Original Article

Diet Quality and Total Daily Price of Foods Consumed among Iranian Diabetic Patients

Abstract

Background: The aim is to investigate the association between diet quality and daily price of foods consumed among Iranian diabetic patients. **Methods:** This cross-sectional study was conducted among 200 patients with type 2 diabetes mellitus (T2DM) aged 30–70 years. General information, socioeconomic status, anthropometric and biochemical characteristics, and food prices were collected by pretested questionnaires. Dietary intakes were assessed using a semi-quantitative reliable and valid food frequency questionnaire. Modified nutritionist IV and SPSS software were used for analyses. **Results:** The results of the present study indicated a direct relationship between total daily price of diet and nutrient adequacy ratio of Vitamin D, Vitamin B1, selenium, zinc, magnesium, potassium, and mean adequacy ratio of 11 micronutrients (Vitamin C, Vitamin E, Vitamin D, Vitamin B1, Vitamin B6, Vitamin B12, selenium, zinc, calcium, magnesium, and potassium) ($P < 0.05$). Furthermore, the total daily price of diet had a positive association with dietary intakes of protein, Vitamin D, Vitamin B1, selenium, zinc, magnesium and potassium among type 2 diabetic patients ($P < 0.05$). However, no significant relationship was observed between the total daily price of diet and anthropometric indices, biochemical characteristics, and socioeconomic status of participants in the present study ($P > 0.05$). **Conclusions:** This study showed that dietary quality and dietary intakes of energy, protein, and micronutrients were directly associated with the total daily price of foods among Iranian patients with type 2 diabetes.

Keywords: *Diabetes, diet costs, diet quality, price of foods*

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Introduction

Diabetes is one of the most important chronic diseases that affect millions of people all over the world. There were 285 million diabetic patients (6.4% of adults in the world) in 2010 and it is estimated that this population will increase to 438 million people (7.8% of adults) by 2030.[1] During the last decade, the prevalence of diabetes has increased in countries with low and medium income.[2] Currently, it is estimated that there are 1.5 million diabetic patients in Iran.[3] World Health Organization has predicted that the prevalence of diabetes will reach about 7 million by 2030 in Iran.[4] It is estimated that diabetes is the 9th and 21st cause of death among Iranian women and men, respectively.[5]

Type 2 diabetes mellitus (T2DM) and its complications including micro- and macro-vascular pathogenic conditions can affect the quality of life and mortality rate.[6] Lifestyle modifications including weight management, physical activity, and diet have an important role in reducing the prevalence of type 2 diabetes.[7,8] The beneficial effects of whole grains, legumes, fruits and vegetables, and nuts, as well as flavonoids, carotenoids, and other bioactive components on diabetes management, are well-established.[6]

Several factors such as socioeconomic status, waist circumference, mental condition, and hypothalamic–pituitary axis function are associated with food choices.[9-12] Furthermore, food choices are also influenced by food prices.[13] It seems that price of healthy foods particularly fruits, legumes, and nuts may be an important factor for intake and may result in buying foods with lower price and nutrients value, and more energy density.[14] Foods with a high density of energy such as cereals, fats and oils, and sugar and sweets provide more energy with less cost. The cost of 1 kJ of nutritious foods such as vegetables, fish, and fruits is much more than low nutritious foods in most countries.[15] Accordingly, the results of observational studies were inconsistent;

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some of them showed that healthy diets cost more than less healthy ones,[16-21] whereas another study did not confirm this relation.[22] Stender *et al*. declared that reducing dietary fat from 35% of calories to 25% could increase the cost of foods about 10%–20% for Danish children.[21]

Moreover, many interventional studies have examined the relationship between quality of diet and cost of foods.[7,22-25] It was shown that increasing the amount of dietary fiber could decrease the dietary cost.[7] Furthermore, Raynor *et al*. showed that reducing the intake of low energy density foods was accompanied by increased diet energy density and decreased food costs.[25]

Although several studies[7,20,22] have shown the importance of the relationship between diet quality and cost of foods during the last decade, there is no study that has assessed this relationship among either Iranian people or diabetic patients. In addition, due to the high price of medical care for diabetic patients, dietary costs can be an important factor which affects dietary choices and dietary intakes, and consequently, reduces the quality of diet. According to the best of our knowledge, there are no data about diet quality indices and cost of foods in patients with T2DM worldwide. In addition, there is no study about the association of diet costs with anthropometric measurements and biochemical indices among diabetic patients. Therefore, the aim of the present study was to evaluate the relationship between quality of diet and cost of foods among patients with type 2 diabetes in Iran.

Methods

Subjects

Among patients attending Samen clinic of diabetes during June-July 2012 in Isfahan, Iran, 200 T2DM patients aged 30–70 years were recruited to this cross-sectional study. According to the formula of cross-sectional studies ($n = Z^2S^2/d^2 = (1.96 + 0.85)^2\ (53.6)^2/(13)^2 = 134$),[26,27] the adequate sample size to induce significant changes in fasting blood sugar (FBS) levels was obtained 134. Due to probable losses resulted from under-reporting, over-reporting and failure to fill out the questionnaires, 200 diabetic patients were included. The study protocol was explained by a trained dietitian, and then all participants completed a written informed consent. Following questionnaires were filled out by a trained dietician: general information, socioeconomic status, and food frequency questionnaire (FFQ). Being a diabetic patient (FBS >126 mg/dl), aged ≥30 years, and willing to participate in this study were considered to be inclusion criteria. However, those who reported energy intakes <800 kcal and more than 4200 kcal were excluded form the study. This study was confirmed by the research and ethic council of Isfahan University of Medical Sciences (No. 192040).

Dietary assessment

Usual dietary intakes were assessed using a reliable and validated 168-item semi-quantitative FFQ.[28] Participants were asked to report the frequency of consumption for each food item during the previous year, and FFQ questionnaires were completed by the study staff. Then, the reported frequency of each food item was converted to daily intake. Daily dietary intakes were assessed using NUTRITIONIST IV software which was modified for Iranian foods.

According to previous studies,[29-38] it seems that following micronutrients have an important role in T2DM pathogenesis: Vitamin C,[29] Vitamin E,[29] Vitamin D,[30] Vitamin B1,[31] Vitamin B6,[32] Vitamin B12,[33] selenium,[34] zinc,[35] calcium,[36] magnesium,[37] and potassium.[38] Therefore, these 11 nutrients were used for Nutrient adequacy ratio (NAR) calculation. NAR was calculated by dividing the amount of daily nutrient intake by dietary recommended intake of that nutrient.[39] The mean of 11 above-mentioned nutrients (mean adequacy ratio (MAR)) was used as an indicator of nutritional quality.[20]

Anthropometric assessment

Height was measured by an inelastic meter in a standing position near to the wall and without shoes; to the nearest 1 cm. Weight was measured to the nearest 0.1 kg by a standard scale with light clothes or without shoes. Using an inelastic tape with an accuracy of 0.1 cm, waist circumference and hip circumference were measured at the narrowest and the largest part, respectively; without any pressure to the body surface. During waist and hip circumference measurements, subjects wore light cloths.[40] Body mass index (BMI) was calculated by dividing body weight in kilogram by the height square in meters. After participants sat for at least 5 min, systolic and diastolic blood pressure were measured three times with mercury sphygmomanometer, and the mean of measurements was reported.

Cost assessment

Prices of all 168 food items of FFQ were collected from an accessible shopping center offering not only good quality but also affordable foods. Furthermore, some other busy stores in different districts were checked, and prices were not considerably different. Then, the price of each food item in Rials was converted to the price of 1 g of that food item (1 US dollar = 21300 Iranian Rials in June and July 2012). The cost of each consumed food item of FFQ was calculated by multiplying the consumed grams by its unit cost (price of one gram). Finally, the sum of all food item costs was considered as the total daily price of diet for each participant.

Assessment of other variables

Biochemical indices including High-density lipoprotein (HDL), Low-density lipoprotein (LDL), Triglyceride (TG), Total cholesterol, HbA_1C, FBS and liver enzymes; history of diseases (liver, kidney, cardiovascular, cancer, and other diseases) and medications were collected by using available medical documents of patients (the last laboratory results during data collection were used for biochemical indices).

In addition, a trained interviewer collected socioeconomic data (income level, education, number of children, house-ownership, car-ownership, and job), demographic data (age, sex, and marriage status) and cigarette smoking.

It must be noticed that socioeconomic questionnaire was designed by the researchers involved in this study.

Statistical assessment

Distribution of data was assessed using Kolmogrov–Smirnov test and histogram curves. All data had a normal distribution. The participants were categorized according to tertiles of the total daily price of diet. One-way ANOVA (with least significant difference as *post hoc* test) and Chi-square test were used to identify significant differences across tertiles of the total daily price of diet. Nutritionist IV was used to analyze dietary intakes. SPSS software (version 19, IBM company, Armonk, New York, United States) was used to conduct the statistical analysis. The value of $P < 0.05$ was considered as statistically significant.

To compare the variations of variables across tertiles of the total daily price of diet, analysis of covariance which was adjusted for energy intake, age, sex, medications, and socioeconomic status (including monthly income, education, number of children, and home ownership) was used.

Results

General characteristics of diabetic patients across tertile categories of the total daily price of diet are shown in Table 1. According to Table 1, there were no significant differences regarding the general characteristics of subjects across tertiles of the total daily price of diet ($P > 0.05$).

Table 2 shows anthropometric and biochemical characteristics of diabetic patients across tertiles of the total daily price of diet. Participants in the highest tertile were taller and had a higher weight in crude model ($P = 0.03$ and $P = 0.043$, respectively). FBS had a marginal level of significance across tertiles of the total daily price of diet. Participants in the lowest tertile of the total daily price of diet had the highest level of FBS ($P = 0.091$). After adjusting for age, sex, energy intake and medications, the significant relationship between weight and FBS and total daily price of diet did not remain, and the relationship between height and total daily price of diet became significant in a marginal way. There was no significant association between the total daily price of diet and other anthropometric and biochemical indices.

Socioeconomic status of diabetic patients across tertiles of total daily price of diet is demonstrated in Table 3. There were no significant differences between socioeconomic statuses across tertiles of total daily price of diet. However, husband/father's education was in a marginal level of significance (the majority of university-educated participants were in the lowest tertile of the total daily price of diet).

Table 4 shows diet quality indices of diabetic patients across tertiles of total daily price of diet. According to Table 4, individuals in the lowest tertile of total daily price of diet had significantly the lowest NAR for Vitamin C, Vitamin B1, Vitamin B6, selenium, zinc, calcium, magnesium, and potassium ($P < 0.05$). Furthermore, participants in the highest tertile of the total daily price of diet had significantly higher NAR for Vitamin B12 and MAR ($P < 0.05$). However, after adjusting for confounder factors, the relationships between Vitamin C, Vitamin B6 and calcium, and total daily price of diet were disappeared and the relation between Vitamin B_{12} and total daily price of diet became marginally significant in Model I and II. After further adjusting for socioeconomic status, the marginally significant association between Vitamin B_{12} and tertiles of diet cost did not remain. There was no significant association between total daily price of diet and NAR of Vitamin E and Vitamin D. However, the association between NAR of Vitamin D and total daily price of diet became statistically significant after adjustment for age, sex, energy intake, and socioeconomic status.

Dietary intakes of diabetic patients across tertiles of total daily price of diet are demonstrated in Table 5. Individuals in the first tertile of total daily price of diet had the lowest intakes of carbohydrate, protein, Vitamin C, Vitamin B1, Vitamin B6, selenium, zinc, calcium, magnesium, and potassium ($P < 0.05$). In addition, subjects in the highest tertile of total daily price of diet received more energy, monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), and Vitamin B12 ($P < 0.05$). There was no significant association between total daily price of diet and other components of dietary intakes (saturated fatty acid, Vitamin E, and Vitamin D). However, after adjusting for confounder factors, the relationships between carbohydrate, MUFA, Vitamin C, Vitamin B6 and calcium intake, and total daily price of diet were disappeared, and the relationships between PUFA and Vitamin B12 intake, and total daily price of diet became marginally significant. Furthermore, the relationship between Vitamin D intake and total daily price of diet became significant in the models which were adjusted for confounder factors (Model I and Model II) ($P < 0.05$).

Discussion

The results of the present study indicated a direct relationship between total daily price of diet and NARs of Vitamin D, Vitamin B1, selenium, zinc, magnesium, potassium, and MAR of 11

Table 1: General characteristics of diabetic patients according to the tertiles of total daily price of diet[a]

	Tertiles of total daily price of diet			P^{2}
	1 (*n*=66)	2 (*n*=66)	3 (*n*=68)	
Age (year)	57.01±9.06	55.71±11.01	56.14±12.39	0.784
Sex, *n* (%)				
Men	19 (28.8)	20 (30.3)	30 (44.1)	0.119
Women	47 (71.2)	46 (69.7)	38 (55.9)	
Marriage, *n* (%)				
Married	55 (83.3)	54 (81.8)	63 (92.6)	0.138
Single	0	0	1 (1.5)	
Widow/widower	11 (16.7)	12 (18.2)	4 (5.9)	
Blood pressure				
Systole (cmHg)	12.12±1.68	12.07±1.54	12.19±1.57	0.916
Diastole (cmHg)	7.57±0.74	7.34±1.04	7.55±0.9	0.277
Smoking cigarette, *n* (%)	3 (4.5)	2 (3)	5 (7.4)	0.507
History of diseases, *n* (%)				
Liver damages	0	0	0	0.549
Renal	3 (4.6)	2 (3)	3 (4.4)	
Cardiovascular	16 (24.6)	9 (13.6)	14 (20.6)	
Liver and kidney	1 (1.5)	0	0	
Kidney and cardiovascular	3 (4.6)	1 (1.5)	3 (4.4)	
Medication use, *n* (%)				
Hypoglycemic agent	15 (22.7)	19 (28.8)	27 (39.7)	0.117
Lipid lowering agent	0	0	0	
Blood pressure lowering agent	0	0	1 (1.5)	
All of these 3 drugs	22 (33.3)	15 (22.7)	18 (26.5)	
1 and 3	15 (22.7)	10 (15.2)	12 (17.6)	
1 and 2	14 (21.3)	22 (33.3)	10 (14.7)	

[a]Data are means±SD unless indicated, [b]*P*-values are resulted from ANOVA for quantitative variables (age, blood pressure) and λ^2 for qualitative variables. ANOVA=Analysis of variance

micronutrients which have an important role in T2DM pathogenesis (Vitamin C, Vitamin E, Vitamin D, Vitamin B1, Vitamin B6, Vitamin B12, selenium, zinc, calcium, magnesium, and potassium). Furthermore, total daily price of diet had a positive association with dietary intakes of protein, Vitamin D, Vitamin B1, selenium, zinc, magnesium, and potassium among type 2 diabetic patients. However, no significant relationship was observed between total daily price of diet and anthropometric indices, biochemical characteristics, and socioeconomic status of participants in the present study.

The study results did not show any significant relationship between total daily price of food and general characteristics including age, sex, marriage status, blood pressure, cigarette smoking, history of diseases, and medication use. According to our knowledge, there are limited studies in the similar line with the present study. However, studies with opposite results are more accessible. For instance, a cross-sectional study conducted by Rehm *et al*. showed a direct relationship between diet costs and age, income, education, and gender among US adults.[41] In addition, Hasan-Ghomi *et al*. showed that being single and having low education levels could increase the consumption of cheap foods in Tehranian adults.[42] There was no significant association between the total daily price of food and anthropometric measurements, biochemical indices and socioeconomic status of diabetic patients in the present study. Although there are few studies with similar results, many studies have different findings. For example, Schröder *et al*. showed that costs of dietary patterns were inversely associated with BMI among 25–74 years free-living Spanish people.[43] Moreover, Drewnowski *et al*. demonstrated that reduced dietary cost resulted in consumption of diets being similar to the diet of people in low-income countries. The diets were high in fat and calorie, and low in meat, fish, fresh vegetable, and fruits, and consequently increased the prevalence of overweight and obesity.[14] In addition, it was shown that there was a direct relationship between food costs and socioeconomic status among US people with different race or ethnicity and Swedish children.[44,45] These inconsistencies between our results and what some other studies showed might be due to the different studied populations with different socioeconomic statuses and nutritional habits (a developing country vs. industrialized countries).

Dietary intakes play an important role in diabetes management. Previous studies showed dietary patterns with a high content of fiber, Healthy, Mediterranean, Prudent, and DASH (Dietary Approach to Stop Hypertension) dietary patterns were associated with lower

Table 2: Anthropometric and Biochemical characteristics of diabetic patients according to the tertiles of total daily price of diet[a]

	Tertiles of total daily price of diet			*P*
	1 (*n*=66)	2 (*n*=66)	3 (*n*=68)	
Anthropometric indices				
Height (cm)	158.74±8.59	158.1±19.09	163.64±9.13	0.030[b,f]
Model I[d]	159.88±6.5	160.8±6.41	162.3±6.43	0.099[c]
Model II[e]	159.87±6.57	160.79±6.46	162.33±6.51	0.098[c]
Weight (kg)	71.78±11.3	74.06±13.48	77.41±13.89	0.377[g]
Model I	74.08±12.1	73.22±11.86	76±11.87	0.385
Model II	74.07±12.19	73.19±11.97	76.05±12.06	0.377
BMI (kg/m^2)	28.57±4.67	28.64±4.19	28.92±4.81	0.892
Model I	29.02±4.38	28.25±4.30	28.86±4.28	0.563
Model II	29.02±4.44	28.25±4.37	28.87±4.40	0.563
Waist circumference (cm)	95.4±21.07	95.09±11.25	97.97±10.61	0.476
Model I	96.19±15.43	94.64±15.11	97.65±15.17	0.518
Model II	96.22±15.55	94.68±15.28	97.58±15.40	0.551
Biochemical indices				
FBS (mg/dl)	160.21±62.19	141.93±51.59	143.01±45.82	0.091[h]
Model I	160.41±54.83	143.12±53.69	141.66±53.84	0.100
Model II	159.86±54.67	142.20±53.71	143.11±54.13	0.121
HbA1c (%)	8.04±1.89	7.58±1.62	7.8±1.51	0.305
Model I	8.06±1.71	7.62±1.68	7.74±1.69	0.313
Model II	8.06±1.72	7.61±1.69	7.76±1.71	0.316
TG (mg/dl)	175.87±88.99	174.77±88.53	165.97±82.39	0.768
Model I	181.72±88.71	172.56±86.92	162.43±87.16	0.458
Model II	180.68±88.21	170.83±86.67	165.13±87.34	0.598
Total cholesterol (mg/dl)	179.92±42.31	188.36±92.42	169.22±36.75	0.205
Model I	177.28±63.77	188.79±62.55	171.35±62.67	0.262
Model II	176.41±63.22	187.34±62.11	173.63±62.61	0.409
LDL (mg/dl)	99.9±32.22	97.49±29.85	89.34±27.3	0.102
Model I	98.75±30.38	97.34±29.81	90.61±29.93	0.252
Model II	98.41±30.29	96.76±29.76	91.52±29.99	0.394
HDL (mg/dl)	46.01±9.13	46.46±9.27	44.36±9.87	0.401
Model I	45.72±9.58	46.33±9.34	44.77±9.4	0.624
Model II	45.70±9.63	46.30±9.46	44.83±9.53	0.670
ALT (SGPT) (U/L)	21.03±13.79	21.24±18.19	23.64±11.64	0.522
Model I	22.17±14.94	20.72±14.62	23.04±14.46	0.652
Model II	22.03±14.91	20.49±14.65	23.41±14.76	0.518
AST (SGOT) (U/L)	23.37±24.6	22.77±9.91	21.58±6.4	0.798
Model I	24.43±15.92	22.09±15.67	21.21±15.66	0.496
Model II	24.36±16.00	21.97±15.76	21.42±15.92	0.542

[a]Data are means±SD, [b]*P*-values are resulted from ANOVA, [c]*P*-values are resulted from ANCOVA, [d]Model I=Adjusted for age, sex, and energy intake, [e]Model II=Adjusted for age, sex, energy intake and drugs, [f]Significant difference between 1 and 3 as well as significant difference between 2 and 3, [g]Significant difference between 1 and 3, [h]In a marginal level of significance. ANOVA=Analysis of variance, ANCOVA=Analysis of covariance, BMI=Body mass index, FBS=Fasting blood sugar, HbA1c=Hemoglobin A1c, TG=Triglyceride, LDL=Low density lipoprotein, HDL=High density lipoprotein, ALT=Alanine aminotransferase, AST=Aspartate aminotransferase, SGPT=Serum glutamate-pyruvate transaminase, SGOT=Serum glutamic oxaloacetic transaminase, SD=Standard devaition

risk of diabetes.[46] In addition, it was shown that there was a negative correlation between glycemic indices and diet quality scores.[47] Among NAR of all 11 micronutrients having an important role in T2DM pathogenesis,[29-38] Vitamin D, Vitamin B1, selenium, zinc, magnesium, and potassium intake had a significant direct association with total daily price of foods in the present study. Furthermore, MAR of Vitamin B_1, B_6, B_{12}, C, D, E, selenium, zinc, calcium, magnesium, and potassium were associated with total price of foods. This relationship between total daily price of foods and diet quality is consistent with previous studies. For instance, by using the HEI-2005 score for diet quality, Rehm *et al*.[41] showed a direct relationship between quality of diet and cost of foods among US adults. In addition, Maillot *et al*.[20] that assessed the quality of diet with MAR, which is the nutritional-quality indicator

Table 3: Socioeconomic status of diabetic patients according to the tertiles of total daily price of diet[a]

	Tertiles of total daily price of diet			P^b
	1 (*n*=66)	2 (*n*=66)	3 (*n*=68)	
Monthly income, *n* (%)				
<7,000,000 Rials	48 (72.7)	48 (72.7)	55 (80.9)	0.223
7,000,000-5,000,000 Rials	14 (21.2)	17 (25.8)	13 (19.1)	
15,000,000-30,000,000 Rials	1 (1.5)	1 (1.5)	0	
>30,000,000 Rials	3 (4.6)	0	0	
Wife/mother's education, *n* (%)				
Illiterate	16 (24.2)	21 (31.8)	17 (25)	0.815
Under diploma	37 (56.1)	34 (51.5)	36 (52.9)	
Diploma	11 (16.7)	7 (10.6)	12 (17.6)	
University education	2 (3)	4 (6.1)	3 (4.5)	
Dead	0	0	0	
Husband/father's education, *n* (%)				
Illiterate	6 (9.1)	5 (7.6)	7 (10.3)	0.063[c]
Under diploma	28 (42.4)	30 (45.5)	35 (51.5)	
Diploma	9 (13.6)	16 (24.2)	17 (25)	
University education	12 (18.2)	3 (4.5)	5 (7.4)	
Dead	11 (16.7)	12 (18.2)	4 (5.8)	
Wife/mother's job, *n* (%)				
Employed	0	1 (1.5)	0	0.253
Retired	3 (4.6)	1 (1.5)	6 (8.8)	
Self-employed	1 (1.5)	0	0	
Housewife	62 (93.9)	64 (97)	62 (91.2)	
Dead	0	0	0	
Husband/father's job, *n* (%)				
Employed	3 (4.5)	3 (4.5)	2 (2.9)	0.223
Retired	29 (43.9)	23 (34.8)	26 (38.2)	
Self-employed	15 (22.7)	24 (36.4)	27 (39.8)	
Unemployed	8 (12.2)	4 (6.1)	9 (13.2)	
Dead	11 (16.7)	12 (18.2)	4 (5.9)	
Number of children, *n* (%)				
0	7 (10.6)	10 (15.2)	10 (14.7)	0.824
1-2	13 (19.7)	12 (18.2)	11 (16.2)	
3-4	31 (47)	24 (36.3)	26 (38.2)	
>4	15 (22.7)	20 (30.3)	21 (30.9)	
Home ownership, *n* (%)				
Leased	11 (16.7)	14 (21.2)	18 (26.5)	0.384
Owner	55 (83.3)	52 (78.8)	50 (73.5)	
Car ownership, *n* (%)				
Yes	34 (51.5)	42 (63.6)	42 (61.8)	0.312
No	32 (48.5)	24 (36.4)	26 (38.2)	

[a]Data are counts (*n*) and percentages, [b]*P*-values are resulted from λ^2, [c]In a marginal level of significance

also used in the current study, declared that cost of diet had a positive association with quality of diet among French adults. Furthermore, Aggarwal *et al*. showed that Vitamin C, D, E, and B12, calcium, potassium, and magnesium intakes were associated with higher diet costs among US people with different ethnicity.[44] Moreover, a potassium-dense diet that contained frequently use of beans, potatoes, coffee, milk, bananas, citrus juices, and carrots was associated with higher cost of diet among 4744 US adults.[48] It was also shown that Vitamin C and E decreased levels of blood glucose, and increased SOD and GSH enzyme activity that can decrease oxidative stress, and consequently reduced insulin resistance.[29] In addition, Vitamin D deficiency is a potential risk factor for obesity and development of insulin resistance resulting in T2DM.[30] Furthermore, patients with type 2 diabetes have low plasma thiamine (Vitamin B1) concentrations, associated with increased thiamine clearance.[31] Moreover, patients with type 2 diabetes in Indonesia showed an increased degradation in Vitamin B6.[32] Biochemical and clinical Vitamin B12 deficiency is also highly prevalent among patients with T2DM.[33] Another study

Table 4: Diet quality indices of diabetic patients according to the tertiles of total daily price of diet[a]

	Tertiles of total daily price of diet			*P*
	1 (*n*=66)	2 (*n*=66)	3 (*n*=68)	
NAR of Vitamin C	3.04±1.11	3.58±1.28	3.48±1.51	0.041[b,g]
Model I[d]	3.18±1.29	3.52±1.28	3.41±1.28	0.340[c]
Model II[e]	3.19±1.21	3.44±1.18	3.48±1.18	0.329[c]
Model III[f]	3.19±1.22	3.45±1.19	3.48±1.20	0.323[c]
NAR of Vitamin E	0.48±0.18	0.49±0.24	0.5±0.47	0.965
Model I	0.51±0.33	0.47±0.32	0.48±0.32	0.757
Model II	0.51±0.33	0.47±0.32	0.49±0.32	0.754
Model III	0.52±0.33	0.48±0.32	0.49±0.32	0.807
NAR of Vitamin D	0.1±0.09	0.08±0.09	0.07±0.08	0.088
Model I	0.11±0.08	0.08±0.08	0.07±0.08	0.018[h]
Model II	0.11±0.08	0.08±0.08	0.06±0.09	0.009[i]
Model III	0.11±0.09	0.08±0.09	0.07±0.09	0.009
NAR of Vitamin B1	1.12±0.25	1.37±0.33	1.34±0.35	0.0001[h]
Model I	1.2±0.24	1.3±0.24	1.3±0.24	0.011[h]
Model II	1.2±0.25	1.33±0.24	1.3±0.25	0.011[h]
Model III	1.21±0.25	1.33±0.24	1.31±0.25	0.013
NAR of Vitamin B6	1.17±0.30	1.43±0.29	1.43±0.30	0.001[h]
Model I	1.31±0.30	1.37±0.29	1.36±0.29	0.555
Model II	1.31±0.30	1.36±0.29	1.36±0.29	0.591
Model III	1.32±0.30	1.36±0.29	1.37±0.30	0.577
NAR of Vitamin B12	1.2±1.34	2.19±2.09	3.2±5.85	0.008[i]
Model I	1.55±3.73	2.03±3.65	3.02±3.62	0.067
Model II	1.55±3.73	2.07±3.65	2.97±3.62	0.088
Model III	1.60±3.75	2.05±3.67	2.96±3.67	0.100
NAR of selenium	1.13±0.45	1.49±0.59	1.33±0.51	0.001[h]
Model I	1.16±0.53	1.47±0.51	1.31±0.51	0.005[g]
Model II	1.16±0.52	1.47±0.51	1.32±0.51	0.004[g]
Model III	1.16±0.54	1.47±0.52	1.32±0.52	0.005
NAR of zinc	0.89±0.25	1.12±0.29	1.01±0.35	0.0001[j]
Model I	0.95±0.27	1.1±0.26	0.98±0.27	0.014[k]
Model II	0.95±0.24	1.1±0.24	1±0.24	0.011[g]
Model III	0.95±0.25	1.08±0.24	1.00±0.25	0.011
NAR of calcium	1.02±0.44	1.24±0.4	1.13±0.6	0.043[g]
Model I	1.13±0.4	1.19±0.4	1.07±0.41	0.210
Model II	1.13±0.41	1.2±0.4	1.05±0.41	0.110
Model III	1.14±0.42	1.21±0.41	1.06±0.41	0.111
NAR of magnesium	0.96±0.22	1.22±0.32	1.13±0.43	0.0001[h]
Model I	1.05±0.28	1.18±0.27	1.09±0.28	0.028[k]
Model II	1.05±0.25	1.16±0.24	1.11±0.25	0.029[g]
Model III	1.05±0.25	1.17±0.24	1.11±0.25	0.023
NAR of potassium	0.79±0.22	1.02±0.28	0.95±0.32	0.0001[h]
Model I	0.88±0.17	0.98±0.17	0.9±0.18	0.002[k]
Model II	0.88±0.17	0.98±0.17	0.9±0.17	0.003[k]
Model III	0.88±0.18	0.99±0.18	0.90±0.17	0.002
MAR[l]	1.08±0.27	1.39±0.34	1.42±0.66	0.0001[h]
Model I	1.19±0.39	1.34±0.38	1.36±0.39	0.027[h]
Model II	1.19±0.39	1.33±0.38	1.37±0.39	0.026[h]
Model III	1.19±0.40	1.33±0.39	1.37±0.40	0.032

[a]Data are means±SD, [b]*P*-values are resulted from ANOVA, [c]*P*-values are resulted from ANCOVA, [d]Model I=Adjusted for energy intake, [e]Model II=Adjusted for age, sex, and energy intake, [f]Model III=Adjusted for age, sex, energy intake and socioeconomic status, [g]Significant difference between 1 and 2, [h]Significant difference between 1 and 2 as well as significant difference between 1 and 3, [i]Significant difference between 1 and 3, [j]Significant difference between 1 and 2 as well as significant difference between 1 and 3 as well as significant difference between 2 and 3, [k]Significant difference between 1 and 2 as well as significant difference between 2 and 3, [l]MAR=Mean of 11 mentioned nutrients. NAR=Nutrient adequacy ratio, MAR=Mean adequacy ratio, ANOVA=Analysis of variance, ANCOVA=Analysis of covariance, SD=Standard deviation

Table 5: Dietary intakes of diabetic patients according to the tertiles of total daily price of diet[a]

	Tertiles of total daily price of diet			*P*[b]
	1 (*n*=66)	2 (*n*=66)	3 (*n*=68)	
Macro nutrients				
Energy (kcal)	1766.92±442.41	2063.84±418.52	2076.95±567.46	0.0001[e]
Carbohydrate (g)	287.67±85.83	354.2±84.15	353.54±121.37	0.0001[e]
Model I[c]	324.91±46.14	337.07±45.16	334.02±44.51	0.299
Model II[d]	325.11±46.3	336.74±45.33	334.15±45.51	0.328
Fat (g)				
MUFA (g)	11.27±6.44	12.77±6.19	14.31±7.29	0.033[f]
Model I	12.34±6.33	12.28±6.17	13.75±6.18	0.308
Model II	12.28±6.3	12.39±6.17	13.7±6.18	0.342
PUFA (g)	10.14±3.97	10.83±4.66	12.57±5.99	0.015[g]
Model I	10.79±4.79	10.53±4.71	12.23±4.7	0.086
Model II	10.74±4.79	10.58±4.71	12.24±4.7	0.085
SFA (g)	11.41±6.28	12.72±4.88	13.38±5.98	0.134
Model I	12.62±5.11	12.16±5.03	12.75±5.03	0.777
Model II	12.62±5.11	12.26±5.03	12.66±5.03	0.880
Protein (g)	60.57±17.82	74.31±15.9	69.79±19.13	0.0001[e]
Model I	65.88±12.83	71.87±12.51	67.01±12.53	0.017[i]
Model II	65.96±12.67	72.11±12.42	66.7±12.45	0.010[i]
Micronutrients				
Vitamin C (mg)	238.81±82.95	283.88±98.98	280.88±113.41	0.015[e]
Model I	252.44±97	277.62±94.8	273.73±94.99	0.286
Model II	252.97±95.13	274.8±93.26	275.96±93.51	0.305
Vitamin E (mg)	7.3±2.84	7.41±3.68	7.53±7.06	0.965
Model I	7.79±4.87	7.18±4.79	7.28±4.78	0.757
Model II	7.77±4.87	7.13±4.79	7.34±4.78	0.754
Vitamin D (mcg)	1.59±1.41	1.28±1.38	1.08±1.25	0.096
Model I	1.7±1.37	1.23±1.34	1.03±1.34	0.018[f]
Model II	1.71±1.35	1.26±1.33	0.99±1.32	0.011[f]
Vitamin B1 (mg)	1.26±0.3	1.56±0.38	1.53±0.39	0.0001[e]
Model I	1.37±0.27	1.51±0.27	1.48±0.27	0.011[e]
Model II	1.37±0.28	1.51±0.27	1.48±0.27	0.012[e]
Vitamin B6 (mg)	1.52±0.45	1.86±0.45	1.86±0.77	0.001[e]
Model I	1.71±0.39	1.78±0.38	1.77±0.39	0.555
Model II	1.71±0.39	1.77±0.38	1.77±0.39	0.591
Vitamin B12 (mcg)	2.88±3.22	5.26±5.03	7.68±14.05	0.008[f]
Model I	3.7±8.93	4.8±8.12	7.2±8.24	0.067
Model II	3.73±8.93	4.98±8.8	7.13±8.8	0.088
Selenium (mg)	0.06±0.02	0.08±0.03	0.07±0.02	0.001[e]
Model I	0.06±0.03	0.08±0.03	0.07±0.02	0.005[h]
Model II	0.06±0.03	0.08±0.03	0.07±0.02	0.004[h]
Zinc (mg)	7.86±2.4	9.92±2.44	9.3±2.91	0.0001[e]
Model I	8.54±2.11	9.61±2.03	8.95±2.06	0.014[h]
Model II	8.55±2.11	9.64±2.03	8.91±2.06	0.011[i]
Calcium (mg)	1152.4±459.8	1400±419.16	1264.09±690.48	0.032[h]
Model I	1265.52±481.99	1347.98±471.19	1204.79±472.17	0.210
Model II	1268.65±482.24	1349.99±472.73	1199.79±473.99	0.185
Magnesium (mg)	323.17±80.66	410.55±106.22	391.97±140.56	0.0001[e]
Model I	357.05±80.91	394.97±79.12	374.21±79.32	0.028[h]
Model II	357.14±81.4	394.72±79.77	374.36±79.98	0.032[h]
Potassium (mg)	3713.5±1042.5	4837.53±1325.5	4474.64±1527.61	0.0001[h]

Contd...

Table 5: Contd...

	Tertiles of total daily price of diet			P^b
	1 (*n*=66)	2 (*n*=66)	3 (*n*=68)	
Model I	4146.25±852.45	4638.53±833.28	4247.76±835.01	0.002[i]
Model II	4154.77±846.28	4632.03±829.54	4245.8±831.79	0.003[i]

[a]Data are means±SD, [b]*P*-values are resulted from ANOVA, [c]Model I=Adjusted for energy intake, [d]Model II=Adjusted for age, sex, and energy intake, [e]Significant difference between 1 and 2 as well as significant difference between 1 and 3, [f]Significant difference between 1 and 3, [g]Significant difference between 1 and 3 as well as significant difference between 2 and 3, [h]Significant difference between 1 and 2, [i]Significant difference between 1 and 2 as well as significant difference between 2 and 3. ANOVA=Analysis of variance, SD=Standard deviation

found that at dietary levels of intake, individuals with higher toenail Selenium levels were at lower risk for T2DM.[34] In addition, according to a systematic review and meta-analysis on the effects of Zinc supplementation in patients with diabetes, Zinc supplementation has beneficial effects on glycemic control.[35] Furthermore, depletion of endoplasmic reticulum Ca2+ occurs in many diseases including T2DM.[36] Moreover, Magnesium intake may be one of the most important factors for diabetes prevention and management.[37] The other evidence supporting our results found that people at high risk of type 2 diabetes showed low levels of serum Potassium concentrations.[38]

To the best of our knowledge, this is the first study that assessed the relation between quality of diet, anthropometric and biochemical indices including height, weight, waist circumference, FBS, HbA1c, TG, total cholesterol, LDL, HDL, alanine aminotransferase (Serum glutamate-pyruvate transaminase), and Aspartate aminotransferase (Serum glutamic oxaloacetic transaminase), and total daily price of foods among T2DM patients in a developing country. Furthermore, a validated semi-quantitative FFQ was used to assess dietary intakes of participants. Hence, these can be considered as strengths of the present study.

However, there are some limitations in this study. Prices of some FFQ food items considerably changed along with their abundance during seasons and sometimes months in Iran (i.e., fruits and vegetables). In addition, as a cultural norm, people refuse to answer the questions about their incomes in Iran. Hence, probably, there were some under and over reports for some participants' incomes. Furthermore, FFQ is based on long-term memory, and that could result in under and over reports for participants' nutrient intakes. However, we excluded under and over reports of energy intakes in the present study.

Conclusions

This study showed that diet quality indices and dietary intakes of energy, protein and micronutrients were directly associated with total daily price of foods among Iranian patients with type 2 diabetes. It seems that larger population is needed to confirm the relationship between diet quality and cost of foods.

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Conflicts of interest

There are no conflicts of interest.

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