Original Article

Dietary Patterns Are Associated with Risk of Diabetes Type 2: A Population-Based Case-Control Study

Marsa Zaroudi MSc[1,3], Jamshid Yazdani Charati PhD•[2], Sharmin Mehrabi BSc[1], Elham Ghorbani BSc[1], Jalal Norouzkhani BSc[1], Hamid Shirashiani BSc[1], Bahar Nikzad BSc[1], Mirhossein Seiedpour MSc[1], Morteza Izadi BSc[1], Mohammadreza Mirzaei MD[1], Ghasem Oveis MD[1], Nader Ahangar MD[1], Hossein Azadeh MD[1], Ozra Akha MD[1], Akbar Fazel-tabar Malekshah PhD•[1,3]

Abstract

Objective: We aimed to assess the relationship between major dietary patterns and risk of diabetes type 2 among Iranian adults.

Methods: In this population-based case-control study in Mazandaran province, we enrolled 332 subjects (110 newly diagnosed cases and 222 controls) aged 43 – 77 years. Dietary intakes were collected using a validated semi-quantitative food frequency questionnaire (FFQ). Data on demographic, anthropometric, socioeconomic characteristics and other covariates were collected using structured lifestyle questionnaires. Factor analysis was used to identify major dietary patterns. Odds ratios (OR) were calculated for risk of type 2 diabetes across quartiles of dietary pattern scores.

Results: Three major dietary patterns were identified, including: “healthy”, “transitional” and “traditional”. A significant direct association was found between the transitional dietary pattern and risk of diabetes type 2 after adjustment of potential confounders (OR = 2.17; 95% CI: 1.0, 4.50; P_{trend} = 0.02). The traditional dietary pattern was significantly associated with the increased risk of diabetes type 2 after controlling for confounders (OR = 2.13; 95% CI: 1.03, 4.41; P_{trend} = 0.01). There was no significant relationship between healthy dietary pattern and risk of diabetes type 2.

Conclusions: In conclusion, transitional dietary pattern characterized by high consumption of salt, organ meats, dried fruits, poultry, tea, low- fat dairy and other vegetables. Traditional dietary pattern characterized by high intakes of garlic, dough, high- fat dairy, dried fruits, red meats, grains, as well as animal and hydrogenated fats were associated with an increased risk of type 2 diabetes. No significant associations were found between the healthy dietary pattern and risk of diabetes type 2.

Keywords: Case-control, diabetes type 2, diet, dietary pattern, food frequency questionnaire

Cite this article as: Zaroudi M, Yazdani Charati J, Mehrabi S, Ghorbani E, Norouzkhani J, Shirashiani H, Nikzad B, Seiedpour M, Izadi M, Mirzaei MR, Oveis G, Ahangar N, Azadeh H, Akha O, Fazel-tabar Malekshah A. Dietary patterns are associated with risk of diabetes type 2: A population-based case-control study. *Arch Iran Med*. 2016; **19(3):** 166 – 172.

Introduction

The prevalence of type 2 diabetes (T2D) is rapidly increasing[1] worldwide.[2,3] It is predicted that the developing countries will contribute 77.6% of the total number of diabetic patients in the world by the year 2030.[4,5] The prevalence of T2D ranges from 1.2% to 14.6% in Asia, 4.6% to 40% in the Middle East,[4,6] and 8.7% in Iran.[7] This rapidly-growing prevalence among developing countries is attributed to the effects of urbanization.[8,9] The urbanization of the population with the migration of people from rural to urban areas may account in part for the increasing prevalence of T2D in Iran.[1] In addition, diabetes and its complications are risk factors for chronic diseases with significant morbidity and mortality.[10]

It is well accepted that diet has an important influence on the etiology of type 2 diabetes. Focuses on individual dietary components intake, such as individual nutrients or foods were used to investigate diet–disease associations, previously.[11,12] While, foods are consumed in combination not in isolation; therefore it is difficult to investigate the effects of individual dietary components separately.[13] For clarifying relationships between diet and health, dietary pattern approach was used in the field of nutritional epidemiology.[14,15] The study of dietary patterns shows the effect of diet as a whole, thus it may provide insight beyond the effects characterized for individual nutrients and foods.[14] Dietary patterns, which reflect food consumption in reality, may simplify the translation of findings to public health recommendations.[16] Studies have indicated that interventions focused on dietary patterns can decrease blood pressure[17] and cardiovascular complications.[18] The relationship between T2D and dietary pattern has been investigated in several recent studies.[13,16,19–25] It has been shown that dietary patterns characterized by a high consumption of high-fat foods, red meat, processed meat and refined grains was associated with a higher incidence of T2D.[16,19]

Major dietary patterns are different based on sex, ethnicity and geographical region.[26] To the best of our knowledge, information on dietary patterns and the risk of T2D in Middle-East population is scarce. Assessment of dietary patterns in relation to T2D is particularly relevant for Middle-Eastern populations due to the unique characteristics of their dietary intakes as well as their high prevalence of T2D. Furthermore, findings from western popula-

Authors’ affiliations: [1]Mazandaran University of Medical Sciences, Sari, Iran, [2]Department of Biostatistics, Health Sciences Research Center, Mazandaran University of Medical Sciences, Sari, Iran, [3]Digestive Diseases Research Institute, Tehran University of Medical Sciences, Tehran, Iran.

•**Corresponding author and reprints:** Akbar Fazel-tabar Malekshah PhD, Public Health Center, Mazandaran University of Medical Sciences, P. O. Box: 486717–887. Tel: +98-11-333996600, E–mail: afmalekshah@yahoo.com.

Jamshid Yazdani Charati PhD, Department of Biostatistics, Health Sciences Research Center, School of Health, Mazandaran University of Medical Sciences, Sari, Iran, P. O. Box: 48175-1553 Tel: +98-15-13543080-5, E-mail: jamshid_1380@yahoo.com.

Accepted for publication: 17 December 2015

tions cannot be easily extrapolated to the non-western nations. Therefore, we conducted the current population-based case-control study to identify and characterize dietary patterns of adult people living in Mazandaran province of Iran, using factor analysis. We also assessed the association between dietary patterns and T2D.

Methods

Study population

T2D cases in this study were recruited between August 2011 and July 2012. To create the case group, 110 adults (≥ 30 years old) who were newly diagnosed with T2D were recruited from the medical laboratory of Sari health center, the capital city of Mazandaran province, in which patients screened and referred to from rural health centers of Sari. Diabetic patients were diagnosed based on the American Diabetes Association diagnosis criteria.[27] The control group comprised 222 (two matched controls for each case) normoglycemic subjects who were randomly selected from the general population and matched for age (within 5 year-age interval), gender and neighborhood of residence to cases. We asked Behvarz- personnel of health centers in rural- to find the first one in neighbor of subjects who had matching criteria for each control. We excluded control subjects who reported having diabetes, cardiovascular disease (myocardial infarction, angina pectoris, coronary artery surgery, or stroke), or cancer because diagnosis of these diseases may affect diet or reporting of diet. In the current analysis, we excluded participants with a reported total daily energy intake outside the range of 800 – 4200 Kcal (9 from cases and 13 from controls). These exclusions left 332 participants in the present analysis.

This study was approved by Mazandaran University of Medical Sciences. Written informed consent was obtained from all subjects.

Dietary intake assessment

Usual dietary intakes of study participants were assessed using a validated semi-quantitative food frequency questionnaire (FFQ). The FFQ consisted of 147 food items with standard portion sizes commonly consumed by Iranians. The questionnaire was administered by trained interviewers. Participants were asked to indicate their usual consumption frequency of a given serving of foods during the previous year on a daily (e.g., bread), weekly (e.g., rice or meat), monthly (e.g., fish), or yearly (e.g., tongue) basis. All reported consumption frequencies were converted to grams per day using household measures.[28] Daily intakes of energy and nutrients were determined using the US Department of Agriculture (USDA) food composition database[29] that was modified for Iranian foods. To identify dietary patterns, first we aggregated food items from the FFQ into 36 food groups (Table1) based on their similarity in nutrients and earlier studies in Iran.[30,31] Some individual food items were classified individually if their composition differed substantially from that of other foods or if its consumption represented distinct dietary habits.

A previous validation study of this FFQ revealed good correlations between intake of several food groups assessed by a similar FFQ and those from multiple days of 24-h dietary recalls completed during an earlier year-long study.[32] The reliability of the FFQ was evaluated by comparing nutrient intake determined using responses to the FFQ on two occasions.[33] Generally, these data indicate that the FFQ provides reasonably valid and reliable measures of the average long-term dietary intake.

Assessment of other variables

A structured general questionnaire was used by trained interviewers to collect data on age, gender, family history of diabetes, cigarette smoking, marital status, education, family size, house size and occupation. To assess the socioeconomic status, we used data on house ownership (yes, no), house size (quartile), education score (0, 1, 2, 3), family size (< 3, 3 – 4, 5 – 7 and > 8) and home appliance score based on price (television, color TV, car, washing machine, motorcycle, bath, vacuum cleaner, refrigerator, fridge freezer, and computer). Anthropometric measurements, including weight, height and circumferences of waist and hips, were taken according to a standard protocol. Body mass index (BMI) and waist-to-hip ratio (WHR) were calculated. Information on physical activity was collected, using a validated questionnaire.[34,35] Data on physical activity expressed as metabolic equivalent hours per day (MET-h/d). To evaluate fasting plasma glucose (FPG), blood samples were taken from all participants after 10 – 12 hours overnight fasting according to a standard protocol using an autoanalyzer (Biotechnic 3000, Italy). FPG was measured on the day of blood collection by the enzymatic colorimetric method and using glucose oxidase.

Statistical analysis

Normal distribution of variables was examined using histogram and Kolmogrov-Smirnov test. To compare continuous variables between cases and controls, independent samples *t*-test was applied. Distribution of participants in terms of categorical variables was assessed using Chi-square. To identify major dietary patterns based on 36 predefined foods or food groups, factor analysis with the principal component method were used. Energy adjusted means of each food group was calculated using the residual method. The natural interpretation of the factors in conjunction with Eigen values (>1.8) and Scree plot determined whether a factor should be retained. The eigenvalues of the factors dropped substantially after the third factor and remained more similar to each other after the fourth factor. The derived factors (dietary patterns) were labeled on the basis of factor loadings of foods and food groups as well as our prior knowledge of nutrition and literature. The factor score for each pattern was calculated by summing intakes of food groups weighted by their factor loadings and each subject received a factor score for each identified pattern. To categorize participants, first we obtained quartile cut-points of factor scores in control subjects. Then these cut-off points were applied to both cases and controls for categorization. We used one-way ANOVA for continuous variables and Chi-square test for categorical variables to identify significant differences across quartile categories of dietary pattern scores. Age-, gender- and energy-adjusted means of food and nutrient intakes across quartiles of dietary pattern scores were compared using analysis of covariance. We calculated odds ratios and 95% CIs using conditional logistic regression in different models to determine the association of dietary patterns with diabetes. First, we obtained crude ORs, and then in the first model we adjusted for age (continuous), gender (categorical) and total energy intake (continuous). We further controlled for education (literate, illiterate), marital status (single, married), socioeconomic status score (continuous), family history of diabetes (yes-no), physical activity (continuous), and waist (continuous) in the second model. The linear trends of ORs across increasing quartiles of dietary pattern scores were examined by assigning the median value of each quartile to the subpopulation in that quartile and treating these values as continuous variables. All statistical analyses were done by SPSS statistical software package, version 19 (SPSS Inc, Chicago IL).

Results

Using factor analysis, we identified three major dietary patterns (Table 2) including: 1) "healthy dietary pattern" that was rich in vegetables, vegetable oils, fish, fruits and nuts; 2) "transitional dietary pattern" that was greatly loaded with salt, organ meats, dried fruits, poultry, tea, low-fat dairy products and other vegetables; 3) "traditional dietary pattern" which was high in garlic, dough, high-fat dairy products, dried fruits, red meats, grains, as well as animal and hydrogenated fats. Overall, these dietary patterns explained 22.2% of total variance.

The general characteristics of the cases and controls are shown in Table 3. Compared with control subjects, patients with diabetes had higher weight, waist, BMI, WHR and energy intake from proteins. The distribution of cases and controls regarding other general characteristics was not statistically different.

The general characteristics of the control subjects across quartiles of dietary pattern scores are shown in Table 4. Compared with participants in the lowest quartile, those in the highest quartile of the healthy dietary pattern had a higher socioeconomic status. Those in the top quartile of the transitional and traditional dietary patterns were less illiterate than those in the bottom quartile. Individuals in the highest quartile of transitional dietary pattern had lower weight, waist circumference and BMI compared with those in the lowest quartile. Other general characteristics variables of the control subjects across quartiles of dietary pattern scores had no significant difference.

Crude and multivariable-adjusted odds ratios for diabetes across quartile categories of dietary pattern scores are shown in Table 5. No significant association was found between the healthy dietary pattern and diabetes, either in crude or adjusted models. After controlling for age, gender, energy intake, marital status, education, SES, family history of diabetes, physical activity and waist in model 2, a significant direct association was found between the transitional dietary pattern and diabetes (OR for highest vs. lowest quartile = 2.17; 95% CI: 1.0 – 4.50, P_{trend} = 0.024). The traditional dietary pattern was associated with increased odds of diabetes after controlling for potential confounders in model 2; individuals in the highest quartile of this dietary pattern were 113% more likely to have diabetes than those in the lowest quartile (OR = 2.13; 95% CI: 1.03 – 4.41, P_{trend} = 0.016).

Table 1. Food groupings used in the dietary pattern analysis

Foods or food groups	Food items
Processed meats	Sausages
Red meat	Beef, lamb, veal
Organ meats	Liver, heart, tongue
Fish	Fish, Canned tuna fish, other fish
Poultry	Chicken with or without skin, all preparations
Eggs	All preparations, including egg salad and egg substitutes
Butter	Butter
Industrial fruit juices	Apple juice, orange juice, grape juice and other fruits juice
Dairy (low fat)	Low-fat (< 2%) Milk, yogurt and cheese
Dairy (high fat)	Whole and high-fat (> 2%) Milk, yogurt, cheese, cream chees
Tea	Black tea, green tea
Fruits	Pears, apricots, cherries, apples, grapes, bananas, cantaloupe, melon, watermelon, oranges, kiwi, strawberries, peaches, nectarine, tangerine, mulberry, palm, pomegranates, lemon, pineapples, fresh figs, date
Natural fruit juices	Oranges, lime, other natural juices
Green leafy vegetables	Spinach, lettuce
Yellow vegetables	Carrot, Yellow (winter) squash
Tomatoes	Tomatoes, tomato sauce
Cruciferous vegetables	Broccoli, cauliflower, cabbage, Brussels sprouts, coleslaw
Other vegetables	cucumber, pepper, mushroom, onion, peas, green beans, sweet corn, eggplant, mushrooms, celery, bean sprouts
Legume	Soybeans, baked beans, other beans, lentils
Garlic	Garlic
Potato	Potatoes
Fried potato	Fried potatoes
Nuts and seeds	Almonds, peanuts, walnuts, seeds, other nuts and seeds
Mayonnaise	Mayonnaise
Dried fruits	Dried raisins, figs, mulberries, dates and other dried fruits
Olives	Olives, olive oil
Sweets and dessert	Chocolates, cookies, cakes
Pickles	Pickles
Animal and hydrogenated oils	Animal and hydrogenated fats
Non-hydrogenated vegetable oils	Corn oil, Sunflower oil, canola oil, soy oil and all other vegetable oils (except for olive oil)
Sugar	Sugar cube, sugar, Honey
Drinks	Soft drinks, colas, industrial fruit juices
Dough	Dough
Condiments	Condiments
Salt	Salt
Grains	Breads (local breads like barbari, sangak, lavash, baguettes), rice, macaroni, vermicelli, pasta, wheat flour

Table 2. Factor-loading matrix for major dietary patterns [a]

Food groups	Dietary patterns		
	Healthy	Transitional	Traditional
Green leafy vegetables	0.63	- - -	- - -
Yellow vegetables	0.62	- - -	- - -
Other vegetables	0.58	0.35	- - -
Animal and hydrogenated fats	-0.56	- - -	0.21
Non-hydrogenated vegetable oils	0.56	- - -	- - -
Fish	0.52	0.3	- - -
Fruits	0.47	- - -	- - -
Nuts and seeds	0.45	-0.21	- - -
Tomatoes	0.44	- - -	-0.36
Cruciferous vegetables	0.44	- - -	- - -
Mayonnaise	0.38	- - -	- - -
Condiments	0.37	- - -	- - -
Tea	-0.32	0.38	- - -
Low- fat dairy products	0.3	0.35	- - -
Natural fruit juices	0.28	- - -	- - -
Grains	- - -	-0.76	0.21
Salt	- - -	0.43	- - -
Organ meats	-0.22	0.43	- - -
Dried fruits	- - -	0.4	0.35
Poultry	- - -	0.38	-0.34
Industrial fruit juices	- - -	0.29	- - -
Eggs	- - -	0.25	- - -
Sweets and desserts	- - -	0.23	- - -
Legume	- - -	0.23	- - -
Garlic	- - -	- - -	0.5
Dough	- - -	- - -	0.49
High- fat dairy products	- - -	- - -	0.4
Processed meats	- - -	- - -	-0.4
Pickles	- - -	- - -	-0.37
Sugar	-0.22	- - -	-0.32
Fried potato	- - -	- - -	-0.31
Butter	- - -	- - -	-0.27
Red meats	- - -	- - -	0.25
Potato	- - -	- - -	- - -
Olives	- - -	- - -	- - -
Drinks	- - -	- - -	- - -
Variance explained,%	10.87	5.88	5.46

[a]Values less than 0.2 were omitted for ease of reading

Discussion

We identified three major dietary patterns that explained about 22.2% of total variance in the diet. The transitional and traditional dietary patterns were associated with the risk of diabetes. The associations were independent of other lifestyle factors. We found no significant association between the healthy dietary pattern and diabetes. To our knowledge, studies evaluating the association between major dietary patterns and the risk of diabetes type 2 in the Middle East are scarce.

Diet has long been known as a contributing factor to diabetes type 2. Several studies have investigated the relationship between T2D and dietary patterns in Western and Asian populations.[13,16,19–25] Overall, it has been shown that dietary patterns characterized by high intake of high-fat and low-fiber foods, red and processed meat and refined grains were associated with a higher incidence of T2D[16,19] and dietary patterns characterized by higher intake of plant-based foods and lower intake of fried or high-fat foods have been associated with a lower risk of T2D populations.[13,16,23,24,36–38] However, data describing the associations between dietary patterns and risk of T2D in Middle-Eastern population is scarce. In the present study, using factor analysis we derived dietary patterns to identify dietary patterns of population with the unique characteristics in dietary intakes and evaluate their associations with the risk of T2D.

The healthy dietary pattern that was identified in the current study is similar to the dietary patterns that have been labeled as "prudent",[16,19] "healthy"[36,39–41] and "more vegetables, fruits and fish"[38] in earlier studies. The non-significant odds ratio was observed in this study amongst the healthy dietary pattern and diabetes. Consistent with our findings, some of the previous studies have shown that the association between prudent and healthy dietary patterns and risk of T2D were not statistically significant.[16,19,39,40] However, several studies have shown the inverse association between risk of T2D , and food patterns which were rich in fruits and vegetables.[23,24,36,38,41,42] In a cohort study by Nettleton, et al. consumption of a dietary pattern that was rich in whole grains, fruit, nuts/seeds, green leafy vegetables, and low-fat dairy was associated with an

Table 3. General characteristics of the study subjects

Characteristics (n = 332)	Cases (n = 110)	Controls (n = 222)	*P* [a]
Gender			0.52
Male	45.0	45.5	
Female	55.0	54.5	
Marital status			0.52
Single	9.9	9.5	
Married	90.1	90.5	
Education			0.29
Illiterate	45.0	44.6	
Primary school education	27.9	35.1	
Guidance school education	10.8	7.2	
High school education	15.3	10.4	
University degree	0.9	2.7	
Cigarette smoking			0.83
Non smokers	8.1	6.3	
Current smokers	84.7	86.0	
Age (y)	55.9 ± 7.6	55.8 ± 7.6	0.9
Socioeconomic Status score	13.4 ± 7.3	14.2 ± 7.7	0.14
Weight (kg)	75.0 ± 15.2	66.5 ± 15.8	< 0.001
Waist (cm)	99.8 ± 11.8	89.7 ± 14.4	< 0.001
BMI (kg/m²)	29.9 ± 5.4	26.0 ± 5.1	< 0.001
Waist to hip ratio	0.99 ± 0.07	0.92 ± 0.11	< 0.001
Physical activity (MET-h/d)	9.6 ± 4.7	9.9 ± 5.9	0.6
Energy (Kcal/d)	1959.0 ± 518.0	2034.0 ± 496.0	0.2
Carbohydrate (% total energy)	54.8 ± 6.5	56.2 ± 6.2	0.07
Protein (% total energy)	16.1 ± 3.7	14.3 ± 2.6	< 0.001
Fat (% total energy)	31.4 ± 5.0	31.9 ± 5.2	0.4
Fiber (g/d)	20.3 ± 6.3	20.7 ± 6.3	0.6

Data are presented as means ± SD or %; [a]Using independent samples *t*-test or Chi-square, where appropriate.

Table 4. General characteristics of control subjects according to quartiles (Q) of dietary pattern scores

Characteristics	Healthy dietary pattern			Transitional dietary pattern			Traditional dietary pattern		
	Q1 (lowest)	Q4 (highest)	*P*[a]	Q1 (lowest)	Q4 (highest)	*P*	Q1 (lowest)	Q4 (highest)	*P*
Female sex	52.5	59.3	0.89	42.9	56.0	0.15	60.7	54.2	0.72
Marital status, married	94.9	85.2	0.24	92.9	90.0	0.71	87.5	93.8	0.52
Education, illiterate	39.0	51.9	0.11	42.9	30.0	0.001	53.6	27.1	0.02
Smoking, current smokers	86.4	88.9	0.86	82.1	90.0	0.90	82.1	89.6	0.46
Age (y)	56.6 ± 6.5	54.6 ± 7.8	0.2	55.3 ± 7.2	57.3 ± 7.9	0.4	56.1 ± 8.4	57.7 ± 7.8	0.48
Socioeconomic Status score	13.0 ± 7.2	17.4 ≥ 8.6	0.002	14.1 ± 7.9	13.9 ± 7.9	0.18	14.2 ± 7.5	14.3 ± 8.3	0.9
Weight (kg)	63.8 ± 15.3	68.5 ± 14.6	0.4	71.5 ± 14.6	60.6 ± 14.7	0.004	67.6 ± 13.9	61.9 ± 16.3	0.14
Waist (cm)	86.9 ± 14.8	90.7 ± 12.1	0.3	93.0 ± 12.5	83.8 ± 13.3	0.007	90.2 ± 12.3	85.4 ± 14.7	0.13
BMI (kg/m²)	25.4 ± 5.2	26.1 ± 4.6	0.8	26.7 ± 4.8	24.3 ± 4.5	0.06	25.9 ± 4.9	24.9 ± 5.9	0.3
Physical activity (MET-h/d)	9.1 ± 5.1	10.8 ± 5.3	0.49	10.4 ± 6.6	10.9 ± 6.7	0.3	10.2 ± 5.7	8.9 ± 5.2	0.5
Waist/hip ratio	0.9 ± 0.09	0.92 ± 0.07	0.45	0.94 ± 0.09	0.89 ± 0.08	0.09	0.93 ± 0.09	0.9 ± 0.1	0.5

Data are presented as means ± SD or %; [a]Using Analysis of Variance (ANOVA) or Chi-square, where appropriate.

Table 5. Odds ratios and 95% CIs for diabetes type 2based on quartiles of the major dietary pattern scores[a]

Diabetes	Quartiles of major dietary patterns				
	Q1	Q2	Q3	Q4	*P*-trend
Healthy dietary pattern					
Crude	1.00	1.392 (0.73–2.67)	1.23 (0.64–2.37)	1.32 (0.69–2.54)	0.49
Model 1	1.00	1.32 (0.68–2.55)	1.32 (0.68–2.55)	1.30 (0.68–2.52)	0.51
Model 2	1.00	1.13 (0.54–2.37)	0.91 (0.44–1.89)	1.18 (0.56–2.46)	0.80
Transitional dietary pattern					
Crude	1.00	0.89 (0.46–1.72)	0.93 (0.48–1.78)	1.37 (0.73–2.59)	0.24
Model 1	1.00	0.85 (0.44–1.65)	0.89 (0.46–1.75)	1.34 (0.70–2.55)	0.25
Model 2	1.00	1.05 (0.50–2.18)	1.10 (0.53–2.30)	2.17 (1.0–4.50)	0.024
Traditional dietary pattern					
Crude	1.00	0.79 (0.40–1.55)	0.93 (0.48–1.78)	1.51 (0.80–2.85)	0.11
Model 1	1.00	0.77 (0.40–1.50)	0.88 (0.46–1.70)	1.50 (0.8–2.84)	0.11
Model 2	1.00	0.73 (0.34–1.53)	0.94 (0.45–1.93)	2.13 (1.03–4.41)	0.016

[a]Data are given as odds ratio (95% confidence interval) unless otherwise specified; Crude: unadjusted; Model 1: adjusted for age, gender and energy; Model 2: additionally adjusted for marital status, education level, Socioeconomic Status, family history of diabetes, physical activity and waist.

increased risk of T2D.[23] Another cohort study conducted in China showed that vegetables, fruits and fish pattern was significantly associated with the risk of diabetes (OR per 1 SD increase in score = 0.76; 95% CI: 0.58, 0.99).[38] The same finding was also found between healthy pattern and T2D in Finland.[41] Different characteristics of study populations might have affected the results.

We observed a significant positive association between the transitional dietary pattern and risk of diabetes type 2, after taking potential confounders into account. This transitional dietary pattern included both non-healthy (salt and organ meats) and healthy (such as dried fruits, low-fat dairy and vegetables) items. This dietary pattern is comparable to "beans, tomatoes, and refined grains" dietary pattern, reported by a previous cohort study in the framework of Multi-Ethnic Study of Atherosclerosis, in terms of having healthy and non-healthy items. Nettlenton, et al.[23] indicated the dietary pattern characterized by high intake of tomatoes, beans, refined grains, high-fat dairy, and red meat was associated with an increased risk of diabetes. In our study, the positive association between the transitional dietary pattern and diabetes could be attributed to the higher intakes of organ meats,[43] this association was also observed in studies with identified food patterns rich in meats.[38,42,44] Furthermore, since the non-healthy foods derived from the transitional dietary pattern by higher factor loadings than healthy foods, it is possible that non-healthy foods' effects overwhelmed healthy ones.

We found that the traditional dietary pattern was positively associated with the risk of diabetes type 2. This dietary pattern that was identified in our study was somewhat similar to the Western dietary pattern identified from previous studies.[16,19,23,38] Due to urbanization, rapid changes in life style, physical activity and diet, as well as better socioeconomic status in Iran[45] lead to a similar traditional dietary pattern to western pattern.

The positive association between the traditional dietary pattern and risk of diabetes might be explained by its content of red meat,[19,46] as well as animal and hydrogenated fats.[47] Additionally, high energy density foods (such as high-fat dairy) in this dietary pattern might also provide a reason.[21] Besides, saturated fat provided by prominent foods in the transitional and traditional dietary patterns may play a role in the patterns' positive association with the risk of T2D. The quality of dietary fat could be of importance for development of T2D. Insulin sensitivity may decrease on the saturated fatty acid diet, but doesn't change on the monounsaturated fatty acid diet.[48] Also, high saturated fat and low fiber intake may lead to hyperglycaemia and hyperinsulinaemia, therefore higher risk of diabetes.[38] Furthermore, the low fiber and whole grain content of these dietary patterns may contribute to their direct relationship with T2D. Diets high in whole grains and fiber (especially cereal fiber), appear to protect against T2D.[11]

The present study has several strengths, including: its population-based design, measurement of socioeconomic status confounding variable for the first time, as well as adjustment of confounding variable in our analysis and controlling other known potential confounders. The use of validated methods for assessment of exposure and outcome is another strength point.

This study has some limitations, which have to be pointed out. First is the well-known methodological shortcoming of case-control studies, which may make the results prone to selection and information bias. Due to a random selection of neighborhood controls, major selection bias in this study is unlikely. Second, despite careful attention to the issue of confounder adjustment, the existence of residual confounding cannot be excluded. Third, dietary assessment by FFQ has its own measurement errors. Fourth, similar factor analysis of all statistical methods that have been used for data reduction have limitations. For example, its subjective decisions involved in grouping of different food items and the definition of dietary patterns, including determination of number of factors, the type of rotation, as well as the interpretation and naming of the factors.[49]

Finally, it should be noted that the dietary pattern approach is population-dependent; therefore, the external validity of these findings, comparison across studies, especially between populations with different dietary habits is difficult.

In conclusion, the current study identified three major dietary patterns. The transitional and traditional dietary patterns were associated with an increased risk of type-2 diabetes, and no significant association was found between the healthy dietary pattern and risk of diabetes type 2.

Funding

This study was supported by Mazandaran University of Medical Sciences.

Conflicts of interest

Authors declared no potential conflicts of interest.

Acknowledgments

This study was supported by grant from the Mazandaran University of Medical Sciences, Sari, Iran. We thank Mr. Hadi Tabibi and also all participants of this study.

References

1. Azimi–Nezhad M, Ghayour–Mobarhan M, Parizadeh MR, Safarian M, Esmaeili H, Parizadeh SM, et al. Prevalence of type 2 diabetes mellitus in Iran and its relationship with gender, urbanisation, education, marital status and occupation. *Singapore Medical Journal*. 2008; 49(7): 571 – 576.
2. Gadsby R. Epidemiology of diabetes. *Advanced Drug Delivery Reviews*. 2002; 54(9): 1165 – 1172.
3. De Lusignan S, Sismanidis C, Carey IM, DeWilde S, Richards N, Cook DG. Trends in the prevalence and management of diagnosed type 2 diabetes 1994–2001 in England and Wales. *BMC Family Practice*. 2005; 6(1): 13.
4. Azizi F, Guoya M, Vazirian P, Dolatshati P, Habbibian S. Screening for type 2 diabetes in the Iranian national programme: a preliminary report. *East Mediterr Health J*. 2003; 9(5 – 6): 1122 – 1127.
5. Hussain A, Vaaler S, Sayeed M, Mahtab H, Ali SK, Khan AA. Type 2 diabetes and impaired fasting blood glucose in rural Bangladesh: a population–based study. *The European Journal of Public Health*. 2007; 17(3): 291 – 296.
6. Azizi F, Gouya M, Vazirian P, Dolatshahi P, Habibian S. The diabetes prevention and control programme of the Islamic Republic of Iran. *East Mediterr Health J*. 2003; 9(5 – 6): 1114 – 1121.
7. Esteghamati A, Ashraf H, Khalilzadeh O, Rshidi A, Mohammad K, Asgari F, et al. Trends of diabetes according to body mass index levels in Iran: results of the national Surveys of Risk Factors of Non-Communicable Diseases (1999–2007). *Diabetic Medicine*. 2010; 27(11): 1233 – 1240.
8. Al–Moosa S, Allin S, Jemiai N, Al–Lawati J, Mossialos E. Diabetes and urbanization in the Omani population: an analysis of national survey data. *Population Health Metrics*. 2006; 4(1): 5.
9. Shetty P, Schmidhuber J. Introductory lecture the epidemiology and determinants of obesity in developed and developing countries. *In-*

ternational Journal for Vitamin and Nutrition Research 2006; 76(4): 157 – 162.

10. Stamler J, Vaccaro O, Neaton JD, Wentworth D. Diabetes, other risk factors, and 12-yr cardiovascular mortality for men screened in the Multiple Risk Factor Intervention Trial *Diabetes Care.* 1993; 16(2): 434 – 444.
11. Hu FB, Van Dam R, Liu S. Diet and risk of type II diabetes: the role of types of fat and carbohydrate. *Diabetologia.* 2001; 44(7): 805 – 817.
12. Lopez-Ridaura R, Willett WC, Rimm EB, Liu S, Stampfer MJ, Manson JE, et al. Magnesium intake and risk of type 2 diabetes in men and women. *Diabetes Care.* 2004; 27(1): 134 – 140.
13. Heidemann C, Hoffmann K, Spranger J, Klipstein–Grobusch K, Möhlig M, Pfeiffer A, et al. A dietary pattern protective against type 2 diabetes in the European Prospective Investigation into Cancer and Nutrition (EPIC)-Potsdam Study cohort. *Diabetologia.* 2005; 48(6): 1126 – 1134.
14. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Current Opinion in Lipidology.* 2002; 13(1): 3 – 9.
15. Newby P, Tucker KL. Empirically derived eating patterns using factor or cluster analysis: A review. *Nutrition Reviews.* 2004; 62(5): 177 – 203.
16. van Dam RM, Rimm EB, Willett WC, Stampfer MJ, Hu FB. Dietary patterns and risk for type 2 diabetes mellitus in US men. *Annals of Internal Medicine.* 2002; 136(3): 201 – 209.
17. Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, et al. A clinical trial of the effects of dietary patterns on blood pressure. *New England Journal of Medicine.* 1997; 336(16): 1117 – 1124.
18. Michel de Lorgeril M, Salen P, Martin JL, Monjaud I, Delaye J, Mamelle N. Mediterranean diet, traditional risk factors, and the rate of cardiovascular complications after myocardial infarction. *Heart Failure.* 1999; 11: 6.
19. Fung TT, Schulze M, Manson JE, Willett WC, Hu FB. Dietary patterns, meat intake, and the risk of type 2 diabetes in women. *Archives of Internal Medicine.* 2004; 164(20): 2235 – 2240.
20. Duc Son LNT, Hanh TTM, Kusama K, Kunii D, Sakai T, Hung NTK, et al. Anthropometric characteristics, dietary patterns and risk of type 2 diabetes mellitus in Vietnam. *Journal of the American College of Nutrition.* 2005; 24(4): 229 – 234.
21. McNaughton SA, Mishra GD, Brunner EJ. Dietary patterns, insulin resistance, and incidence of type 2 diabetes in the Whitehall II Study. *Diabetes Care.* 2008; 31(7): 1343 – 1348.
22. Mizoue T, Yamaji T, Tabata S, Yamaguchi K, Ogawa S, Mineshita M, et al. Dietary patterns and glucose tolerance abnormalities in Japanese men. *The Journal of Nutrition.* 2006; 136(5): 1352 – 1358.
23. NettletonJA, Steffen LM, Ni H, Liu K, Jacobs DR. Dietary patterns and risk of incident type 2 diabetes in the Multi – Ethnic Study of Atherosclerosis (MESA). *Diabetes Care.* 2008; 31(9): 1777 – 1782.
24. Odegaard AO, Koh WP, Butler LM, Duval S, Gross MD, Mimi CY, et al. Dietary Patterns and Incident Type 2 Diabetes in Chinese Men and Women The Singapore Chinese Health Study. *Diabetes Care.* 2011; 34(4): 880 – 885.
25. Villegas R, Yang G, Gao YT, Cai H, Li H, Zheng W, et al. Dietary patterns are associated with lower incidenceof type 2 diabetes in middle–aged women: the Shanghai Women's Health Study. *International Journal of Epidemiology.* 2010; 39(3): 889 – 899.
26. Willett WC. Nutritional epidemiology. 2nd ed. New York: Oxford University Press; 1998.
27. Association AD. Diagnosis andclassification of diabetes mellitus. *Diabetes Care.* 2008; 31(Suppl 1): S55 – S60.
28. Azar M, Sarkisian E. Food Composition Table of Iran Tehran: National Nutrition and Food Research Institute. Shaheed Beheshti university 1980. [inPersian]
29. US Department of Agriculture ARS. Available from: URL: http: //www.ars.usda.gov/Services/docs.htm?docid=22115. (Accessed date: 10 september 2011).
30. Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Dietary patterns, insulin resistance, and prevalence of the metabolic syndrome in women. *The American Journal of Clinical Nutrition.* 2007; 85(3): 910 – 918.
31. Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Dietary patterns and markers of systemic inflammation among Iranian women. *The Journal of Nutrition.* 2007; 137(4): 992 – 998.
32. Hosseini–Esfahani F, Asghari G, Mirmiran P, Jalali Farahani S, Azizi F. Reproducibility and Relative Validity of Food Group Intake in a Food Frequency Questionnaire Developed for the Tehran Lipid and Glucose Study. *Razi Journal of Medical Sciences.* 2010; 17(71): 41 – 55.
33. Esmaillzadeh A, MirmiranP, Azizi F. Whole–grain consumption and the metabolic syndrome: a favorable association in Tehranian adults. *European Journal of Clinical Nutrition.* 2005; 59(3): 353 – 362.
34. Aadahl M, Jørgensen T. Validation of a new self – report instrument for measuring physical activity. *Medicine and Science in Sports and Exercise.* 2003; 35(7): 1196 – 1202.
35. Booth ML, Ainsworth BE, Pratt M, Ekelund U, Yngve A, Sallis JF, et al. International physical activity questionnaire: 12–country reliability and validity. *Medicine& Science in Sports & Exercise.* 2003; 195(9131/03): 3508 – 1381.
36. Williams DE, Prevost AT, Whichelow MJ, Cox BD, Day NE, Wareham NJ. A cross–sectional study of dietary patterns with glucose intolerance and other features of the metabolic syndrome. *British Journal of Nutrition.* 2000; 83(03): 257 – 266.
37. Montonen J, Järvinen R, Heliövaara M, Reunanen A, Aromaa A, Knekt P. Food consumption and the incidence of type II diabetes mellitus. *European Journal of Clinical Nutrition.* 2005; 59(3): 441 – 448.
38. Yu R, Woo J, ChanR, Sham A, Ho S, Tso A, et al. Relationship between dietary intake and the development of type 2 diabetes in a Chinese population: the Hong Kong Dietary Survey. *Public Health Nutrition.* 2011; 14(07): 1133 – 1141.
39. Esmaillzadeh A, Azadbakht L. Food intake patterns may explain the high prevalence of cardiovascular risk factors among Iranian women. *The Journal of Nutrition.* 2008; 138(8): 1469 – 1475.
40. Kim HS, Park SY, Grandinetti A, Holck PS, Waslien C. Major dietary patterns, ethnicity, and prevalence of type 2diabetes in rural Hawaii. *Nutrition.* 2008; 24(11): 1065 – 1072.
41. Montonen J, Knekt P, Härkänen T, Järvinen R, Heliövaara M, Aromaa A, et al. Dietary patterns and the incidence of type 2 diabetes. *American Journal of Epidemiology.* 2005; 161(3): 219 – 227.
42. Erber E, Hopping BN, Grandinetti A, Park SY, Kolonel LN, Maskarinec G. Dietary Patterns and Risk for Diabetes The Multiethnic Cohort. *Diabetes Care.* 2010; 33(3): 532 – 538.
43. Aune D, UrsinG, Veierød M. Meat consumption and the risk of type 2 diabetes: a systematic review and meta–analysis of cohort studies. *Diabetologia.* 2009; 52(11): 2277 – 2287.
44. Hodge AM, English DR, O'Dea K, Giles GG. Dietary patterns and diabetes incidence in the Melbourne Collaborative Cohort Study. *American Journal of Epidemiology.* 2007; 165(6): 603 – 610.
45. Galal O. Nutrition–related health patterns in the Middle East. *Asia Pacific Journal of Clinical Nutrition* 2003; 12(3).
46. Pan A, Sun Q, Bernstein AM, Schulze MB, Manson JE, Willett WC, et al. Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta–analysis. *The American Journal of Clinical Nutrition.* 2011; 94(4): 1088 – 1096.
47. Thanopoulou AC, Karamanos BG, Angelico FV, Assaad–Khalil SH, Barbato AF, Del Ben MP, et al. Dietary Fat Intake as Risk Factor for the Development of Diabetes Multinational, multicenter study of the Mediterranean Group for the Study of Diabetes (MGSD). *Diabetes Care.* 2003; 26(2): 302 – 307.
48. Vessby B, Uusitupa M, Hermansen K, Riccardi G, Rivellese AA, Tapsell LC, et al. Substituting dietary saturated for monounsaturated fat impairs insulin sensitivity in healthy men and women: The KANWU Study. *Diabetologia.* 2001; 44(3): 312 – 319.
49. McCann SE, Marshall JR, Brasure JR, Graham S, Freudenheim JL. Analysis of patterns of food intake in nutritional epidemiology: food classification in principal components analysis and the subsequent impact on estimates for endometrial cancer. *Public Health Nutrition.* 2001; 4(05): 989 – 997.