nuts, juice, dry fruits, vegetable-oil, liver and organic meat, and coconuts; low in hydrogenated fat and non-leafy vegetables); 'vegetarian' (high in potatoes, legumes, fruits rich in vitamin C, rice, green leafy vegetables, and fruits rich in vitamin A); 'high-fat dairy' (consisted of high fat yogurt and milk; low in low fat yogurt, peas, and bread); 'chicken and plants' (mostly consisted of chicken, fruits rich in vitamin A, green leafy vegetables, and mayonnaise; low in beef, liver and organic meats). The factor loadings of the food groups across the five dietary patterns are presented in Table 1. Totally, these dietary patterns explained a variance of 25.6%.

General characteristics of participants across tertiles of major dietary patterns are provided in Table 2. Those in the top tertile of the 'western pattern' were older (45.2 ± 6.00 vs. 42.3 ± 6.1 years, $P < 0.001$), more likely to be female (91% vs. 79%, $P < 0.05$) and centrally obese (54% vs. 37%, $P < 0.009$) as compared with those in the lowest tertile. The distribution of participants with regard to educational qualifications and physical activity was significantly different across the tertiles of the 'healthy pattern'. No significant differences were seen across tertiles of other food patterns.

Multivariate adjusted means of anthropometric measures across tertiles of major dietary patterns are shown in Table 3. A significantly higher BMI was seen in the upper tertile of the 'western pattern' as compared with those in the lowest tertile (30.6 ± 4.2 vs. 29.1 ± 3.6 kg/m^2, $P < 0.01$). Adjustment for potential confounders (age, sex, physical activity, and education) attenuated the association but even after controlling for these confounders, this difference remained significant (30.4 ± 0.3 vs. 29.1 ± 0.3 kg/m^2, $P < 0.05$). Compared with those in the lowest tertile of the 'high-fat dairy food pattern', those in the top tertile had lower WHR either before (0.80 ± 0.08 vs. 0.83 ± 0.6, $P < 0.001$) or after (0.81 ± 0.00 vs. 0.83 ± 0.00, $P < 0.01$) controlling for confounding variables. There were no significant associations between other dietary patterns and anthropometric measures.

Odds ratios for general and central obesity across tertiles of major dietary patterns are presented in Table 4. Those in the top tertile of the 'western pattern' had greater odds for general (OR = 1.73; 95%CI = 1.07 – 2.78) and central obesity (OR = 2.00; 95%CI = 1.24 – 3.22). These associations were not significant after accounting for the confounding variables for general (OR=1.48; 95%CI = 0.85 – 3.58) and central obesity (OR = 1.71; 95%CI = 0.97 – 3.03). The 'high-fat dairy food pattern' was associated with greater odds for general obesity only after adjustment for confounding variables (OR = 1.73; 95%CI = 1.01 – 2.96), but the association for central obesity was not significant. Other dietary patterns were not associated with obesity, either general or central.

Discussion

Table 3. Multivariate-adjusted means for anthropometric measures across tertiles of major dietary patterns

	Tertiles of ' Western pattern'		P[1]	Tertiles of ' Healthy 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)	
N	144	144	---	144	144	---	144	144	---	144	144	---	144	144	---
BMI, kg/m2															
Crude	29.1±3.6[1]	30.6±4.2	0.006	29.6±3.9	30.1±4.2	.315	29.7±3.6	30.0±4.3	0.431	29.5±4.2	30.1±4.1	0.425	29.5±4.3	29.8±4.0	0.803
Adjusted[2]	29.1±0.3	30.4±0.3	0.035	29.8±0.3	29.8±0.3	0.632	29.9±0.3	29.9±0.3	0.337	29.4±0.3	30.2±0.3	0.226	29.4±0.3	29.8±0.3	0.776
Waist circumference[3](cm)															
Crude	89.3±7.7	90.5±1.3	0.408	90.1±8.9	90.2±8.7	0.361	89.6±1.4	89.7±8.4	0.998	90.3±0.93	88.3±10.5	0.106	89.9±9.2	89.8±11.1	0.961
Adjusted	89.1±0.9	90.8±0.85	0.371	90.9±0.87	90.1±0.9	0.152	90.1±0.86	89.9±0.87	0.869	90.1±0.87	88.8±.0.850.	0.347	90.1±0.86	89.7±0.87	0.961
Waist to hip ratio[4](cm)															
Crude	0.83±0.06	0.82±0.09	0.175	0.83±0.06	0.82±0.01	0.531	0.82±0.09	0.82±0.82	0.336	0.83±0.6	0.80±0.08	0.001	0.83±0.05	0.82±0.09	0.404
Adjusted	0.83±0.00	0.83±0.00	0.206	0.84±0.00	0.82±0.00	0.205	0.83±0.00	0.82±0.00	0.534	0.83±0.00	0.81±0.00	0.007	0.83±0.00	0.83±0.00	0.576

1 = Data are means ± SD for crude models and means ± SEM for adjusted models; 2 = Adjusted for sex, age, education and physical activity.

Table 4. Multivariate-adjusted odds ratios (95% CIs) for general and central obesity across tertiles of major dietary patterns

	Tertiles of ' Western pattern'		Tertiles of 'Healthy pattern'		Tertiles of ' Vegetarian pattern'		Tertiles of ' High fat dairy pattern'		Tertiles of 'Chicken and plants pattern'	
	1(Lowest)	3(Highest)	1(Lowest)	3(Highest)	1(Lowest)	3(Highest)	1(Lowest)	3(Highest)	1(Lowest)	3(Highest)
General obesity[1]										
Crude	1.00	1.73(1.07–2.78)[4]	1.00	0.83(0.52–1.32)	1.00	1.13(0.71–1.81)	1.00	1.45(0.90–2.33)	1.00	1.24(0.77–1.99)
Adjusted[2]	1.00	1.48(0.85–3.58)	1.00	0.64(0.37–1.13)	1.00	1.10(0.65–1.87)	1.00	1.73(1.01–2.96)[4]	1.00	1.34(0.79–2.29)
Central obesity[3]										
Crude	1.00	2.00(1.24–3.22)[4]	1.00	1.01(0.63–1.62)	1.00	1.14(0.71–1.82)	1.00	0.97(0.61–1.56)	1.00	1.14(0.71–1.82)
Adjusted	1.00	1.71(0.97–3.03)[4]	1.00	0.75(0.42–1.33)	1.00	1.11(0.65–1.91)	1.00	0.94(0.54–1.62)	1.00	1.18(0.68–2.04)

1 = General obesity: BMI ³ 30 kg/m2 ; 2 = Adjusted for age, sex, physical activity and education; 3 = Central obesity: waist circumference ³ 88 cm in women and ³ 102 cm in men; 4 = P for trend < 0.05.

In this cross-sectional study, we identified five major dietary patterns. The 'western pattern' was characterized by high intakes of sweets, butter, soda, mayonnaise and sugar. This pattern had a positive association with BMI. The 'high-fat dairy pattern' was inversely associated with WHR. This pattern was characterized by a high intake of high-fat dairy products and fruits, and low intake of bread and potatoes. We documented a significant positive association between the 'high-fat dairy pattern' and general obesity. The association was significant only after controlling for age, sex, education, and physical activity.

The relation between major dietary patterns and obesity is not new.[12] However as obesity, in particular central obesity, is the underlying cause of major chronic diseases such as diabetes and has a pivotal role in hyperglycemia and insulin resistance, it is interesting to see the extent which major dietary patterns are related to the obesity epidemic.[11,13]

Our 'western pattern' is comparable to the western pattern reported by Khani et al.[14] and Hu et al.[15] and to some extent similar to the finding of a cross-sectional study by Esmaillzadeh et al.[11]. The high loading factors of refined sugar and hydrogenated fat in this pattern is not surprising, These factors are two major sources of energy in the Iranian diet, as previous studies have shown.[16–19] Iran has experienced a socioeconomic transition coupled with a westernized lifestyle that has lead to the widespread use of a dietary pattern very similar to western countries.[12] A positive relation between the 'western pattern' and the risk of general and central obesity can be explained by the high intake of energy-producing macronutrients such as sugar and fat, and a lower intake of beneficial components such as fruits and vegetables in this pattern.[16] Although taken from a different population, our finding was consistent with a previous study of 486 Iranian women that showed a positive association between the 'western pattern' and different types of obesity.[11] Besides observational cross-sectional studies, the association of dietary patterns with obesity was also demonstrated by prospective studies. In the EPIC-Postam Study, Schulz et al.[20] reported a positive association between the high intake of high energy, high fat foods (such as sweets, sauces, processed meats, soft drinks, fat and eggs) and weight gain. Investigators from the Nurses' Health Study[21] as well as Slattery et al.[22] have identified a significant association between the western dietary pattern and elevated BMI.

We also found an inverse relationship between the 'high-fat dairy pattern' and WHR; the mechanisms whereby a greater intake of these foods may contribute to this relation are not fully understood. The mechanisms regarding dairy and obesity as have been suggested by previous investigations[23–30] may not apply to our study because findings from our logistic regression model have revealed a positive association between the 'high-fat dairy pattern' and general obesity. The exact reason for such a relationship is not clear. It must be kept in mind that we have not controlled our analysis for energy intake, a major determinant of obesity. Another explanation for the different associations of this dietary pattern with WHR and general obesity is that consumption of dairy products might result in fat accumulation in the buttocks, a phenomenon that would in turn lead to decreased WHR. Brook et al.[31] have reported an inverse association between dairy consumption and WHR in white males.

Several limitations should be considered in the interpretation of our findings. The first, major limitation is the cross-sectional design of this study that did not allow for conferring causality. Second, factor analysis has some limitations for subjectivity in nature and difficulty of replicating in another population.[32,33] Thirdly, the limitation of our FFQ for assessing dietary intakes should be taken into account. For example, we were unable to separate refined and whole grains in our dietary pattern analysis. Fourth, energy intake was not controlled in our analysis as we have used a qualitative FFQ, rather than quantitative one. We agree that to come to a clear conclusion of the association between dietary patterns and obesity, energy intake must be controlled for in the statistical models.

In conclusion, we found that the use of factor analysis among Iranian people with abnormal glucose homeostasis resulted in meaningful dietary patterns. These dietary patterns were significantly associated with obesity. This finding supported the idea that a dietary pattern approach might be a useful tool for dietary counseling, with focus on overall eating habits rather than emphasis on individual nutrients, which might be efficacious in these people. However, further prospective studies are required to confirm our findings.

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