

Association of healthy eating index with metabolic syndrome and its components among type 2 diabetes patients in Gaza Strip, Palestine: A cross sectional study

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Abstract

The prevalence of metabolic syndrome is raising worldwide; however, the role of diet in the origin of metabolic syndrome is not understood well. This study was conducted to determine the association between Healthy Eating Index-2010 (HEI-2010) with metabolic syndrome and its components among type 2 diabetes patients in Gaza Strip, Palestine. 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 intakes of patients. HEI-2010 was used to assess diet quality of patients. Metabolic syndrome was defined based on the International Diabetes Federation criteria. Additional information regarding demographic and medical history variables was obtained with an interview-based questionnaire. Statistical analysis was performed using SPSS version 20. After adjustment for potential confounders, patients in the lowest quartile (Q1) of HEI-2010 had the highest risk of (Metabolic syndrome, central obesity, high triglycerides, low HDL-cholesterol and high blood pressure), (Odds ratio [OR] = 1.804, 95% confidence interval [CI] = [1.494-2.178]), (OR = 1.351, 95% CI = [1.077-1.694]), (OR = 2.270, 95% CI = [1.911-2.697]), (OR = 2.089, 95% CI = [1.763-2.475]), (OR = 1.361, 95% CI = [1.145-1.618]), respectively, (P value < 0.005 for all), compared with those in the upper quartile (Q4). In conclusion, the highest HEI-2010 score may be associated with a lower prevalence of metabolic syndrome and its components among type 2 diabetes patients.

Abbreviations: HEI-2010: Healthy eating index-2010; Q: Quartile; OR: Odds ratio; CI: Confidence interval; MetS: Metabolic syndrome; IDF: International diabetes federation; T2DM: Type 2 diabetes mellitus; PHCs: Primary healthcare centers; FFQ: Food frequency questionnaire; WC: Waist circumference; BMI: Body mass index; BP: Blood pressure; IPAQ: International physical activity questionnaire; MET: Metabolic equivalents; FPG: Fasting plasma glucose; HDL-c: High-density lipoprotein cholesterol; TGs: Triglycerides.

Introduction

Metabolic syndrome (MetS) is a collection of cardiovascular risk factors, which is related to increased risk of diabetes, stroke and mortality [1]. MetS has shown an increasing prevalence globally because of the constant increase of health-related factors such as obesity and physical inactivity [1,2]. MetS is a major health problem worldwide; based on the International Diabetes Federation (IDF) appreciation about one quarter of the world's adult population have MetS [3]. Several studies show that, the prevalence of MetS among type 2 diabetes mellitus (T2DM) patients is more than double of the prevalence in the general populations [4,5]. MetS is a multifactorial disorder; several factors including genetic, metabolic and environmental factors can contribute to the etiology of MetS [1]. Therefore, finding modifiable risk factors of MetS is of great importance. Among the modifiable risk factors, dietary intakes have been highlighted as an effective approach for prevention and management of MetS [6]. Previous studies have widely reviewed the effect of several single foods, and nutrients on MetS

and its components [7-9]. These studies provide beneficial data about the effects of dietary intake on MetS development but the obtained results may not be applicable for MetS management. As single foods and nutrients are not usually consumed alone, studying the dietary patterns provides opportunity to consider the effects of whole diet on MetS and its components and offer a functional approach for MetS management [6]. Dietary pattern is potentially useful in making dietary recommendations because overall dietary patterns might be easy for the public to interpret or translate into diets [10].

On the other hand, an impressive body of evidence from epidemiological and clinical trials indicated that consumption of foods rich in antioxidants, omega-3, or minerals rather than sodium, present in the Mediterranean diet pattern protect people against MetS and its components [11,12]. The cumulative results of these studies highlight the importance of diet quality in reducing risk factors for cardiometabolic disorders [11,12]. Diet quality indices are widely used to evaluate the relationship between total diet and chronic diseases risk factors [13].

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In addition, the majority of studies used the Healthy Eating Index-2010 (HEI-2010) for evaluation of diet quality [13,14]. The HEI-2010 is an updated tool for assessing diet quality as specified by the Dietary Guidelines for Americans, that contains twelve main components and a total score of one hundred points [15]. The HEI-2010 can be used for a variety of applications, including population monitoring [16]; epidemiologic research [17]; and evaluations of the food environment [18], food assistance packages, nutrition interventions [19], and the relation between diet cost and diet quality [20]. Furthermore, the HEI-2010 is a summary measure of diet quality; it's a simple facility for monitoring the changes in eating habits and decision-making in order to improve nutrition [21,22]. Schwingshackl *et al.* [23] 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. Furthermore, high-quality diets were inversely associated with overall mortality and cancer mortality among cancer survivors. Additionally, Onvani *et al.* [24] in a meta-analysis show that, the highest level of adherence to the HEI-2010 was significantly associated with a reduced risk of all-cause mortality, cardiovascular mortality and cancer mortality.

In Palestine, El Bilbeisi *et al.* [25] in a meta-analysis show that, MetS is highly prevalent (37.0%) among Palestinian adults. However, dietary intakes of Middle-Eastern population have their own characteristics: Large intake of carbohydrates mostly in the form of refined grains, high intakes of trans and saturated fat, and low consumption of fruits and vegetables along with lack of alcohol intake makes their dietary pattern of great interest for the assessment of diet-disease relations [26]. Moreover, different from Western people, stressful life is highly prevalent in this region, which might further complicate diet-disease relations in this area [27]. Therefore, understanding the association between HEI-2010 with MetS and its component may be helpful in reducing disease-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 MetS and its components among T2DM patients in Gaza Strip, Palestine. This study was conducted to determine the association between HEI-2010 with MetS and its components among T2DM patients.

Materials and 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 [3]. 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 [10]. 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 [15]. 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 [28]. The USDA food composition tables were used to analyze nutrients consumption [29]. For all components, higher scores reflect better diet quality and greater adherence to Dietary Guidelines for Americans recommendations [15].

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 [30]. 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 [31]. 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 [32]. The body mass index (BMI) was calculated by dividing weight in kilograms by the square of height in meters [32].

Assessment of blood pressure (BP)

The systolic and diastolic BP was measured from the left arm (mmHg) by mercury sphygmomanometer [33]. 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) [34]. 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 [34].

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 vacutainer 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 [3]. 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. 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.

Definition of metabolic syndrome (MetS)

MetS was defined based on the IDF criteria [35]. However, in this study all participants were previously diagnosed patients with T2DM under management and therefore, were classified as hyperglycemic irrespective of the level of FPG at the time of sampling.

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 [36]. 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 MetS and its components across quartiles of HEI-2010 were tested by binary logistic regression. P value less than 0.05 was considered as statistically significant.

Results

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

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

Variables		Quartiles of Healthy Eating Index-2010				P value
		Q1 (Lowest) No. (297)	Q2 No. (299)	Q3 No. (296)	Q4 (Highest) 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)	
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)	
Diabetes duration (years)	Less than five	52.0 (16.7)	58.0 (18.6)	69.0 (22.2)	132.0 (42.5)	0.001
	Five to ten	88.0 (20.0)	111.0 (25.1)	111.0 (25.1)	132.0 (29.8)	
	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)	0.001
	Insulin injections	156.0 (25.1)	171.0 (27.5)	162.0 (26.0)	133.0 (21.4)	
	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)	0.025
	No	176.0 (28.3)	160.0 (25.6)	148.0 (23.7)	140.0 (22.4)	
History of smoking	Yes	34.0 (21.1)	42.0 (26.1)	38.0 (23.6)	47.0 (29.2)	0.434
	No	263.0 (25.6)	257.0 (25.0)	258.0 (25.2)	248.0 (24.2)	
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
FPG (mg/dl)	Mean±SD	173.4±30	167.6±27	171.5±31	166.1±26	0.006

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, standard deviation; MET, metabolic equivalent; FPG, fasting plasma glucose.

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 FPG level, and were more likely to be obese. 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 and FPG), the difference was statistically significant across quartiles of HEI-2010 (P value < 0.05 for all). On the other hand, the distribution of study population by MetS and its components across quartiles of HEI-2010 are shown in Table 2. Our results revealed that, 62.5% of T2DM patients had MetS based on the IDF criteria. Furthermore, in comparison with the upper quartile, patients who were assigned to the lowest quartile of HEI-2010 had higher prevalence of MetS (33.0 vs. 12.3%), central obesity (28.4 vs. 20.0%), high TGs levels (37.3 vs. 0.8%), low HDL-c levels (36.3 vs. 0.4), and had higher BP or treatment of previously diagnosed hypertension (30.7 vs. 13.9%). Moreover, for the following factors (MetS, central obesity, high TGs, low HDL-c and high BP or treatment of previously diagnosed hypertension), the difference was statistically significant across quartiles of HEI-2010 (P value < 0.05 for all).

Additionally, 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 MetS and its components 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 (MetS, central obesity, high TGs levels, low HDL-c levels and high BP or treatment of previously diagnosed hypertension), (OR =1.804, 95% CI = [1.494-2.178]), (OR = 1.351, 95% CI = [1.077-1.694]), (OR = 2.270, 95% CI = [1.911-2.697]), (OR = 2.089, 95% CI = [1.763-2.475]), (OR = 1.361, 95% CI = [1.145-1.618]), respectively, (P value < 0.005 for all), compared with those in the upper quartile.

Table 2. Distribution of study population by metabolic syndrome and its components across quartiles of HEI-2010

Variables		Quartiles of Healthy Eating Index-2010				P value
		Q1 (Lowest) No. (297)	Q2 No. (299)	Q3 No. (296)	Q4 (Highest) No. (295)	
Metabolic syndrome	Yes	245.0 (33.0)	229.0 (30.9)	177.0 (23.8)	91.0 (12.3)	0.001
	No	52.0 (11.7)	70.0 (15.8)	119.0 (26.7)	204.0 (45.8)	
Central obesity (waist circumference > 90 cm for men or > 80 cm for women)	Yes	277.0 (28.4)	262.0 (26.8)	242.0 (24.8)	195.0 (20.0)	0.001
	No	20.0 (9.5)	37.0 (17.5)	54.0 (25.6)	100.0 (47.4)	
Triglycerides ≥ 150 mg/dl or specific treatment for this lipid abnormality	Yes	186.0 (37.3)	175.0 (35.1)	134.0 (26.8)	4.0 (0.8)	0.001
	No	111.0 (16.1)	124.0 (18.0)	162.0 (23.6)	291.0 (42.3)	
HDL-c < 40 mg/dl in males and < 50 mg/dl in females or specific treatment for this lipid abnormality	Yes	175.0 (36.3)	173.0 (35.9)	132.0 (27.4)	2.0 (0.4)	0.001
	No	122.0 (17.3)	126.0 (17.9)	164.0 (23.3)	293.0 (41.5)	
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)	

In our study, all participants previously diagnosed T2DM

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; HDL-c, high-density lipoprotein cholesterol; HTN, hypertension.

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

Food and nutrients		Quartiles of Healthy Eating Index-2010				P value
		Q1 (Lowest) No. (297)	Q2 No. (299)	Q3 No. (296)	Q4 (Highest) 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
Protein (g per day)	Mean±SD	72±9	73±12	76±17	73±12	0.160
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	0.210
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	0.080
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 metabolic syndrome and its components across quartiles of HEI-2010

Quartiles of Healthy Eating Index-2010					
Q1 (Lowest)	Q2	Q3	Q4 (Highest)	P value	OR (95%CI)
Metabolic syndrome (62.5%)					
33.0	30.9	23.8	12.3	0.001	2.260 (1.997-2.558)
Adjusted*				0.001	1.804 (1.494-2.178)
Central obesity (waist circumference > 90 cm for men or > 80 cm for women) (82.2%)					
28.4	26.8	24.8	20.0	0.001	1.915 (1.646-2.227)
Adjusted*				0.009	1.351 (1.077-1.694)
Triglycerides ≥ 150 mg/dl or specific treatment for this lipid abnormality (42.0%)					
37.3	35.1	26.8	0.8	0.001	2.517 (2.218-2.855)
Adjusted*				0.001	2.270 (1.911-2.697)
HDL-c < 40 mg/dl in males and < 50 mg/dl in females or specific treatment for this lipid abnormality (40.6%)					
36.3	35.9	27.4	0.4	0.001	2.412 (2.129-2.733)
Adjusted*				0.001	2.089 (1.763-2.475)
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)
In our study, all participants previously diagnosed type 2 diabetes mellitus					

The OR and CI for the metabolic syndrome and its components across quartiles of HEI-2010 were tested by binary logistic regression. *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 and fasting plasma glucose. P value less than 0.05 was considered as statistically significant. Q, quartile; OR, odds ratio; CI, confidence interval; HDL-c, high-density lipoprotein cholesterol.

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 MetS and its components 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 (MetS, central obesity, high TGs, low HDL-c and high BP), compared with those in the upper quartile. In fact, very few studies have explored the relationship between HEI-2010 score with MetS and its components in patients with T2DM, which made the comparison of our results with previous studies difficult. Previous studies examining diet have focused on single nutrients, such as proteins [7], carbohydrates [8] and/or dietary fats [9]. However, single nutrients do not measure overall diet quality as well as an examination of the overall diet by HEI [14,37]. 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 [6]. Diet quality indices are widely used to evaluate the relationship between total diet and chronic diseases risk factors [13]. 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 [15]. Several prospective studies have evaluated HEI-2010 scores in relation to T2DM [17,38]. Results from a recent meta-analysis of 15 cohort studies, with follow-up time ranging from 5 to ≥ 24 years, show that diets of the highest quality (Compared highest vs. lowest quintile scores), as assessed by the HEI-2010, are associated with a significant risk reduction for all-cause mortality, T2DM and other chronic diseases [23]. The meta-analysis included seven reported studies on T2DM as the main disease outcome, with age ranging from 30 to 79 years, among individuals from different ethnic groups including Caucasian (European), non-Hispanic White, African American, Hispanic, and Asian; of these studies, the main result indicates that diets that score highly on the HEI-2010 are associated with a significant reduction in the risk of T2DM [23].

In addition, Saraf-Bank *et al.* [28] in a cross sectional study show that, adherence to HEI-2010 is inversely associated with MetS and its components (Abdominal obesity, high BP, high TGs and low HDL-c) among Iranian adult women. Another study showed that, based on HEI-2010 values, low diet quality can be related to MetS and its components [11]. Our results are in line with previous studies that showed a negative association between HEI-2010 and risk of MetS and its components. Furthermore, Tande *et al.* [39] in a cross sectional study show that, dietary consumption that follows the HEI is associated with a lower risk for abdominal obesity. Cespedes *et al.* [40] show that, according to HEI-2010 values, a three years improvements in diet quality was modestly protective against gain in WC and partially explained by less weight gain among post-menopausal women. Moreover, Schwingshackl *et al.* [23] indicated that, dietary consumption that follows the HEI is associated with a lower risk for abdominal obesity. Additionally, many of the previous study indicated that dietary consumption that follows the HEI is associated with a lower risk for high TGs level, low HDL-c and high BP [41,42]. The results of our study support these findings. On the other hand, the results of our study revealed that, 62.5% of T2DM patients had MetS based on the IDF criteria. There are several studies reporting prevalence of the MetS in this T2DM population more than double the prevalence in the general populations [4,5]. In similar studies amongst T2DM subjects in Nigeria, a high prevalence rate of 62.5%, was seen, while a lower prevalence rate of 56% was seen in patients of Saudi Arabian origin [43,44]. In our study, the high prevalence of MetS could be due to the low level of HDL-c, high BMI and large WC amongst our people, which considered the main risk factors for the MetS.

Additionally, 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. Furthermore, 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 the MetS

and its components [6] and are associated with lower concentrations of inflammatory markers [3]. Esmailzadeh et al [45] show that, higher intakes of fruit and vegetables are associated with a lower risk of the MetS; and the author concluded that, the lower risk may be the result of lower C-Reactive Protein concentrations. In a previous study, we have demonstrated the inverse associations between the Asian-like pattern characterized by a high intake of whole grains, potatoes, beans, legumes, vegetables, tomatoes and fruits with (MetS, central obesity, high TGs, low HDL-c and high BP) [6]. Moreover, another study showed that, higher intakes of hydrogenated vegetable oils were associated with a greater risk of the MetS and insulin resistance, whereas higher intakes of non-hydrogenated vegetable oils, in the range of energy requirements, were associated with a lower risk of insulin resistance [46]. It is assumed that this association could be attributed to healthy ingredients including vitamins, phytochemicals, dietary fibers, potassium, magnesium and antioxidants of fruits and vegetables. These nutrients have been independently associated with reduced metabolic risks related to MetS. Soluble dietary fibers in these foods may decrease the intestinal absorption of cholesterol and bile salts, which may improve serum lipid profile [47]. Magnesium and potassium in many fruits and vegetables could contribute to lower BP [48]. Furthermore, antioxidants in these foods may have beneficial effects on the risk of MetS [49]. Additionally, vegetables and fruits increase satiety and may be associated with a lower risk of obesity [50]. Actually, the underlying cause of desirable association between HEI-2010 with MetS and its components 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 MetS and its components 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 MetS and its components among T2DM patients. Further prospective cohort studies are needed to confirm the results of this study.

Declarations

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.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AA and AHB participated in the design of the study, data collection, performed the statistical analysis and drafted the manuscript. KD and AHB supervising the study and participated in draft review. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

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