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Association of Healthy Eating Index with Diabetes Complications Among Type 2 Diabetes Patients in Gaza Strip, Palestine: A Cross Sectional Study

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Abstract

Background: The prevalence of diabetes mellitus is rising worldwide. When diabetes is uncontrolled, it has dire consequences for health and well-being. The aim of this study was to determine the association between Healthy Eating Index-2010 (HEI-2010) score with diabetes complications among type 2 diabetes patients.

Methods: This cross-sectional study was conducted among 1187 previously diagnosed type 2 diabetes mellitus (both genders, aged 20-64 years), patients receiving care in primary healthcare centers in Gaza Strip, Palestine. A validated semi-quantitative food frequency questionnaire was used to assess the dietary intake of patients. HEI-2010 score was used to assess diet quality of patients. Additional information regarding demographic and medical history variables was obtained with an interview-based questionnaire. All statistical analysis was performed using SPSS version 20.

Results: After adjustment for potential confounders, patients in the lowest quartile (Q1) of HEI-2010 had the highest risk of (High blood pressure and heart problems), (Odds ratio [OR] =1.361, 95% confidence interval [CI] = [1.145-1.618]), (OR = 1.469, 95% CI = [1.148-1.878]), respectively, (P value < 0.005 for all), compared with those in the upper quartile (Q4). No significant association was found between HEI-2010 quartiles with eyes problems, kidney problems, extremities problems and neurological problems.

Conclusion: The highest HEI-2010 score may be associated with a lower prevalence of high blood pressure and heart problems among type 2 diabetes patients. Further prospective cohort studies are needed to confirm the results of this study

Keywords: Diabetes complications; Healthy eating index; Palestine; Type 2 diabetes mellitus

Abbreviations: HEI-2010: Healthy Eating Index-2010; Q: Quartile; OR: Odds Ratio; CI: Confidence Interval; DM: Diabetes Mellitus; T2DM: Type 2 Diabetes Mellitus; PHCs: Primary Healthcare Centers; FFQ: Food Frequency Questionnaire; WC: Waist Circumference; BMI: Body Mass Index; IPAQ: International Physical Activity Questionnaire; MET: Metabolic Equivalents; FPG: Fasting Plasma Glucose; HDL-C: High-Density Lipoprotein Cholesterol; TGs: Triglycerides; DASH: Dietary Approaches To Stop Hypertension

Introduction

Diabetes mellitus (DM) is a global public health problem with a majority in developing countries [1]. DM is recognized as an important cause of premature death and disability [2]. Globally, the World Health Organization estimates that, 422 million adults were living with DM in 2014, and projects that DM will be the seventh leading cause of death in 2030 [1]. Most of DM deaths (More than 80%) occur in low and middle-income countries [3]. In fact, the majority of people with diabetes are affected by type 2 diabetes mellitus (T2DM) [1]. In Palestine, the prevalence rate of DM was 10.5% in the West Bank and 11.8% in the Gaza Strip among the registered Palestinian refugees [4]. Abu Rmeileh et al, [5] estimated the prevalence of DM in Palestine at 20.8% and 23.4% in 2020 and 2030, respectively. When DM is uncontrolled, it has dire consequences for health and well-being [1]. In addition, diabetes and its complications impact harshly on the finances of individuals and their families and to health systems and national economies through direct medical costs and loss of work and wages [1].

Complications can arise as the disease progresses. Long term complications such as coronary heart disease which can lead to a heart attack, cerebrovascular disease which can lead to stroke, retinopathy (disease of the eye) which can lead to blindness, nephropathy (disease of the kidney) which can lead to kidney failure and the need for dialysis, and neuropathy (disease of the nerves) which increases the chance of foot ulcers, infection and the eventual need for limb amputation may be attenuated by dietary interventions [2]. The etiology of T2DM complications is poorly understood [6]. Diet is one of the lifestyle factors that may play an important role in preventing and managing these conditions [7,8]. However, few studies have explored the relationship between dietary patterns and diabetes complications. Most studies have examined the associations between individual foods or food groups and nutrients and diabetes complications [9-11], instead of focusing on dietary patterns which is the most sensible approach to test the role of the overall diet on nutrition-related diseases.

Diet quality indices developed on the bases of dietary recommendations and available evidence of the diseases are design to evaluate compliance to healthy dietary guidelines [12]. Furthermore, the diet quality indices are widely used to evaluate the relationship between total diet and chronic diseases [13]. The majority of the previous studies used the Healthy Eating Index-2010 (HEI-2010) for evaluation of diet quality [12,14]. The HEI-2010 is an updated tool for assessing diet quality as specified by the Dietary Guidelines for Americans, that contains 12 main components and a total score of 100 points [13]. The HEI-2010 is a summary measure of diet quality, it is a simple facility for monitoring the changes in eating habits and decision-making in order to improve nutrition [15,16].

Schwingshackl et al, [17] in the updated meta-analyses show that, diets that score highly on the HEI-2010 were associated with a significant reduction in the risk of all-cause mortality, cardiovascular disease, cancer, T2DM, and neurodegenerative disease by 22%, 22%, 16%, 18%, and 15%, respectively. Therefore, understanding the association between HEI-2010 with diabetes complications may be helpful in reducing diabetes-related premature mortality and improve outcomes among T2DM patients. To the best of our knowledge, there is no data about the association of HEI-2010 score with diabetes complications among T2DM patients in Gaza Strip, Palestine. This study was conducted to determine the association between HEI-2010 with diabetes complications among T2DM patients.

Methods

Study design and study population

This cross-sectional study was conducted in the years 2015 and 2016 among a representative sample of Palestinian T2DM patients, selected by a cluster random sampling method. A total of 1187 patients, aged 20-64 years receiving care in the primary healthcare centers (PHCs) in Gaza Strip, Palestine, were included in the study. Gaza Strip is divided into five smaller governorates, which include North Gaza, Gaza City, Mid Zone, Khan Younis and Rafah. The total number of PHCs in Gaza Strip is fifty-four [18]. The PHCs were distributed in each governorate as follows (Eight, fourteen, sixteen, eleven and five PHCs respectively). The study sample was distributed according to the number of PHCs in each governorate as follows (176, 308, 353, 241 and 109 patients respectively). Pregnant, lactating women, patients with total energy intake < 800 and > 4200 kcal, and patients with other types of serious illness such as cancer or acute myocardial infarction were excluded from the study.

Assessment of dietary intake

Data about dietary intake were collected by an expert nutritionist, using a validated semi-quantitative food frequency questionnaire (FFQ). The FFQ in our study contains a list of 98 food items; it was developed and validated among Palestinian population in 2014 [19]. All participants were asked to estimate the number of times per day, week or month he/she consumed these particular food products and the amount usually eaten per food item by making comparisons with the specified reference portion. Common household measures including measuring cups, spoons and a ruler were shown to assist the participants in the estimation process. The answer categories ranged from 1 to 7 times (7 categories) including never, one to three times per month, one to two times per week, three to four times per week, five to six times per week, one time per day or two to three times per day. The food composition of mixed dishes was determined by using common recipes consumed in the country. The mean intake of each food item in grams was calculated by multiplying specified portion size by the average reported frequency.

Healthy Eating Index-2010 (HEI-2010)

The HEI-2010 is an updated tool for assessing diet quality as specified by the 2010 Dietary Guidelines for Americans, that contains 12 main components and a total score of 100 points [13]. Total fruits, whole fruits, total vegetables, greens and beans, total protein foods and seafood and plant proteins scored 5 in the highest consumption and 0 in the lowest consumption. The highest consumption of three components including whole grains, dairy and fatty acid scored as 10 and the lowest consumption of them scored as 0. Two components (Refined grains and sodium) scored 10 in the lowest consumption and 0 in the highest consumption. One component that is, empty calories (Energy from solid fats, added sugars and any alcohol in excess of 13 g/1000 kcal) scored 0-20. The highest frequency of consumption scored as 0 and the lowest frequency of consumption scored as 20. The total HEI-2010 score was calculated by adding the 12 components' score [20]. The USDA Food Composition Table was used to analyze nutrients consumption [21]. Higher scores in all components indicate a more healthful diet and greater adherence to Dietary Guidelines for Americans recommendations [13].

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Assessment of anthropometric measurements

Height was measured in all patients (Patients bare footed and head upright) with a measuring rod attached to the balanced beam scale; the height was reported to the nearest 0.5 cm [22]. Weight (kg) was measured using standard scale (Seca); the scale was placed on a hard-floor surface; patients were asked to remove their heavy outer garments and weight was measured and recorded to the nearest 0.1 kg [23]. Furthermore, a stretch-resistant tape was used for measuring waist circumference (WC); WC was measured at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest [24]. The body mass index (BMI) was calculated by dividing weight in kilograms by the square of height in meters [25].

Assessment of blood pressure

The systolic and diastolic blood pressure was measured from the left arm (mmHg) by mercury sphygmomanometer [26]. Three readings on different days, while the patient was seated after relaxing for at least fifteen minutes in a quiet environment, empty bladder. The average of the measurements was recorded.

Assessment of physical activity

Data on physical activity were obtained using the International Physical Activity Questionnaire (IPAQ short version) [27]. The internationally accepted protocol was used to estimate the weekly calorie expenditure expressed as metabolic equivalents per week (MET/wk). The IPAQ scoring protocol assigns the following MET values to walking, moderate and vigorous intensity activity: 3.3 METs, 4.0 METs, and 8.0 METs, respectively [27].

Biochemical analysis

After 12 hours fasting, venous blood samples were collected from all patients in the PHCs (In the second meeting with the patients) by well-trained and experienced nurses. Venous blood (4.0 ml) was drawn into vacationer tubes and was used for blood chemistry analysis. Serum was separated immediately, and the extracted serum was investigated for (Fasting Plasma Glucose (FPG) mg/dl, High-Density Lipoprotein Cholesterol (HDL-c) mg/dl and Triglycerides (TGs) mg/dl). Mindray BS-300 chemistry analyzer instrument was used for blood chemistry analysis [28]. The laboratory tests were analyzed in a private licensed laboratory.

Assessment of other variables

Additional information regarding demographic and medical history variables was obtained with an interview-based questionnaire. Diagnosis and classification of diabetes complications was defined according to Palestinian guidelines for diagnosis and management of diabetes mellitus criteria [29]. History of diabetes complications and any previous treatment for these complications was recorded by the PHCs doctors on the patient's files. Moreover, reports and all relevant documentation, including medical records were checked. Pilot study was carried out on thirty patients to enable the researcher to examine the tools of the study. The questionnaire and data collection process were modified according to the result of the pilot study. The data was collected by ten qualified data collectors (Five nurses and five nutritionists), who were given a full explanation and training by the researcher about the study.

Statistical analysis

Statistical analysis was performed using SPSS version 20. Normal distribution of data was checked by histogram curves and Kolmogorov-Smirnov test. In this study, all variables had normal distribution. Patients were categorized based on quartile cut-points of HEI-2010 including ≤ 63, 64-67.5, 67.51-73 and ≥ 74 [30]. Characteristics of the study population across quartiles of HEI-2010 were examined using analysis of variance for continuous variables or chi-square test for categorical variables. Age and energy adjusted food and nutrients consumption across quartiles of HEI-2010 were calculated using analysis of covariance (One-way ANCOVA). Finally, the odds ratio (OR) and 95% confidence interval (CI) for the diabetes complications across quartiles of HEI-2010 were tested by binary logistic regression. P value less than 0.05 was considered as statistically significant.

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Tehran University of Medical Sciences (Code: IR.TUMS.REC.1394.58) and by the Palestinian Health Research Council (Helsinki Ethical Committee of Research PHRC/HC/60/15). In addition, written informed consent was also obtained from each participant.

Results

Table 1: Characteristics of the study population by quartiles of HEI-2010.

Variables		Quartiles of Healthy Eating Index-2010				P value
		Q1 (Lowest)	Q2	Q3	Q4 (Highest)	
		No. (297)	No. (299)	No. (296)	No. (295)	
Age (years)	Mean±SD	54.0±9.1	51.4±10.0	49.8±11.4	43.8±10.9	0.001
Gender	Male	103.0 (21.6)	114.0 (23.8)	121.0 (25.3)	140.0 (29.3)	0.013
	Female	194.0 (27.4)	185.0 (26.1)	175.0 (24.7)	155.0 (21.8)	

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Marital status	Married	289.0 (25.2)	291.0 (25.4)	285.0 (24.8)	282.0 (24.6)	0.584
	Unmarried	8.0 (20.0)	8.0 (20.0)	11.0 (27.5)	13.0 (32.5)	
Educational level	Low education	150.0 (28.3)	159.0 (30.0)	127.0 (24.0)	94.0 (17.7)	0.001
	High education	147.0 (22.4)	140.0 (21.3)	169.0 (25.7)	201.0 (30.6)	
Family size	Less than five	94.0 (22.1)	103.0 (24.2)	105.0 (24.6)	124.0 (29.1)	0.059
	Five or more	203.0 (26.7)	196.0 (25.7)	191.0 (25.1)	171.0 (22.5)	
Monthly income	≤ 2000 (NIS)	272.0 (26.0)	262.0 (25.1)	270.0 (25.9)	240.0 (23.0)	0.001
	> 2000 (NIS)	25.0 (17.5)	37.0 (25.9)	26.0 (18.1)	55.0 (38.5)	
	Less than five	52.0 (16.7)	58.0 (18.6)	69.0 (22.2)	132.0 (42.5)	
Diabetes duration (years)	Five to ten	88.0 (20.0)	111.0 (25.1)	111.0 (25.1)	132.0 (29.8)	0.001
	More than ten	157.0 (35.3)	130.0 (29.2)	116.0 (26.1)	42.0 (9.4)	
Use diabetes medications	Yes	297.0 (25.0)	299.0 (25.2)	296.0 (24.9)	295.0 (24.9)	-
Type of diabetes medications used	Diabetes pills	117.0 (24.1)	106.0 (21.8)	109.0 (22.4)	154.0 (31.7)	
	Insulin injections	156.0 (25.1)	171.0 (27.5)	162.0 (26.0)	133.0 (21.4)	0.001
	Pills & injections	24.0 (30.4)	22.0 (27.8)	25.0 (31.7)	8.0 (10.1)	
Received diabetes care instructions	Yes	121.0 (21.5)	139.0 (24.7)	148.0 (26.3)	155.0 (27.5)	
	No	176.0 (28.3)	160.0 (25.6)	148.0 (23.7)	140.0 (22.4)	0.025
History of smoking	Yes	34.0 (21.1)	42.0 (26.1)	38.0 (23.6)	47.0 (29.2)	
	No	263.0 (25.6)	257.0 (25.0)	258.0 (25.2)	248.0 (24.2)	0.434
History of alcohol intake	No	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	-
Physical activity (total MET)	Mean±SD	1049.5±1328	1024.8±1326	1568.8±1669	2074.7±1483	0.001
Body mass index (kg/m^2)	Mean±SD	31.7±6.15	31.7±6.12	30.0±6.48	27.2±5.11	0.002
Waist circumference (cm)	Mean±SD	110.0±14	108.6±15	104.3±17	95.9±15	0.015
FPG (mg/dl)	Mean±SD	173.4±30	167.6±27	171.5±31	166.1±26	0.006
Triglycerides level (mg/dl)	Mean±SD	179.7±54	168.4±47	168.6±63	124.3±15	0.001
HDL-c level (mg/dl)	Mean±SD	43.2±7	41.8±7	44.5±8	50.9±5	0.001

Data are expressed as means ± SD for continuous variables and as percentage for categorical variables. The characteristics of the study population across quartiles of HEI-2010 were examined using analysis of variance for continuous variables or chi-square test for categorical variables. P value less than 0.05 was considered as statistically significant. Q, quartile; SD, stander deviation; MET, metabolic equivalent; FPG, fasting plasma glucose; HDL-c, high-density lipoprotein cholesterol.

The OR and CI for the diabetes complications across quartiles of HEI-2010 were tested by binary logistic regression.

A total of 1187 patients with T2DM aged 20 to 64 years old (59.7% females, 40.3% males) were included in this study. The characteristics of study population across HEI-2010 quartiles are shown in (Table 1). The results revealed that the mean age (years) for patients in the lowest quartile (Q1) was 54.0±9.1 vs. 43.8±10.9 for patients in the upper quartile (Q4). In comparison with the upper quartile, those who were assigned to the lowest quartile of HEI-2010 were older, had lower educational level, had lower monthly income, had higher diabetes duration, had lower rate of physical activity, had higher BMI, WC, FPG, TGs and HDL-c levels.

In addition, for the following factors (Age, gender, educational level, monthly income, diabetes duration, type of diabetes medications used, received diabetes care instructions, physical activity, BMI, WC, FPG, TGs and HDL-c), the difference was statistically significant a cross quartiles of HEI-2010 (P value < 0.05 for all). On the other hand, the distribution of diabetes complications for the study population a cross quartiles of HEI-2010 are shown are shown in (Table 2). Our results revealed

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that, in comparison with the upper quartile, those who were assigned to the lowest quartile of HEI-2010, had higher blood pressure (≥ 130/85 mmHg) or treatment of previously diagnosed hypertension (30.7 vs. 13.9%), had higher eyes problems (28.4 vs. 18.8%), kidney problems (38.0 vs. 10.1%), heart problems (44.7 vs. 0.0%), extremities problems (32.9 vs. 11.1%), and neurological problems (25.6 vs. 23.3%), compared with those in the upper quartile.

Table 2: Distribution of diabetes complications for the study population by quartiles of HEI-2010.

Variables		Quartiles of Healthy Eating Index-2010				P value
		Q1 (Lowest)	Q2	Q3	Q4 (Highest)	
		No. (297)	No. (299)	No. (296)	No. (295)	
High blood pressure (≥ 130/85 mmHg) or treatment of previously diagnosed HTN	Yes	235.0 (30.7)	238.0 (31.1)	186.0 (24.3)	106.0 (13.9)	0.001
	No	62.0 (14.7)	61.0 (14.4)	110.0 (26.1)	189.0 (44.8)	
Eyes problems	Yes	195.0 (28.4)	175.0 (25.5)	188.0 (27.3)	129.0 (18.8)	0.001
	No	102.0 (20.4)	124.0 (24.8)	108.0 (21.6)	166.0 (33.2)	
Kidney problems	Yes	49.0 (38.0)	37.0 (28.7)	30.0 (23.2)	13.0 (10.1)	0.001
	No	248.0 (23.4)	262.0 (24.8)	266.0 (25.1)	282.0 (26.7)	
Heart problems	Yes	38.0 (44.7)	20.0 (23.5)	27.0 (31.8)	0.0 (0.0)	0.001
	No	259.0 (23.5)	279.0 (25.3)	269.0 (24.4)	295.0 (26.8)	
Extremities problems	Yes	86.0 (32.9)	76.0 (29.1)	70.0 (26.9)	29.0 (11.1)	0.001
	No	211.0 (22.8)	223.0 (24.1)	226.0 (24.4)	266.0 (28.7)	
Neurological problems	Yes	280.0 (25.6)	285.0 (26.0)	275.0 (25.1)	255.0 (23.3)	0.001
	No	17.0 (18.5)	14.0 (15.2)	21.0 (22.8)	40.0 (43.5)	

Data are expressed as percentage for categorical variables. The chi-square test was used to examine differences in the prevalence of different categorical variable. P value less than 0.05 was considered as statistically significant. Q, quartile; HTN, hypertension.

Furthermore, for the following factors (High blood pressure or treatment of previously diagnosed hypertension, eyes problems, kidney problems, heart problems, extremities problems and neurological problems), the difference was statistically significant a cross quartiles of HEI-2010 (P value < 0.05 for all).

Furthermore, the dietary intakes of study population across quartiles of HEI-2010 are presented in (Table 3). Our findings revealed that, patients in the upper quartile of HEI-2010 had higher intakes of carbohydrate (237±27 vs. 219±17), dietary fiber (21±4 vs. 8±2), fruits (244±81 vs. 147±34), vegetables (292±69 vs. 189±73), meat and fish (152±78 vs. 124±57), whole grains (84±27 vs. 30±12), and nuts & legumes (85±16 vs. 35±12), compared with those in the lowest quartile (P value < 0.05 for all).

On the other hand, (Table 3) show that, the energy intake, fat and refined grain consumption decreased significantly across HEI-2010 quartiles (P value < 0.05 for all). No significant association was found between HEI-2010 quartiles with protein, cholesterol and dairy consumption. Finally, we computed the OR and 95% CI for the diabetes complications across quartiles of HEI-2010 (Table 4). Our findings demonstrate that, after adjustment for potential confounders, patients in the lowest quartile of HEI-2010 had the highest risk of (High blood pressure and heart problems), (OR =1.361, 95% CI = [1.145-1.618]), (OR = 1.469, 95% CI = [1.148-1.878]), respectively, (P value < 0.005 for all), compared with those in the upper quartile. No significant association was found between HEI-2010 quartiles with eyes problems, kidney problems, extremities problems and neurological problems.

Table 3: Dietary intakes of the study population by quartiles of HEI-2010.

Food and Nutrients No. (297)		Quartiles of Healthy Eating Index-2010				P value
		Q1 (Lowest)	Q2	Q3	Q4 (Highest)	
		No. (297)	No. (299)	No. (296)	No. (295)	
Total energy (kcal per day)	Mean±SD	2538±303	2360±141	2274±212	2133±198	0.001
Carbohydrate (g per day)	Mean±SD	219±17	227±20	232±24	237±27	0.001

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Protein (g per day)	Mean±SD	72±9	73±12	76±17	73±12	0.16
Fat (g per day)	Mean±SD	118±32	103±28	86±35	82±37	0.001
Cholesterol (mg per day)	Mean±SD	252±58	255±62	254±73	246±60	0.21
Dietary fiber (g per day)	Mean±SD	8±2	13±3	17±4	21±4	0.001
Fruits	Mean±SD	147±34	183±56	233±78	244±81	0.001
Vegetables	Mean±SD	189±73	264±95	267±91	292±69	0.001
Meat and fish	Mean±SD	124±57	142±68	145±74	152±78	0.001
Whole grains	Mean±SD	30±12	42±22	75±19	84±27	0.001
Refined grains	Mean±SD	395±72	360±92	337±129	332±138	0.001
Dairy	Mean±SD	239±89	269±68	281±85	251±78	0.08
Nut and legumes	Mean±SD	35±12	51±21	64±25	85±16	0.001

Food and nutrients consumption across quartiles of HEI-2010 were calculated using analysis of covariance (One-way ANCOVA).
*Adjusted for age and energy intake.
P value less than 0.05 was considered as statistically significant.

Q: quartile; SD: stander deviation.

Table 4: Odd ratio and confidence interval for the diabetes complications across quartiles of HEI-2010.

Quartiles of Healthy Eating Index-2010					
Q1 (Lowest)	**Q2**	**Q3**	**Q4 (Highest)**	**P value**	**OR (95%CI)**
High blood pressure (≥ 130/85 mmHg) or treatment of previously diagnosed hypertension (64.4%)					
30.7	31.1	24.3	13.9	0.001	1.997 (1.771-2.251)
Adjusted*				0.001	1.361 (1.145-1.618)
Eyes problems (57.9%)					
28.4	25.5	27.3	18.8	0.001	1.286 (1.158-1.428)
Adjusted*				0.839	0.987 (0.873-1.117)
Kidney problems (10.9%)					
38	28.7	23.2	10.1	0.001	1.513 (1.271-1.800)
Adjusted*				0.051	1.219 (0.999-1.487)
Heart problems (7.2%)					
44.7	23.5	31.8	0	0.001	1.798 (1.438-2.248)
Adjusted*				0.002	1.469 (1.148-1.878)
Extremities problems (22.0%)					
32.9	29.1	26.9	11.1	0.001	1.424 (1.253-1.618)
Adjusted*				0.374	1.072 (0.920-1.250)
Neurological problems (92.2%)					
25.6	26	25.1	23.3	0.001	1.454 (1.190-1.777)
Adjusted*				0.681	1.046 (0.844-1.297)

*Adjusted for age, gender, educational level, monthly income, diabetes duration, type of diabetes medications used, received diabetes care instructions, physical activity level (total MET), body mass index, waist circumference, fasting plasma glucose and triglycerides.
P value less than 0.05 was considered as statistically significant.
Q: Quartile; OR: Odds Ratio; CI: Confidence Interval

Discussion

This cross-sectional study was conducted among 1187 previously diagnosed T2DM (Both genders, aged 20-64 years), patients receiving care in PHCs in Gaza Strip, Palestine. To the best of our knowledge, this is the first study, which describes the association of HEI-2010 score with diabetes complications among T2DM patients in Gaza Strip, Palestine. The main findings of this study indicate that, after adjustment for potential confounders, patients in the lowest quartile of HEI-2010 had the highest risk of (High blood pressure and heart problems), compared with those in the upper quartile. In fact, very few studies have explored the relationship between HEI-2010 score with diabetes complications

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in patients with T2DM, which made the comparison of our results with previous studies difficult.

Most of the previous studies have examined the associations between individual foods or food groups and nutrients and diabetes complications [9-11]. However, single nutrients do not measure overall diet quality as well as an examination of the overall diet by HEI [31,32]. It is well established that studying whole diet rather than individual foods or nutrients can exhibit overall diet quality better and help predict the association of diet quality with health risks [23]. Diet quality indices are widely used to evaluate the relationship between total diet and chronic diseases risk factors [12]. The HEI-2010 is an updated tool for assessing diet quality as specified by the Dietary Guidelines for Americans, and therefore the high HEI-2010 scores are thought to reflect healthier diets in a population [13].

Our findings demonstrate that 64.4% of the patients had high blood pressure (≥130/85 mmHg) or treatment of previously diagnosed hypertension. Hypertension is a major risk factor for developing cardiovascular diseases [33]. In our study, patients in the lowest quartile of HEI-2010 had the highest risk of high blood pressure. Danico et al, [34] in a meta-analysis show that, healthy dietary patterns such as the Dietary Approaches to Stop Hypertension (DASH) diet, Nordic diet and Mediterranean diet which characterized by a high intake of fruit, vegetables, whole grains, legumes, seeds, nuts, fish and dairy were inversely associated with high blood pressure.

In addition, Saraf-Bank et al, [20] in a cross-sectional study show that, adherence to HEI-2010 is inversely associated with high blood pressure among Iranian adult women. Furthermore, many of the previous study indicated that dietary consumption that follows the HEI is associated with a lower risk for high blood pressure [35,36]. Our results are in line with previous studies that showed a negative association between HEI-2010 and risk of high blood. On the other hand, the results of our study revealed that, 7.2% of the patients had heart problems. In addition, patients in the lowest quartile of HEI-2010 had the highest risk of heart problems. Aljefree et al, [37] in a systematic review reported that adherence to Mediterranean or DASH dietary patterns or their individual food components was associated with a decreased risk of coronary heart disease and it is associated risk factors. The results of our study support these findings.

Furthermore, our findings revealed that, patients in the upper quartile of HEI-2010 had higher intakes of carbohydrate, dietary fiber, fruits, vegetables, meat and fish, whole grains, nuts and legumes, compared with those in the lowest quartile. Additionally, the energy intake, fat and refined grain consumption decreased significantly across HEI-2010 quartiles. Based on the Dietary Guideline for Americans the high HEI-2010 scores are accompanied with high contents of fruits, vegetables and low amounts of saturated fatty acids. The beneficial effects of fruits and vegetables intakes in the framework of dietary patterns were reported previously, and it has been shown that dietary patterns rich in fruit and vegetables may reduce the risk of high blood pressure and heart problems [18].

It is assumed that this association could be attributed to healthy ingredients including magnesium, potassium, and dietary fibers in many fruits and vegetables may be associated with a lower risk of hypertension, reduce cholesterol concentrations and other cardiovascular risk factors in patients with T2DM [38]. In addition, anti-inflammatory and antioxidant effects in these foods may have beneficial effects in alleviating inflammation and oxidative stress, and decreasing insulin resistance and secretion, which are pathogenic factors in diabetes [39] and diabetes complications [40]. Furthermore, vegetables, legumes, and fruits contain minerals, polyphenols, and other phytochemicals that combat oxidative stress, inflammation and insulin resistance [41,42]. Finally, our findings revealed that, 57.9 % of the patients had eyes problems, 10.9% had kidney problems, 22.0% had extremities problems, and 92.2% had neurological problems. In contrary, no significant association was found between HEI-2010 with eyes problems, kidney problems, extremities problems and neurological problems. Our study not adjusted for other confounding variables such as genetics factors, and different diagnostic methods and criteria used, which could contribute to these results.

Actually, the underlying cause of desirable association between HEI-2010 with diabetes complications need more studies in the future. The main limitations of this study is its cross-sectional design; the causal relationship could not be determined and it limits the generalizability of our results. In addition, it is possible that unknown or unmeasured confounding variables affect our results. Unfortunately, we do not have measures of total cholesterol, low-density lipoprotein cholesterol and glycated hemoglobin as a marker of diabetes control. The main strength of our study was its being the first study, which shows the association of HEI-2010 with diabetes complications among T2DM patients in Gaza Strip, Palestine, and its large representative sample size. Finally, using a semi-quantitative FFQ that indicates habitual intakes of patients and precise assessment of confounders are the strengths of the present study.

Conclusion

We conclude that, the highest HEI-2010 score may be associated with a lower prevalence of high blood pressure and heart problems among T2DM patients. Further prospective cohort studies are needed to confirm the results of this study.

Declarations

a) Consent for publication

Not applicable.

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b) Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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