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ADHERENCE TO THE MEDITERRANEAN DIET IN PATIENTS WITH METABOLIC SYNDROME

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ABSTRACT
This descriptive and cross-sectional study evaluated the adherence of patients with Metabolic Syndrome (MetS) to the Mediterranean Diet (MedDiet). Patients who met the National Cholesterol Education Program Adult Panel III (NCEP ATP III) criteria enrolled. Socio-demographic characteristics, physical activity levels, blood tests and anthropometric variables were recorded and evaluated. A 24-hour retrospective record form and Mediterranean Diet Adherence Scale (MEDAS) were used to assess nutritional consumption and adherence, respectively. Of the patients (n=203) 50.2%, 39.9% and 9.9% were non-, moderately and strictly adherent to MedDiet, respectively. MEDAS scores were correlated with body weight (r=-0.147; *P* =0.036), waist circumference (r=-0.141; *P* =0.044), HDL cholesterol (r=0.193; *P* =0.006). Daily omega-3 fatty acids intake increased with higher adherence to MedDiet (*P* <0.001). Significant differences were observed between non-adherent and adherent subjects in daily intakes of dietary fiber, oleic acid and total monounsaturated fatty acids.This study showed low adherence to MedDiet in patients with MetS.
Keywords: Mediterranean diet, adherence, metabolic syndrome, physical activity, anthropometric measurements

METABOLİK SENDROMLU HASTALARDA AKDENİZ DİYETİNE UYUM

ÖZ
Bu tanımlayıcı ve kesitsel çalışma, Metabolik Sendromlu (MetS) hastaların Akdeniz Diyetine (MedDiet) uyumunu değerlendirmiştir. Ulusal Kolesterol Eğitim Programı Yetişkin Paneli III (NCEP ATP III) kriterlerini karşılayan hastalar kabul edilmiştir. Sosyodemografik özellikler, fiziksel aktivite düzeyleri, kan testleri ve antropometrik değişkenler kaydedilmiştir. Besin tüketimini ve uyumu değerlendirmek için sırasıyla 24 saatlik geriye dönük kayıt formu ve Akdeniz Diyeti Uyum Ölçeği (MEDAS) kullanılmıştır. Hastaların (n=203) %9.9'u MedDiet'e sıkı bir şekilde uyumlu, %39.9'u orta derecede uyumlu, %50.2'si ise uyumlu değildi. MEDAS skorları vücut ağırlığı (r=-0.147; *P* =0.036), bel çevresi (r=-0.141; *P* =0.044), HDL kolesterol (r=0.193; *P* =0.006) ile ilişkiliydi. Günlük omega-3 yağ asitleri alımı, MedDiet'e uyum arttıkça arttı (*P* <0.001). Diyet lifi, oleik asit ve toplam tekli

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doymamış yağ asitlerinin günlük alımlarında uyumlu olmayan ve uyumlu hastalar arasında önemli farklılıklar gözlendi. Bu çalışma, MetS'li hastalarda MedDiet'e uyumun düşük olduğunu göstermiştir.
Anahtar kelimeler: Akdeniz diyeti, uyum, metabolik sendrom, fiziksel aktivite, antropometrik ölçümler

INTRODUCTION

Metabolic Syndrome (MetS) is a noncommunicable disease referring to coexisting diabetes, hypertension and obesity (Bakaloudi et al., 2021). Forty-one million people die annually from noncommunicable diseases, corresponding to 7 out of 10 deaths worldwide (WHO, 2022). As a risk factor, MetS affects the prognosis and progression of Type-2 diabetes, cancer, cardiovascular disease and respiratory diseases (Kargin et al., 2019). The coexistence of three or more metabolic disorders like obesity, insulin resistance, dyslipidemia and hypertension play a role in the development of MetS (Bakaloudi et al., 2021). Its worldwide prevalence in adults is 25% and is associated with a 2- to 5-fold higher risk of early cardiovascular mortality, diabetes, coronary heart and cerebrovascular diseases, and a 1.5-fold increase in the risk of deaths of all causes (WHO, 2022).

A balanced diet and nutritional diversity are central to maintaining a healthy life. Mediterranean Diet (MedDiet) is considered one of the healthiest nutrition models (Kargin et al., 2019). It includes a complete and balanced combination of components such as extra virgin olive oil, vegetables, fresh fruits, nuts, legumes, fish and red wine, molecules with antioxidant and anti-inflammatory properties such as mono/polyunsaturated fatty acids, polyphenols, phytosterols, vitamins and minerals (Finicelli et al., 2022). Various studies have shown the health-promoting effects of MedDiet, together with lifestyle changes through increased physical activity (Kargin et al., 2019; Finicelli et al., 2022).

Cross-sectional or prospective studies have shown inverse correlations between adherence to MedDiet and the prevalence of MetS (Godos et al., 2017; Bakaloudi et al., 2021). Some studies have demonstrated the benefits of adherence to MedDiet in reducing the risk of obesity, Type-2 diabetes, cardiovascular diseases, and death from any causes (Martínez-González et al., 2011; Franquesa et al., 2019).

The preventive effect of MedDiet on the risk and formation of MetS has been reported (Godos et al., 2017; Franquesa et al., 2019). However, studies examining whether different levels of adherence to MedDiet may positively affect MetS are limited (Bakaloudi et al., 2021). The present study evaluated the association between different levels of adherence to MedDiet and anthropometric and biochemical variables in patients with MetS.

MATERIALS AND METHODS

Study settings, time and sample selection

The present descriptive, cross-sectional study enrolled patients with MetS admitted to the Endocrine and Metabolic Diseases Polyclinic of Pamukkale University Hospital between July and September 2021.

The main inclusion criterion was a diagnosis of MetS that was determined by the physician using the National Cholesterol Education Program Adult Panel III (NCEP ATP III) criteria (Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults, 2001).

Patients under 19 years and over 64 years of age, pregnant or breastfeeding women, and patients with cancer, mental disorders, eating disorders, recent diagnosis of hematological disease, recent surgery history, goiter, and anatomical abnormality in the neck region were excluded. The minimum required sample size was calculated as 175, by taking into account the prevalence of MetS as 43.3% and power 0.80 (Abacı et al., 2018).

Lokman Hekim University Ethics Committee approved the study protocol (2021/066) and the participants signed the informed consent.

Data Collection

Data were collected via face-to-face interviews. The study questionnaire included socio-demographic characteristics, medical information and nutritional habits. Biochemical variables were extracted from the patient files. Body weight and composition, height, body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), Neck circumference (NC) and waist-to-height ratio were obtained.

Nutritional Assessment and Anthropometric Measurements

Body weight was measured with Tanita Body Composition Analyzer BC-418 (Tanita, Illinois, USA) and height was measured with a stadiometer (AS-TARTI, Turkiye). BMI was calculated by dividing body weight (in kilograms) by the square of height (in meters) (WHO, 2021). WC was measured at the midpoint between the lower ribs and the iliac bone, and hip circumference was measured (in centimeters) horizontally from the widest circumference of the hip (WHO, 2011). WHR was calculated by dividing the WC by the hip circumference. NC was measured just below the larynx (Adam's apple) (TUBER, 2016). Systolic blood pressure and diastolic blood pressure were measured using Ombron M2 Intellisense (Japan).

A "24-hour Retrospective Food Consumption Record Form" was collected from each patient to determine the energy, macro and micronutrient amounts (Pekcan, 2013). A photographic food atlas showing different quantities of foods was used to estimate the portion size of the participant in each meal (Rakıcıoğlu et al., 2009). The data were transferred to Nutrition Information System 9 software (BeBIS, Stuttgart, Germany). Energy consumption and nutrient intake were examined using the Türkiye Nutrition Guide-2015 (TUBER-2016) (12). According to the daily acceptable intake, the coverage ratio was evaluated as <67%, insufficient intake, 67-133% as adequate intake, and >133% as over-intake (Meyers et al., 2006).

Patients' adherence to MedDiet was evaluated using a 14-item Mediterranean Diet Adaptation Scale (MEDAS) (Martínez-González et al., 2016) which is a valid and reliable scale in the local language (Pehlivanoglu et al., 2020). Responses to each item in the MEDAS are assigned "1" or "0", and the scores of 7 and above indicate an acceptable level of adherence. The scores between 7 and 9 indicate moderate and higher scores indicate strict adherence to MedDiet.

Individuals' physical activity levels were classified as inactive (<600 MET-min/week), minimally active (600-3000 MET-min/week), and very active (>3000 MET-min/week) according to the International Physical Activity Questionnaire-IPAQ (Saglam et al., 2010).

Statistical analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) Statistics for Windows, version 20.0 (IBM Corp., Armonk, NY: USA, 2011). Chi-square test was performed to determine the dependencies of categorical variables. Fisher's exact test was used when the assumptions of the chi-square analysis were not met. One-Way Analysis of Variance (ANOVA) and Kruskal-Wallis H test were used for multiple comparisons. For ANOVA analyses, in cases where variances from Post-Hoc tests were equally distributed, LSD; Mann Whitney-U test was used for Kruskal-Wallis H analysis. In cases where the distribution was not normal, Spearman correlation analysis was used for the correlation between the variables.

RESULTS AND DISCUSSION

A total of 203 patients with MetS (142 women and 61 men) participated. Their mean age was 46.9±11.33 years. While primary education was higher among female patients, male patients had more undergraduate or higher education (P <0.001). There was no significant difference in the numbers of retired male and female patients with MetS. However, the number of working people was more among male patients (P <0.001) (Table 1). The incidence of MetS in Western societies is 24% and above (Bakaloudi et al., 2021), and also increases with age (Abacı et al., 2018; Oğuz, 2018). Although there was no statistically significant difference in the present study, the proportion of patients with MetS increased with age. According to the prevalence studies in Turkiye, the frequency of MetS is very high, especially among women (Abacı et al., 2018; Oğuz, 2018). In the current study, 142 of 203 individuals with MetS were women (70%). The present study findings supported the existing literature data that the risk of MetS was higher in low-income and low-educated populations (Oğuz, 2018; Kim et al., 2018). Individuals with low level of education lacks the ability to comply with health guidelines since they don't have sufficient knowledge of what healthy nutrition is and its importance. This may also explain why individuals with low level of education exhibit low adherence to MedDiet (Tsofliou et al., 2022) (Table 1).

Table 1: Distribution of socio-demographic characteristics of patients with Metabolic Syndrome by gender.

	Male (n=61)	Female (n=142)	Total (n=203)	X^2	*P*
Age (years), mean±SD	47.1±10.8	46.8±11.6	46.9±11.3	32.76[2]	0.828
Age bands, n (%)					
19-24	2 (3.3)	9 (6.3)	11 (5.4)	1.38[1]	0.848
25-34	6 (9.8)	15 (10.6)	21 (10.3)		
35-44	15 (24.6)	29 (20.4)	44 (21.7)		
45-54	22 (36.1)	47 (33.1)	69 (34.0)		
55-64	16 (26.2)	42 (29.6)	58 (28.6)		
Education Level, n (%)					
Illiterate	1[a] (1.6)	2[a] (1.4)	3 (1.5)	23.32[2]	<0.001*
Literate	2[a] (3.3)	2[a] (1.4)	4 (2.0)		
Primary education	19[a] (31.1)	88[b] (62.0)	107 (52.7)		
Higher education	15[a] (24.6)	32[a] (22.5)	47 (23.1)		
Graduate Education	20[a] (32.8)	16[b] (11.3)	36 (17.7)		
Master/Doctorate	4[a] (6.6)	2[b] (1.4)	6 (3.0)		
Occupation, n (%)					
Worker	27[a] (44.3)	23[b] (16.2)	50 (24.6)	65.81[1]	<0.001*
Officer	7[a] (11.5)	5[b] (3.5)	12 (5.9)		
Self-employed	9[a] (14.7)	3[b] (2.1)	12 (5.9)		
Retired	18[a] (29.5)	30[a] (21.1)	48 (23.6)		
Housewife	- (-)	81 (57.1)	81 (40.0)		

a, b: The letters a and b are used in distributions where the dependence between categorical variables is statistically significant, to reveal which variables result from the proportional differences in this significance.
SD: Standard deviation
[1]Pearson Chi-square test.
[2]Fisher's Exact test
* P <0.001

Of the patients, 50.2% were non-adherent, 39.9% were moderately adherent, and 9.9% were strictly adherent to MedDiet. The average adherence score was 6.4±1.8, which remained below the acceptable level (Pehlivanoglu et al., 2020) (Table 2). MedDiet shows a positive impact on metabolic and cardiovascular diseases and cognitive functions. The quality of life increased in parallel with adherence to MedDiet in past studies (Soltani et al., 2019). Besides, MedDiet has turned into almost a 'prescription' to prevent and treat metabolic diseases (Godos et al., 2017; Soltani et al., 2019; Bakaloudi et al., 2021;). Finally, meta-analyses concluded that adherence to MedDiet prevents the development of MetS (Godos et al., 2017; Bakaloudi et al., 2021). The results of the current study support the existing knowledge. The mean MEDAS score was 6.4±1.8, indicating that the participants overall were low-adherent to MedDiet. A meta-analysis has sought the importance of the degree of adherence and concluded that a 2-point increase in adherence to MedDiet was associated with a 10% lower risk of death from any causes (Soltani et al., 2019) (Table 2).

Table 2: Patients' adherence to the Mediterranean Diet by gender and average adherence scores.

Adherence to Mediterranean Diet	Male	Female	Total
No adherence (<7 points), n (%)	35 (57.4)	67 (47.2)	102 (50.2)
Moderate adherence (7-8 points), n (%)	18 (29.5)	63 (44.4)	81 (39.9)
Strict adherence (≥9 points), n (%)	8 (13.1)	12 (8.4)	20 (9.9)
Total score, mean±SD	6.2±2.1	6.5±1.7	6.4±1.8
Lower-Upper	2-11	2-10	2-11

SD: Standard deviation

There was a low, negative correlation between adherence to MedDiet and body weight (r =-0.147; *P* =0.036) and WC (r =-0.141; *P* =0.044) and a low, positive correlation between high-density lipoprotein cholesterol (HDL-C) and adherence to MedDiet (r=0.193; *P* =0.006). Correlations between adherence to MedDiet and NC, hip circumference, WHR, BMI, triglyceride, low-density lipoprotein cholesterol (LDL-C), total cholesterol, and hemoglobin A1c (HbA1c) were not significant. A low, positive correlation was found between adherence to MedDiet and physical activity levels (r=0.21; *P* =0.003) (Table 3). An inverse association between body weight and WC and adherence to MedDiet in the whole sample was observed. This finding is in line with the literature (Bouzas et al., 2019; Bakaloudi et al., 2021; Zhang et al., 2022). No significant correlation was found for body fat ratio, BMI, NC, and WHR. Although BMI and body weight are important factors for abdominal obesity in the definition of MetS, some studies suggested disease risk factors could be more useful than BMI and body weight (Eguaras et al., 2015; Aslani et al., 2019). The present study findings also supported the existing knowledge that adherence to MedDiet and BMI do not correlate. Concerning the association between adherence to MedDiet and WC as a measure of adiposity, several authors reported a lower incidence of MetS as adherence is improved (Eguaras et al., 2015; Estruch et al., 2019). Both physical activity and MedDiet reduce the likelihood of developing MetS (Gallardo-Alfaro et al., 2020). A high level of adherence to MedDiet is associated with increased physical activity, which is critical for overall health (Bizzozero-Peroni et al., 2022). Similarly, in the current study, physical activity levels increased in parallel to adherence to MedDiet (Table 3).

Previous studies have reported a positive correlation between higher adherence to MedDiet and HDL-C level (Franquesa et al., 2019; Bakaloudi et al., 2021; Montemayor et al., 2022). Furthermore, MedDiet is favorable for the microbiome due to its high polyphenol content and higher adherence to the MedDiet has been linked to lower fasting triglyceride and plasma glucose levels (Bakaloudi et al., 2021; Shatwan et al., 2021; Montemayor et al., 2022). In this study, parallel to the literature, a positive correlation between HDL-C and MedDiet adherence scores was observed in the whole sample. Although the studies supported the positive effects of Mediterranean diet on cardiovascular diseases (Rees et al., 2019), correlations with triglyceride, total cholesterol, LDL-C and HbA1c were not significant in the present study. It wasHo thought that these results were related with the patients' low adherence to the MedDiet (Table 3).

Food consumption and adherence to MedDiet

Table 4 shows average daily energy, water and nutrients intakes (macronutrients and micronutrients) according to the level of adherence to MedDiet, and their percentages of meeting the reference values according to the TUBER-2015 (TUBER. 2016). Average water consumption was higher in participants strictly adherent to MedDiet than the participants who were non- or moderately adherent (*P* =0.031). Carbohydrate and fat consumption were lowest and fiber consumption was the highest in strictly adherent participants (*P* =0.014, 0.044, 0.047 respectively). Macronutrient intake and MetS were investigated in 10000 Iranians aged 20 to 69 years (Hasanizadeh et al., 2020). Patients with high carbohydrate intake had 67% more probability of developing MetS than patients with high protein and fat intake (Hasanizadeh et al., 2020). It has been suggested that the content of carbohydrates was more important than the ratio of carbohydrates consumed in MedDiet (Bakaloudi et al., 2021). Therefore, consuming complex carbohydrates instead of simple carbohydrates has been recommended (Pérez-Martínez et al., 2017). In accordance with the literature (Gallardo-Alfaro et al., 2020 ; Bakaloudi et al., 2021), the effect of the Mediterranean diet on glycemic control was manifested by a low level of HbA1c in the present study. Several studies have shown improved HbA1c and blood lipids in MetS patients consuming more fiber (Papamichou et al., 2019; Tettamanzi et al., 2021). In the present study, a parallel increase in daily fiber consumption and adherence to MedDiet were observed as reported in the literature (Dominguez et al., 2023) (Table 4).

Table 3: Correlations between MEDAS scores and anthropometric measurements, biochemical parameters and physical activity level(n=203).

Variable	MEDAS Scores	
	r	*P*
Anthropometric Measurements		
Body weight (kg)	-0.147	0.036*
BMI (kg/m²)	-0.097	0.169
Body fat ratio (%)	0.003	0.968
Neck circumference (cm)	-0.126	0.072
Waist circumference (cm)	-0.141	0.044*
Hip circumference (cm)	-0.036	0.611
Waist/hip ratio	-0.134	0.055
Waist/height ratio	-0.059	0.400
Biochemical Parameters		
Systolic Blood Pressure (mmHg)	0.009	0.897
Diastolic Blood pressure (mmHg)	0.014	0.844
Fasting Plasma Glucose (mg/dL)	0.076	0.278
Triglyceride (mg/dL)	-0.099	0.160
LDL-C (mg/dL)	-0.110	0.120
HDL-C (mg/dL)	0.193	0.006**
Total cholesterol (mg/dL)	-0.131	0.065
HbA1c (%)	-0.026	0.740
Physical Activity Levels	0.210	0.003**

MEDAS: Mediterranean Diet Adherence Scale, BMI: Body Mass Index, LDL-C: Low-density lipoprotein cholesterol, HDL-C: High-density lipoprotein cholesterol HgA1c: Hemoglobin A1c, *P <0.05 ** P <0.01, r: Spearman correlation analysis.

Table 4: Comparison of energy, water and nutrients intakes with TUBER according to adherence to the Mediterranean Diet

Energy, water and nutrients	Adherence to the Mediterranean Diet						*P*	Post-hoc differences
	No adherence (a)		Moderate adherence (b)		Strict adherence (c)			
	TUBER Mean	Mean± SD	TUBER Mean	Mean± SD	TUBER Mean	Mean± SD		
Energy (kcal)	98.5	1899.2±767.3	98.5	1905±796.1	104.5	2019.9±536.9	0.804[1]	-
Water (ml)	-	1976.4±1293.3	-	2054.8±1197.8	-	2511.5±1148.3	0.031[2]*	a vs. c, b vs. c
Protein (%)	-	14.9±4.9	-	16.8±11.8	-	16.4±4.1	0.129[2]	-
Fat (%)	-	38.8±10.5	-	37.7±10.6	-	36.9±9.4	0.044[1]*	a vs. b
CHO (%)	-	51.4±10.8	-	46.7±12.3	-	46.3±11.6	0.014[1]*	a vs. b
Fiber (g)	87.9	22.0±11.0	101.5	25.4±13.4	104.5	26.1±8.3	0.047[2]*	a vs. c
MUFA (g)	-	25.1±15.0	-	28.6±17.2	-	33.7±14.2	0.013[2]*	a vs. c
Oleic Acid (g)	-	22.6±14.0	-	25.8±15.5	-	30.8±13.1	0.010[2]*	a vs. c
PUFA (g)	-	14.1±9.8	-	14.4±10.7	-	12.7±5.8	0.990[2]	-
Omega 3 (g)	-	1.3±0.7	-	1.6±1.1	-	1.9±0.8	0.001[2]**	a vs. b, b vs. c, a vs. c
Omega 6 (g)	-	12.6±9.4	-	12.5±10.0	-	10.5±5.2	0.992[2]	-
Saturated Fatty Acid (g)	-	26.1±14.1	-	30.5±18.3	-	30.7±13.1	0.059[2]	-
Vitamin A (μg)	204.7	1412.5±2541.7	444.9	3034.7±9345.7	373.1	2661.3±6255.3	0.026[2]*	a vs. b, a vs. c
Vitamin D (μg)	16.1	2.4±2.3	18.5	2.8±2.4	22.9	3.4±3.6	0.267[2]	-
Vitamin E (mg)	141.9	16.6±13.1	144.1	16.5±10.2	127.2	14.8±5.8	0.746[2]	-
Thiamine (mg)	90.3	1.0±0.5	100.5	1.1±0.6	101.4	1.2±0.4	0.198[1]	-
Riboflavin (mg)	119.4	1.4±0.9	166.7	1.9±2.0	186.4	2.2±1.5	0.000[2]***	a vs. b, b vs. c, a vs. c
Niacin (mg)	388.9	26.2±15.4	406.6	27.2±17.8	467.1	31.9±17.2	0.292[2]	-
Vitamin B6 (mg)	101.9	1.4±0.8	114.5	1.6±0.9	127.5	1.9±0.8	0.013[2]*	a vs. b, a vs. c
Folate (μg)	0	346.4±193.9	0	448.6±348.1	0	462.3±204.2	0.003[2]**	a vs. b, a vs. c
Vitamin B12 (μg)	133.3	5.3±16.7	238.22	9.5±3	204.4	8.2±13.5	0.009[2]**	b vs. c, a vs. c
Vitamin C (mg)	160.5	159.4±127.5	158.16	154.5±92.1	217.4	216.8±128.2	0.066[2]	-
Sodium (mg)	313.5	4500.2±7944.5	250.5	3533.4±1729.4	264.6	3665.5±1621.0	0.814[2]	-
Potassium (mg)	63.6	2990.1±1502.7	76.8	3472.8±1566.3	84.9	3988.8±1385.7	0.010[1]*	a vs. b, a vs. c
Calcium (mg)	73.3	706.8±355.4	85.6	832.2±426.3	87.1	839.2±352.5	0.032[2]*	a vs. b, a vs. c
Magnesium (mg)	92.9	295.7±136	103.6	323.1±162.3	114.3	361.0±130.3	0.068[2]	-
Selenium (μg)	22.7	15.9±31.3	24.7	17.3±32.6	42.7	29.9±60.8	0.168[2]	-
Iron (mg)	101	11.1±5.2	96.9	12.7±7.8	125.1	15.2±7.8	0.029[2]*	b vs. c, a vs. c
Zinc (mg)	94.6	9.6±4.6	105.5	10.7±6.0	129.8	13.3±7.0	0.080[2]	-

[1]One-Way Analysis of Variance (ANOVA), [2]Kruskal Wallis-H Test, TUBER mean: The average of the percentage of meeting the reference values of the 'Türkiye Nutrition Guide', TUBER: Türkiye Nutrition Guide

a vs.b: Significant difference between 'No adherence' and 'Moderate adherence', a vs.c: Significant difference between 'No adherence' and 'Strict adherence', b vs. c: Significant difference between 'Moderate adherence' and 'Strict adherence'

P: Significance was checked over normal values. * $P<0.05$ ** $P<0.01$ *** $P<0.001$. SD: Standard deviation, CHO: Carbohydrate, MUFA: Monounsaturated fat, PUFA: Polyunsaturated fat

The daily amount of omega-3 fatty acids intake increased simultaneously with adherence level to MedDiet and there were between-group differences (*P* <0.001). Daily oleic acid and the total amount of monounsaturated fatty acids (MUFA) intakes were low in non-adherent participants and were high in strictly adherent participants (*P* =0.013). Concerning the fat intake in our sample, the amounts of MUFA, oleic acid, and omega-3 fatty acids were higher in those who were strictly adherent to MedDiet. Previous studies reporting high adherence demonstrated reversal of MetS outcomes and reduced prevalence of cardiometabolic risk factors (Gallardo-Alfaro et al., 2020; Montemayor et al., 2022). In this respect, the current study found a negative correlation between adherence to MedDiet and HDL levels. However, MedDiet did not significantly correlate with triglycerides and LDL-C. In terms of these metabolic syndrome parameters, it is thought that the expected results could not be achieved, due to the fact that the entire sample was a patient group and no intervention was applied. In addition, these findings are in line with the literature, supporting the importance of healthy fat consumption in MedDiet and its positive effects on MetS (Gallardo-Alfaro et al., 2020; Bakaloudi et al., 2021; (Table 4).

In terms of micronutrients, the average daily intakes of potassium, calcium, vitamin A, vitamin B6 (p=0.013), vitamin B2 and folate were different between non-adherent participants compared with the moderately and strictly adherent participants (*P* <0.001, *P* =0.003 respectively). There were no between-group differences concerning energy, protein, omega-6, saturated fatty acids, thiamine, vitamins D, E and C, and sodium, magnesium, selenium, zinc and iron intakes. On the other hand, daily selenium, calcium, potassium and vitamin D intakes were below TUBER-2015 (TUBER, 2016) reference values in all groups. When examined in detail, the coverage ratio according to the daily acceptable intake was insufficient in potassium in the non-compliant group and in vitamin D and selenium intakes in all groups (Table 4). A lower risk of developing MetS has been reported in individuals adopting MedDiet rich in vitamins and minerals (Eleftheriou et al., 2018; Gantenbein et al., 2021). In the current study, some micronutrient (potassium, calcium, vitamin A, vitamin B6, vitamin B2, and folate) intake was higher in patients adherent to MedDiet. The average percentages of meeting the reference intake values of vitamin D and selenium were insufficient in all adherence levels. Low vitamin D consumption is prevalent due to limited dietary sources of vitamin D (Santa et al., 2023). However, potassium intakes were insufficient in only non-adherent group. A meta-analysis has concluded that a lower risk of MetS was lower in individuals with higher potassium intake (Cai et al., 2016). This meta-analysis indirectly supports our result. Trace elements such as zinc and selenium are essential for maintaining human physiological homeostasis, and therefore, an imbalance in trace elements is considered an independent risk factor for MetS (Khazdouz et al., 2020; Djalalinia et al., 2021) (Table 4).

Strengths and limitations

This is the first cross-sectional report from Turkiye on the adherence to MedDiet in patients with MetS. However, there are several limitations to the procedures and findings. First, the sample size was small and there was no control group. Second, food consumption was assessed through self-reports which were inherently subject to errors.

In conclusion, this study showed that patients with MetS had low adherence to MedDiet. A higher level of adherence to MedDiet was associated with favorable MetS parameters (lower WC and higher HDL-C) and higher physical activity levels.

CONFLICT OF INTEREST

There are no conflicts of interest or competing with the results of the presented article.

AUTHORS' CONTRIBUTIONS

Gülnur Pürdik Tatık: Conceptualization, Data Collection, Review. Anıl Evrim Güngör: Conceptualization, Writing-Original Draft, Review, Editing.

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REFERENCES
Abaci, A., Kilickap, M., Goksuluk, H., Karaaslan, D., Barçın, C., Kayıkçıoğlu, M., Özer, N., Yılmaz, M. B., Şahin, M., Tokgözoğlu, L. (2018). Data on prevalence of metabolic syndrome in Turkiye: Systematic review, meta-analysis and meta-regression of epidemiological studies on cardiovascular risk factors. *Türk Kardiyoloji Derneği Arşivi*, 46(7): 591-601.

Aslani, Z., Qorbani, M., Hébert, J. R., Shivappa, N., Motlagh, M. E., Asayesh, H., Mahdavi-Gorabi, A., Kelishadi, R. (2019). Association of Dietary Inflammatory Index with anthropometric indices in children and adolescents: The weight disorder survey of the Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable Disease (CASPIAN)-IV study. *British Journal of Nutrition*, 121(3): 340-350.

Bakaloudi, D. R., Chrysoula, L., Kotzakioulafi, E., Theodoridis, X., Chourdakis, M. (2021). Impact of the level of adherence to Mediterranean diet on the parameters of metabolic syndrome: A systematic review and meta-analysis of observational studies. *Nutrients*, 13(5): 1-25.

Bizzozero-Peroni, B., Brazo-Sayavera, J., Martínez-Vizcaíno, V., Fernández-Rodríguez, R., López-Gil, J. F., Díaz-Goñi, V., Cavero-Redondo, I., Mesas, A. E. (2022). High adherence to the Mediterranean Diet is associated with higher physical fitness in adults: A systematic review and meta-analysis. *Advances in Nutrition (Bethesda, MedDiet.)*, 13(6): 2195-2206.

Bouzas, C., Bibiloni, M. D. M., Julibert, A., Ruiz-Canela, M., Salas-Salvadó, J., Corella, D., Tur, J. A. (2020). Adherence to the Mediterranean lifestyle and desired body weight loss in a Mediterranean adult population with overweight: A predimed-plus study. *Nutrients,* 12(7): 2114.

Cai, X., Li, X., Fan, W., Yu, W., Wang, S., Li, Z., Scott, E. M., Li, X. (2016). Potassium and obesity/metabolic syndrome: A systematic review and meta-analysis of the epidemiological evidence. *Nutrients,* 8(4): 183.

Djalalinia, S., Hasani, M., Asayesh, H., Ejtahed, H. S., Malmir, H., Kasaeian, A., Zarei, M., Baygi, F., Rastad, H., Mahdavi Gorabi, A., Qorbani, M. (2021). The effects of dietary selenium supplementation on inflammatory markers among patients with metabolic diseases: A systematic review and meta-analysis of randomized controlled trials. *Journal of Diabetes and Metabolic Disorders*, 20(1): 1051-1062.

Dominguez, L. J., Veronese, N., Di Bella, G., Cusumano, C., Parisi, A., Tagliaferri, F., Ciriminna, S., Barbagallo, M. (2023). Mediterranean diet in the management and prevention of obesity. *Experimental Gerontology* 174, 112121.

Eguaras, S., Toledo, E., Buil-Cosiales, P., Salas-Salvadó, J., Corella, D., Gutierrez-Bedmar, M., Santos-Lozano, J. M., Arós, F., Fiol, M., Fitó, M., Ros, E., Serra-Majem, L., Pintó, X., Martínez, J. A., Sorlí, J. V., Muñoz, M. A., Basora, J., Estruch, R., Martínez-González, M. A. (2015). Does the Mediterranean diet counteract the adverse effects of abdominal adiposity? *Nutrition Metabolism and Cardiovascular Diseases*, 25(6): 569-574.

Eleftheriou, D., Benetou, V., Trichopoulou, A., La Vecchia, C., Bamia, C. (2018). Mediterranean Diet and its components in relation to all-cause mortality: Meta-analysis. *British Journal of Nutrition*, 120(10): 1081-1097.

Estruch, R., Martínez-González, M. A., Corella, D., Salas-Salvadó, J., Fitó, M., Chiva-Blanch, G., Fiol, M., Gómez-Gracia, E., Arós, F., Lapetra, J., Serra-Majem, L., Pintó, X., Buil-Cosiales, P., Sorlí, J. V., Muñoz, M. A., Basora-Gallisá, J., Lamuela-Raventós, R. M., Serra-Mir, M., Ros. E., PREDIMED Study Investigators. (2019). Effect of a high-fat Mediterranean diet on bodyweight and waist circumference: A prespecified secondary outcomes analysis of the PREDIMED randomised controlled trial. *Lancet Diabetes & Endocrinology*, 7(5): e6-e17.

Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. (2001). Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert Panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *Journal of American Medical Association*, 285(19): 2486-2497.

Finicelli, M., Di Salle, A., Galderisi, U., Peluso, G. (2022). The mediterranean diet: An update of the clinical trials. *Nutrients*, 14: 2956.

Franquesa, M., Pujol-Busquets, G., García-Fernández, E., Rico, L., Shamirian-Pulido, L., Aguilar-Martínez, A., Medina, F. X., Serra-Majem, L., Bach-Faig, A. (2019). Mediterranean diet and cardiodiabesity: A systematic review through evidence-based answers to key clinical questions. *Nutrients*, 11(3): 655.

Gallardo-Alfaro, L., Bibiloni, M. D. M., Mascaró, C. M., Montemayor, S., Ruiz-Canela, M., Salas-Salvadó, J., Corella, D., Fitó, M., Romaguera, D., Vioque, J., Alonso-Gómez, Á. M., Wärnberg, J., Martínez, J. A., Serra-Majem, L., Estruch, R., Tercero-Maciá, C., Sorto-Sánchez, C., Sayón-Orea, C., García-Gavilán, J., Muñoz-Martínez, J., Tur, J. A. (2020). Leisure-time physical activity, sedentary behaviour and diet quality are associated with metabolic syndrome severity: The PREDIMED-Plus study. *Nutrients*, 12(4): 1013.

Gantenbein, K. V., Kanaka-Gantenbein, C. (2021). Mediterranean diet as an antioxidant: The impact on metabolic health and overall wellbeing. *Nutrients,* 13(6): 1951.

Godos, J., Zappalà, G., Bernardini, S., Giambini, I., Bes-Rastrollo, M., Martinez-Gonzalez, M. (2017). Adherence to the Mediterranean diet is inversely associated with metabolic syndrome occurrence: A meta-analysis of observational studies. *International Journal of Food Sciences and Nutrition*, 68(2): 138-148.

Hasanizadeh, S., Nadjarzadeh, A., Mirzaei, M., Salehi-Abargouei, A., Hosseinzadeh, M. (2020). The association between macronutrient intake and the metabolic syndrome in Yazdian adult population. *Journal of Nutrition and Food Security*, 5(1): 66-75.

Kargin, D., Tomaino, L., Serra-Majem, L. (2019) Experimental outcomes of the Mediterranean diet: Lessons learned from the Predimed randomized controlled trial. *Nutrients*, 11(12), 2991.

Khazdouz, M., Djalalinia, S., Sarrafi Zadeh, S., Hasani, M., Shidfar, F., Ataie-Jafari, A., Asayesh, H., Zarei, M., Gorabi, A. M., Noroozi, M., Qorbani, M. (2020). Effects of zinc supplementation on cardiometabolic risk factors: A systematic review and meta-analysis of randomized controlled trials. *Biological Trace Element Research*, 195(2): 373-398.

Kim, I., Song, Y. M., Ko, H., Sung, J., Lee, K., Shin, J., Shin, S. (2018). Educational disparities in risk for metabolic syndrome. *Metabolic Syndrome and Related Disorders*, 16(8): 416-424.

Martínez-González, M. A., García-López, M., Bes-Rastrollo, M., Toledo, E., Martínez-Lapiscina, E. H., Delgado-Rodriguez, M., Vazquez, Z., Benito, S., Beunza, J. J. (2011). Mediterranean diet and the incidence of cardiovascular disease: A Spanish cohort. Nutrition, metabolism, and cardiovascular diseases: *Nutrition Metabolism and Cardiovascular Diseases*, 21(4): 237-244.

Martínez-González, M. A., García-Arellano, A., Toledo, E., Salas-Salvadó, J., Buil-Cosiales, P., Corella, D., Covas, M. I., Schröder, H., Arós, F., Gómez-Gracia, E., Fiol, M., Ruiz-Gutiérrez, V., Lapetra, J., Lamuela-Raventos, R. M., Serra-Majem, L., Pintó, X., Muñoz, M. A., Wärnberg, J., Ros, E., Estruch, R., PREDIMED Study Investigators. (2012). A 14-item Mediterranean diet assessment tool and obesity indexes among high-risk subjects: The PREDIMED trial. *PloS One*, 7(8): e43134.

Meyers, L. D., Hellwig, J. P. Otten, J. J. (2006). Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. The National Academies Press, Washington DC, USA, 19 p.

Montemayor, S., Mascaró, C. M., Ugarriza, L., Casares, M., Llompart, I., Abete, I., Zulet, M. Á., Martínez, J. A., Tur, J. A., Bouzas, C. (2022).

Adherence to Mediterranean Diet and NAFLD in patients with metabolic syndrome: The FLIPAN study. *Nutrients*, 14(15): 3186.

Oğuz A. (2018). The Prospective urban rural epidemiology (PURE) study: PURE Turkiye. *Turk Kardiyoloji Derneği Arşivi*, 46(7): 613-623.

Papamichou, D., Panagiotakos, D. B., Itsiopoulos, C. (2019). Dietary patterns and management of type 2 diabetes: A systematic review of randomised clinical trials. *Nutrition, Metabolism and Cardiovascular Diseases*, 29(6): 531-543.

Pehlivanoğlu, E. F. O., Balcıoğlu, H., Unluoğlu, I. (2020). Akdeniz Diyeti Bağlılık Ölçeği'nin Türkçe'ye Uyarlanması Geçerlilik ve Güvenilirliği. *Osmangazi Tıp Dergisi*, 42(2): 160-164.

Pekcan, G. (2013). Beslenme Durumunun Saptanması. In: *Diyet El Kitabı*, Baysal, A.; Aksoy, M., Besler, H. T., Bozkurt, N., Keçecioğlu, S., Mercanlıgil, S. M., Kutluay Merdol, T., Pekcan, G., Yıldız, E. (editors). Hatiboglu Yayinlari, Ankara, Türkiye, pp. 67-142.

Pérez-Martínez, P., Mikhailidis, D. P., Athyros, V. G., Bullo, M., Couture, P., Covas, M. I., de Koning, L., Delgado-Lista, J., Díaz-López, A., Drevon, C. A., Estruch, R., Esposito, K., Fitó, M., Garaulet, M., Giugliano, D., García-Ríos, A., Katsiki, N., Kolovou, G., Lamarche, B., Maiorino, M. I., Mena-Sánchez, G., Muñoz-Garach, A., Nikolic, D., Ordovás, J. M., Pérez-Jiménez, F., Rizzo, M., Salas-Salvadó, J., Schröder, H., Tinahones, F. J., de la Torre, R., van Ommen, B., Wopereis, S., Ros, E., López-Miranda, J. (2017). Lifestyle recommendations for the prevention and management of metabolic syndrome: An international panel recommendation. *Nutrition Reviews*, 75(5): 307-326.

Rakicioglu N, Acar Tek N, Ayaz A, Pekcan G. (2009). *Yemek ve besin fotoğraf kataloğu: Ölçü ve miktarlar.* Ata Ofset, Ankara, Türkiye.

Rees, K., Takeda, A., Martin, N., Ellis, L., Wijesekara, D., Vepa, A., Das, A., Hartley, L., Stranges, S. (2019). Mediterranean-style diet for the primary and secondary prevention of cardiovascular disease. *Cochrane Database of Systematic Reviews*, 3(3): CD009825.

Saglam, M., Arikan, H., Savci, S., Inal-Ince, D., Bosnak-Guclu, M., Karabulut, E., Tokgozoglu, L. (2010). International physical activity questionnaire: Reliability and validity of the Turkish version. *Perceptual and Motor Skills*, 111(1): 278-284.

Santa, K., Kumazawa, Y., Nagaoka, I. (2023). Prevention of metabolic syndrome by phytochemicals and vitamin D. *International Journal of Molecular Sciences*, 24(3): 2627.

Shatwan, I. M, Alhinai, E. A., Alawadhi, B., Surendran, S., Aljefree, N. M., Almoraie, N. M. (2021). High adherence to the Mediterranean diet is associated with a reduced risk of obesity among adults in gulf countries. *Nutrients*, 13(3): 995.

Soltani, S., Jayedi, A., Shab-Bidar, S., Becerra-Tomás, N., Salas-Salvadó, J. (2019). Adherence to the Mediterranean diet in relation to all-cause mortality: A systematic review and dose-response meta-analysis of prospective cohort studies. *Advances in Nutrition*, 10(6): 1029-1039.

Tettamanzi, F., Bagnardi, V., Louca, P., Nogal, A., Monti, G. S., Mambrini, S. P., Lucchetti, E., Maestrini, S., Mazza, S., Rodriguez-Mateos, A., Scacchi, M., Valdes, A. M., Invitti, C., Menni, C. (2021). A high protein diet is more effective in improving insulin resistance and glycemic variability compared to a Mediterranean Diet-a cross-over controlled inpatient dietary study. *Nutrients*, 13(12): 4380.

Tsofliou, F., Vlachos, D., Hughes, C., Appleton, K. M. (2022). Barriers and facilitators associated with the adoption of and adherence to a Mediterranean style diet in adults: A systematic review of published observational and qualitative studies. *Nutrients*, 14(20): 4314.

TUBER (2016). Türkiye Beslenme Rehberi 2015 (TUBER). T. C. Sağlık Bakanlığı Yayin No: 1031, Ankara, Türkiye.

WHO (2011). Waist circumference and waist-hip ratio report of a WHO expert consultation. https://www.who.int/publications/i/item/9789241501491 [accessed 2 February 2023].

WHO (2022). Noncommunicable diseases. https://www.who.int/news-room/factsheets/detail/noncommunicable-diseases [accessed 2 February 2023].

WHO (2021). BMI classification. https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi/ [accessed 21 February 2021].

Zhang, X., Guo, Y., Yao, N., Wang, L., Sun, M., Xu, X., Yang, H., Sun, Y., Li, B. (2022). Association between dietary inflammatory index and metabolic syndrome: Analysis of the NHANES 2005-2016. *Frontiers in Nutrition*, 9: 991907.