Iran J Public Health, Vol. 45, No.11, Nov 2016, pp.1491-1501

Original Article

Association of Major Dietary Patterns with Cardio-metabolic Risk Factors in Type 2 Diabetic Patients

Zhaleh SHADMAN [1], ***Mahdieh AKHOUNDAN*** [1], ***Nooshin POORSOLTAN*** [1], ***Bagher LARIJANI*** [1], ***Mostafa QORBANI*** [2, 3], ***Mehdi HEDAYATI*** [4], ****Mohsen KHOSHNIAT NIKOO*** [5]

1. *Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Science Institute, Tehran University of Medical Sciences, Tehran, Iran*
2. *Dept. of Community Medicine, Alborz University of Medical Sciences, Karaj, Iran*
3. *Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran*
4. *Cellular and Molecular Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
5. *Diabetes Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran*

***Corresponding Author:** Email: m.khoshniatnikoo@yahoo.com

(Received 23 Sep 2015; accepted 15 Feb 2016)

Abstract

Background: Role of dietary modifications on the treatment and management of diabetes and complications was shown by many researchers. This study was designed to examine the association of major dietary patterns with diabetes-related cardio-metabolic risk factors in Iranian diabetes.

Methods: Totally, 525 type 2 diabetic subjects with mean age 55 ± 10 yr were included in this cross-sectional study in 2014 that followed for at least two years by the Diabetes and Metabolic disease Clinic of Tehran University of Medical Sciences, Tehran, Iran. Blood samples were collected after 12 h fasting for glycemic and lipid profiles. Information on the general characteristics, anthropometric, blood pressure measurements and physical activity level was collected. Dietary data were obtained by a validated food frequency questionnaire. Dietary patterns were obtained factor analysis (principal component analysis).

Results: Three major dietary patterns retained through principal component analysis: Western like (high in sweets, fast foods, carbonated drinks, red meat, mayonnaise, nuts, refined grains, potato and visceral meat), Asian like (high in vegetables, low-fat dairy, fish, poultry and egg), and Traditional like (high in high fat dairy, oils, whole grains, vegetables and fruits). Western like dietary pattern was positively associated with fasting serum glucose (P=0.05), total cholesterol (P=0.005) and low-density lipoprotein cholesterol (P=0.008). After extensive adjustment for potential confounders, the association of serum total cholesterol and Western like dietary pattern remained significant (P=0.03).

Conclusion: Modifications in dietary pattern, especially in those who have a Western dietary pattern, may be effective in preventing or delaying diabetes-associated cardio metabolic complications.

Keyword: Diet, Principal component analysis, Diabetes mellitus type 2, Risk factors

Introduction

In recent decades, the prevalence of diabetes has been augmented dramatically, mostly due to the changes in lifestyle, rapid population growth, urbanization and aging (1). Global prevalence of diabetes grows 54% by 2030. This increase would be more aggressive in developing countries (69%) compared to developed nations (20%) (1). Middle Eastern countries have been highlighted as

regions with high prevalence of diabetes. Accordingly, in Iran, the prevalence of diabetes has been reported to be 7.7%, although, the figure reaches 14% in crowded cities like the Iranian capital Tehran (2).
The essential role of diabetes in the development of long-term complications such as retinopathy, nephropathy, neuropathy, cardiovascular disease (CVD) has been confirmed in several studies (3, 4). CVD, as the leading cause of death in more than 70% of diabetic patients, occurs at least two to four times more in diabetics compared to none- diabetics (5). Diabetes and its micro and macrovascular complications impose a heavy burden on the society and result in reduced quality of life, disability and mortality in diabetic patients (3, 4). However, several studies have underlined the importance of blood glucose control in preventing the complications in diabetic patients (4, 6). The role of nutrients and dietary modifications in glycemic control and improving diabetes complications risk factors have been investigated in several studies (7, 8). Recently, dietary pattern analysis has been introduced as an alternative and complementary approach that allows the evaluation of cumulative effects of nutrients and their interactions (9). Taking into account the cultural and ethnic preferences, food availability and individual circumstances can be considered as other advantages of this method (10). The approach provides more effective and understandable recommendations than studies in which the focus is more on the role, amount and distribution of some nutrients and food items (10). Studies showed higher risk of diabetes in western (11, 12) dietary pattern compared to prudent and healthy dietary patterns (12, 13). A systematic review and meta-analysis of 15 cohort studies indicated that risk of type 2 diabetes increased by adopting unhealthy dietary patterns (RR: 1.44, 95% CI :1.33–1.57, $P< 0.005$) and on the contrary adherence to healthy dietary patterns reduced the risk (RR: 0.79, 95% CI: 0.74–0.86, $P< 0.005$) (14). Following the Mediterranean dietary pattern, caused attenuation of fasting glucose and insulin levels and subsequently insulin resistance in both norm glycemic (15, 16) and metabolic syndrome subjects (17, 18). However, few studies have evaluated the association between dietary patterns and diabetes-related risk factors (19).
The present study investigated the dietary patterns in type 2 diabetic patients and evaluated the association of the dietary pattern with state of glycemic control, blood pressure, lipid profile and anthropometric indicators in this group.

Methods

Subjects

This cross-sectional study was performed on 525 type 2 diabetic patients in 2014. Participants were selected from patients followed at least 2 yr by the Diabetes and Metabolic Disease Clinic of Tehran University of Medical Sciences. Individuals aged between 35-65 yr, diagnosed with diabetes after the age of 30 at least 5 yr were recruited through convenience sampling. Patients were on insulin, medication had been changed during the past year, had a positive history of myocardial infarction, angina pectin, stroke, chronic inflammation, thyroid, genital, liver or renal disease, alcohol consumption or smoking, vegetarians and pregnant women were excluded. At the beginning, the aim of the study was explained to the subjects and a written informed consent was obtained.
The Endocrinology and Metabolism Research Center Ethics Committee (E00192) approved this cross-sectional study.

Dietary assessment

An adjusted validated 168-food item food frequency questionnaire (FFQ) (20) was completed by trained dietitians to assess the typical food intake of the participants through a face-to-face interview. To identify the major dietary patterns, categorization of food items into 22 food groups based on their nutrient content was applied (21). The consumption frequency of different food categories was transformed to serving per week. Macronutrients were assessed by analyzing dietary data using adjusted N4software (Nutritionist: version 4.0; Tinuviel Software, Warrington, United Kingdom).

Anthropometric measurements and physical activity assessment

Height and weight were measured by standard methods to the nearest 0.1cm and 0.1kg, respectively. Body mass index (BMI) was estimated as the ratio of body weight to height squared and expressed as kg/m^2. Waist circumference was determined by placing a measuring tape around the abdomen just above the right iliac crest.

Physical activity level (PAL) was assessed by a validated questionnaire defined by nine different metabolic equivalent (MET) levels ranged from sleep/rest (0.9 METs) to high-intensity physical activities (> 6 METs) (22). Over 24 h, for each activity level, MET equivalent was multiplied by the time spent on that physical activity. Daily MET average was calculated as sum of MET-time divide by 24.

Clinical and Biochemical assessment

Venous blood was collected after 12 h overnight fasting for biochemical analysis. Serum glucose concentration was measured by the fluorometric method according to glucose oxidase principle (Glucose determination kit, Parsazmun, Tehran, Iran) using auto-analyzer (Hitachi 902, Roche, Basel, Switzerland). Glycated hemoglobin was determined on whole blood samples by HbA1c Pink Kit and DS5 analyzer. The intra-assay coefficient of variation (CV %) and inter-assay coefficient of variation for glucose and hemoglobin A1C (HbA1c) were 1.3%, 3.1%, 1.6%, and 3.0% respectively. Serum triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol were measured by relevant biochemical kits (Parsazmun, Tehran, Iran) employing auto-analyzer (Hitachi 902, Roche, Basel, Switzerland). The intra-assay CV% for above substances was 3.6, 1.3, 2.1 and 1.7 and the inter-assay CV% was 4.2, 2.0, 2.2, and 2.0 respectively. Accuracy assessment was done based on Bio-Rad accuracy three controls level.

Both systolic and diastolic blood pressure (SBP and DBP) were measured after patients sat for at least 15 min using Korotkoff's auscultator method.

Statistical analyses

To obtain dietary patterns, principal component analysis (a type of factor analysis) was conducted on 22 food groups retained from categorizing the food items of the FFQ. Sampling adequacy and inter-correlation of variables were supported by KMO (Kaiser-Meyer-Olkin) value=0.67 and Bartlett's test of sphericity <0.0001. Extracted factors rotated orthogonally (Varimax rotation) to a simpler and more interpretable structure. The number of dietary patterns was determined using scree plot, eigenvalues of greater than 1.5 and interpretability of the factors. The factor score for each pattern was calculated by summing the consumption of each food group weighted by factor loading and each person received an individual factor score for each identified pattern (9).

Linear regression models used to assess the association of adherence to three major dietary patterns with each physical activity level, age, diabetes duration, income, blood pressure, anthropometric measurements, dietary intakes and the mean concentrations of serum glucose, lipid profiles and HbA1c. In addition, the effect of confounding factors including age, sex, diabetes duration, type and drug dosage (such as hypoglycemic, antihypertensive and cardiovascular drugs) and calorie intake was taken into account in multivariate linear regression models to distinguish the possible effect of adherence to each dietary pattern and other related factors. *P* value of less than 0.05 was accepted in all tests as statistically significant.

Results

Overall, 56% of participants were female and 67% of the responders had education higher than high school. Table 1 shows the basic characteristics of the studied patients. Factor analysis revealed three main dietary patterns: Western like (high in sweets, fast foods, carbonated drinks, red meat, mayonnaise, nuts, refined grains, potato and visceral meat), Asian like (high in vegetables, fish, poultry, egg and nuts, low-fat dairy), and Traditional like (rich in high-fat dairy, oils, whole grains, vegetables, fruits). These three dietary patterns explained 29.02% of the total variance in food intake. The factor loadings for each dietary pattern are presented in Table 2.

Table 1: Basic characteristics of patients [a]

Variables	Mean ± SD[b, c]
Age (yr)	55 ± 10
Sex	
Male	231 (44)
Female	294 (56)
BMI (kg/m²)	28.8 ± 4.9
WC (cm)	95.7±12.2
Education	
Illiterate	3 (0.5)
Primary school	21 (4.1)
Guidance school	147 (28.1)
High school	329 (62.7)
University	25 (4.6)
Duration of diabetes (month)	125 ± 94
Glycated hemoglobin (%)	8.04 ± 1.93
Serum triglyceride (mg/dl)	165 ± 87
Serum total cholesterol (mg/dl)	166 ± 25
LDL- cholesterol (mg/dl)	89 ± 16
HDL- cholesterol (mg/dl)	50 ± 31
SBP (mmHg)	127.3±16.3
DBP (mmHg)	81.7±8.8

[a] n=525/[b] Quantitative data presented as the mean ± (SD) [c] Qualitative data presented as n (%)/BMI body mass index, WC waist circumference, LDL-cholesterol low density lipoprotein cholesterol, HDL-cholesterol high density lipoprotein cholesterol, SBP systolic blood pressure, DBP diastolic blood pressure

Anthropometric, socio- demographic and biochemical characteristics of patients were evaluated by tertiles of each dietary pattern.

Western like dietary pattern showed no association with anthropometric indices and there was none linear association statistically difference in the mean physical activity levels among tertiles of the dietary pattern (*P*=0.02). Age was inversely associated with tendency to following the Western like dietary pattern (*P*<0.001). The highest tertile of this pattern included patients with more income (*P*=0.04). Western like dietary pattern was also associated with a significant increase in number of daily snacks (*P*=0.01), calorie, dietary cholesterol, fiber intake (*P*<0.001) proportion of dietary fat, mono and polyunsaturated fat (*P*<0.05) intake and attenuation of protein intake (*P*<0.001). Among biochemical parameters, only serum LDL cholesterol showed a positive association with Western like dietary pattern (*P*=0.03).

We found a significant nonlinear association between the Asian like dietary pattern and patients' PAL (*P*=0.04). Patients with shorter duration of diabetes were more likely to follow this pattern (*P*=0.03).

Table 2: Factor loading matrix [a] for major dietary patterns identified by factor analysis

Food items	Western like	Asian like	Traditional like
Sweet	0.691		
Fast food	0.612		
Drink	0.560		
Red meat	0.489		
Mayonnaise	0.489		
Nut	0.425	0.394	
Refined grain	0.386		-0.272
Potato	0.375	0.319	-0.307
Visceral meat	0.367		
Vegetables		0.635	0.453
Low fat dairy		0.612	
Fish poultry		0.509	0.233
Eggs		0.422	
High fat dairy	0.247		0.519
Liquid oil	0.269		0.512
Whole grain	-0.219		0.493
Solid oil	0.235		-0.408
Fruits	0.374	0.280	0.403
Pickles		0.291	-0.325
Percentage of variance explained (%)	13.54	8.81	6.66

[a] The correlation among the food groups and each dietary pattern. For simplicity, factor loading values less than 0.30 omitted from the table

Adherence to the pattern showed a significant positive relationship with calorie intake, dietary cholesterol, fiber and protein intake (*P*<0.001), daily snacks (*P*=0.009) and a negative correlation with saturated fat (*P*=0.02). Biochemical and anthropometrical assessments were not associated to Asian like dietary pattern.

A positive association was revealed between age and Traditional like dietary pattern (*P*=0.002). Similar to the aforementioned patterns, the amount of calorie intake, dietary cholesterol and fiber were higher in the top tertile of this pattern (*P*<0.001). The intake of dietary mono and polyunsaturated fats were significantly associated with the Traditional like dietary pattern (*P*=0.003 and 0.008, respectively). There was no association between following the Traditional-like dietary pattern and glycemic and lipid profile and anthropometrical indices.

The results of extracted confounders-adjusted multivariate linear regression models are shown in table 3-5. Table 3 indicates that in the models adjusted for confounders, serum total and LDL cholesterol are positively associated with Western like dietary pattern (*P*=0.005 and *P*=0.008, respectively). These associations were consistent in additional adjustments for calorie intake (*P*=0.01 and *P*=0.02, respectively) and physical activity level (*P*=0.02 and 0.04, respectively). In addition, fasting serum glucose associated with the Western like dietary pattern in models 2 and 3 (*P*=0.01 and 0.03, respectively); but not in models 1 and 4 (*P*=0.05 and 0.06, respectively). Further adjustment for proportion of dietary protein and fat showed only an association between serum TC and the pattern (*P*=0.03). Extracted confounders adjusted regression models for Asian like and Traditional like dietary patterns showed no association with glycemic factors and lipid profile. No significant difference was observed in relationship of dietary patterns and risk factors in female and male (data not shown).

Table 3: Association of clinical and biochemical parameters with western like dietary pattern[a]

	Model 1			Model 2			Model 3			Model 4		
	B (SE)	***P* value**	**95% CI**	**B (SE)**	***P* value**	**95% CI**	**B (SE)**	***P* value**	**95% CI**	**B (SE)**	***P* value**	**95% CI**
FBS	11.03 (5.65)	0.05	-0.20–23.04	14.73 (5.97)	0.01	2.37–25.15	12.49 (5.99)	0.03	0.27–23.12	11.52 (6.22)	0.06	- 0.74–23.79
HbA1c	0.12 (0.15)	0.42	-0.11–0.49	0.16 (0.16)	0.33	-0.20–0.44	0.12 (0.16)	0.47	-0.24–0.40	0.09 (0.17)	0.58	-0.24–0.43
TG	11.24 (9.92)	0.25	-9.26–27.37	15.81 (10.52)	0.13	-7.61–33.09	15.76 (10.75)	0.14	- 8.77–33.44	19.62 (11.12)	0.08	- 2.30–41.55
TC	10.11 (3.53)	0.005	2.63–16.34	9.52 (3.75)	0.01	1.96–16.40	8.71 (3.81)	0.02	1.11–15.78	8.64 (3.97)	0.03	0.81–16.47
HDL-c	2.05 (3.96)	0.60	-4.47–9.39	0.09 (4.20)	0.98	-7.93–7.95	1.09 (4.27)	0.79	-7.10–9.03	2.23 (4.43)	0.61	- 6.50–10.98
LDL-c	5.90 (2.21)	0.008	1.48–9.91	5.48 (2.36)	0.02	1.05-10.12	5.04 (2.40)	0.04	0.58–9.81	4.61 (2.49)	0.06	-0.30–9.53

n=525

FBS fasting blood sugar, HbA1c hemoglobin A1c, TG triglyceride, TC total cholesterol, HDL-c high density lipoprotein, LDL-c low density lipoprotein, CI confidence interval

[a] Multivariate linear regression models. In all cases regression coefficient was expressed as B and standard error as SE and P-value of regression

Model 1 was adjusted for Age, sex, diabetes duration, type and drug dosage

Model 2 was adjusted for Age, sex, diabetes duration, type and drug dosage, calorie intake

Model 3 was adjusted for Age, sex, diabetes duration, type and drug dosage, calorie intake, physical activity

Model 4 was adjusted for Age, sex, diabetes duration, type and drug dosage, calorie intake, physical activity, proportion of dietary protein and fat

Table 4: Association of clinical and biochemical parameters with Asian like dietary pattern [a]

	Model 1			Model 2			Model 3			Model 4		
	B (SE)	***P* value**	**95% CI**	**B (SE)**	***P* value**	**95% CI**	**B (SE)**	***P* value**	**95% CI**	**B (SE)**	***P* value**	**95% CI**
FBS	-4.81 (5.43)	0.37	-13.34–6.53	-3.12 (5.92)	0.59	-15.08–7.45	-0.08 (5.91)	0.98	-12.06–10.53	2.48 (6.44)	0.70	-10.22–15.02
HbA1c	0.04 (0.14)	0.77	-0.21–0.36	0.07 (0.16)	0.65	-0.29–0.33	0.13 (0.16)	0.42	-0.24–0.40	0.21 (0.17)	0.23	-0.14–0.56
TG	5.80 (9.49)	0.54	-8.64–25.98	10.46 (10.32)	0.32	-11.62–28.23	11.55 (10.51)	0.27	-11.03–29.70	10.07 (11.49)	0.38	-12.58–32.74
TC	1.49 (3.43)	0.66	-3.06–9.79	-0.45 (3.73)	0.90	-7.37–6.95	0.76 (3.77)	0.83	-6.29–8.25	2.13 (4.12)	0.60	-5.99–10.26
HDL-c	4.61 (3.77)	0.22	-2.56–10.51	2.86 (4.10)	0.48	-5.04–10.46	1.96 (4.16)	0.63	-6.04–9.75	0.56 (4.55)	0.90	-8.41–9.54
LDL-c	0.86 (2.15)	0.68	-1.77–6.29	-0.34 (2.34)	0.88	-4.46–4.53	0.30 (2.37)	0.89	-3.93–5.21	1.77 (2.57)	0.49	-3.31-6.86

n=525

FBS fasting blood sugar, HbA1c hemoglobin A1c, TG triglyceride, TC total cholesterol, HDL-c high density lipoprotein, LDL-c low density lipoprotein, CI confidence interval

[a] Multivariate linear regression models. In all cases regression coefficient was expressed as B and standard error as SE and p-value of regression

Model 1 was adjusted for Age, sex, diabetes duration, type and drug dosage

Model 2 was adjusted for Age, sex, diabetes duration, type and drug dosage, calorie intake

Model 3 was adjusted for Age, sex, diabetes duration, type and drug dosage, calorie intake, physical activity

Model 4 was adjusted for Age, sex, diabetes duration, type and drug dosage, calorie intake, physical activity, proportion of dietary protein

Table 5: Association of clinical and biochemical parameters with Traditional like dietary pattern [a]

	Model 1			Model 2		
	B (SE)	***P* value**	**95% CI**	**B (SE)**	***P* value**	**95% CI**
FBS	-3.33 (5.65)	0.55	-13.56–7.38	-1.70 (5.77)	0.76	-12.61–9.69
HbA1c	0.04 (0.16)	0.80	-0.23–0.37	0.06 (0.16)	0.68	-0.19–0.43
TG	1.24 (9.49)	0.89	-15.58–20.96	3.56 (9.70)	0.71	-14.76–24.67
TC	0.55 (3.44)	0.87	-6.23–7.34	-0.89 (3.49)	0.79	-6.62–7.54
HDL-c	-.44 (3.68)	0.90	-6.78–7.03	-1.67 (3.76)	0.65	-9.05–6.29
LDL-c	-0.46 (2.16)	0.83	-4.36–4.15	-1.44 (2.19)	0.51	-5.0-3.88

n=525

FBS fasting blood sugar, HbA1c hemoglobin A1c, TG triglyceride, TC total cholesterol, HDL-c high density lipoprotein, LDL-c low density lipoprotein, CI confidence interval

[a] Multivariate linear regression models. In all cases regression coefficient was expressed as B and standard error as SE and p-value of regression

Model 1 was adjusted for Age, sex, diabetes duration, type and drug dosage

Model 2 was adjusted for Age, sex, diabetes duration, type and drug dosage, calorie intake

Discussion

In investigating the relationship between major dietary patterns and diabetes-related cardio-metabolic risk factors, we identified three dietary patterns. Western like pattern characterized by higher consumption of sweets, fast foods, carbonated drinks, red meat, mayonnaise, nuts, refined grains, potato and visceral meat was associated with poorer glycemic and lipid control. However, after adjustment for proportion of dietary protein and fat, only relationship between TC and this dietary pattern remained significant.

In this study, Western like dietary pattern was almost similar to unhealthy and western dietary pattern in previous studies conducted in similar population (23, 24). Asian like and Traditional like dietary patterns had common components with healthy dietary pattern in aforementioned studies (23, 24). Dietary patterns rich in red or processed meat, refined grains, French fries, potato and sweets increases the risk of developing CVD risk factors (25-27), consequently resulting in a higher risk of mortality from cardiovascular disease in the general population (25, 28, 29). A systematic review based on literature research the association between dietary pattern and risk of CVD among adults in the Middle East and North Africa region (including Iran), revealed a significant association between Western dietary pattern (including sweets, fatty foods, meat, whole dairy products, fast food, salty nuts, and canned foods) with the increased risk of coronary heart disease, strokes, and associated risk factors such as dyslipidemias, diabetes, metabolic syndrome, obesity, and hypertension (30).

Evidences support the effects of dietary intervention on modifying diabetes-related risk factors due to maintenance of blood glucose close to normal levels (31-33), improving lipid profile (31, 32, 34), lowering blood pressure (32, 34) and weight (35).

An association found between western dietary pattern and biomarkers of CVD (36). The association of healthy (26), prudent (25), Mediterranean (37) and DASH diet (38) (rich in vegetables, fruits, nuts and low intake of meats and sugars) with reduced risk of CVD and mortality is reported in the general population.

However, few studies have investigated the relationship between dietary patterns and cardiometabolic risk factors in diabetic patients. Four major dietary patterns reported among Korean type 2 diabetic adults. These four patterns included 'Bread & Meat & Alcohol' with some degree of similarity with the Western-like dietary pattern, 'Noodles & Seafood', 'Rice & Vegetables', and finally 'Korean Healthy' which had common food groups with Asian like and Traditional like dietary patterns. Consistent with our results, serum TC level was increased in the 'Bread & Meat & Alcohol' pattern (high loaded with breads, sugars, meats, oil, beverage, and alcohol) (18). In a prospective study of Japanese type 2 diabetic elderlies, (39) reported three dietary patterns: healthy dietary pattern which was rich in vegetables, seaweeds, fish, and beans (having similar components as the Asian- and Traditional like dietary patterns), snack dietary pattern (which consisted of sweets, potatoes and fruits) and greasy dietary pattern (characterized by high intake of meats and fats similar to the Western like dietary pattern) (39). In their study, higher weight and BMI was reported in those following the snack dietary pattern. In company with our results, there were no significant differences in HbA1c, FBS, and blood pressure of those following these three dietary patterns (39).

The adverse effects of the Western-like pattern can be attributed to high content of sweets, beverages, meat and refined grains, which can influence glucose metabolism and diabetes-related risk factors because of high levels of saturated fatty acids, glycemic index, iron and low level of fiber (11, 12).

Prospective studies discovered that dietary patterns rich in meat increase the risk of all-cause mortality, especially those secondary to diabetes (40). Several studies reported the association between red and processed meat consumption and the development of metabolic syndrome (41, 42), and cardiovascular risk factors (43, 44) in nondiabetic individuals. This could be explained by the high content of high-saturated fatty acids, cholesterol and trance fatty acids in red and processed meat, which may result in increased blood cholesterol and subsequently endothelium impaired function (43). The association between red meat heme iron and high CVD risk and also mortality has been noted in diabetic and non diabetic patients (45, 46). Heme iron may lead to the formation of free radicals, increase oxidative damage and deteriorate the CVD risk factors (46). Heterocyclic amines and aromatic polycyclic hydrocarbures in processed meat play an important role in CVD risk factors (42). Dietary patterns characterized with high carbohydrate, especially rice in the Asian population were associated with higher risk of developing diabetes and CVD (47, 48) due to high glycemic index and low fiber (49). Evaluating the nutrition transition in Iran showed that white rice and refined grains are considered as Iranian staple foods (50). Sweets and carbonated drinks also have a role in developing CVD risk because of their high glycemic load, which increases the levels of inflammatory biomarkers (51).

Lack of significant association between dietary pattern and clinical and laboratory data in our study might be due to extensive adjustment of potentially important confounding factors, including proportion of dietary protein and fat. Previous Studies (19, 39) did not adjust for such confounding factors, leaving a possibility of overestimation of the effect of that dietary pattern. The large sample size, using a validated FFQ, case ascertainment based on physician diagnosis, and extensive adjustment for potentially confounding factors are among the strong points of this study.

This study suffered from several limitations such as its limited ability to infer causality because of its cross-sectional nature and one-time point measurement of dietary intakes, subjective decision making for determination of number of patterns, the method of rotation and patterns labeling. Since dietary pattern varies according to ethical, cultural and environmental circumstances, our results should be tested in other populations.

Conclusion

Three dietary patterns were derived in this study. After extensive adjustment for potential confounders, Western-like dietary pattern consisted of high loaded sweets, fast foods, carbonated drinks, red meat, mayonnaise, nuts, refined grains, potato and visceral meat, was positively associated with higher serum TC levels. This finding may be useful for nutritional prescriptions and dietary modifications in diabetes management and diabetes-associated cardio metabolic complications prevention, especially in those who follow a Western dietary pattern.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgments

The authors would like to thank the Endocrinology and Metabolism Research institute for its financial support. We thank Mohammad Abbasi and Afsaneh Vosoogh along with the staff of the EMRI laboratory for performing the biochemical analysis. The authors declare that there is no conflict of interests.

References

1. Shaw J, Sicree R, Zimmet P (2010). Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Res Clin Pract*, 87(1):4-14.
2. Harati H, Hadaegh F, Saadat N, Azizi F (2009). Population-based incidence of Type 2 diabetes and its associated risk factors: results from a six-year cohort study in Iran. *BMC Public Health*, 9(1):186.
3. Williams R, Van Gaal L, Lucioni C (2002). Assessing the impact of complications on the costs of Type II diabetes. *Diabetologia*, 45(7):S13-S7.
4. Stratton IM, Adler AI, Neil HAW, Matthews DR, Manley SE, Cull CA, et al. (2000). Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *BMJ*, 321(7258):405-12.
5. Association AD (2013). Economic costs of diabetes in the US in 2012. *Diabetes Care*, 36(4):1033-46.

6. Turner R, Holman R, Cull C, Stratton I, Matthews D, Frighi V, et al. (1998). Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet*, 352(9131):837-53.
7. Ajala O, English P, Pinkney J (2013). Systematic review and meta-analysis of different dietary approaches to the management of type 2 diabetes. *Am J Clin Nutr*, 97(3):505-16.
8. Castaneda Gonzalez LM, Bacardi Gascon M, Jimenez Cruz A (2011). Effects of low carbohydrate diets on weight and glycemic control among type 2 diabetes individuals: a systemic review of RCT greater than 12 weeks. *Nutr Hosp*, 26(6):1270-6.
9. Hu FB (2002). Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol*, 13(1):3-9.
10. Jinlin F, Binyou W, Terry C (2007). A new approach to the study of diet and risk of type 2 diabetes. *J Postgrad Med*, 53(2):139.
11. Fung TT, Schulze M, Manson JE, Willett WC, Hu FB (2004). Dietary patterns, meat intake, and the risk of type 2 diabetes in women. *Arch Intern Med*. 164(20):2235-40.
12. Van Dam RM, Rimm EB, Willett WC, Stampfer MJ, Hu FB (2002). Dietary patterns and risk for type 2 diabetes mellitus in US men. *Ann Intern Med*, 136(3):201-9.
13. Montonen J, Knekt P, Härkänen T, Järvinen R, Heliövaara M, Aromaa A, et al. (2005). Dietary patterns and the incidence of type 2 diabetes. *Am J Epidemiol*, 161(3):219-27.
14. Alhazmi A, Stojanovski E, McEvoy M, Garg M (2014). The association between dietary patterns and type 2 diabetes: a systematic review and meta-analysis of cohort studies. *J Hum Nutr Diet*, 27(3):251-60.
15. Martínez González MÁ, de la Fuente Arrillaga C, Nunez Cordoba JM, Basterra Gortari FJ, Beunza JJ, Vazquez Z, et al. (2008). Adherence to Mediterranean diet and risk of developing diabetes: prospective cohort study. *BMJ*, 336(7657):1348-51.
16. Panagiotakos DB, Tzima N, Pitsavos C, Chrysohoou C, Zampelas A, Toussoulis D, et al. (2007). The association between adherence to the Mediterranean diet and fasting indices of glucose homoeostasis: the ATTICA Study. *J Am Coll Nutr*, 26(1):32-8.
17. Esposito K, Marfella R, Ciotola M, Di Palo C, Giugliano F, Giugliano G, et al. (2004). Effect of a Mediterranean-style diet on endothelial dysfunction and markers of vascular inflammation in the metabolic syndrome. *JAMA*, 292(12):1440-6.
18. Kastorini CM, Milionis HJ, Esposito K, Giugliano D, Goudevenos JA, Panagiotakos DB (2011). The Effect of Mediterranean Diet on Metabolic Syndrome and its ComponentsA Meta-Analysis of 50 Studies and 534,906 Individuals. *J Am Coll Cardiol*, 57(11):1299-313.
19. Lim JH, Lee YS, Chang HC, Moon MK, Song Y (2011). Association between dietary patterns and blood lipid profiles in Korean adults with type 2 diabetes. *J Korean Med Sci*, 26(9):1201-8.
20. Azadbakht L, Mirmiran P, Esmaillzadeh A, Azizi F (2005). Dairy consumption is inversely associated with the prevalence of the metabolic syndrome in Tehranian adults. *Am J Clin Nutr*, 82(3):523-30.
21. Safari A, Shariff ZM, Kandiah M, Rashidkhani B, Fereidooni F (2013). Dietary patterns and risk of colorectal cancer in Tehran Province: a case–control study. *BMC Public Health*, 13(1):222.
22. Kelishadi R, Rabiei K, Khosravi A, Famouri F, Sadeghi M, Rouhafza H, et al. (2001). Assessment of physical activity of adolescents in Isfahan. *Shahrekord Univ Med Sci*, 3 (2) :27-33.
23. Esmaillzadeh A, Azadbakht L (2008). Major dietary patterns in relation to general obesity and central adiposity among Iranian women. *J Nutr*, 138(2):358-63.
24. Rezazadeh A, Rashidkhani B, Omidvar N (2010). Association of major dietary patterns with socioeconomic and lifestyle factors of adult women living in Tehran, Iran. *Nutrition*, 26(3):337-41.
25. Hu FB, Rimm EB, Stampfer MJ, Ascherio A, Spiegelman D, Willett WC (2000). Prospective study of major dietary patterns and risk of coronary heart disease in men. *Am J Clin Nutr*, 72(4):912-21.
26. Huijbregrts PP, Feskens EJ, Kromhout D (1995). Dietary patterns and cardiovascular risk

factors in elderly men: the Zutphen Elderly Study. *Int J Epidemiol*, 24(2):313-20.
27. Van Dam RM, Grievink L, Ocké MC, Feskens EJ (2003). Patterns of food consumption and risk factors for cardiovascular disease in the general Dutch population. *Am J Clin Nutr*, 77(5):1156-63.
28. Heidemann C, Schulze MB, Franco OH, van Dam RM, Mantzoros CS, Hu FB (2008). Dietary patterns and risk of mortality from cardiovascular disease, cancer, and all causes in a prospective cohort of women. *Circulation*, 118(3):230-7.
29. Shimazu T, Kuriyama S, Hozawa A, Ohmori K, Sato Y, Nakaya N, et al. (2007). Dietary patterns and cardiovascular disease mortality in Japan: a prospective cohort study. *Int J Epidemiol*, 36(3):600-9.
30. Van Dam RM, Rimm EB, Willett WC, Stampfer MJ, and Hu FB (2002). Summaries for patients. Dietary patterns and the risk for type 2 diabetes in U.S. men. *Ann Intern Med*, 136(3):I30.
31. Rizkalla SW, Taghrid L, Laromiguiere M, Huet D, Boillot J, Rigoir A, et al. (2004). Improved plasma glucose control, whole-body glucose utilization, and lipid profile on a low-glycemic index diet in type 2 diabetic men: a randomized controlled trial. *Diabetes Care*, 27(8):1866-72.
32. Champagne CM (2009). The usefulness of a Mediterranean-based diet in individuals with type 2 diabetes. *Curr Diab Rep*, 9(5):389-95.
33. Bajorek SA, Morello CM (2010). Effects of dietary fiber and low glycemic index diet on glucose control in subjects with type 2 diabetes mellitus. *Ann Pharmacother*, 44(11):1786-92.
34. Tzima N, Pitsavos C, Panagiotakos DB, Skoumas J, Zampelas A, Chrysohoou C, et al. (2007). Mediterranean diet and insulin sensitivity, lipid profile and blood pressure levels, in overweight and obese people; the Attica study. *Lipids Health Dis*, 6:22.
35. Gerhard GT, Ahmann A, Meeuws K, McMurry MP, Duell PB, Connor WE (2004). Effects of a low-fat diet compared with those of a high-monounsaturated fat diet on body weight, plasma lipids and lipoproteins, and glycemic control in type 2 diabetes. *Am J Clin Nutr*, 80(3):668-73.
36. Fung TT, Rimm EB, Spiegelman D, Rifai N, Tofler GH, Willett WC, et al. (2001). Association between dietary patterns and plasma biomarkers of obesity and cardiovascular disease risk. *Am J Clin Nutr*, 73(1):61-7.
37. Sofi F, Cesari F, Abbate R, Gensini GF, Casini A (2008). Adherence to Mediterranean diet and health status: meta-analysis. *BMJ*, 337:a1344.
38. Fung TT, Chiuve SE, McCullough ML, Rexrode KM, Logroscino G, Hu FB (2008). Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. *Arch Intern Med*, 168(7):713-20.
39. Iimuro S, Yoshimura Y, Umegaki H, Sakurai T, Araki A, Ohashi Y, et al. (2012). Dietary pattern and mortality in Japanese elderly patients with type 2 diabetes mellitus: Does a vegetable-and fish-rich diet improve mortality? An explanatory study. *Geriatr Gerontol Int*, 12(s1):59-67.
40. Cai H, Shu XO, Gao YT, Li H, Yang G, Zheng W (2007). A prospective study of dietary patterns and mortality in Chinese women. *Epidemiology*, 18(3):393-401.
41. Azadbakht L, Esmaillzadeh A (2009). Red meat intake is associated with metabolic syndrome and the plasma C-reactive protein concentration in women. *J Nutr*, 139(2):335-9.
42. Babio N, Sorlí M, Bulló M, Basora J, Ibarrola Jurado N, Fernández Ballart J, et al. (2012). Association between red meat consumption and metabolic syndrome in a Mediterranean population at high cardiovascular risk: Cross-sectional and 1-year follow-up assessment. *Nutr Metab Cardiovasc Dis,* 22(3):200-7.
43. Polychronopoulos E, Pounis G, Bountziouka V, Zeimbekis A, Tsiligianni I, Qira BE, et al. (2010). Dietary meat fats and burden of cardiovascular disease risk factors, in the elderly: a report from the MEDIS study. *Lipids Health Dis*, 9(1):30.
44. Tzoulaki I, Brown IJ, Chan Q, Van Horn L, Ueshima H, Zhao L, et al. (2008). Relation of iron and red meat intake to blood pressure: cross sectional epidemiological study. *BMJ*, 337:a258.
45. Peeters PH, Grobbee DE, Marx JJ, van der Schouw YT (2005). Dietary haem iron and coronary heart disease in women. *Eur Heart J*, 26(3):257-62.

46. Qi L, Van Dam RM, Rexrode K, Hu FB (2007). Heme iron from diet as a risk factor for coronary heart disease in women with type 2 diabetes. *Diabetes Care*, 30(1):101-6.
47. Erber E, Hopping BN, Grandinetti A, Park SY, Kolonel LN, Maskarinec G (2010). Dietary patterns and risk for diabetes: the multiethnic cohort. *Diabetes Care*, 33(3):532-8.
48. Park SH, Lee KS, Park HY (2010). Dietary carbohydrate intake is associated with cardiovascular disease risk in Korean: analysis of the third Korea National Health and Nutrition Examination Survey (KNHANES III). *Int J Cardiol*, 139(3):234-40.
49. Nanri A, Mizoue T, Noda M, Takahashi Y, Kato M, Inoue M, et al. (2010). Rice intake and type 2 diabetes in Japanese men and women: the Japan Public Health Center–based Prospective Study. *Am J Clin Nutr*, 92(6):1468-77.
50. Ghassemi H, Harrison G, Mohammad K (2002). An accelerated nutrition transition in Iran. *Public Health Nutr*, 5(1a):149-55.
51. Malik VS, Popkin BM, Bray GA, Després J-P, Hu FB (2010). Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Circulation*, 121(11):1356-64.