

Healthy Dietary Pattern is Related to Blood Lipids in Patients with Type 1 Diabetes Mellitus: A Cross-sectional Study from a Developing Country

Abstract

Background: The association between dietary patterns and cardiovascular disease (CVD) risk factors has been investigated in very limited studies in patients with type 1 diabetes mellitus (T1DM). The aim of this study was to determine the relationship between the major dietary patterns and CVD risk factors in these patients. **Methods:** A cross-sectional study was performed on 169 females of 18--35 years who were diagnosed with T1DM attending Iranian Diabetes Association in Tehran. Anthropometric measures, blood glucose, and lipid levels of all participants were measured. Dietary data was collected using a food frequency questionnaire. Dietary patterns were determined by factor analysis. Using the analysis of covariance (ANCOVA), mean value of the biochemical factors across the tertiles of dietary patterns was compared. **Results:** Three major dietary patterns were identified: the grain, legume and nut (GLN), the fruits and vegetables (FV), and the high calorie foods, salty snacks, sweet and dessert (HSD). After adjustment for age, body mass index and energy intake, subjects who were in the highest tertile of FV pattern had significantly lower levels of LDL-c ($P = 0.01$), triglyceride (TG) ($P = 0.02$), and total cholesterol ($P = 0.01$). GLN and HSD patterns had no significant relationship with blood glucose and lipids. **Conclusions:** This study demonstrates that a dietary pattern rich in vegetables and fruits may be inversely associated with dyslipidemia in patients with T1DM. The results can be used for developing interventions that aim to promote healthy eating for the prevention of CVD in these patients.

Keywords: Blood lipids, cardiovascular, dietary pattern, type 1 diabetes

Introduction

There are 425 million individuals with type 1 (T1DM) or type 2 diabetes mellitus (T2DM) around the globe. Five percent of this figure is T1DM. The risk of developing cardiovascular disease (CVD), dyslipidemia including low blood levels of HDL-c and high levels of total cholesterol (TC), triglyceride (TG), LDL-c, and blood pressure in these patients is two to four times more than nondiabetic individuals.^[1]

Diet as an important modifiable factor is related to CVD risk factors.^[2] Identifying dietary patterns and assessing their relationship with chronic diseases is better than studying the relationships between single nutrients or foods and diseases because the nutrients of different foods may have diminishing or exacerbating effects.^[3] There are two main approaches for determination of dietary patterns, priori and posteriori approaches. In a priori approach,

dietary patterns are identified based on previous knowledge of healthy foods. On the other hand, in a posteriori approach, statistical methods are applied to the dietary data in order to identify patterns.^[3]

American Diabetes Association (ADA) does not recommend a specific percentage of calories from carbohydrate, protein, and fat for diabetic patients. However, it encourages healthy food choices such as vegetables, fruits, whole grains, and monounsaturated and omega-3 fatty acids.^[3]

The study of dietary patterns and CVD risk factors such as dyslipidemia and hypertension in T1DM patients is very limited.^[4-6] Some studies conducted among T1DM patients that showed healthy dietary pattern with high intakes of vegetables, fruits, fish, and yoghurt were related to better glycemic control in T1DM patients.^[4] On the other hand, the direct relationship of unhealthy dietary pattern, featured with high content of high-fat cakes, and pickled vegetables, with serum LDL-c and

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glycated hemoglobin (HbA1c) levels in these patients has been reported.^[5] In addition, a dietary pattern characterized by high intakes of eggs, sweetened beverages, diet soda, potatoes, high-fat meat, and low intakes of sweets/desserts and low-fat dairy was associated with CVD risk factors including dyslipidemia, hypertension, and waist circumference in T1DM.^[6] High content of nutrients and phytochemicals in healthy foods such as fiber, vitamins, minerals, and other compounds may have beneficial effect on lipid profile, blood pressure, and body weight.^[7]

It has been argued that dietary patterns are influenced by sex, geographic, social, environmental, and cultural factors. So it is better to do these investigations in diverse population.^[8] The aim of this study was to find the association of dietary patterns and some cardiometabolic factors in female adults with T1DM.

Methods

Subjects

The present study is part of a cross-sectional study which aimed to investigate the relationship between dietary intake and CVD risk factors in patients with T1DM. The sample size was calculated using the following equation:

$$\frac{(z_{1-\frac{\alpha}{2}} + z_{2,\beta})^2 SD_1^2 + SD_2^2}{\mu_2 - \mu_1}$$

A total of 96 diabetic patients were calculated in each tertile of dietary intake based on total fat intake,^[9] with 95% confidence level and 90% power. The total sample size was 288. In practice, 273 patients with T1DM were recruited. As gender differences have been reported in the dietary patterns and their association with the metabolic syndrome,^[10] we restricted the present study to only 169 female patients. The participants were recruited from Iranian Diabetes Association and Diabetes Research Center of Tehran University of Medical Sciences located in Tehran, Iran, from January 2016 to March 2018. Patients attending these centers were invited to participate in the study. Inclusion criteria were diagnosed with T1DM for at least 6 months, 18--35 years, and HbA1c less or equal to 8%. The exclusion criteria were pregnancy or lactation, smoking, any other diagnosed diseases such as liver and kidney diseases, CVD, cancer, and using any other medication except insulin. The study was completely explained to the participants and a written consent form was obtained from them. The research has been approved by the Ethics Committee of the Tehran University of Medical Sciences.

Dietary analysis

To evaluate the dietary intake, a 147 item, semiquantitative food frequency questionnaire (FFQ) was used.^[11] The patients were requested to mention the consumption of the food items contained in this questionnaire in terms of per day, week, month, and year, and also the amount in each

time, keeping in mind their food consumption in the past year. The reliability and validity of the questionnaire was confirmed.^[11] The food items were converted to g/d and analyzed for their energy content using the Nutritionist 4 software modified for Iranian foods.

Anthropometry and physical activity assessment

Height was recorded from the medical file of patients and weight was measured with minimal clothing and shoes off, on a digital scale with the accuracy of 100 g. Body mass index (BMI) was calculated as the division of weight by square height. Waist circumference was measured with an accuracy of 0.5 cm, midway between the last rib and the iliac crest. All measurements were done by the first author as a nutrition student.

The short form of international physical activity questionnaire (IPAQ) was used to assess physical activity of participants during the previous 7 days.^[12] To compute activities, the duration and number of activities were multiplied by the metabolic equivalent task (MET) value of the activity and summed all activities to gain an estimate of total physical activity.

Laboratory measurements

Due to funding limitations, 58 women, using random sample table, were selected from the participants for biochemical evaluation. After 12 h of fasting, 10 ml of venous blood sample was collected. The blood samples were centrifuged for 10 min at 3,000 rpm, in order to separate the serum. The serum was used to assess fasting blood sugar (FBS), HDL-c, TG, and TC levels. Pars Azmoon kit (manufactured in Iran) was used to assay the latter biochemical factors. TG was measured by enzymatic colorimetry and photometry.^[13] FBS and total cholesterol levels were detected with enzymatic colorimetry and single point with photometric method.^[13,14] LDL-c was calculated through Freidewald formula.^[15]

Statistical analysis

The SPSS, version 24 (Armonk, NY: IBM Corp), was used for analysis. As it has been suggested, for dealing with under or over reporting of energy intake in women,^[16] those who had reported energy intake out of 500 to 3,500 kcal per day were excluded from the study ($n = 6$).^[16] The Kolmogorov-Smirnov test was used to evaluate the normality of the data. Logarithmic transformation was applied to skewed variables. The geometric mean (standard error of mean) was calculated for the transformed data. Dietary patterns were obtained based on factor analysis using the principal component analysis method.^[17] First, the foods were categorized into 13 groups in terms of food items similarity and a previous study.^[18] The number of factors was chosen by the scree plot, and eigenvalues of over 1.^[19] A varimax rotation was carried out to create a simple and definitive component matrix.^[19] The factor

score for each pattern was calculated by summing intakes of food groups weighted by their factor score matrix. Then we categorized participants into tertiles of dietary patterns scores. To evaluate the relationship between education and dietary supplement intake with dietary patterns, Chi-square test was used. To compare the mean value of the biochemical factors across the tertiles of dietary patterns, a one-way ANOVA test was employed. Further, using the analysis of covariance (ANCOVA), the mean value of the biochemical factors across the tertiles of dietary patterns was compared with adjustment for age, BMI, and energy intake.

Results

In this study, 179 women were invited to participate. Six patients refused to participate and four women were not eligible for the study. In addition, six patients reported energy intake less than 500 kcal and more than 3,500 kcal which were excluded from the analysis. So the final analysis was performed on 163 patients. The mean age of the participants was 25.5 ± 5.1 years, with T1DM duration of 13.1 ± 5.9 years. Their mean serum HbA1c level was $6.9\% \pm 0.8\%$ [Table 1].

Three major dietary patterns were found: the grain, legume, and nut (GLN), the fruits and vegetables (FV), and the high calorie foods, salty snacks, sweet and dessert (HSD). Table 2 shows the food groups and Table 3 shows the factor loading of each of the three obtained dietary patterns. The three presented dietary patterns cover 33.87% of the total variance of all exploratory dietary patterns. The variance for GLN, FV, and HSD patterns were 11.4%, 11.4% and 11.0%, respectively.

In the FV dietary pattern, subjects in the third tertile were older than the subjects of the first tertile ($P < 0.001$). In the GLN dietary pattern, subjects in the third tertile had lower BMI ($P = 0.01$). In addition, in all three dietary patterns, energy intake in the third tertiles was significantly higher than the first tertiles ($P < 0.04$) [Table 4]. No relationship was found between dietary patterns and education or dietary supplement intake [Table 5].

After adjustment for age, BMI, and energy intake, subjects in the third tertile of the FV pattern had a significantly lower serum LDL-c ($P = 0.01$), TG ($P = 0.02$), and TC ($P = 0.01$) compared with the subjects in the first tertile. This difference for FBS was close to significant ($P = 0.06$). Subjects in the third tertile of the GLN pattern had lower serum FBS and some blood lipids. In addition, adherence to HSD pattern was associated to higher serum FBS and higher blood lipids. However, these differences were not significant [Table 6].

Discussion

In this cross-sectional study, which is the first study to investigate dietary patterns in Iranian females with

Table 1: Characteristics of patients with type 1 diabetes mellitus

Variable	Mean±SD or n (%)
Age (year)	25.5±5.1 ^a
Weight (kg)	60.6±8.6
Diabetes duration (year)	13.1±5.9
Waist circumference (cm)	82.4±9.1 ^a
BMI (kg/m ²)	23.1±3.1 ^a
Insulin dosage (U/day)	45.1±15.3
Physical activity (MET)	1218.7±1441.5 ^a
Energy intake (kcal/day)	2243±599.4
Systolic blood pressure (mmHg)	105.8±10.9
Diastolic blood pressure (mmHg)	73.6±6.3
HbA1c (%)	6.9±0.8
Fasting blood sugar (mg/dl)	162.2±10.7 ^a
HDL-c (mg/dl)	54±1.2 ^a
LDL-c (mg/dl)	100.3±24.7
Triglyceride (mg/dl)	72.3±4.8 ^a
Total cholesterol (mg/dl)	172.2±27.9
Education	
Associate degree and less	47 (28.8)
Bachelor and more	116 (71.2)
Dietary supplement intake	66 (40.5)

^ageometric mean±SEM

Table 2: Food groups and their components.

Food Groups	Subgroups
Grains	White breads, Baguette, Rice, Spaghetti, Vermicelli, Corn, Oat, Potato
Salty snacks	Cracker, Chips, Cheese puff
Red meat	Beef, Lamb, Ground beef, Hamburger, Organ Meat (liver, kidney, face, etc)
White meat and egg	Egg, Chicken, Fish, Tuna Fish
High calorie foods	Pizza, Sausage, Kielbasa, Fried potato
Dairy	High/Low fat milk, High/Low fat yogurt, Strained yogurt, Cheese, Cream cheese, Yogurt drink, Cream, Curd, Ice cream
Hydrogenated oil	Hydrogenated oils, Animal fat, Butter
Liquid oils	Olive oil, Other liquid oil, Mayonnaise
Vegetables	Cucumber, Zucchini, Celery, Green pea, Green bean, Green pepper, Lettuce, Cruciferous, Tomato, Pumpkin, etc.
Pickles/Olive	Olive, Picked vegetables
Fruits	Fresh fruit juice, Dried fruit, Melons, Watermelon, Pear, Apricot, Cherry, Apple, Peach, Nectarine, Fig, Grapes, Pomegranate, Kiwi, etc.
Nuts and Legume	Peanut, Almond, Walnut, Pistachio, Hazelnut, Seeds, Beans, Lentil, Chickpea, Soy bean, Split pea
Sweets and Dessert	Sugar, Honey, Soft Drinks, Candies and rock candy, Jam, Cake, Biscuits, Halva, Pastry

T1DM, major dietary patterns have been determined and the association of these dietary patterns and some CVD risk factors was assessed in a subgroup of patients. The

results of this study show that the FV dietary pattern is inversely related to serum LDL-c, TG, and TC. However, no significant relationship was found between CVD risk factors and other dietary patterns.

A diet rich in vegetables, fruits, fish, and yogurt was related to better glycemic control in T1DM patients.^[4] Another study found that a dietary pattern low in wheat products and high in cakes, beans and pickled vegetable was positively associated with serum LDL-c and HbA1c.^[5] In addition, high adherence to a dietary pattern characterized by high intakes of eggs, sweetened beverages, diet soda, potatoes, high-fat meat, and low intakes of sweets/desserts, and low-fat dairy was associated with better lipid profile, blood pressure, and waist circumference in T1DM.^[6] Different age of participants, different dietary intake measurements (FFQ or other methods), and different dietary analysis (factor analysis or reduced rank regression methods) may in part explain these differences.

In the present study, the FV dietary pattern was loaded with high fruits and vegetables. In addition, it contains higher amounts of legume, nuts, and liquid oils. This pattern may have a beneficial effect on serum TG, LDL-c, and TC. Fruits and vegetables intake is known to improve glucose and lipid disturbances.^[20] Furthermore, consumption of legumes has beneficial effects on CVD risk factors.^[21]

In this study, unexpectedly, no relationship was observed between the GLN and HSD patterns and CVD risk factors. The GLN dietary pattern which is rich in grain, legume and nut (GLN) also contains dairy, sweets, desserts, olive, and pickled vegetable. This finding might be due to high consumption of grains in this pattern, which are refined

Table 3: Factor loading for major dietary patterns

	Food groups	Dietary patterns		
		GLN	FV	HSD
1	Grain	0.79		
2	Legume and Nut	0.71	0.33	
3	Fruit		0.79	
4	Vegetable		0.73	
5	High energy foods			0.77
6	Salty snacks			0.64
7	Sweets and dessert	0.24		0.56
8	Hydrogenated oils			
9	Red Meat		0.20	
10	Olive/Pickles	0.25		
11	White meat and egg			
12	Liquid oils		0.22	
13	Dairy	0.38		
	Variance explained, %	11.44	11.44	11.02

Values <0.20 were excluded from the table. Bartlett's test of Sphericity=204.654, $P < 0.001$, $DF = 78$ Kaiser Meyer Olkin=0.616 Total variance=33.87% GLN dietary pattern: Grain, Legume and nut FV dietary pattern: Fruit and Vegetable; HSD dietary pattern: High calorie foods, Salty snacks, Sweet and dessert

Table 4: Mean and standard deviation of variables across dietary patterns tertiles in female adults with type one diabetes (n=163)

Dietary Patterns	GLN Mean±SD			FV Mean±SD			HSD Mean±SD			P-trend
	T1	T2	T3	T1	T2	T3	T1	T2	T3	
Age (year) ^a	24.9±1.02	24.07±1.02	25.5±1.03	23.2±1.02	24.7±1.02	26.8±1.02	25.7±1.02	25.1±1.02	23.7±1.04	0.1
BMI (kg/m2) ^a	23.6±1.01	22.03±1.01	23.1±1.01	22.8±1.01	22.81±1.01	23.1±1.01	23.2±1.01	22.7±1.01	22.8±1.01	0.6
Waist	81.7±1.01	80.7±1.01	83.02±1.01	81.3±1.01	81.9±1.01	82.1±1.01	82.1±1.01	82.1±1.01	81.1±1.01	0.7
Circumference (cm) ^a	14.63±5.1	12.0±5.7	12.9±6.7	12.0±6.0	13.6±5.5	13.8±6.2	13.9±6.0	13.4±6.3	12.1±5.4	0.1
Diabetes duration (year)	45.1±15.3	43.5±13.4	46.8±17.0	44.6±13.9	48.4±16.9	42.2±14.4	43.0±14.2	46.3±17.1	46.0±14.3	0.3
Insulin dose (U/day)	1869.0±509.2	2149.7±477.6	2712.1±480.5	1942.6±561.7	2164.7±506.4	2623.2±525.3	<0.001*	2100.6±628.0	2193.3±548.1	0.03*
Energy Intake (kcal)	710.6±1.1	626.8±1.1	679.5±1.1	522.3±1.1	692.5±1.1	848.4±1.1	620±1.1	691.4±1.1	703.4±1.1	0.8
Physical activity (MET) ^a										

*One-way ANOVA test, values less than 0.05 are significant. Mean quantitative factors in dietary patterns tertiles were compared with the one-way ANOVA test.^ageometric mean±SEM
GLN dietary pattern: Grain, Legume and nut FV dietary pattern: Fruits and Vegetables HSD dietary pattern: High calorie foods, Salty snacks, Sweet and dessert

Table 5: Demographic variables distribution across dietary patterns tertiles in female adults with type one diabetes (n=163)

Variable	Pattern	GLN			P	FV			P	HSD			P
		T1	T2	T3		T1	T2	T3		T1	T2	T3	
Education	Cycle, Diploma, Associate degree	14 (29.8)	16 (34)	17 (36.2)	0.8	18 (38.3)	15 (31.9)	14 (29.8)	0.6	15 (31.9)	15 (31.9)	17 (36.2)	0.8
	Bachelors, Masters, PHD, Medicine and dentistry	40 (34.5)	39 (33.6)	37 (31.9)		36 (31)	40 (34.5)	40 (34.5)		39 (33.6)	40 (34.5)	37 (31.9)	
Dietary supplement intake	Yes	20 (30.3)	22 (33.3)	24 (36.4)	0.7	22 (33.3)	24 (36.4)	20 (30.3)	0.7	23 (34.8)	20 (30.3)	23 (34.8)	0.7
	No	34 (35.1)	33 (34)	30 (30.9)		32 (33)	31 (32)	34 (35.1)		31 (32)	35 (36.1)	31 (32)	

*Chi-square test, P values less than 0.05 are significant. Demographic variables distribution across dietary patterns tertiles were compared with Chi-square test. GLN dietary pattern: Grain, Legume and nut; FV dietary pattern: Fruit and Vegetable HSD dietary pattern: High calorie foods, Salty snacks, Sweet and dessert

Table 6: Mean and standard deviation of cardiovascular disease risk factors across dietary patterns tertiles in female adults with type one diabetes mellitus (n=58)

Dietary patterns	Tertiles	HbA1c	FBS ^a	LDL	HDL ^a	TG ^a	Total cholesterol
GLN	T1	6.9±0.7	157.8±1.1	102.5±24.8	55.1±1.03	71.1±1.1	175.2±26.9
	T2	6.9±0.7	168±1.09	106.5±30.0	52.6±1.03	70.3±1.1	179.5±34.1
	T3	6.9±0.7	152.9±1.09	91.9±17.5	53.7±1.04	71.1±1.08	162.1±20.7
	P*	0.6	0.8	0.1	0.6	0.9	0.1
	p-trend**	0.8	0.7	0.1	0.3	0.6	0.1
FV	T1	7.0±0.8	197.8±1.1	109.9±24.8	50.8±1.05	84.7±1.1	181.3±28.9
	T2	6.8±0.7	131.8±1.1	88.7±17.7	55.3±1.03	60.4±1.08	159.4±23.3
	T3	6.9±0.8	160.5±1.08	103.2±26.9	54.7±1.03	71.9±1.08	176.7±28.0
	P*	0.5	0.03	0.3	0.3	0.053	0.6
	p-trend**	0.5	0.06	0.01	0.1	0.02	0.01
HSD	T1	6.8±0.9	145.6±1.1	97.4±22.5	54.7±1.04	75.5±1.1	171.7±26.6
	T2	7.0±0.6	167.3±1.1	97.7±24.1	52.7±1.03	64.1±1.09	157.7±28.9
	T3	7.0±0.8	164.3±1.1	108.6±28.4	54.5±1.04	77.4±1.1	180.8±28.0
	P*	0.1	0.5	0.2	0.7	0.3	0.3
	p-trend**	0.2	0.5	0.2	0.6	0.4	0.4

*One-way ANOVA, unweighted values **ANCOVA test, adjusted for age, BMI, and energy intake ^ageometric mean±SEM GLN dietary pattern: Grain, Legume and nut, FV dietary pattern: Fruit and Vegetable, HSD dietary pattern: High calorie foods, Salty snacks, Sweet and dessert

grains. Refined grains contain complex carbohydrate, which increase serum TG and result in dyslipidemia.^[22] The HSD dietary pattern is also high in sweets and dessert, high calorie foods, and salty snacks. All of these food groups have higher content of trans-fatty acids, simple carbohydrate, and salt which have adverse effect on blood lipids.^[22,23]

There were limitations to this study. First, collecting dietary data using FFQ rely on participants' memory. Second, factor analysis does not have any special protocol to follow. The food groups are arranged by the researcher based on experience. Third, cross-sectional studies only observe the current situation and no reason or cause is understood completely. Fourth, the findings of the present study might not be generalized to all T1DM patients including male patients. Fifth, residual confounding remains a possible concern for our results, since besides dietary pattern, food consumption

behaviors such as timing, number of meals, and ways of preparing the food are also important.^[24] However, the present study is one of the few studies that have examined the relationship between dietary patterns and CVD risk factors in T1DM.

Conclusions

We have found that the FV dietary pattern is inversely related to serum LDL-c, TG, and TC in females with T1DM which is implicated in the development of CVD in these patients; hence, female patients can reap the benefits of healthy dietary pattern to reduce the risk of CVD.

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Conflicts of interest

There are no conflicts of interest.

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