Biomedicine Advances

Biomedicine Advances. 2025;2(3):152-163
doi: 10.34172/bma.25
https://biomedad.ae

Original Article

Dietary quality indices, cardio-metabolic risk factors, and depression in women with type 2 diabetes: A cross-sectional study

Nazli Namazi[1], Mahnaz Sanjari[2], Mostafa Qorbani[3,4], Bagher Larijani[5], Maryam Aalaa[6], Mohammad-Reza Amini[1], Hossein Adibi[7], Farideh Razi[8], Hamid Reza Aghaei Meybodi[9], Neda Mehrdad[1*]

[1]Diabetes Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[2]Osteoporosis Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[3]Non-Communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran
[4]Chronic Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[5]Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[6]Department of E-Learning in Medical Education, Center of Excellence for E-Learning in Medical Education, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran
[7]Elderly Health Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[8]Metabolomics and Genomics Research Center, Endocrinology and Metabolism Molecular-Cellular Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[9]Evidence-Based Medicine Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

*__Corresponding Author:__ Neda Mehrdad, Email: nmehrdad@tums.ac.ir

Summary

Introduction: Prior studies have indicated that high-quality dietary patterns play a pivotal role in improving metabolic and psychological disorders; however, there are limited studies in this regard for patients with type 2 diabetes mellitus (T2DM). We aimed to examine the association of adherence to some dietary quality indices, cardio-metabolic risk factors, and depression in women with T2DM.

Methods: In this cross-sectional study, 456 women with T2DM were recruited using random multistage cluster sampling. Adherence to dietary patterns, including Dietary Approaches to Stop Hypertension (DASH), Alternate Healthy Eating Index (AHEI), dietary energy density (DED), dietary diversity score (DDS), and Mediterranean scores was examined as suggested by previous publications. The Beck Depression Inventory (BDI) questionnaire was also used to assess depression. Dietary intake was examined using three 24-h dietary recalls. To compare subjects with less or more than the median score for each dietary index, analysis of covariance (ANCOVA) was used. Adjusted logistic regression was performed to examine the association of dietary quality indices and depression.

Findings: The mean age and duration of diabetes were 51.8±7.7 and 6.8±5.9 years, respectively. Overall, the prevalence of depression was 41.3% in the study population. After controlling for potential confounders, we found that total cholesterol (TC) and low-density lipoprotein concentrations (LDL-C) in individuals with high DED scores were significantly higher than those with a low one ($P=0.02$ for both). However, there were no significant associations among other dietary quality indices, cardio-metabolic risk factors, and depression.

Conclusion: Adherence to a high-energy-dense diet was positively associated with TC and LDL-C concentrations in Iranian women with T2DM. Due to low median scores for all healthy dietary patterns, no differences were found for other biochemical parameters and depression between categories. Prospective studies that used adaptive dietary quality indices for patients with T2DM are required.

Keywords: Diet, Depression, Metabolic status, Women, Type 2 diabetes

Received: March 9, 2025, **Revised:** May 27, 2025, **Accepted:** June 18, 2025, **ePublished:** July 1, 2025

Introduction

Type 2 diabetes mellitus (T2DM) is a consequential non-communicable disease that is increasing around the world.[1] Over recent decades, the prevalence of T2DM has grown dramatically and it has been estimated that it will reach 489 million cases by 2030. Identifying efficient strategies for the treatment and prevention of T2DM is, therefore, a crucial step toward reducing the burden of this public health crisis.[2] Targeting modifiable risk factors such as dietary patterns could effectively reduce the growth and disease burden of T2DM in the region.[3]

Promoting healthy diet that consists of diverse choices from each main food groups while providing healthy diets with essential nutrients is an acknowledged strategy to manage existing status of patients.[4,5] Previous studies have investigated the association between diet, DM, and diabetes complications by studying certain foods,[6-8] nutrients in isolation,[9] and examining overall diet quality.[5,10,11] As nutrients in isolation are not consumed, the association between diet and T2DM can only be elucidated by assessing diet as a whole.[12] Different dietary indices have been developed to measure dietary quality, including dietary energy density (DED), dietary diversity score (DDS), Dietary Approaches to Stop Hypertension (DASH), Alternate Healthy Eating Index (AHEI) and Mediterranean scores.[12-14] Low-quality diets can cause insulin resistance and other diabetes-related metabolic disorders.[15] Low-quality diets are usually high-energy, dense diets with sufficient amounts of nutrients.

In addition to metabolic complications, patients with DM are at increased risk for depression. It has been reported that the risk of depression in patients with DM is twice as much as people without diabetes.[16] Furthermore, depression can be involved in diabetes complications.[17] Although in the past decades less attention was paid to depression and other mental disorders in diabetes care,[18,19] recently such disorders have been considered as one of the main diabetes complications in most countries. Dietary patterns play key roles in reducing depressive symptoms, particularly in patients with T2DM.[20]

To the best of our knowledge, no studies have examined the association of DDS and DED with depression and biochemical parameters in T2DM in Iran, and there are limited studies with conflicting results on the association of dietary quality indices, depression and metabolic disorders. Our study therefore aimed to explore the association between dietary quality indices with depression and cardio-metabolic risk factors in women with T2DM in Tehran, Iran.

Methods

Study design and participants

In this cross-sectional research, 456 women with T2DM were studied in Tehran, Iran in 2018-2019. Eligible patients were selected using a random multistage cluster sampling method from five geographical regions of Tehran, Iran. One distinctive district was chosen randomly from each geographical region. Patients were identified from (i) all primary health centers in which diabetics were admitted and followed up, and (ii) two referral diabetes clinics affiliated with Endocrine and Metabolism Research Institute (EMRI), Tehran University of Medical Sciences. The calculation of sample size was explained elsewhere.[21]

Inclusion and exclusion criteria

Inclusion criteria were women aged between 20 and 60 years old with T2DM who were able to speak in Persian and had HbA1c between 6.5 to less and equal to 9% throughout 6 months ago. Diagnosis of T2DM was based on the criteria of the American Diabetes Association: fasting blood sugar (FBS) $\geq$ 126 mg/dL, blood sugar 2-hour postprandial $\geq$ 200 mg/dL, and HbA1c $\geq$ 6.5%.[22] Subjects were excluded if they were on weight loss or vegetarian diets through the previous six months, had a serious illness with reduced cognitive capacity, or participated in other diabetes education courses scheduled simultaneously with our study. Pregnant and lactating women were also excluded.

After dietary intake analysis, we excluded the participants whose dietary energy intake was out of 800 to 4200 kcal/day[23,24] (n = 21) or had fewer than two completed 24-hour dietary recalls (n = 10). Finally, the data for 426 women were considered for analysis. All eligible women signed written informed consents at the baseline. The present study has been approved by the ethics committee of Endocrinology and Metabolism Research Institute of Tehran University of Medical Sciences (code: EC-00378) in accordance with the Helsinki Declaration and the guidelines of Iranian Ministry of Health and Medical Education. This paper covers a cross-sectional part of the main experimental project entitled "the effectiveness of diabetes education by peer coaching on controlling and management of disease".

Assessments

Dietary intake

To assess the dietary intake of participants, three 24-h dietary recalls (2 working days, 1 weekend) were used. Dietary recalls were filled out through a face-to-face interview and they were completed by dietitians. Eventually, the reported amounts of each food item were converted to grams. The Data on dietary intake were analyzed using the modified version of Nutritionist IV (First Databank Inc., Hearst Corp., San Bruno, CA, USA) for Iranian foods.

Calculation of dietary quality indices

Dietary diversity score

The DDS was calculated based on the method by Kant et al.[25,26] Briefly, according to the Food Guide Pyramid, we classified consumed food into five main groups, namely bread & grains, fruits, vegetables, dairy, and meats. Then, the aforementioned five groups were divided into 23 sub-classifications. In accordance with the Food Guide Pyramid quantity criteria, if at least 0.5 serving/ day had been consumed, it would have been considered as a consumption of that certain food group. Each of the five main groups got a maximum score of 2 out of 10. The total score was obtained by summing the scores of the five main groups. Total DDSs were between 0 and 10. To calculate diversity scores in each main food group, which were between 0 and 2, the same method was applied.

Dietary energy density

To estimate the DED, an individual's daily energy intake (kcal/day) was divided by the total weight of consumed foods (excluding non-caloric beverages) (g/day).[27] We did not consider the weight of consumed non-caloric beverages, including water, tea, coffee without milk and sugar, because findings from the previous publication[28] support the issue that the effect of DED on body weight are related to changes in the weight of solid foodstuffs, not such beverages.

AHEI score

The AHEI was calculated based on the scores for 12 main items, and its total score is 100. Scores for the highest and the lowest intake of total fruits, whole fruits, vegetables, beans, total protein foods, seafood, and plant proteins are 5 and 0, respectively. Score for the highest intake of whole grains, dairy, and fatty acids ratio ((polyunsaturated fatty acid and MUFA)/SFA) is 10, and the score for the lowest consumption of these foods is 0. Two unhealthy components (refined grains and sodium) get a score of 10 for the lowest intake and 0 for the highest intake. Consumption of foods that contain solid fats or sugars and also alcohol intake (more than 13 g/1000 kcal) is scored 0–20 (highest intake = 0, lowest intake = 20). The highest frequency of consumption is scored 0, and the lowest frequency of consumption gets the score of 20.[29]

DASH score

We calculated the DASH dietary score based on the Fung method [30]. In this method, participants who consumed the highest amount of fruits, vegetables, nuts and legumes, low-fat dairy products or whole grains got score of 1. Moreover, participants got additional scores (score of 1 for each item), if they had the lowest intake of sodium, red or processed meats and sweetened beverages.

Mediterranean diet

Mediterranean dietary scores were calculated based on the methodology of Trichopoulou et al.[31] Its maximum score is nine. Accordingly, if participants consumed legumes, vegetables, fruits, fish, whole grains, nuts and monounsaturated fatty acid (MUFA) to saturated fatty acids (SFAs) ratio equal to or more than the median of the study population, they got one point for each aforementioned item. Furthermore, daily consumption less than the median of the study population for meats (red meat, poultry, and processed meats) and dairy products had one additional point for each food group. In the present study, before the scoring, energy adjustment was performed for all food groups.

Anthropometric measurements

Participants were weighed using a Seca scale (Seca, Hamburg, Germany) with minimal clothes and no shoes. For measuring the height of the subjects, a tape measure with a precision of 0.1 cm was used. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared. Waist circumference (WC) was measured using a non-stretching tape measure. The mid-point between the last rib and the iliac crest was recorded as WC. Hip circumference was measured around the biggest part of the buttocks. Waist to hip ratio (WHR) was calculated by dividing WC by hip circumference.

Biochemical assessment

Blood samples (12 mL) were obtained after 12-14 hours fasting. Blood samples were centrifuged (Hettich D-78532, Tuttlingen, Germany) at 3500 rpm for 10 min to separate serums. HbA1c was measured within two days of sampling, and serum samples were stored in -80 °C till analyses. The serum levels of fasting blood glucose (FBS), total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C), aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were measured by commercial kits (Pars Azmun, Tehran, Iran) using automated chemistry Hitachi 902 analyzer (Hitachi LTD, Tokyo, Japan). HbA1c was measured in whole blood by an automated high-performance liquid chromatography analyzer (Tosoh HLC-723 G8, Tosoh Bioscience, Tokyo, Japan). Total precision in terms of coefficients of variations (CVs) was less than 1.5% for HbA1c, while it was less than 3% for other tests.

Depression Assessment

Depression was assessed using the Persian-language version of the second edition of the Beck Depression Inventory (BDI-II), which consists of 21 items. For each item, four choices have been presented.[32] BDI-II Persian was validated earlier, and it has high internal consistency (Cronbach's $\alpha = 0.87$) and acceptable test-retest reliability ($r = 0.74$).[32]

Sufficient explanations were presented for patients to select the best answer that describes their present feelings. The total score was calculated by summing the score (0 for absent or mild, 3 for severe depression symptoms) of 21 items. The maximum score for this questionnaire was 63. The total score between 0 to 4, 5 to 7, 8 to 15, and more than 16 was considered as no depression, mild, moderate, and severe depression.[33]

Assessment of other variables

The socio-economic characteristics of participants were collected using a demographic questionnaire via interview. The questionnaire consisted of the following items: education, economic status, occupation, taken medications, duration of diabetes, disease history, etc. The levels of physical activity were determined with the International Physical Activity Questionnaire (IPAQ).[34] The rate of physical activity was reported based on MET/day.

Statistical Analysis

The possible normal distribution of variables in DDS, DED, DASH, AHEI, and Mediterranean categories was examined using Kolmogorov–Smirnov test. The results were checked by observing the histogram curve. Variables with normal and non-normal distribution were presented as mean ± SD and median (25th percentile, 75th percentile), respectively. Based on the median of dietary quality indices, participants were classified as subjects who had either less or more than median scores, which named high and low score groups, respectively. The cutoff points for each dietary quality category were as follows: DDS (less or more than 3.7), DED (less or more than 1.2), DASH (less or more than 20.0), AHEI (less or more than 18.0), and Mediterranean diet (less or more than 4.0). Depression was considered as a qualitative variable and subjects were classified into three groups (normal, mild/moderate, and severe). To compare groups, independent t-test and chi-square tests were used for quantitative and qualitative variables, respectively. Anthropometric indices, depression, and biochemical parameters were adjusted for potential confounders using analysis of covariance (ANCOVA). To detect the role of dietary quality indices on depression, binary logistic regression in two models was used. It was presented as crude and adjusted models. The adjustment was performed for important covariates (energy intake, BMI, income, education, medications, physical activity, duration of diabetes, etc). To calculate the odds ratio (OR) in the categories of dietary quality indices, first category (lower than median score) was considered as a reference group. All statistical analyses were done using the SPSS software (SPSS Inc., Chicago IL, USA; version 16). *P* values less than 0.05 were considered statistically significant.

Results

Basal characteristics

Characteristics of the participants who had higher and lower scores than the median for DDS and DED are represented in Table 1. No significant differences in demographic characteristics (age, education, income, weight, BMI, WC, medications, duration of diabetes, and physical activity) were observed across the groups according to DDS and DED classifications. Of 426 participants, 46.7% suffered from depression (38.0% mild/moderate, 8.7% severe), and 53.3% were normal. As presented in Table 1, based on depression, no statistically significant differences were observed in basal characteristics of the participants. Compared with those with lower score for DASH ($P = 0.04$) and Mediterranean ($P = 0.02$) scores, women with greater adherence, were more physically active. In addition, the duration of diabetes among women in the top category of the Mediterranean diet was significantly more than the lowest one (0.02) (Table 2). There were no significant differences in demographic characteristics of women in the AHEI categories except for WHR ($P = 0.001$). Participants with the highest adherences to the Mediterranean diet had greater WHR compared to those with the lowest one (Table 2).

Dietary intake

Table 3 gives information about dietary intake in the categories of DDS, DED and depression for the study participants. There were no significant differences in the dietary intake of subjects with higher dietary diversity compared to those with lower one except for total fat ($P = 0.02$) and SFAs ($P = 0.03$), and zinc ($p = 0.03$). Comparison of participants in two DDS categories indicated that subjects with higher DDS score consumed more grain, fruits, meats, cereals and dairy compared to those with lower one. We also found that there were significant differences in dietary intake parameters between subjects with high and low DED, except for protein ($P = 0.09$), vitamin B1 ($P = 0.5$), and dietary fiber intake ($P = 0.8$) (Table 2). Based on the DED category, there were no significant differences in the amount of main food groups except for total meat intake ($P < 0.01$). Comparison subjects in depression categories showed no significant differences dietary intake. Women who adhered more to the DASH diet, consumed less carbohydrate ($P = 0.002$), while the intake of vitamin E ($P = 0.001$) and calcium ($P = 0.03$) was greater than those with low adherence. Moreover, the amount of main food groups except total meat was different between two categories of DASH score. Compared to those with the lowest Mediterranean score, subjects with the greatest one, had more dietary intake except for PUFA ($P = 0.4$), vitamin B6 ($P = 0.7$), zinc ($n = 0.1$), calcium ($P = 0.4$) and total grain ($P = 0.4$). In participants with high score for AHEI, energy intake ($P = 0.001$), protein ($P = 0.01$), and PUFA ($P = 0.01$) were more than those with low score. There were no differences in meat ($P = 0.1$) and dairy products ($P = 0.8$) between two categories of Mediterranean diet (Table 4).

Biochemical parameters

As presented in Table 5, according to the DDS, DDS to DED ratio, DASH, Mediterranean and AHEI scores, there were no significant differences in glycemic status, lipid profile and liver enzymes between subjects with high and low adherence. However, serum levels of TG ($P = 0.04$) and LDL-C ($P = 0.01$) in upper category of the DED were significantly more than those in the lower one. Additionally, serum concentrations of TC was marginally

Table 1. Basal characteristics of participants in dietary diversity scores (DDS), energy density (ED) and depression categories

Variables	DDS		*P* value[c]	ED		*P* value[c]	Depression			*P* value[d]
	Low (n = 211)	High (n = 215)		Low (n = 212)	High (n = 214)		Normal (n = 227)	Mild/Moderate (n = 162)	Severe (n = 37)	
Age (year)	51.7 ± 7.7[a]	52.1 ± 7.7	0.6	51.4 ± 7.3	52.3 ± 8.1	0.2	52.1 ± 7.7	51.2 ± 7.8	53.1 ± 6.9	0.3
Weight (kg)	75.4 ± 13.8	75.9 ± 12.6	0.6[d]	75.4 ± 11.8	76.0 ± 14.4	0.6[d]	75.0 ± 13.3	76.5 ± 13.0	76.0 ± 13.8	0.5
BMI (kg/m²)	31.4 ± 6.1	31.6 ± 5.8	0.7[d]	30.4 ± 4.3	32.5 ± 7.1	0.7[d]	31.4 ± 5.6	31.5 ± 6.2	31.8 ± 6.9	0.9
WC (cm)	102.3 ± 11.9	103.5 ± 11.1	0.3[d]	101.9 ± 11.0	103.9 ± 12.0	0.06[d]	102.2 ± 11.9	103.6 ± 11.6	104.2 ± 8.9	0.4
WHR	0.96 ± 0.52	0.93 ± 0.07	0.3[d]	0.96 ± 0.52	0.94 ± 0.06	0.6[d]	0.96 ± 0.52	0.93 ± 0.06	0.94 ± 0.04	0.7
Medications (n)										
Insulin	19	24	0.09[e]	19	24	0.2[e]	14	9	1	0.1
Oral	182	191		191	190		213	153	36	
Duration of diabetes (months)	48.0 (24.0, 108.0)[b]	72.0 (36.0, 120.0)	0.5	60.0 (24.0, 120.0)	60.0 (33.0, 120.0)	0.7	48.0 (24.0, 120.0)	60.0 (24.0, 120.0)	54.0 (36.0, 120.0)	0.4
Physical activity (MET/day)	180 (120, 300)	180 (120, 300)	0.7	240.0 (120.0, 300.0)	180.0 (120.0, 300.0)	0.9	180 (120, 300)	180 (120, 300)	240.0 (120.0, 330.0)	0.4

WC, Waist circumference; WHR, Waist to Hip ratio; BMI, body mass index.
[a] Mean ± SD; [b] Median (25th, 75th); [c] Independent t-test; [d] ANCOVA (adjusted for energy intake and physical activity; [e] Chi-Square test.

Table 2. Basal characteristics of participants in the DASH, AHEI and Mediterranean categories

Variables	DASH		*P* value[c]	AHEI		*P* value[c]	Mediterranean		*P* value[c]
	Low (n = 235)	High (n = 191)		Low (n = 155)	High (n = 179)		Low (n = 220)	High (n = 163)	
Age (year)	51.2 ± 7.4[a]	52.7 ± 7.9	0.05	51.4 ± 7.2	51.9 ± 7.9	0.5	51.0 ± 8.0	52.9 ± 7.6	0.02
Weight (kg)	75.5 ± 13.2	75.9 ± 13.1	0.7[d]	75.0 ± 12.2	75.6 ± 12.7	0.67[d]	75.1 ± 13.0	76.5 ± 13.5	0.3[d]
BMI (kg/m²)	31.7 ± 6.7	31.4 ± 5.4	0.5[d]	31.5 ± 6.5	31.5 ± 5.7	0.93[d]	31.7 ± 6.6	31.7 ± 5.8	0.9[d]
WC (cm)	101.6 ± 11.5	104.5 ± 11.4	0.03[d]	101.2 ± 10.4	103.9 ± 11.8	0.1[d]	102.2 ± 10.8	104.7 ± 12.4	0.09[d]
WHR	0.95 ± 0.50	0.94 ± 0.06	0.8[d]	0.91 ± 0.07	0.94 ± 0.06	0.001[d]	0.92 ± 0.07	0.98 ± 0.59	0.1[d]
Medications (n)									
Insulin	24	19	0.5	11	19	0.16	24	12	0.1
Oral	197	162		137	149		183	140	
Duration of diabetes (months)	60.0 (24.0, 120.0)[b]	60.0 (36.0, 120.0)	0.2	60.0 (24.0, 120.0)	60.0 (28.5, 120.0)	0.14	48.0 (24.0, 120.0)	180.0 (120.0, 300.0)	0.02
Physical activity (MET/day)	180.0 (120.0, 300.0)	240.0 (120.0, 300.0)	0.04	180.0 (90.0, 300.0)	240.0 (120.0, 300.0)	0.19	60.0 (36.0, 120.0)	240.0 (120.0, 300.0)	0.01

WC, Waist circumference; WHR, Waist to Hip ratio; BMI, body mass index.
[a] Mean ± SD; [b] Median (25th, 75th); [c] Independent t-test; [d] ANCOVA (adjusted for energy intake and physical activity; [e] Chi-Square test.

significant in participants with higher DED compared to those with lower score (*P* = 0.05). After taking possible confounder, macro- and micro-nutrient intakes, into account, no significant differences were remained for TG (*P* = 0.3) between DED categories, while for subjects with high dense diet, greater serum levels of LDL-C (*P* = 0.02) and TC (*P* = 0.02) were found.

Associations between dietary indices and depression

Unadjusted and adjusted logistic regression between each dietary quality index and depression are summarized in Table 6. After controlling for possible confounders, we found that there were no significant associations between depression, DDS (OR: 0.95; 95% CI: 0.65, 1.40; *P* = 0.8), DED (OR: 0.91; 95% CI: 0.62, 1.34) and DDS/DED (OR: 0.81; 95% CI: 0.55, 1.18; *P* = 0.2). Moreover, there were no differences in the risk of depression between subjects who highly adhered to DASH (OR: 1.08; 95% CI: 0.74, 1.16; *P* = 0.6), AHEI (OR: 1.08; 95% CI: 0.70, 1.66; *P* = 0.7) and Mediterranean diet (OR: 1.06; 95% CI: 0.70, 1.5; *P* = 0.76) compared to those with low adherence.

Overall, missing data was between 2 to 4% among different variables. Based on imputation methods, wherever possible missing data was filled out based on the existence information. However, due to un-accessibility to some participants to ask about food and beverages they consumed during the past 24 hours, fewer than two 24-hour dietary recalls were filled out for some participants. Due to limited information about dietary intake for such participants (n = 10), they were not included for statistical analysis.

Table 3. Dietary intake based on the categories of DDS, ED and depression

Variables	DDS		*P* value[d]	ED		*P* value[d]	Depression			*P* value[d]
	Low (n = 211)	High (n = 215)		Low (n = 212)	High (n = 214)		Normal (n = 227)	Mild/ Moderate (n = 162)	Severe (n = 37)	
Total energy (kcal/day)	1694 ± 390[a]	1756 ± 343	0.06[c]	1565 ± 392	1883 ± 259.2	< 0.01[c]	1706 ± 367	1749 ± 374	1716 ± 340	0.5[c]
Carbohydrate (g/day)	226.1 ± 58.0	231.0 ± 53.9	0.4	219.1 ± 60.4	237.6 ± 49.8	< 0.01	226.7 ± 55.7	230.5 ± 53.9	224.5 ± 65.3	0.7
Protein (g/ day)	56.3 ± 19.2	57.4 ± 15.0	0.1	55.8 ± 19.4	57.8 ± 14.8	0.09	17.3 ± 1.1	17.5 ± 1.3	53.1 ± 14.7	0.3
Fat (g/day)	65.6 (47.0, 81.9)[b]	70.0 (51.5, 87.3)	0.02	55.8 (39.9, 68.4)	80.0 (66.6, 92.3)	< 0.01	66.2 ± 22.5	70.3 ± 27.9	67.2 ± 21.3	0.2
Dietary fiber (g/day)	13.6 (10.1, 15.5)	14.4 (11.1, 16.8)	0.08	14.3 (10.0, 16.6)	13.6 (11.1, 15.6)	0.8	13.3 (10.6, 16.1)	13.0 (10.8, 16.5)	12.8 (10.4, 15.5)	0.7
PUFA (g/day)	22.0 (14.1, 28.5)	22.4 (16.0, 27.9)	0.05	19.5 (11.5, 26.2)	25.0 (19.6, 28.8)	< 0.01	21.2 ± 9.2	23.1 ± 11.8	24.0 ± 9.0	0.1
SFA (g/day)	15.5 (11.5, 18.3)	16.7 (12.3, 19.9)	0.03	14.2(10.2, 17.2)	18.0 (13.9, 20.8)	< 0.01	15.7 ± 6.1	16.9 ± 7.8	15.0 ± 5.5	0.1
Vitamin B1(mg/day)	1.3 (1.1, 1.5)	1.3 (1.1, 1.5)	0.6	1.3 (1.0, 1.5)	1.3 (1.1, 1.5)	0.5	1.3 ± 0.3	1.3 ± 0.3	1.3 ± 0.4	0.7
Vitamin B6 (mg/day)	1.2 (0.8, 1.5)	1.3 (0.9, 1.4)	0.4	1.2 (0.8, 1.4)	1.3 (1.0, 1.5)	< 0.01	1.2 (0.98, 1.4)	1.2(0.9, 1.5)	0.9 (0.7, 1.2)	0.2
Vitamin C (mg/day)	70.2 (40.6, 85.0)	74.5 (41.3, 93.5)	0.08	82.7 (47.0, 104.9)	61.9 (36.2, 81.8)	< 0.01	63.5 (45.1, 93.3)	59.8(40.0, 91.3)	51.9 (32.1, 75.1)	0.1
Vitamin E (mg/day)	10.6 (1.3, 20.3)	14.1 (2.1, 25.6)	0.05	3.9 (1.2, 4.0)	20.7 (16.2, 28.0)	< 0.01	5.2 (1.8, 23.7)	5.1 (1.7, 23.3)	2.4(1.2, 20.5)	0.4
Zinc (mg/ day)	6.4 (5.1, 7.7)	7.0 (5.7, 8.2)	0.03	6.3 (4.6, 7.7)	7.2 (6.0, 8.1)	< 0.01	6.8 (5.5, 7.8)	6.9(5.3, 8.5)	6.2(4.5, 7.4)	0.06
Calcium (mg/ day)	520.2 (350.8, 641.2)	554.4 (389.7, 670.0)	0.5	582.9 (381.2, 757.4)	491.3 (373.5, 579.2)	< 0.01	4.8 (3.8, 6.5)	4.9(3.5, 6.6)	4.6(3.5, 6.4)	0.8
Total grain (g/ day)	145.7 (94.0 185.0)	173.5 (108.0, 217.0)	0.1	155.4 (106.0, 195.0)	164.5 (94.7, 206.5)	0.3	148.0 (105.0, 202.0)	142.5 (100.2, 142.5)	139.0 (73.5, 175.0)	0.3
Total vegetables (g/ day)	127.0 (74.5, 167.5)	146.5(80.0, 186.0)	0.1	134.5 (78.0, 174.0)	139.6 (77.7, 185.0)	0.7	123.0 (77.0, 185.0)	118.0 (79.7, 172.2)	105.0 (65.0, 164.5)	0.5
Total fruits (g/ day)	132.3 (37.5, 119.2)	173.9 (115.0, 195.0)	< 0.01	146.7 (85.0, 185.0)	158.7 (75.0, 191.2)	0.9	134.0 (75.0, 185.0)	144.0 (80.0, 196.2)	140.0 (85.0, 185.0)	0.5
Total meat (g/ day)	45.1 (27.5, 55.0)	59.1 (40.0, 73.0)	< 0.01	47.7 (30.0, 55.0)	56.6 (35.0, 75.0)	< 0.01	46.0 (30.0, 67.0)	50.0 (36.7, 67.2)	40.0 (31.5, 50.0)	0.1
Total cereal (g/day)	15.5 (0, 20)	23.8 (8.0, 35.0)	0.01	20.0 (8.0, 25.0)	19.3 (0, 26.5)	0.4	14.0 (0, 26.0)	15.0 (3.7, 25.0)	12.0 (2.5, 36.5)	0.3
Total dairy (g/ day)	80.3 (30.0, 115.0)	126.2 (50.0, 170.0)	< 0.01	102.2 (56.0, 133.0)	105.0 (30.0, 140.0)	0.6	90.0 (30.0, 130.0)	95.0 (43.7, 136.2)	100.0 (85.0, 185.0)	0.1

[a] Mean ± SD; [b] Median (25th, 75th); [c] Independent t-test; [d] ANCOVA (adjusted for energy intake).

Discussion

The present study showed that women with type 2 diabetes who experienced higher energy dense diets had greater serum levels of TC and LDL-C than those with lower ones. However, no association was found for other dietary quality indices and biochemical parameters in patients with T2DM. In addition, no significant associations were observed between dietary quality indices and the risk of depression. To the best of our knowledge, the current study is one of the first cross-sectional studies on T2DM examining the association of DDS and DED with cardiovascular disease (CVD) risk factors and depression.

A prospective cohort study with a 12-year follow-up in the UK indicated that an energy-dense diet can increase the risk of DM by 60%.[35] Due to the cross-sectional design of the present study, we were not able to examine the effects of DED on the incidence of DM. However, when we examined the association of DED, FBS and, HbA1C, no significant association was found. From the biochemical point of view, our study was in line with Khayatzadeh et al study.[36] They reported that energy-dense diets were related to dyslipidemia (higher serum levels of TC, TG, LDL-C and, HDL-C) with no significant relationship with FBS concentrations in Iranian women.[36] In another study, they revealed that higher score for DED increased the risk of metabolic syndrome and all feathers of this disorder in Iranian population.[37] However in our study, no significant differences were found in anthropometric indices of the participants with either lower or higher DED score. Hence, our study was focused on patients with T2DM, it is likely to encounter into considerable under report for dietary intake. Furthermore, such patients prefer to report less sugar, fat or other foods that should be restricted in their diets. Accordingly, we might obtain no real range for DED. Therefore, observing no association among most evaluated parameters might

Table 4. Dietary intake based on the categories of DASH, AHEI and Mediterranean dietary diets

Variables	DASH		*P* value[c]	AHEI		*P* value[c]	Mediterranean		*P* value[c]
	Low (n = 235)	High (n = 191)		Low (n = 155)	High (n = 179)		Low (n = 220)	High (n = 163)	
Total energy (kcal/day)	1721 (1208, 1908)[a]	1742 (1331, 1928)	0.1[b]	1670 (993, 1894)	1781 (1565, 1963)	0.001[b]	1667 (1185, 1829)	1886 (1550, 2024)	0.0001[b]
Carbohydrate (g/day)	235.8 (195.3, 296.4)	218.7 (181.8, 264.2)	0.002	231.9 (195.3, 309.5)	230.5 (199.2, 269.3)	0.2	216.1 (187.5, 270.8)	243.9 (200.1, 272.1)	0.001
Protein (g/day)	58.7 (48.8, 89.8)	57.4 (48.4, 71.7)	0.3	58.8 (48.7, 92.6)	55.7 (46.6, 65.6)	0.01	55.0 (45.2, 71.3)	60.6 (52.6, 88.1)	0.0001
Fat (g/day)	67.7 (51.6, 88.6)	73.8 (54.7, 91.1)	0.1	67.7 (50.5, 85.8)	70.8 (54.3, 88.7)	0.4	66.8 (48.1, 84.6)	84.2 (65.0, 99.2)	0.0001
Dietary fiber (g/day)	14.2 (11.4, 21.2)	14.1(11.2, 19.3)	0.5	12.8 (10.4, 19.8)	14.4 (11.8, 17.7)	0.1	13.3 (10.9, 19.6)	15.5 (13.0, 21.8)	0.0001
PUFA (g/day)	20.4 (14.5, 20.4)	21.0 (14.1, 26.9)	0.6	19.6 (13.2, 26.4)	22.7 (16.4, 28.6)	0.01	20.9 (13.3, 27.2)	21.7 (15.4, 27.7)	0.4
SFA (g/day)	15.2 (11.9, 21.6)	15.8 (12.1, 20.8)	0.3	15.6 (12.1, 21.8)	15.1 (11.8, 18.8)	0.1	14.7 (10.7, 19.9)	18.2 (13.9, 18.2)	0.0001
Vitamin B1(mg/day)	1.3 (1.1, 1.5)	1.3 (1.1, 1.6)	0.06	1.2 (1.0, 1.4)	1.3 (1.1, 1.5)	0.01	1.2 (1.0, 1.4)	1.4 (1.2, 1.8)	0.0001
Vitamin B6 (mg/day)	1.2 (0.9, 1.9)	1.2 (0.9, 1.5)	0.1	1.2 (0.9, 2.4)	1.2 (0.9, 1.5)	0.1	1.2 (0.9, 1.8)	1.2 (1.0, 1.6)	0.7
Vitamin C (mg/day)	51.9 (27.2, 85.5)	55.2 (28.4, 82.8)	0.9	46.9 (22.3, 77.7)	63.5 (40.5, 93.5)	0.02	49.0 (26.3, 81.8)	52.9 (26.0, 84.5)	0.6
Vitamin E (mg/day)	4.8 (0.9, 23.0)	17.2 (2.1, 26.9)	0.001	2.4 (0.5, 22.6)	16.4 (2.1, 25.6)	0.001	3.7 (1.1, 23.2)	21.1 (10.9, 27.6)	0.0001
Zinc (mg/day)	6.1 (3.8, 7.5)	6.3 (4.6, 7.9)	0.1	5.8 (3.5, 7.3)	7.0 (5.4, 8.2)	0.5	5.8 (3.8, 7.3)	7.0 (5.2, 8.1)	0.1
Calcium (mg/day)	441.9 (257.4, 597.1)	454.3 (342.9, 637.3)	0.03	441.9 (235.9, 614.7)	473.7 (350.4, 638.4)	0.8	414.9 (273.3, 557.0)	462.6 (266.7, 633.6)	0.4
Total grain (g/day)	250.0 (188.0, 320.2)	286.5 (205.0, 357.7)	0.01	248.5 (185.9, 318.5)	292.0 (220.0, 357.0)	0.03	260.0 (195.0, 335.0)	290.0 (208.5, 364.5)	0.4
Total vegetables (g/day)	100.0 (70.0, 152.0)	153.0 (97.2, 223.0)	0.001	85.0 (63.0, 127.0)	149.0 (99.0, 211.0)	0.001	97.5 (70.0, 145.7)	153.0 (99.0, 217.0)	0.001
Total fruits (g/day)	85.0 (0.0, 155.0)	145.0 (98.5, 194.2)	0.001	75.0 (0.0, 130.0)	155.0 (115.0, 215.0)	0.001	105.0 (25.0, 150.0)	152.5 (96.2, 215.0)	0.001
Total meat (g/day)	50.0 (37.0, 70.0)	47.5 (32.0, 75.0)	0.3	53.0 (40.0, 72.0)	45.0 (30.0, 67.0)	0.1	47.0 (34.2, 63.0)	55.0 (40.0, 82.5)	0.004
Total cereal (g/day)	0.0 (0.0, 12.0)	23.0 (12.0, 40.0)	0.001	5.0 (0.0, 12.0)	17.0 (10.0, 35.0)	0.001	8.5 (0, 15.0)	18.0 (10.0, 37.2)	0.001
Total dairy (g/day)	65.0 (30.0, 115.0)	105.0 (55.7, 155.0)	0.001	90.0 (45.0, 130.0)	90.0 (35.0, 135.0)	0.8	101.5 (57.2, 135.0)	64.5 (30.0, 113.7)	0.01

[a]Median (25th, 75th) , [b] Independent t-test; [c]ANCOVA (adjusted for energy intake).

be influenced by this matter. In a case-control study by Menegotto et al, there was a positive association between a high DED at lunch and metabolic syndrome in patients with T2DM.[38] The findings of Menegotto and colleagues' study were restricted to only energy density at lunch and overall DED score was not evaluated. Vernarelli et al concluded that DED is not associated with FBS levels in the U.S population. From the view point of changes in FBS levels, our study was in line with Vernarelli et al study.[39] Population-based cohort study by Hu et al, demonstrated that lower energy-dense diets did not inversely associate with weight gain. However, it showed a weak potentially positive effect on abdominal obesity prevention.[40] In contrast to the aforesaid study, we did not observe an association between anthropometric indices and DED score. Although weight, BMI and WC in the group with higher score of DED was slightly more than the lower one, no statistically significant differences were found between two DED categories. The mean of DED, energy intake and taking anti-diabetic medications of the study groups can be involved in different results. On the whole, high-dense diet possess lower dietary fiber, higher energy, fat and simple carbohydrate; therefore higher risk for CVD is expected following energy-dense diets. Furthermore, differences in disease background, age range, medications, cut off points for DED and total energy intake might be led to such discrepancy results.

In the present study, no association was found between DDS and biochemical parameters. Additionally, anthropometric indices were not associated with this dietary index. Our findings were in line with a recent systematic review and meta-analysis study. It revealed that there was no significant association between DDS and BMI.[41] Using different methods for dietary assessment and scoring for dietary diversity might cause various results among studies. However, due to the design of the present study (cross-sectional), the cause and effect relationship between DDS and anthropometric indices remained unclear.

Overall, DDS is calculated based on diversity score of seven food groups. It is greatly importance to know which food group plays a determinative role in the total score of dietary diversity. For instance, if it is related to high intake of healthy foods including fruits, vegetables and whole

Table 5. Biochemical parameters based on dietary indices in the study participants

	FBS (mg/dL)	HbA1c (%)	TC (mg/dL)	TG (mg/dL)	LDL-C (mg/dL)	HDL-C (mg/dL)	AST (U/L)	ALT (U/L)
DDS								
Low (n=211)	136.0±43.9[a]	7.3±1.4	184.50±37.3	130.0 (91.5, 183.7)	95.7±24.1	43.8±9.8	19.0 (16.0, 23.0)[b]	20.0 (16.0, 27.0)
High (n=215)	137.7±45.1	7.3±1.4	182.2±37.6	148.0 (107.5, 186.0)	95.0±23.3	44.7±9.0	20.0 (17.0, 25.0)	19.0 (15.0, 27.0)
P value [c]	0.7	0.5	0.5	0.5	0.8	0.3	0.9	0.6
ED								
Low (n=212)	135.1±45.0	7.2±1.4	179.9±37.8	132.0 (100.0, 184.7)	92.7±23.6	44.8±9.9	19.0 (16.2, 24.0)	20.0 (17.0, 24.5)
High (n=214)	138.9±43.9	7.4±1.3	186.9±36.7	144.5 (102.7, 186.0)	98.1±23.4	43.6±8.7	19.5 (15.0, 26.0)	20.0(16.0, 29.0)
P value	0.3	0.1	0.02	0.3	0.02	0.1	0.6	0.1
DDS/ED								
Low	136.8±46.4	7.3±1.3	183.1±38.3	135.5 (102.0, 180.5)	94.7±24.2	44.1±11.2	19.0 (17.0, 23.0)	20.0 (16.0, 27.7)
High	136.6±43.5	7.3±1.5	182.7±40.0	141.0 (100.0, 198.0)	95.2±25.6	46.1±32.6	20.0 (17.0, 25.7)	19.5 (15.0, 26.7)
P value	0.5	0.5	0.6	0.8	0.4	0.4	0.4	0.1
DASH								
Low	138.0±44.4	7.3±1.4	183.8±40.8	135.5 (102.0, 180.5)	96.2±25.3	45.4±31.6	19.0 (17.0, 23.0)	20.0 (16.0, 27.7)
High	135.2±45.5	7.2±1.5	181.7±36.8	141.0 (100.0, 198.0)	93.4±24.2	44.7±9.8	20.0 (17.0, 25.7)	19.5 (15.0, 26.7)
P value	0.1	0.2	0.2	0.3	0.07	0.4	0.4	0.9
Mediterranean								
Low	138.5±46.5	7.3±1.4	183.0±40.8	138.5 (100.0, 187.7)	95.2±25.1	45.9±32.2	19.0 (16.0, 24.0)	20.0 (15.0, 28.0)
High	133.8±43.2	7.3±1.5	182.7±34.6	138.5 (104.2, 184.7)	94.5±23.6	44.4±11.3	20.0 (17.0, 24.7)	20.0 (16.0, 27.0)
P value	0.4	0.2	0.4	0.8	0.4	0.4	0.6	0.5
AHEI								
Low	140.2±47.6	7.3±1.5	181.7±44.1	138.0 (92.0, 187.0)	93.7±26.5	46.6±38.4	20.0 (16.7, 25.2)	21.0 (16.0, 30.0)
High	134.1±43.1	7.3±1.4	184.1±36.9	144.0 (108.0, 192.0)	96.5±23.8	43.6±9.2	20.0 (17.0, 24.0)	19.0 (15.0, 26.0)
P value	0.1	0.3	0.8	0.6	0.8	0.2	0.1	0.3

[a] Mean±SD; [b] Median (25th, 75th); [c] ANCOVA (adjusted for energy intake, macronutrients, age, duration of diabetes, physical activity, body mass index, waist circumference, medications).

Table 6. The association of depression risk with the dietary quality indices categories in the study participants

Dietary index	Category	95% CI	*P* value[a†]
DDS	Low	1.0	0.83
	High	1.0 (o.69, 1.49)	
ED	Low	1.0	0.33
	High	0.91 (0.62, 1.34)	
DDS/ED	Low	1.0	0.20
	High	0.81(0.55, 1.18)	
DASH	Low	1.0	0.67
	High	1.08 (0.74, 1.60)	
AHEI	Low	1.0	0.72
	High	1.08 (0.70, 1.66)	
Mediterranean	Low	1.0	0.76
	High	1.06 (0.70, 1.50)	

Reference group=normal subjects; CI: Confidence Interval.
[†]Binary Logistic Regression
[a]Adjusted for age, menopause status, duration of diabetes, medications, energy intake, physical activity level, body mass index.

grain, the possibility for obesity due to consumption of such foods are low. However, high diversity in the consumption of unhealthy foods can be a consequence of obesity.[42] Given that, adherence to high dietary diversity diet is not always related to higher anthropometric indices. In the present study, we also reported the ratio of DDS to DED and we did not find any association with biochemical parameters. As this ratio clarify the DDS considering energy density of diet it can be more useful than DDS alone.

In the present study, no association was found between adherence to high-quality diets and biochemical parameters. However, a systematic review revealed that long-term interventions (more than 16 weeks) of DASH diet can improve the glycemic status.[43] Azadbakht et al also concluded that DASH diet can improve glycemic status and serum levels of LDL-C and HDL-C with no changes in TC and TG concentrations after 8- week intervention among patients with T2DM.[44] From glycemic status point of view, our study was in line with Liese et al study.[45] They indicated that there was an association between LDL-C concentrations and adherence to DASH diet, whereas no relationship was found for DASH dietary pattern, glycemic status and other lipid profiles in American young patients with T2DM.[45] A cross-sectional study revealed that patients with T2DM in the top tertile of Mediterranean (score 6-9) diet had lower HbA1c concentrations compared to those in the bottom tertile.[46] However, we did not found any association. Based on a meta-analysis, Mediterranean diet may play a protective role against CVD compared to usual diet.[47] However, in our study there was no intervention and we only examine the score for Mediterranean diet in a certain period of time. A follow-up was needed to clarify this issue. On the other hand, there is no definite cut off points for dietary quality indices, each study considered different ranges. This parameter along with differences in the mean of dietary quality indices can play a promising role in different findings.

Overall, the mean scores for all dietary patterns in our study population were lower than previous studies. It means that adherence to healthy diets was generally low. Therefore, cut off points that were considered as lower and higher than median score, could not clarify the differences among individuals with different dietary patterns. Our study population did not receive any diabetic diets and it seems that their information about the effects of diet on metabolic status was substantially low. Based on a systematic review, Mediterranean and DASH diets may prevent heart failure and improve CVD risk factors. However, these findings were obtained from studies that most of them had low methodological quality.[48] Therefore, considering the quality in the interpretation of the results are important.

Several prior studies have linked depression to non-adherence with diabetes treatments, which can include diet, exercise and the use of medications.[18] The mutual effects of DM and depression present a substantial clinical challenge, as the outcome of each is aggravated by the presence of the other. The prevalence of depression (41.3%) in the present study was relatively similar to the prevalence in Palestine (40.2%)[49] and Saudi Arabia (49.6%)[50] among patients with T2DM. However, the depression rate was considerably lower in Korea (28.8%)[51] and Basque (9.8%)[52] compared to our findings.

To the best of our knowledge, no studies have examined the association of DDS, DED, and depression. However, prior studies assessed whether depression can be attributed to dietary intake. There are discrepancy results in this association. A systematic review by Sparling et al revealed the protective effects of several healthy dietary patterns on depression. However, it emphasized that due to methodological differences across the studies we cannot draw a certain conclusion in this regard.[53] Based on a recent meta-analysis although high-quality diets are linked with a lower risk for depression, not all available studies are in line with this hypothesis and many confounding factors can affect this associations.[54] Therefore, methodological differences and confounding factors are two main causes for inconsistence findings. Based on the National Health and Nutrition Examination Study in adult population, a healthy dietary pattern can reduce the symptoms of depression in patients with T2DM by 32%.[27] The importance of healthy diets on depressive symptoms can be explained by their effects on metabolic status. Dietary patterns can affect serum levels of hormones including insulin, leptin and, ghrelin. Inflammation and oxidative stress are two main factors that impact upon the risk for depression and can be controlled by dietary patterns).[55] In the present study, we found no significant association of depression, DED and DDS. Higher DDS and lower DED mostly are associated with the consumption of healthy foods. However, in the present study, mean DDS was lower than reported scores in the previous studies on healthy subjects; thereby, we did not observe an association between DDS or DED and depression. A systematic review revealed that there was limited evidence supporting an association between healthy diets and depression, and more studies are needed to clarify this association.[56] As each healthy dietary pattern considers different dietary items and there are various methods for scoring, this association remained unclear.

However, a meta-analysis indicated that high adherence to Mediterranean diet was inversely linked with depression.[57] Valipour et al found that there was an inverse link between moderate adherence to DASH diet (score range: 41-50) and depression in Iranian population, while the score of less than 41 for DASH dietary pattern showed no association.[58] Perez-Cornago et al also reported that in a cohort study, moderate adherence to DASH diet reduced the risk of depression during 8 years of follow up.[59] The two aforementioned studies revealed that the mean score of adherence to healthy diets is more important than assignment in the top or bottom tertile. As the current study was a cross-sectional study, no intervention including nutritional education was presented. Therefore, only the association between depression and usual diet was examined. Due to mean score of healthy diets, generally low adherence to healthy diets existed among our study population.

A meta-analysis showed that Mediterranean diet is associated with reduced risk for depression [57]. Based on Olveira et al study, patients with bronchiectasis who highly adhered to Mediterranean diet experienced less depression symptom.[60] Adibade et al also demonstrated that French women who adhered to Mediterranean diet had the lower risk for the incident of depression.[61] Saneei et al also indicated that in young subjects (less than 40 years old) with high adherence to altered healthy eating index-2010, depression was identified in fewer individuals than those with lower adherence.[62] However, Exebio et al showed that patients with T2DM who had a greater healthy eating index (HEI) score suffered from more depressive symptoms.[63] They suggested that other parameters such as age and physiological factors can be involved in the incidence of depression. Type of depression, depression causes, age and other environmental factors can play roles in the incidence of depression. Furthermore, the types of index related to dietary intake and its mean score can impact upon the association.

As our study was on women, the findings cannot be generalized to men in our society due to the effects of sex differences on our interest outcomes. However, in the present study women can be considered as a representative of women with T2DM that controlled their glycemic status well. Because they were chosen from different regions of a city and might cover different social, economic and educational status. However, it is likely to observe different results in women with other ranges of age. Therefore, more studies in both genders with different ranges of HbA1c and age are needed in various societies.

The present study had several limitations. First, we used a cross-sectional study design to identify the association of dietary quality indices with CVD risk factors and depression. This study design did not allow us to examine cause-effect associations. Second, due to study on only women, the interested associations were remained unclear in men populations. Third, there was a narrow range for all dietary quality indices compared to the previous studies and their mean score was lower than previous studies which could not identify the differences between higher and lower score, thoroughly. However, our study had several strengths. We evaluated the association of DDS, DED and depression in T2DM for the first time. Data were controlled for several known potential confounders which influenced the association. The effects of other dietary quality indices in studies with prospective design are suggested for the future research. Furthermore, the adaptation of the current dietary quality indices for patients with T2DM can be more helpful to clarify the association of diet with physiological and psychological disorders.

Conclusion

The present study showed that there was a positive association between the DED score and the serum levels of TC and LDL-C, whilst no association was found for other dietary quality indices, biochemical parameters and the risk for depression in patients with T2DM. Given that, efforts to reduce the energy density of diets by emphasizing using higher sources of fiber including cereals, vegetable and some fruits and controlling total energy intake may be helpful. Due to low-quality diet among the study population, nutritional education is recommended. Further studies are needed to identify the association between dietary quality indices and the risk of depression in patients with T2DM.

Acknowledgments

We would like to thank the municipality of Tehran for helping in sampling. We also express our thankfulness to Novo Nordisk Company for financial support and all patients with T2DM for their participation.

Authors' Contribution

Conceptualization: Nazli Namazi, Bagher Larijani, Hossein Adibi.
Data curation: Mahnaz Sanjari, Maryam Aalaa, Mohammad-Reza Amini.
Formal analysis: Mostafa Ghorbani, Nazli Namazi, Mahnaz Sanjari, Farideh Razi.
Methodology: Mostafa Ghorbani, Neda Mehrdad, Farideh Razi, Hossein Adibi.
Writing-original draft: Nazli Namazi.
Writing-review & editing: Nazli Namazi, Mahnaz Sanjari, Mostafa Ghorbani, Bagher Larijani, Maryam Aalaa, Mohammad-Reza Amini, Hossein Adibi, Farideh Razi, Hamidreza Aghaei-Meybodi, Neda Mehrdad.

Competing Interests

The authors declare there are no conflicts of interest.

Ethical Approval

The present study has been approved by the ethics committee of Endocrinology and Metabolism Research Institute of Tehran University of Medical Sciences (code: EC-00378) in accordance with the Helsinki Declaration and the guidelines of Iranian Ministry of Health and Medical Education.

Funding

This work was supported by the Tehran University of Medical University and Novo Nordisk Company.

Intelligence Use Disclosure

This article has not utilized artificial intelligence (AI) tools for research and manuscript development, as per the GAMER reporting guideline.

References

1. Beaglehole R, Bonita R, Horton R, Adams C, Alleyne G, Asaria P, et al. Priority actions for the non-communicable disease crisis. Lancet. 2011;377(9775):1438-47. doi: 10.1016/s0140-6736(11)60393-0.
2. Backholer K, Peeters A, Herman WH, Shaw JE, Liew D, Ademi Z, et al. Diabetes prevention and treatment strategies: are we doing enough? Diabetes Care. 2013;36(9):2714-9. doi: 10.2337/dc12-2501.
3. Namazi N, Saeedi Moghaddam S, Esmaeili S, Peimani M, Sharifnejad Tehrani Y, Bandarian F, et al. Burden of type 2 diabetes mellitus and its risk factors in North Africa and the Middle East, 1990-2019: findings from the Global Burden of Disease study 2019. BMC Public Health. 2024;24(1):98. doi: 10.1186/s12889-023-16540-8.
4. de Oliveira Otto MC, Padhye NS, Bertoni AG, Jacobs DR Jr, Mozaffarian D. Everything in moderation--dietary diversity and quality, central obesity and risk of diabetes. PLoS One. 2015;10(10):e0141341. doi: 10.1371/journal.pone.0141341.
5. Conklin AI, Monsivais P, Khaw KT, Wareham NJ, Forouhi NG. Dietary diversity, diet cost, and incidence of type 2 diabetes in the United Kingdom: a prospective cohort study. PLoS Med. 2016;13(7):e1002085. doi: 10.1371/journal.pmed.1002085.
6. Babashahi M, Mirlohi M, Ghiasvand R, Azadbakht L. Comparison of soymilk and probiotic soymilk effects on serum high-density lipoprotein cholesterol and low-density lipoprotein cholesterol in diabetic Wistar rats. ARYA Atheroscler. 2015;11(Suppl 1):88-93.
7. Saraf-Bank S, Esmaillzadeh A, Faghihimani E, Azadbakht L. Effect of non-soy legume consumption on inflammation and

serum adiponectin levels among first-degree relatives of patients with diabetes: a randomized, crossover study. Nutrition. 2015;31(3):459-65. doi: 10.1016/j.nut.2014.09.015.
8. Namazi N, Larijani B, Azadbakht L. Low-carbohydrate-diet score and its association with the risk of diabetes: a systematic review and meta-analysis of cohort studies. Horm Metab Res. 2017;49(8):565-71. doi: 10.1055/s-0043-112347.
9. Tabesh M, Azadbakht L, Faghihimani E, Tabesh M, Esmaillzadeh A. Effects of calcium plus vitamin D supplementation on anthropometric measurements and blood pressure in vitamin D insufficient people with type 2 diabetes: a randomized controlled clinical trial. J Am Coll Nutr. 2015;34(4):281-9. doi: 10.1080/07315724.2014.905761.
10. Schulze MB, Hoffmann K, Manson JE, Willett WC, Meigs JB, Weikert C, et al. Dietary pattern, inflammation, and incidence of type 2 diabetes in women. Am J Clin Nutr. 2005;82(3):675-84. doi: 10.1093/ajcn.82.3.675.
11. McNaughton SA, Mishra GD, Brunner EJ. Dietary patterns, insulin resistance, and incidence of type 2 diabetes in the Whitehall II study. Diabetes Care. 2008;31(7):1343-8. doi: 10.2337/dc07-1946.
12. Alhazmi A, Stojanovski E, McEvoy M, Brown W, Garg ML. Diet quality score is a predictor of type 2 diabetes risk in women: the Australian Longitudinal Study on Women's Health. Br J Nutr. 2014;112(6):945-51. doi: 10.1017/s0007114514001688.
13. Kourlaba G, Panagiotakos DB. Dietary quality indices and human health: a review. Maturitas. 2009;62(1):1-8. doi: 10.1016/j.maturitas.2008.11.021.
14. Ruel MT. Is dietary diversity an indicator of food security or dietary quality? A review of measurement issues and research needs. Food Nutr Bull. 2003;24(2):231-2. doi: 10.1177/156482650302400210.
15. Mendoza JA, Drewnowski A, Christakis DA. Dietary energy density is associated with obesity and the metabolic syndrome in US adults. Diabetes Care. 2007;30(4):974-9. doi: 10.2337/dc06-2188.
16. Haghighatdoost F, Azadbakht L. Dietary treatment options for depression among diabetic patient, focusing on macronutrients. J Diabetes Res. 2013;2013:421832. doi: 10.1155/2013/421832.
17. Mendenhall E, Norris SA, Shidhaye R, Prabhakaran D. Depression and type 2 diabetes in low- and middle-income countries: a systematic review. Diabetes Res Clin Pract. 2014;103(2):276-85. doi: 10.1016/j.diabres.2014.01.001.
18. Holt RI, de Groot M, Golden SH. Diabetes and depression. Curr Diab Rep. 2014;14(6):491. doi: 10.1007/s11892-014-0491-3.
19. Park M, Katon WJ, Wolf FM. Depression and risk of mortality in individuals with diabetes: a meta-analysis and systematic review. Gen Hosp Psychiatry. 2013;35(3):217-25. doi: 10.1016/j.genhosppsych.2013.01.006.
20. Dipnall JF, Pasco JA, Meyer D, Berk M, Williams LJ, Dodd S, et al. The association between dietary patterns, diabetes and depression. J Affect Disord. 2015;174:215-24. doi: 10.1016/j.jad.2014.11.030.
21. Aalaa M, Sanjari M, Aghaei Meybodi HR, Amini MR, Qorbani M, Adibi H, et al. The effectiveness of a peer coaching education on control and management of type 2 diabetes in women: a protocol for a randomized controlled trial. Int J Community Based Nurs Midwifery. 2017;5(2):153-64.
22. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2014;37 Suppl 1:S81-90. doi: 10.2337/dc14-S081.
23. Esmaillzadeh A, Azadbakht L. Food intake patterns may explain the high prevalence of cardiovascular risk factors among Iranian women. J Nutr. 2008;138(8):1469-75. doi: 10.1093/jn/138.8.1469.
24. Saraf-Bank S, Haghighatdoost F, Esmaillzadeh A, Larijani B, Azadbakht L. Adherence to Healthy Eating Index-2010 is inversely associated with metabolic syndrome and its features among Iranian adult women. Eur J Clin Nutr. 2017;71(3):425-30. doi: 10.1038/ejcn.2016.173.
25. Kant AK, Schatzkin A, Ziegler RG. Dietary diversity and subsequent cause-specific mortality in the NHANES I epidemiologic follow-up study. J Am Coll Nutr. 1995;14(3):233-8. doi: 10.1080/07315724.1995.10718501.
26. Kant AK, Block G, Schatzkin A, Ziegler RG, Nestle M. Dietary diversity in the US population, NHANES II, 1976-1980. J Am Diet Assoc. 1991;91(12):1526-31.
27. Esmaillzadeh A, Azadbakht L. Dietary energy density and the metabolic syndrome among Iranian women. Eur J Clin Nutr. 2011;65(5):598-605. doi: 10.1038/ejcn.2010.284.
28. Ledikwe JH, Blanck HM, Khan LK, Serdula MK, Seymour JD, Tohill BC, et al. Dietary energy density determined by eight calculation methods in a nationally representative United States population. J Nutr. 2005;135(2):273-8. doi: 10.1093/jn/135.2.273.
29. Hariri N, Darafshi Ghahroudi S, Nasseri E, Bondarianzadeh D, Houshyar-Rad A, Zayeri F. Evaluation of the Alternative Healthy Eating Index as a predictor of 10-year cardiovascular disease risk in a group of Iranian employees. J Hum Nutr Diet. 2017;30(4):499-505. doi: 10.1111/jhn.12416.
30. Fung TT, Chiuve SE, McCullough ML, Rexrode KM, Logroscino G, Hu FB. Adherence to a DASH-style diet and risk of coronary heart disease and stroke in women. Arch Intern Med. 2008;168(7):713-20. doi: 10.1001/archinte.168.7.713.
31. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. N Engl J Med. 2003;348(26):2599-608. doi: 10.1056/NEJMoa025039.
32. Ghassemzadeh H, Mojtabai R, Karamghadiri N, Ebrahimkhani N. Psychometric properties of a Persian-language version of the Beck Depression Inventory--second edition: BDI-II-PERSIAN. Depress Anxiety. 2005;21(4):185-92. doi: 10.1002/da.20070.
33. Scogin F, Beutler L, Corbishley A, Hamblin D. Reliability and validity of the short form Beck Depression Inventory with older adults. J Clin Psychol. 1988;44(6):853-7. doi: 10.1002/1097-4679(198811)44:6<853::aid-jclp2270440604>3.0.co;2-7.
34. Hagströmer M, Oja P, Sjöström M. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. Public Health Nutr. 2006;9(6):755-62. doi: 10.1079/phn2005898.
35. Wang J, Luben R, Khaw KT, Bingham S, Wareham NJ, Forouhi NG. Dietary energy density predicts the risk of incident type 2 diabetes: the European Prospective Investigation of Cancer (EPIC)-Norfolk Study. Diabetes Care. 2008;31(11):2120-5. doi: 10.2337/dc08-1085.
36. Khayatzadeh S, Saneei P, Khosravi Boroujeni H, Azadbakht L, Esmaillzadeh A. Consumption of energy-dense diets in relation to cardiometabolic abnormalities among Tehranian women. Avicenna J Clin Med. 2013;20(1):38-48.
37. Esmaillzadeh A, Khosravi Boroujeni H, Azadbakht L. Consumption of energy-dense diets in relation to cardiometabolic abnormalities among Iranian women. Public Health Nutr. 2012;15(5):868-75. doi: 10.1017/s1368980011002680.
38. Menegotto G, Moraes Silva F, de Azevedo MJ, de Almeida JC. Lunch energy density and the metabolic syndrome in patients with type 2 diabetes mellitus. Br J Nutr. 2013;110(9):1656-63. doi: 10.1017/s0007114513000846.

39. Vernarelli JA, Mitchell DC, Rolls BJ, Hartman TJ. Dietary energy density is associated with obesity and other biomarkers of chronic disease in US adults. Eur J Nutr. 2015;54(1):59-65. doi: 10.1007/s00394-014-0685-0.
40. Bes-Rastrollo M, van Dam RM, Martinez-Gonzalez MA, Li TY, Sampson LL, Hu FB. Prospective study of dietary energy density and weight gain in women. Am J Clin Nutr. 2008;88(3):769-77. doi: 10.1093/ajcn/88.3.769.
41. Salehi-Abargouei A, Akbari F, Bellissimo N, Azadbakht L. Dietary diversity score and obesity: a systematic review and meta-analysis of observational studies. Eur J Clin Nutr. 2016;70(1):1-9. doi: 10.1038/ejcn.2015.118.
42. Azadbakht L, Mirmiran P, Azizi F. Dietary diversity score is favorably associated with the metabolic syndrome in Tehranian adults. Int J Obes (Lond). 2005;29(11):1361-7. doi: 10.1038/sj.ijo.0803029.
43. Shirani F, Salehi-Abargouei A, Azadbakht L. Effects of Dietary Approaches to Stop Hypertension (DASH) diet on some risk for developing type 2 diabetes: a systematic review and meta-analysis on controlled clinical trials. Nutrition. 2013;29(7-8):939-47. doi: 10.1016/j.nut.2012.12.021.
44. Azadbakht L, Rashidi Pour Fard N, Karimi M, Baghaei MH, Surkan PJ, Rahimi M, et al. Effects of the Dietary Approaches to Stop Hypertension (DASH) eating plan on cardiovascular risks among type 2 diabetic patients: a randomized crossover clinical trial. Diabetes Care. 2011;34(1):55-7. doi: 10.2337/dc10-0676.
45. Liese AD, Bortsov A, Günther AL, Dabelea D, Reynolds K, Standiford DA, et al. Association of DASH diet with cardiovascular risk factors in youth with diabetes mellitus: the SEARCH for Diabetes in Youth study. Circulation. 2011;123(13):1410-7. doi: 10.1161/circulationaha.110.955922.
46. Esposito K, Maiorino MI, Di Palo C, Giugliano D. Adherence to a Mediterranean diet and glycaemic control in type 2 diabetes mellitus. Diabet Med. 2009;26(9):900-7. doi: 10.1111/j.1464-5491.2009.02798.x.
47. Liyanage T, Ninomiya T, Wang A, Neal B, Jun M, Wong MG, et al. Effects of the Mediterranean diet on cardiovascular outcomes-a systematic review and meta-analysis. PLoS One. 2016;11(8):e0159252. doi: 10.1371/journal.pone.0159252.
48. Sanches Machado d'Almeida K, Ronchi Spillere S, Zuchinali P, Corrêa Souza G. Mediterranean diet and other dietary patterns in primary prevention of heart failure and changes in cardiac function markers: a systematic review. Nutrients. 2018;10(1):58. doi: 10.3390/nu10010058.
49. Sweileh WM, Abu-Hadeed HM, Al-Jabi SW, Zyoud SH. Prevalence of depression among people with type 2 diabetes mellitus: a cross sectional study in Palestine. BMC Public Health. 2014;14:163. doi: 10.1186/1471-2458-14-163.
50. El Mahalli AA. Prevalence and predictors of depression among type 2 diabetes mellitus outpatients in eastern province, Saudi Arabia. Int J Health Sci (Qassim). 2015;9(2):119-26.
51. Park CY, Kim SY, Gil JW, Park MH, Park JH, Kim Y. Depression among Korean adults with type 2 diabetes mellitus: Ansan-community-based epidemiological study. Osong Public Health Res Perspect. 2015;6(4):224-32. doi: 10.1016/j.phrp.2015.05.004.
52. Alonso-Morán E, Satylganova A, Orueta JF, Nuño-Solinis R. Prevalence of depression in adults with type 2 diabetes in the Basque country: relationship with glycaemic control and health care costs. BMC Public Health. 2014;14:769. doi: 10.1186/1471-2458-14-769.
53. Sparling TM, Henschke N, Nesbitt RC, Gabrysch S. The role of diet and nutritional supplementation in perinatal depression: a systematic review. Matern Child Nutr. 2017;13(1):10.1111/mcn.12235. doi: 10.1111/mcn.12235.
54. Molendijk M, Molero P, Ortuño Sánchez-Pedreño F, Van der Does W, Angel Martínez-González M. Diet quality and depression risk: a systematic review and dose-response meta-analysis of prospective studies. J Affect Disord. 2018;226:346-54. doi: 10.1016/j.jad.2017.09.022.
55. Anjom-Shoae J, Namazi N, Ayati MH, Darbandi M, Najafi F, Pasdar Y. Dietary insulin index and load in relation to cardiometabolic risk factors in patients with type 2 diabetes mellitus: a cross-sectional study on the RaNCD cohort study. Nutrition. 2023;105:111830. doi: 10.1016/j.nut.2022.111830.
56. Lai JS, Hiles S, Bisquera A, Hure AJ, McEvoy M, Attia J. A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults. Am J Clin Nutr. 2014;99(1):181-97. doi: 10.3945/ajcn.113.069880.
57. Psaltopoulou T, Sergentanis TN, Panagiotakos DB, Sergentanis IN, Kosti R, Scarmeas N. Mediterranean diet, stroke, cognitive impairment, and depression: a meta-analysis. Ann Neurol. 2013;74(4):580-91. doi: 10.1002/ana.23944.
58. Valipour G, Esmaillzadeh A, Azadbakht L, Afshar H, Hassanzadeh A, Adibi P. Adherence to the DASH diet in relation to psychological profile of Iranian adults. Eur J Nutr. 2017;56(1):309-20. doi: 10.1007/s00394-015-1081-0.
59. Perez-Cornago A, Sanchez-Villegas A, Bes-Rastrollo M, Gea A, Molero P, Lahortiga-Ramos F, et al. Relationship between adherence to Dietary Approaches to Stop Hypertension (DASH) diet indices and incidence of depression during up to 8 years of follow-up. Public Health Nutr. 2017;20(13):2383-92. doi: 10.1017/s1368980016001531.
60. Olveira C, Olveira G, Espildora F, Girón RM, Vendrell M, Dorado A, et al. Mediterranean diet is associated on symptoms of depression and anxiety in patients with bronchiectasis. Gen Hosp Psychiatry. 2014;36(3):277-83. doi: 10.1016/j.genhosppsych.2014.01.010.
61. Adjibade M, Assmann KE, Andreeva VA, Lemogne C, Hercberg S, Galan P, et al. Prospective association between adherence to the Mediterranean diet and risk of depressive symptoms in the French SU.VI.MAX cohort. Eur J Nutr. 2018;57(3):1225-35. doi: 10.1007/s00394-017-1405-3.
62. Saneei P, Hajishafiee M, Hassanzadeh Keshteli A, Afshar H, Esmaillzadeh A, Adibi P. Adherence to Alternative Healthy Eating Index in relation to depression and anxiety in Iranian adults. Br J Nutr. 2016;116(2):335-42. doi: 10.1017/s0007114516001926.
63. Exebio JC, Zarini GG, Exebio C, Huffman FG. Healthy Eating Index scores associated with symptoms of depression in Cuban-Americans with and without type 2 diabetes: a cross sectional study. Nutr J. 2011;10:135. doi: 10.1186/1475-2891-10-135.