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Original Article

Dietary Patterns and Cardiovascular Risk: Are the Mediterranean Diet, the Heart-Healthy Diet, and Phytochemicals Associated with Lower Cardiovascular Risks?

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Abstract

Background: Dietary pattern may be one of the determinants of cardiovascular health. This study aimed to examine the relationship between a heart-healthy diet, the phytochemical content of a diet, and Mediterranean diet and cardiovascular disease (CVD) risks.

Methods: This study was conducted with healthy volunteers (n=1446) from Turkey between August 2022 and September 2022. As risk assessment systems to determine CVD risks, SCORE (Systematic Coronary Risk Evaluation) and ASCVD (Atherosclerotic Cardiovascular Disease) were used. We utilized MEDFICTS (Meats, Eggs, Dairy, Fried foods, Fat in Baked Goods, Convenience Foods, Fats Added at the Table, and Snacks) to establish the suitability of the current diet for heart health, and MEDAS (Mediterranean Diet Adherence Screener) to examine the Mediterranean diet characteristics of the current diet. The phytochemical content of the diet was determined using the Phytochemical Index method developed by McCarty.

Results: The lifetime and 10-year risk scores of SCORE and ASCVD were positively correlated with the MEDFICTS score ($r=0.12$, $P<0.001$; $r=0.06$, $P=0.020$; $r=0.10$, $P=0.001$, respectively). Mediterranean diet characteristics were correlated with lower CVD risk as per the SCORE categories ($r=-0.07$, $P=0.009$). A one-unit increase in MEDFICTS scores increased high-to-very high CVD risk and 10-year moderate-to-high CVD risk by 1.01 times, while a one-unit increase in the Mediterranean diet score decreased high-to-very high CVD risk and 10-year moderate-to-high CVD risk by 0.91 times and 0.95 times, respectively. In addition, high values of body weight, body mass index, waist circumference, waist-height ratio, and neck circumference were associated with higher CVD risk ($P<0.001$).

Conclusion: Adopting a Mediterranean diet and a heart-healthy diet may be a good strategy to reduce CVD risks.

Keywords: Dietary patterns; Cardiovascular risk; Mediterranean diet; Phytochemicals

Introduction

Cardiovascular diseases (CVD) are among major health problems and the leading causes of morbidity and mortality globally (1). Modifiable factors including smoking, inadequate physical activity, increased body mass index (BMI), and unhealthy dietary patterns are associated with CVD and related deaths (1). Unhealthy dietary patterns take an active part in the development of CVD (2). Furthermore, WHO emphasizes that one of the most important risk factors for CVD is maintenance of unhealthy eating habits (3). A sedentary lifestyle, adopting an unhealthy diet pattern, and being overweight or obese are implicated in increased CVD risk (4).

Recently, studies investigating dietary patterns using dietary guidelines and diet quality indices have revealed the relationship between the diet and CVD (5-7). Among adults without CVD, those with a healthy diet were less likely to be at high risk of developing CVD over the 10 years ahead (6). Some argue that reductions in excess energy intake and improved dietary patterns can prevent many primary and secondary cardiovascular events (8-10). Dietary fat and cholesterol intake is considered as a risk factor for CVD, and behaviour changes towards decreasing the excess intake of fat and cholesterol seem to be beneficial for the prevention of CVD (11). Meats, Eggs, Dairy, Fried foods, Fat in Baked Goods, Convenience Foods, Fats Added at the Table, and Snacks (MEDFICTS) questionnaire is a brief dietary assessment tool developed as part of the National Cholesterol Education Program Adult Treatment Panel guidelines, and it measures the adherence to Step 1 and Step 2 diets that are recommended for the prevention and treatment of CVD (11, 12).

Optimal, 10-year, and lifetime CVD risk is determined using the biochemical parameters, systolic blood pressure measurements, age, gender, statin or aspirin use, diabetes history, and smoking status. Both the Systematic Coronary Risk Evaluation (SCORE, developed by the European Society of Cardiology) and the Atherosclerotic Cardiovascular Disease (ASCVD) Risk Estimator Plus program (developed by the American College of Cardiology) are assessment models used to predict lifetime and 10-year cardiovascular disease risk (13).

Studies investigating the relation of dietary patterns and characteristics to CVD risks are limited. This study was conducted to reveal the relationship between a heart-healthy diet (MEDFICTS), the phytochemical content of a diet, and Mediterranean diet and CVD risks. Because a diet is much easier to modify compared to many other CVD risk factors, establishing the relations of diet and CVD risks through research will be an important step for the reduction of morbidity and mortality risks due to CVD.

Materials and Methods

Study Population

This study was carried out with 40-75-year-old healthy volunteers (n=1446) from community health centers (n=9) and family medicine clinics (n=9) in Turkey between August 2022 and September 2022. Patients with a history of chronic CVD such as stroke, myocardial infarction, coronary artery bypass surgery, percutaneous coronary intervention, coronary angiography, heart failure, or peripheral artery disease; patients with cancer, hepatic or renal disease; individuals following a special diet program, individuals younger than 40 yr of age or over the age of 75, and pregnant and breastfeeding women were excluded. Individuals in the age range of 40-75 yr, who agreed to participate in the study were included. Figure 1 shows the patient recruitment flowchart.

The study protocol was approved by the Istanbul Medipol University, Non-Interventional Clinical Research Ethics Committee on July 26, 2022, with decision number 633.

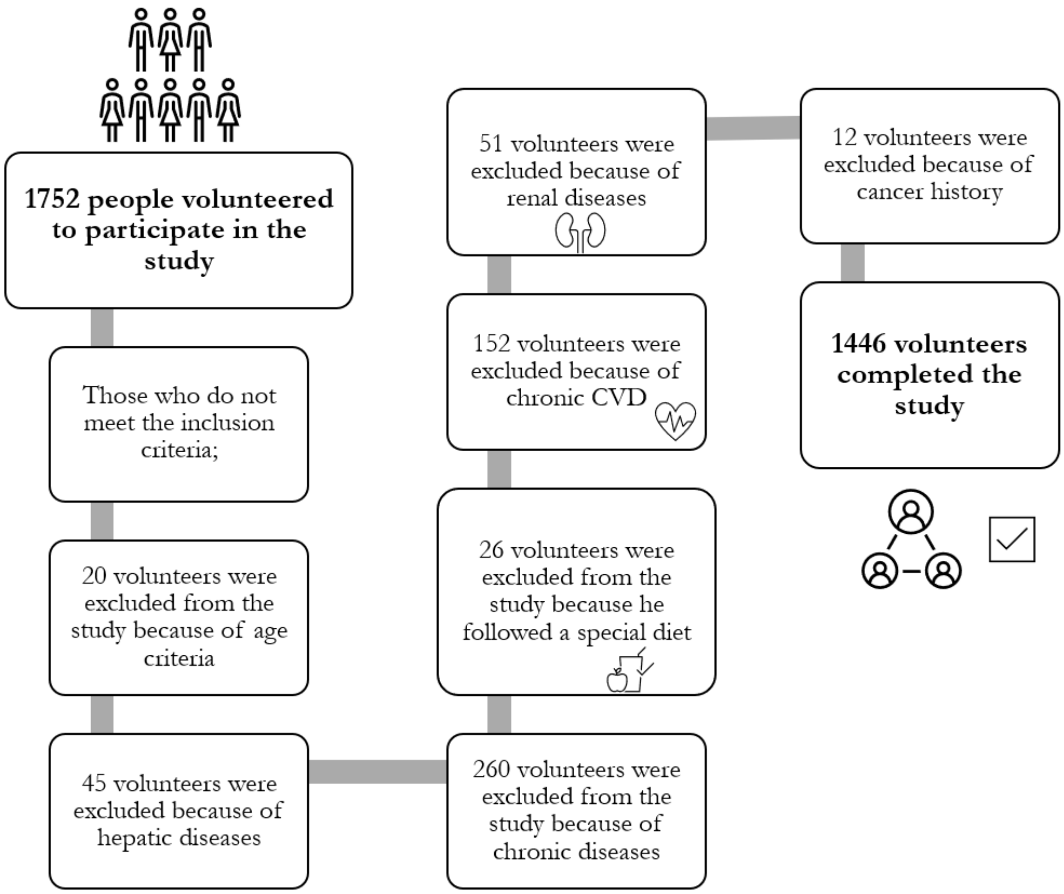

Fig. 1: Patient recruitment flow chart

Data collection and evaluation

Demographics and health information, dietary pattern, and physical activity status were obtained using a questionnaire form. The values for biochemical parameters were retrieved from patient files.

Assessment of cardiovascular risks

CVD risk was determined using SCORE, a risk assessment system developed by the European Society of Cardiology (https://www.heartscore.org/en_GB/). Based on SCORE assessments, the risk is categorized as low, moderate, high, and very high for scores of <1, 1-5, ≥5, <10, and ≥10, respectively (14). The ASCVD Risk Estimator Plus program was used to determine the optimal risk, 10-year risk, and lifetime risk (https://tools.acc.org/ascvd-risk-estimator-plus/#!/calculate/estimate/). A total score of <5 was considered low risk, scores of 5-7.4 borderline risk, scores of 7.5-19.9 intermediate risk, and scores of ≥20 high risk (15).

Determination of physical activity levels

A two-question physical activity assessment tool was used during face-to-face interviews in order to list the physical activity levels of subjects. Based on the total score of two questions, physical activity levels were listed as “inadequately active” or “adequately active” for scores of 0-3 or ≥4, respectively (16).

Measurement and assessment of anthropometric measurements

Body weight was measured using a calibrated scale and height was measured using a stadiometer. BMI was calculated by dividing body weight (kg) by the square of height (m^2) (17). Waist and neck circumference was measured with a stretch-resistant tape, after obtaining the ideal position for the measurement (18, 19). The waist-height ratio, as an indicator of chronic disease risk, was calculated by dividing the waist circumference (cm) by the height (cm) (20).

Evaluation of the suitability of dietary patterns for heart health

Validated version of MEDFICTS questionnaire assessing the suitability of the individuals' current diets for heart health (11, 21) was administered by the researcher during face-to-face interviews with participants. Scores of ≥ 70 indicate that the individual needs to make some dietary changes; scores of 40-70 indicate that the individual has healthy dietary habits for heart health, and scores of <40 indicate that the individual's diet is considered compatible with the therapeutic lifestyle diet (22).

Assessment of the phytochemical content of the diet

A 24-hour retrospective food intake recall record was obtained from participants, showing total energy intake and energy intake from phytochemicals. The "Phytochemical Index (PI)" method developed by McCarty was used to determine the total dietary phytochemical intake of individuals (23). Dietary PI value was calculated in percentages as the ratio of energy from phytochemical-rich foods to the total daily energy intake (energy from phytochemical-rich foods (kcal)/total energy intake (kcal) *100). Foods rich in phytochemicals included fruits and vegetables, pulses, whole grains, oilseeds, soy products, olives, and olive oil.

Assessment of Mediterranean Diet Characteristics

Mediterranean diet characteristics were evaluated through face-to-face interviews, using the validated 14-item Mediterranean Diet Adherence Screener (MEDAS) (24, 25). MEDAS score of ≤5 was considered poor adherence, scores of 6-9 moderate adherence, and score of ≥10 good adherence (24).

Statistical Analysis

The collected study data were analyzed using the E-PICOS software (www.e-picos.com, New York) and the MedCalc statistical software package. Continuous variables from scales were described in mean and standard deviation. Categorical variables were described in frequency and percentage. The One-Way ANOVA test was used to compare the mean scale scores across more than two groups. Differences revealed by ANOVA were analyzed by the Tukey statistic as a post hoc test. Chi-square test statistics were utilized to evaluate the associations between categorical variables. Pearson's correlation coefficient was used to examine associations between continuous variables. The exposure ratio (odds ratio) was obtained by Logistic Regression in order to estimate the exposure risk of factors affecting the cardiac risk status. In multivariable analysis, we adjusted for age, body mass index, physical activity, menopausal status and total energy intake.

Results

The characteristics of participants by adherence to MEDFICTS and Mediterranean diet adherence categories were presented in Table 1. Total cholesterol levels of subjects having dietary patterns compatible with the therapeutic lifestyle diet were statistically significantly lower compared to other groups (181.7±34.35 vs. 190.2±37.65 mg/dL, P=0.001; 181.7±34.35 vs. 196.6±38.53 mg/dL, P<0.001, respectively).

The cardiovascular risk scores of the participants by SCORE and ASCVD system assessments were presented in Table 2. Compared to subjects on the therapeutic lifestyle diet and those with healthy dietary patterns, subjects needing dietary changes had significantly higher ASCVD lifetime CVD risk scores (41.6±14.45 vs. 39.1±14.51, 39.3±13.73, P=0.04) and significantly higher SCORE risk scores (3.4±2.81 vs. 2.7±2.02, 2.64±1.91, P<0.001). CVD risk was significantly higher in subjects with poor adherence to the Mediterranean diet compared to those with good adherence (2.8±1.92 vs. 2.1±1.01, *P*=0.03), and subjects with moderate adherence compared to those with good adherence (2.9±2.41 vs. 2.1±1.01, *P*=0.007).

The MEDFICTS categories, Mediterranean diet characteristics, and PI of participants were presented in Table 3. Based on the SCORE assessments, subjects with low CVD risk (7.4±2.24) had significantly higher MEDAS scores compared to those with moderate, high, and very high risk (6.7±2.23, 6.3±2.00, 6.5±1.71, respectively) (*P*=0.005, *P*<0.001, *P*=0.03, respectively).

Correlations of dietary characteristics, physical activity with SCORE and ASCVD risk scores were presented in Table 4. The effects of diet characteristics in the estimation of CVD risk were presented in Table 5. A one-unit increase in MEDFICTS scores increased high-very high CVD risk by 1.01 times, while a one-unit increase in Mediterranean diet scores reduced high-very high CVD by 0.91 times.

Table 1: Characteristics of participants according to MEDFICTS, Mediterranean dietary patterns

		MEDFICTS				***Mediterranean diet***			
		Compatible with the therapeutic lifestyle diet n (%)	Having healthy dietary habits for heart health n (%)	Need to make some dietary changes n (%)	*P*-value	Poor n (%)	Moderate n (%)	Good n (%)	*P*-value
Age (yr)	40-44	142 (35.4)	257 (34)	101 (34.8)		179 (41.5)	271 (31.5)	50 (32.1)	
	45-64	226 (56.4)	452 (59.9)	179 (61.7)	0.12	238 (55.2)	524 (61)	95 (60.9)	0.001
	65-75	33 (8.2)	46 (6.1)	10 (3.4)		14 (3.2)	64 (7.5)	11 (7.1)	
	Mean ± SD	49.7±8.7	49.2±8.1	48.7±7.2	0.30	47.8±7.3	49.8±8.30	49.9±8.3	<0.001
Gender	Female	266 (66.3)	462 (61.2)	138 (47.6)	<0.001	243 (56.4)	523 (60.9)	100 (64.1)	0.16
	Male	135 (33.7)	293 (38.8)	152 (52.4)		188 (43.6)	336 (39.1)	56 (35.9)	
Diabetes	Yes	41 (10.2)	71 (9.4)	32 (11)	0.72	43 (10)	87 (10.1)	14 (9)	0.91
	No	360 (89.8)	684 (90.6)	258 (89)		388 (90)	772 (89.9)	142 (91)	
Hypertension	Yes	61 (15.2)	90 (11.9)	36 (12.4)	0.27	49 (11.4)	124 (14.4)	14 (9)	0.09
	No	340 (84.8)	665 (88.1)	254 (87.6)		382 (88.6)	735 (85.6)	142 (91)	
Medication	Statin Yes	12 (3)	25 (3.3)	17 (5.9)	0.10	19 (4.4)	32 (3.7)	3 (1.9)	0.37
	No	389 (97)	730 (96.7)	273 (94.1)		412 (95.6)	827 (96.3)	153 (98.1)	
	Hypertension Yes	60 (15)	85 (11.3)	36 (12.4)	0.19	43 (10)	125 (14.6)	13 (8.3)	0.02
	No	341 (85)	670 (88.7)	254 (87.6)		388 (90)	734 (85.4)	143 (91.7)	
Physical activity	Inactive	289 (72.1)	616 (81.6)	230 (79.3)	0.001	360 (83.5)	672 (78.2)	103 (66)	<0.001
	Adequate active	112 (27.9)	139 (18.4)	60 (20.7)		71 (16.5)	187 (21.8)	53 (34)	
Anthropometric measurement (Mean ± SD)	BMI (kg/m²)	26.3±4.75	27.2±4.71	27.8±5.12	<0.001	27.6±5.52	27.0±4.58	26.0±3.89	0.001
	Waist circumference (cm)	87.2±14.42	89.8±13.86	91.6±15.21	<0.001	90.0±4.83	90.0±15.27	89.7±14.03	0.07
	Waist height ratio	0.53±0.09	0.53±0.08	0.53±0.09	0.07	0.53±0.1	0.53±0.09	0.5±0.08	0.03
	Neck circumference (cm)	35.0±4.56	35.9±4.71	36.9±5.21	<0.001	35.9±5.07	35.9±4.64	35.6±4.98	0.84
Lipid parameters (Mean±SD) (mg/dL)	Total cholesterol	181.7±34.35	190.2±37.65	196.6±38.53	<0.001	190.7±37.94	190.5±37.57	177.1±31.47	<0.001
	LDL	51.8±12.47	51.0±10.77	50.6±13.49	0.34	50.2±12.13	51.3±11.41	53.1±13.07	0.03
	HDL	107.5±28.09	115.9±32.48	122.1±33.2	<0.001	116.6±32.52	111.9±32.43	104 ±24.04	<0.001

One-Way ANOVA, PostHoc- Tukey, Chi square, *P*<0,05. BMI: body mass index, LDL: low density lipoprotein, HDL: high density lipoprotein

Table 2: Cardiovascular risk scores and classification according to dietary characteristics of the participants

	MEDFICTS				***Meditarrenean diet***			
	Compatible with the therapeutic lifestyle diet n (%)	Having healthy dietary habits for heart health n (%)	Need to make some dietary changes n (%)	*P*-value	Poor n (%)	Moderate n (%)	Good n (%)	*P*-value
			ASCVD classification					
Low	294 (73.7)	549 (73)	197 (68.2)		311 (72.3)	614 (71.8)	115 (74.2)	0.19
Borderline	40 (10)	65 (8.6)	32 (11.1)	0.58	42 (9.8)	74 (8.7)	21 (13.5)	
Intermediate	49 (12.3)	103 (13.7)	42 (14.5)		60 (14)	119 (13.9)	15 (9.7)	
High	16 (4)	35 (4.7)	18 (6.2)		17 (4)	48 (5.6)	4 (2.6)	
10-year ASCVD risk score [a]	4.7±7.93	4.7±6.64	5.4±7.91	0.34	4.7±6.97	5.14±7.76	3.8±4.85	0.12
Lifetime ASCVD risk score [a]	39.1±14.51	39.3±13.73	41.6±14.45	0.04	40.8±13.84	39.3±14.13	38.9±14.81	0.20
Optimal ASCVD risk score [a]	2.1±1.34	1.9±1.63	1.8±1.51	0.48	2.1±1.93	1.6±1.79	1.8±1.23	0.03
SCORE risk score [a]	2.7±2.02	2.6±1.91	3.4±2.81	<0.001	2.8±1.92	2.9±2.41	2.1±1.01	0.01
			SCORE classification					
Low	20 (5)	54 (7.2)	25 (8.6)		19 (4.4)	60 (7)	20 (12.8)	
Moderate	313 (78.1)	580 (76.8)	200 (69)	0.04	334 (77.5)	637 (74.2)	122 (78.2)	0.002
High	52 (13)	95 (12.6)	45 (15.5)		61 (14.2)	120 (14)	11 (7.1)	
Very high	16 (4)	26 (3.4)	20 (6.9)		17 (3.9)	42 (4.9)	3 (1.9)	

One-Way ANOVA, PostHoc- Tukey, Chi square, *P*<0,05. [a] Mean ± SD

Table 3: MEDFICTS, Mediterranean diet characteristics and phytochemical index score according to CVD risk classifications of the participants

Variables	***SCORE***					***10-year ASCVD risk***				
	Low	Moderate	High	Very high	*P*-value	Low	Borderline	Intermediate	High	*P*-value
MEDFICTS score (Mean ± SD)	57.8±25.06	52.2±21.28	56.6±27.54	60.1±27.37	0.001	52.5±21.94	54.5±23.15	56.4±25.98	57.9±24.81	0.04
MEDAS score (Mean ± SD)	7.4±2.24	6.7±2.23	6.3±2.00	6.5±1.71	<0.001	6.7±2.21	6.9±2.35	6.4±2.12	6,5±1,87	0.25
Phytochemical index score (Mean ± SD)	30.3±13.68	28.9±16.78	30.0±17.15	28.3±14.56	0.69	28.9±16.43	31.4±17.56	28.6±17.34	29.6±13.89	0.39

One-Way ANOVA, PostHoc- Tukey, *P*<0.05.

Table 4: Relationship between dietary characteristics, physical activity and SCORE and ASCVD risk score

Variable	*10-year ASCVD risk*		*Lifetime ASCVD risk*		*Optimal ASCVD risk*		*SCORE*	
	r	*P*- value	r	*P*- value	r	*P*- value	r	*P*- value
MEDFICTS	0.06	0.020	0.10	0.001	-0.02	0.40	0.12	<0.001
Meat score	0.07	0.009	0.15	<0.001	0.02	0.55	0.05	0.04
Egg score	0.01	0.67	0.08	0.008	-0.01	0.59	-0.006	0.82
Dairy products score	0.12	<0.001	0.04	0.19	0.09	0.001	0.18	<0.001
MEDAS score	-0.04	0.11	-0.04	0.18	0.02	0.40	-0.07	0.009
Phytochemical index score	-0.003	0.91	-0.02	0.56	0.02	0.39	-0.009	0.73
Physical activity score	-0.09	<0.001	0.06	0.06	-0.07	0.01	-0.12	<0.001

Pearson Correlation, p<0.05.

Table 5: Evaluation of diet characteristics factor in predicting CVD risk status

Variable	*Model 1 Odds Ratio (95% CI)*	*P-value*	*Model 2 Odds Ratio (95% CI)*	*P-value*
MEDFICTS score	1.01 (1.01-1.02)	0.002	1.01 (1.00-1.02)	<0.001
MEDAS score	0.91 (0.86-0.97)	0.005	0.95 (0.89-1.01)	0.09
Phytochemical index score	1.01 (0.99-1.01)	0.56	0.98 (0.97-1.01)	0.78

(Logistic Regression-Odds ratio), Model 1: SCORE risk (high-very high/low-moderate), Model 2: ASCVD-10-year risk (intermediate -high/low-borderline)

Discussion

Foods and dietary components are associated with CVD risk (26-28). Particularly healthy dietary patterns have been shown to reduce the incidence and mortality of CVD significantly (29, 30). A 25% increase in the healthy eating patterns was correlated with reduced CVD risk, which ranged from 10% to 20% (29). In Atherosclerosis Risk in Communities study (n=12 413), compared to participants in the lowest quintile of diet quality, the participants in the highest quintile had a 16% lower incidence of CVD (95% CI, *P*<0.001), 32% lower risk of CVD mortality (95% CI, *P*<0.001), and an 18% lower risk of all-cause mortality (95% CI, *P*<0.001) (30). Similarly, Zhang et al. (28) found that participants in the highest quartile of diet quality had lower 10-year CVD risk compared to participants in the lowest quartile (β = -2.37, 95% CI, *P*<0.0001) (28). In this study, a one-unit increase in MEDFICTS scores is associated with 1.01 times increases in high very high CVD risk and 10-year moderate-high CVD risk. Thus, consistent with the information in the literature, our study results highlight that healthy eating behavior can help reduce CVD risk.

The Mediterranean diet may help reduce CVD risk. Approximately one-third of CVD-related metabolites were significantly associated with adherence to the Mediterranean diet (31). Every 2 units increase in adherence to the Mediterranean diet was associated with a significant reduction of 15% in the risk of death from all causes and that the pooled HR for the risk of death from CVD was 0.91 (32). A meta-analysis study (n=29) emphasizes that the Mediterranean diet is protective against CVD risk, particularly against coronary heart disease and ischemic stroke; however, it does not help prevent a hemorrhagic stroke (33). In our study, a one-unit increase in Mediterranean diet scores reduces the risk of high-very high CVD by 0.91 times and 10-year moderate-to-high CVD risk by 0.95 times. A Mediterranean diet intervention may help prevent CVD by reducing high plasma concentrations of ceramides (34). Mediterranean diet can reduce CVD risk by increasing nitric oxide bioavailability and by alleviating triggering factors of CVD such as increased blood pressure, glucose as well as lipid levels, endothelial dysfunction, increased reactive oxygen species levels (35).

Phytochemicals may exhibit protective effects through their antioxidant activity by inhibiting reactive oxygen and nitrogen species, implicated in the pathogenesis of many chronic diseases (36). Phytochemicals may improve the lipid profile and alleviate inflammation by inhibiting prostaglandin synthesis, platelet aggregation and nuclear factor-κB activity, by enzyme inhibition, and by increasing cytokine production (37, 38). Furthermore, phenolic acids may be involved in the prevention of cardiovascular events by preventing the accumulation of vascular smooth muscle cells, which play a key role in the formation and development of atherosclerotic lesions (39). In addition, phytochemicals may promote the de-novo expression of endogenous antioxidant defense genes such as glutathione peroxidase, superoxide dismutase, and heme oxygenase-1 (40). Despite these favorable effects of phytochemicals, the evidence showing their relation to CVD risk is inadequate. In this study, phytochemical intake alone was not associated with CVD risk, however, the Mediterranean diet, one of the best examples of a diet rich in phytochemicals, was associated with lower CVD risk. This might result from the adequacy of the diet, which contains cardioprotective components in addition to phytochemicals along with all nutrients, leading to the suggestion that the diet composition should be considered as a whole. However, the number of studies examining CVD risk and phytochemical intake is not adequate. Despite the striking results of the study, there are some limitations, including a lack of dietary intervention and the use of a recall-based assessment of current dietary patterns, diet characteristics, and the phytochemical intake. Such assessments depend on the subject's memory and cognition. Furthermore, other non-dietary factors that might affect CVD risk need to be eliminated. It will be beneficial if future studies include the investigation of such factors such as age, gender, family history, and genetics. Long-term prospective studies with follow-up of subjects will be important for revealing the relationship between dietary patterns and CVD risk.

Conclusion

A dietary pattern that includes balanced and healthy eating behaviors may help reduce the risk of CVD. Adopting a Mediterranean diet and a heart-healthy diet may be a good strategy to reduce CVD risks.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interests.

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