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Original article

Relationship between Metabolic Syndrome and Mediterranean Diet in Adolescents: A Cross-Sectional Study

Feray Çağıran Yılmaz
Lecturer in Fırat University, Faculty of Health Sciences, Department of Nutrition, and Dietetics, Elazığ, Turkey

Abstract. *Objectives:* The objective of the present study is to investigate the relationship between Metabolic Syndrome (MetS) and Mediterranean Diet in adolescents. *Methods:* This cross sectional study included 367 adolescents who visited Primary Health Service Centers in 7 cities in Turkey. Participants' biochemical parameters, anthropometric measurements and blood pressures were measured. The level of adherence to Mediterranean Diet was evaluated by a clinical questionnaire, the Mediterranean Diet Quality Index for children and adolescents (KIDMED). *Results:* A poor adherence to Mediterranean diet was seen in 31,9% of subjects, while 68,1% had a medium-high compliance. In total, 51,2% adolescents with MetS had poor adherence to a Mediterranean diet. Although the data were not statistically significant, most of the participants with metabolic syndrome physically inactive and skipped meals. In this study the prevalence of MetS was 21,8%. IFG, hypertension and abdominal obesity were more frequent in girls compared to boys ($p<0,001$). A poor adherence to Mediterranean diet group showed the highest level of triglycerides level when compared with those with medium-high adherence to a Mediterranean diet. *Conclusions:* A poor adherence to Mediterranean diet is associated with MetS. Results support the need to engage adolescents in regular physical activity and adherence to the Mediterranean diet.

Keywords: Mediterranean diet, Metabolic syndrome, Adolescents, KIDMED

Introduction

The childhood obesity epidemic is widespread, with the World Health Organization (WHO) reporting that in 2013 more than 42 million children were overweight and obese around the world (1). The prevalence of childhood and adolescent obesity has steadily increased in Turkey, too. According to Turkey Nutrition and Health Survey data, 8.2% of 6-18 year old children and adolescents are obese, and 14.3% are overweight (2).

Increasing prevalence of childhood obesity, the prevalence of metabolic syndrome is rising too and leading to fears for future epidemics of abnormal lipid profile, hypertension, insulin resistance, type 2 diabetes and cardiovascular disease in the young (3,4).

The metabolic syndrome, defined as a constellation of metabolic abnormalities and composed of 5 diagnostic characteristics: waist circumference, triglycerides, blood glucose, HDL cholesterol (HDL-C) and blood pressure. It is diagnosed when abnormalities are seen in a critical number of these characteristics (4,5).

A study reported that 90% of obese adolescents present with at least one MetS component (6).

The Mediterranean diet is perhaps one of the healthiest dietary models to prevent childhood obesity. A Mediterranean diet is often characterized by a high consumption of fruits, vegetables, legumes, nuts, cereals, a moderately high intake of fish, dairy products, wine and olive oil, a low intake of saturated lipids and sweets (7,8,9). Mediterranean diet has a positive effect against myocardial infarct, certain tumours, diabetes and other pathologies associated with oxidative stress (8). Mediterranean-style diet also reduces metabolic syndrome components in obese children and adolescents with obesity (10).

This study aimed to evaluate the relationship between MetS and Mediterranean Diet in adolescents.

Methods

Study design and data collection

Data were collected from 367 adolescents aged between 10 and 18 who visited the Primary Health Service Centers in 7 cities in Turkey from February 2019 to April 2019. Informed consent was obtained from the adolescents and their parents. Anthropometric measurements were taken by the researcher. Fasting blood samples were collected between 8:30 am and 11:30 am, blood pressures were measured by an experienced nurse, and KIDMED scale was administered. Adolescents who had any chronic illness, refused to give blood, or were not in the 10-18 age range were excluded from the study. As a measure of physical activity in the last 7 days, we used the International Physical Activity Questionnaire-short form. The results were expressed in metabolic-equivalent hours per week. Participants were categorized as highly active (60 min or more on all 7 days), medium active (30–59 min on all 7 days) and low active (<30 min on all 7 days) (11,12). This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Ethics Committee of Fırat University (Ethics approval code 13/13, 2019).

Anthropometric measurements

Anthropometric measurements were collected to assess the nutritional status of the children. Body weight, height, and waist circumference (WC) were taken in the adolescents. Body mass index (BMI) (kg/m^2) was evaluated. All the children stood barefooted against a vertical wall and height was obtained using a stediometer to the nearest 0.1 cm. Body weight of the children with lightweight clothes was measured to the nearest 0.1 kg using a digital balance which was validated before starting the weight measurements. Body weight and height were standardized into age specific percentiles for height-for-age, weight-for-age and BMI-for-age by WHO Anthro Plus 1.0.4 and Epi Info 3.5.1 software (13). BMI values at 85th and higher percentile for the subjects' age were classified as overweight, and BMI values at 95th and higher percentile for their age were classified as obese (13).

Biochemical measurements

All blood samples were collected by an experienced nurse in the morning after 8-12 h fasting. The tubes were shaken gently and centrifuged for 10-15 min (3200 rpm). Then they were sent to the laboratory where the analyses would be done in heat-proof ice molds. Three tubes of blood were drawn from each participant, and whole blood (Sysmex XN-550, Sysmex Corporation, Kobe, Japan), hormone (Cobas 6000 E 601, Roche Diagnostics GmbH, Mannheim, Germany) and biochemistry analyses (Cobas 6000 E 501, Roche Diagnostics GmbH, Mannheim , Germany) were done.

Blood pressure measurement

Adolescents' blood pressures were measured by an experienced nurse working in the Primary Health Service Centers. All measurements were taken by the same nurse to minimize personal errors. Standard mercury sphygmomanometer was used. Lower end of the cuff was approximately 2 cm above the antecubital fossa and the cuff was at least 40% of arm circumference wide (Sorof and Daniels 2002). Three measurements

were taken from each adolescent and blood pressure was determined by taking the average of the last two of these measurements (14,15).

Diet Quality Index (KIDMED Index)

The KIDMED index is a tool to evaluate the adherence to the Mediterranean Diet for children and youths. It was developed and validated by Serra-Majem and Ribas The KIDMED Index consists of 16 questions about food habits, and the assessment is based on the responses to these questions. The test classifies individuals according to the quality of the Mediterranean Diet categorized as high (≥ 8 points), medium (4–7 points), and poor (≤ 3 points) (8).

Definition of the MetS

The MetS was defined as the presence of ≥3 of the following factors: impaired fasting blood glucose (IFG), hypertension, abdominal obesity, hypertriglyceridemia, and low HDL-C. IFG was defined as ≥100 mg/dl (5), and hypertension as systolic (SBP) or diastolic (DBP) blood pressure ≥90th percentile for height, age and sex (16). For subjects aged >17 years, the adult cut-offs for the above variables were used [National Cholesterol Education Program (NCEP) Expert Panel 2002]. Cut-offs for abdominal obesity were defined as WC ≥90th percentile (13). Hypertriglyceridemia was defined as triglycerides (TG) ≥90th percentile and low HDL-C as HDL-C ≤10th percentile for age and sex (5).

Statistical analysis

Statistical analysis was performed using SPSS version 21.0 (Statistical Package for the Social Sciences) software for Windows. The data were expressed as medians with interquartile ranges (IQR). Kolmogrov–Smirnov and Shapiro Wilk tests were used to assess the normality of the data. Categorical variables are presented as frequencies and percentages. Chi-Square test was used to test for differences in proportions. The difference between metabolic syndrome criteria between the subjects with MetS and subjects without MetS groups was determined by Mann-Whitney U test. The difference between some biochemical characteristics values in three Mediterranean Diet categories was determined by Kruskal-Wallis test. For all statistical comparisons, a 5% ($p<0.05$) significance level was used.

Results

Basic descriptive statistics of the study participants are presented in Table 1. Half of the participants with MetS were girls and half were men. In total, 51,2% adolescents with MetS had poor adherence to a Mediterranean diet ($p < 0,001$). Although the data were not statistically significant, most of the participants with metabolic syndrome had low socioeconomic status, physically inactive and skipped meals.

In adolescents, 22,9% of boys and 20,8% of girls were classified as having the MetS. IFG, Low HDL-C, hypertension and abdominal obesity were more frequent in girls compared to boys ($p<0,001$), whereas the opposite occurred for hypertriglyceridaemia (21,7% vs. 19,3%, $p<0,001$) (Table 2).

Comparison between components of the metabolic syndrome criteria in the two groups are presented in table 3. FG, LDL-C, Triglycerides, DBP and SBP levels were higher in subjects with MetS compared to subjects without MetS ($p<0,001$), whereas HDL-C level was higher in subjects without MetS (49,8 mg/dL vs. 40,0 mg/dL $p<0,001$).

A poor adherence to Mediterranean diet was seen in 31,9% of subjects, while 68,1% had a medium-high compliance. A poor adherence to Mediterranean diet group showed the highest level of triglycerides level and lowest level of DBP when compared with those with medium-high adherence to a Mediterranean diet (Table 4).

Discussion

The main purpose of the present study was to determine the associations between the MetS and adherence to a Mediterranean diet, gender,

Table 1. Basic descriptive characteristics of the study participants

Study Variables	Subjects with MetS N (%)	Subjects without MetS N (%)	p*
Sex			
Male	40 (50,0)	135 (47,0)	
Female	40 (50,0)	152 (53,0)	0,639
Mediterranean Diet Quality Index Score			
Poor adherence (≤3 points)	41 (51,2)	76 (26,5)	
Average adherence (4–7 points)	29 (36,3)	112 (39,0)	**<0,001**
Good adherence (≥8–12 points)	10 (12,5)	99 (34,5)	
Socioeconomic status			
Low	32 (40,0)	114 (39,7)	
Middle	30 (37,5)	127 (44,3)	0,338
High	18 (22,5)	46 (16,0)	
Moderate-to-vigorous physical activity			
Low	30 (37,5)	107 (37,3)	
Medium	29 (36,3)	110 (38,3)	0,923
High	21 (26,2)	70 (24,4)	
Meal skipping			
Yes	42 (52,5)	140 (48,8)	
No	38 (47,5)	147 (51,2)	0,556

*Chi-square test MetS:Metabolic Syndrome

Table 2. Prevalence of individual metabolic syndrome risk factors in adolescents

	MetS	Impaired fasting glucose	Hyper-triglyceridaemia	Low HDL-C	Hypertension	Abdominal obesity
Gender group	N (%)					
Total Sample	80 (21,8)	98 (26,7)	75 (20,4)	79(21,5)	39 (10,6)	76 (20,7)
Boys		45 (25,7)	38 (21,7)	39 (22,3)	17 (9,7)	36 (18,8)
Girls		53 (27,6)	37 (19,3)	40 (20,8)	22 (11,5)	40 (22,9)
p value*		<0,001	<0,001	<0,001	<0,001	<0,001

*Chi-square test

Table 3. Comparison between components of the metabolic syndrome criteria in the two groups.

Factors [median (IQR)]	Subjects with MetS	Subjects without MetS	p*
Glucose, mg/dL	103,0 (43.8)	89,0 (13.0)	**<0,001**
HDL-C, mg/dL	40,0 (13,7)	49,8 (12,0)	**<0,001**
LDL-C, mg/dL	98,5 (44.4)	77,4 (28,6)	**<0,001**
Triglycerides, mg/dL	165,0 (49,0)	75,0 (35,0)	**<0,001**
DBP, mmHg	80,0 (16,8)	70,0 (15,0)	**<0,001**
SBP, mmHg	120,0 (20,0)	114,0 (10,0)	**<0,001**

*Mann-Whitney U test

Table 4. Some biochemical characteristics of the adolescents in three Mediterranean Diet categories

Factors [median (IQR)]	Very poor diet (≤ 3 points)	Diet needs improvement (4-7 points)	Optimal Mediterranean diet (≥ 8 points)	p*
Glucose, mg/dL	89,0 (19,5)	92,0 (17,0)	91,0 (14,6)	0,197
HDL-C, mg/dL	47,0 (14,5)	48,4 (13,1)	48,0 (11,3)	0,531
LDL-C, mg/dL	81,0 (34,3)	80,0 (32,9)	79,0 (30,7)	0,453
Triglycerides, mg/dL	105,0 (101,1)	77,0 (58,0)	81,7 (32,3)	**<0,001**
DBP, mmHg	68,0 (16,0)	70,0 (11,0)	75,0 (11,5)	**0,001**
SBP, mmHg	111,0 (10,0)	120,0 (12,0)	119,0 (10,0)	0,065

*Kruskal Wallis test

socioeconomic status, moderate-to-vigorous physical activity, and sedentary behavior among adolescents in Turkey.

In this study the prevalence of MetS was 21,8%, this prevalence is higher than the other studies. In the data set study of National Health and Nutrition Examination Survey (NHANES 1988-1992) (17), the prevalence was 4.2% and it increased to 6.4% in the NHANES study of 1999-2000 (18). The other studies found the prevalence of MetS was <5% (19,20). This high result might be due to 32.7% of the participants were overweight and obese.

In the present study, the prevalence of MetS was similarly among girls and boys. Another studies found higher prevalence in males than females (17,21,22).

A poor adherence to Mediterranean diet was seen in 31,9% of subjects, while 68,1% had a medium-high compliance. The majority of individuals with metabolic syndrome (51,2%) have poor adherence with the Mediterranean Diet. A study conducted in Turkey found that 60.0% of the adolescents had a poor adherence to Mediterranean diet, the diets of 34.7% needed improving, and that 5.3% had optimal diet quality score (23). In addition the adherence to Mediterranean Diet was lower in participants with MetS compared to without MetS (p<0,001). The results of Linardakis et al. were also similar to our findings (24).

No statistically significant relationship was found between MetS and socioeconomic status, physical activity and meal skipping values in this study (p>0.05). But, majority of subjects with MetS were physically inactive (37,5%) and skipping meal (52,5%). An inverse relationship between the MetS and physical activity was found in the other studies (25,26).

In the present study, the prevalence of IFG, low HDL-C, abdominal obesity hypertriglyceridemia, and hypertension was 26,7%, 21,5%, 20,7%, 20,4%, and 10,6%, respectively. Thus, in our subjects IFG was the most common, while high blood pressure was least constituent of MetS. Singh et al indicated that low HDL-C was the most common (10,66%), while high blood pressure was the least common (2,75%) component (22).

This study showed that boys had lower HDL-C and higher hypertriglyceridemia level than girls. Sekokotla et al found similar results in their study (27).

There was a specific abnormality in triglyceride levels in the group of poor adherence with the Mediterranean Diet compared to those with the other groups. Martino et al found serum triglycerides and almost a 7-fold increased prevalence of MetS as compared to those with the optimal adherence with the Mediterranean Diet group (28).

Strengths and limitation

Our investigation has some limits. First, the investigation was cross-sectional and no longitudinal data were obtained. Second, we did not ask the participants about their cigarette and alcohol consumption.

Conclusion

We report that the MetS is modestly prevalent in adolescents in Turkey. As childhood overweight/obesity often continues into adulthood, it is important to address the causes of increased risk for the MetS earlier in life to prevent disease development in adult life. There is an apparent importance of healthier lifestyle habits including physical activity and adherence to the Mediterranean diet also among children and adolescents. We recommend that further research be carried out in this population with a larger sample size with equal numbers of females and males in order to clarify the risk of MetS in Turkey.

Authorship: Feray Çağiran Yilmaz analysed the data, wrote the manuscript, made general checks of the work and adapted it to the format of the journal.

Place of Study: Primary Health Service Centers in 7 cities in Turkey

Centre Ethics Approval: This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Ethics Committee of Fırat University (Ethics approval code 13/13, 2019).

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Correspondence:
Feray Çağıran Yılmaz
Lecturer in Fırat University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Elazığ, Turkey
Email: feraycagiran@hotmail.com