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Association of Mediterranean Diet Adherence With Anthropometric Measures and Lipid Profile in Adolescents With Overweight or Obesity

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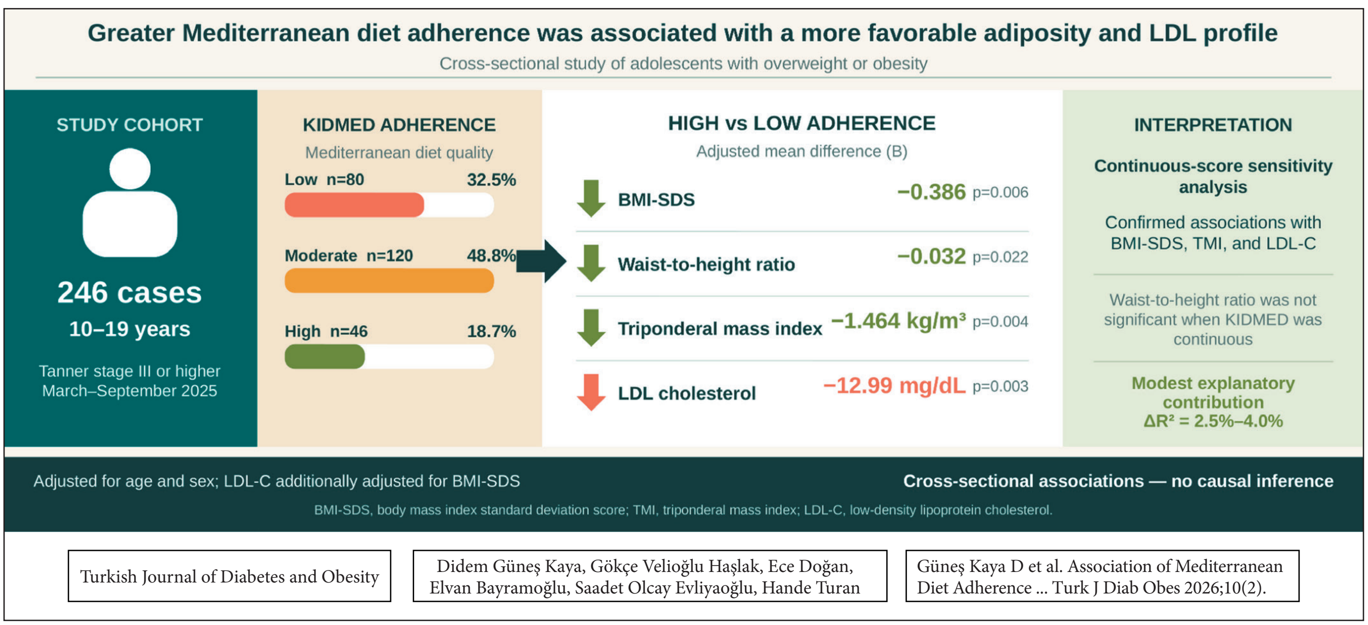
GRAPHICAL ABSTRACT



ABSTRACT

Aim: This study examined the association of Mediterranean diet adherence with anthropometric measures, body composition, and lipid profile in adolescents with overweight or obesity.

Material and Methods: Data from 246 adolescents aged 10–19 years were analyzed in this cross-sectional study. Mediterranean dietary adherence was scored with Mediterranean Diet Quality Index (KIDMED). Anthropometric and body composition measurements were obtained during the study assessme nt, whereas lipid results were extracted from medical records. Comparisons across adherence categories were performed with parametric, nonparametric, or chi-square tests, as appropriate. Hierarchical linear regression was used to estimate independent associations. Age and sex were included in the anthropometric models, and body mass index standard deviation score (BMI-SDS) was added as a covariatein the LDL cholesterol model.

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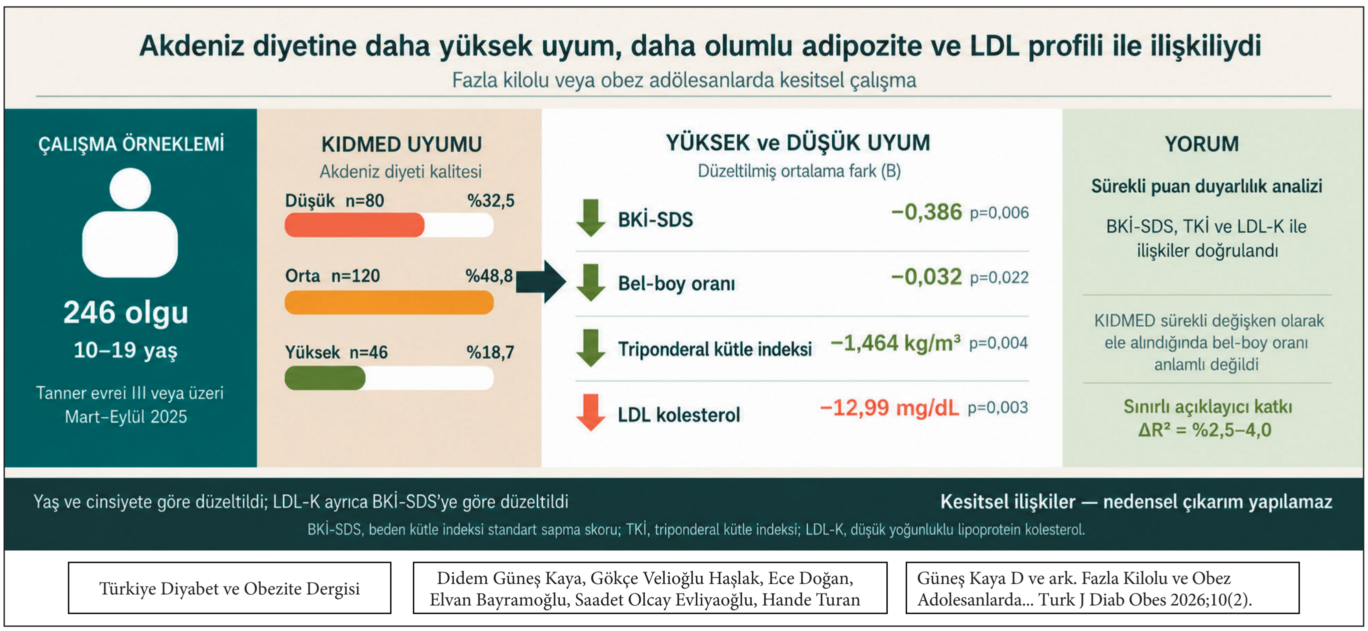
Results: Low, moderate, and high Mediterranean diet adherence accounted for 32.5%, 48.8%, and 18.7% of cases, respectively. BMI-SDS, waist circumference, waist-to-height ratio, triponderal mass index, and LDL cholesterol varied across the three adherence categories. In the regression models, the coefficients for high versus low adherence were −0.386 for BMI-SDS (p=0.006), −0.032 for waist-to-height ratio (p=0.022), −1.464 for triponderal mass index (p=0.004), and −12.986 mg/dL for LDL cholesterol (p=0.003). No between-group differences were detected in body fat percentage, trunk fat percentage, visceral adiposity index, total cholesterol, HDL cholesterol, triglycerides, or dyslipidemia prevalence.

Conclusion: Among adolescents with overweight or obesity, those with high Mediterranean diet adherence had lower values for weight-related anthropometric indices and LDL cholesterol.

Keywords: *Adolescent, Anthropometry, Lipid profile, Mediterranean diet, Obesity, Overweight*

Fazla Kilolu ve Obez Adolesanlarda Akdeniz Diyetine Uyumun Antropometrik Ölçümler ve Lipid Profili ile İlişkisi

GRAFİKSEL ÖZET



ÖZ

Amaç: Bu çalışmada, fazla kilolu veya obez adölesanlarda Akdeniz diyetine uyum ile antropometrik ölçümler, vücut kompozisyonu ve lipid profili arasındaki ilişki incelendi.

Gereç ve Yöntemler: Bu kesitsel çalışmada 10–19 yaşlarındaki 246 adölesana ait veriler analiz edildi. Akdeniz diyetine uyum, Çocuklar ve Adölesanlar için Akdeniz Diyeti Kalite İndeksi (KIDMED) kullanılarak puanlandı. Antropometrik ölçümler ve vücut kompozisyonu verileri çalışma değerlendirmesi sırasında elde edilirken, lipid sonuçları tıbbi kayıtlardan alındı. Uyum grupları, verilerin özelliklerine göre parametrik, parametrik olmayan veya ki-kare testleriyle karşılaştırıldı. Bağımsız ilişkilerin belirlenmesinde hiyerarşik doğrusal regresyon kullanıldı. Antropometrik modellere yaş ve cinsiyet, LDL kolesterol modeline ise ek olarak beden kütle indeksi standart sapma skoru (BKİ-SDS) dahil edildi.

Bulgular: Olguların %32,5'i düşük, %48,8'i orta ve %18,7'si yüksek Akdeniz diyeti uyum grubundaydı. Beden kütle indeksi standart sapma skoru, bel çevresi, bel-boy oranı, triponderal kütle indeksi ve LDL kolesterol düzeyi üç uyum kategorisi arasında farklılık gösterdi. Regresyon analizinde, yüksek uyum düşük uyumla karşılaştırıldığında BKİ-SDS (B=−0,386; p=0,006), bel-boy oranı (B=−0,032; p=0,022), triponderal kütle indeksi (B=−1,464; p=0,004) ve LDL kolesterol düzeyi (B=−12,986 mg/dL; p=0,003) daha düşüktü. Vücut yağ yüzdesi, gövde yağ yüzdesi, visseral adipozite indeksi, total kolesterol, HDL kolesterol, trigliserit ve dislipidemi sıklığı açısından gruplar arasında fark saptanmadı.

Sonuç: Fazla kilolu veya obez adölesanlar arasında Akdeniz diyetine uyumu yüksek olanlarda, ağırlıkla ilişkili antropometrik göstergeler ve LDL kolesterol değerleri daha düşüktü.

Anahtar Sözcükler: *Adölesan, Akdeniz diyeti, Antropometri, Fazla kiloluluk, Lipid profili, Obezite*

INTRODUCTION

During adolescence, food choices and meal routines often change as independence increases. Irregular eating and greater exposure to energy-dense foods can contribute to further weight gain and unfavorable lipid changes. This is clinically relevant in adolescents with overweight or obesity, who are already vulnerable to insulin resistance and dyslipidemia and whose excess weight may persist into adulthood. Diet quality is an important component of cardiometabolic risk assessment in this population (1).

The Mediterranean diet centers on plant foods, particularly vegetables, fruits, whole grains, legumes, nuts, and olive oil, with fish and dairy products consumed in moderate amounts. Red and processed meats, refined carbohydrates, and ultra-processed foods are less prominent. Its fiber, unsaturated fat, antioxidant, and bioactive compound content may influence lipid metabolism, inflammation, and oxidative stress (2). Intervention studies in children and adolescents have reported favorable changes in systolic blood pressure and several lipid measures (3). Observational findings are less consistent, however, and an umbrella review found mixed results for overweight, adiposity, inflammation, and other cardiometabolic outcomes in adolescents (4).

Mediterranean Diet Quality Index (KIDMED) is frequently used to describe how closely the eating habits of children and adolescents follow the Mediterranean dietary pattern. The questionnaire assigns positive or negative scores to specific dietary behaviors and combines them into a single measure of diet quality (5). Its revised form, KIDMED 2.0, has shown acceptable psychometric properties in children and adolescents (6). A Turkish version of the original questionnaire is also available and has been validated for use in adolescents (7).

Body mass index remains the most common measure used to identify overweight and obesity in pediatric practice. It does not separate fat mass from fat-free mass or indicate how body fat is distributed. This limitation is relevant during adolescence, when growth and pubertal maturation alter body composition. Studies examining Mediterranean diet adherence have therefore included body fat percentage alongside BMI and other anthropometric measurements (8). Waist circumference, waist-to-height ratio, and triponderal mass index can provide additional information on central and overall adiposity (9,10).

Abdominal adiposity is an important marker of cardiometabolic risk. The visceral adiposity index was developed as an indirect measure of visceral fat dysfunction and is calculated using waist circumference, body mass index, triglycerides, and high-density lipoprotein cholesterol (11). It has been studied mainly in adults. Evidence on its association with Mediterranean diet adherence in adolescents with overweight or obesity remains limited.

Lipid abnormalities may develop during childhood and adolescence and can reflect early atherosclerotic risk. Assessment of total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, non-high-density lipoprotein cholesterol, and triglycerides is recommended as part of cardiovascular risk evaluation in the pediatric age group (12). Mediterranean diet-based interventions have shown favorable effects on several lipid parameters in children and adolescents (3). In pediatric patients with primary dyslipidemia, greater Mediterranean diet adherence assessed using the updated KIDMED score has also been associated with lower low-density lipoprotein and non-high-density lipoprotein cholesterol concentrations (13).

Most studies of Mediterranean diet adherence in adolescents have focused on a limited set of outcomes, such as body mass index, waist circumference, physical activity, or individual lipid measures. Anthropometric indices, body composition, visceral adiposity, and lipid profile have rarely been evaluated together in adolescents with overweight or obesity. We examined these outcomes within the same sample to determine their associations with KIDMED adherence.

MATERIALS and METHODS

Study Design and Cases

This single-center, cross-sectional study included adolescents aged 10-19 years with overweight or obesity. Cases were recruited from the Department of Pediatrics, Istanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, between March 2025 and September 2025.

The required sample size was estimated before the study for a one-way analysis of variance involving three independent KIDMED adherence categories. With Cohen's f set at 0.25, the significance level at 0.05, and statistical power at 80%, the calculation indicated that at least 159 cases were needed. The analytic sample ultimately comprised 246 adolescents.

Cases were eligible if they were aged 10-19 years, were classified as having overweight or obesity according to age- and sex-specific BMI-SDS, and had pubertal development at Tanner stage III or higher as documented in their medical records. Restriction to Tanner stage III or higher was used to reduce heterogeneity related to pubertal development. Adolescents with type 1 or type 2 diabetes mellitus, thyroid disease, chronic kidney or liver disease, chronic inflammatory disease, or another endocrine or systemic disorder that could affect body weight, body composition, or lipid metabolism were excluded. Cases receiving regular medication and those with an acute infection at the time of assessment were also excluded.

Written informed consent was obtained from adolescents aged 18 years or older. For adolescents younger than 18 years, written informed consent was obtained from a parent or legal guardian, and assent was obtained from the adolescents when appropriate. The study protocol was approved by the Clinical Research Ethics Committee of Istanbul University-Cerrahpaşa (approval date: February 4, 2025; approval no: E-83045809-804.01-1225960). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Assessment of Mediterranean Diet Adherence

Mediterranean diet adherence was evaluated with the validated Turkish version of KIDMED (7). The instrument contains 16 items covering dietary practices that either align with or diverge from the Mediterranean pattern. Each favorable practice contributes +1 point, whereas each unfavorable practice contributes −1 point, yielding a possible total between −4 and 12. Higher totals indicate closer adherence. For the present analyses, scores of ≤3 were categorized as low adherence, scores of 4-7 as moderate adherence, and scores of ≥8 as high adherence.

Anthropometric Measurements and Body Composition

Anthropometric and body composition assessments took place on the same day as KIDMED administration. Standardized measurement procedures were followed. Weight was obtained while cases wore light clothing without shoes. For height measurement, cases stood barefoot and upright against a stadiometer. BMI was derived by dividing weight in kilograms by the square of height in meters.

BMI-SDS values were derived from age- and sex-specific Turkish pediatric reference data (14). As the reference curves end at 18 years, an age of 18.0 years was used for the three older cases to avoid extrapolation beyond the available range. These cases represented 1.2% of the sample. Overweight was defined as a BMI-SDS from ≥+1 to <+2, and obesity as a BMI-SDS of ≥+2. Waist circumference was measured midway between the lowest rib and the iliac crest with a non-elastic tape while the case was standing. The measurement was taken at the end of a normal expiration. Waist-to-height ratio was calculated by dividing waist circumference by height, with both values expressed in centimeters.

Triponderal mass index was derived from body weight in kilograms divided by height in meters raised to the third power. Together with BMI-SDS, waist circumference, and waist-to-height ratio, it was used to provide complementary information on overall and central adiposity (9,10).

Body Composition Assessment

Body composition was measured with a Tanita BC-480MA bioelectrical impedance analyzer (Tanita Corporation, Tokyo, Japan). Assessments were scheduled in the morning following an overnight fast. Adolescents were asked to refrain from strenuous physical activity for the preceding 24 hours. Shoes, socks, and metal accessories were removed before measurement, and light clothing was worn. Total body fat and trunk fat percentages were retained as continuous variables in the analyses.

Visceral Adiposity Index

VAI was computed with the sex-specific equations proposed by Amato et al. (11), which incorporate waist circumference, BMI, triglycerides, and HDL cholesterol. Triglyceride and HDL cholesterol results were taken from fasting laboratory records. Only measurements obtained within one month of the anthropometric and body composition assessment were eligible. If several results met this criterion, the one closest to the assessment date was selected. Before VAI calculation, triglyceride and HDL cholesterol concentrations reported in mg/dL were converted to mmol/L using factors of 0.01129 and 0.02586, respectively.

For females, VAI was calculated as follows:
VAI = [waist circumference / (36.58 + 1.89 × BMI)] × [triglycerides / 0.81] × [1.52 / HDL-cholesterol]

For males, VAI was calculated as follows:
VAI = [waist circumference / (39.68 + 1.88 × BMI)] × [triglycerides / 1.03] × [1.31 / HDL-cholesterol]

In both formulas, waist circumference was expressed in centimeters, BMI in kg/m^2, and triglycerides and HDL-cholesterol in mmol/L.

Biochemical Measurements

Fasting total cholesterol, LDL cholesterol, HDL cholesterol, and triglyceride results were extracted retrospectively from the medical records. To be included, the test had to be performed in the institutional biochemistry laboratory as part of routine care and no more than one month before or after the anthropometric and body composition assessment. When multiple eligible measurements were present, the result nearest to the assessment date was chosen.

Lipid values were examined both continuously and by clinical category. Classification was based on the pediatric cutoffs recommended in the National Heart, Lung, and Blood Institute/American Academy of Pediatrics Expert Panel guidelines (12). Dyslipidemia was recorded when at least one of the following criteria was met: total cholesterol ≥200 mg/dL, LDL cholesterol ≥130 mg/dL, HDL cholesterol <40 mg/dL, or triglycerides ≥130 mg/dL.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 28 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro-Wilk test. Normally distributed variables are presented as mean ± standard deviation, non-normally distributed variables as median with the 25th and 75th percentiles, and categorical variables as number and percentage.

Cases were compared across low, moderate, and high KIDMED adherence categories. Normally distributed continuous variables were analyzed using one-way analysis of variance. Homogeneity of variances was assessed with Levene's test, and Welch's analysis of variance was used when this assumption was not met. Non-normally distributed continuous variables were compared using the Kruskal-Wallis test. When an overall difference was significant, pairwise comparisons were performed using Tukey's honestly significant difference test, Games-Howell test, or Bonferroni-adjusted pairwise comparisons following the Kruskal-Wallis test, as appropriate. Categorical variables, including sex, body mass index category, and dyslipidemia status, were compared using Pearson's chi-square test.

Hierarchical linear regression analyses were conducted to examine the associations of KIDMED adherence categories with BMI-SDS, waist-to-height ratio, triponderal mass index, and low-density lipoprotein cholesterol. These outcomes were selected to represent complementary anthropometric and lipid domains among the continuous variables that differed across KIDMED adherence categories. BMI-SDS represented age- and sex-standardized overall adiposity, waist-to-height ratio represented central adiposity relative to stature, triponderal mass index provided an alternative height-adjusted measure of adiposity, and LDL cholesterol represented the principal atherogenic lipid outcome. Waist circumference was not modeled separately because waist-to-height ratio was selected as the more size-adjusted measure of central adiposity across the broad age range, thereby avoiding a largely redundant additional model. Low KIDMED adherence was used as the reference category. All regression analyses were specified as hierarchical multivariable models; no initial univariable screening or univariable-to-multivariable variable selection procedure was performed. For BMI-SDS, waist-to-height ratio, and triponderal mass index, age and sex were entered in the first block, followed by moderate and high KIDMED adherence categories in the second block. For low-density lipoprotein cholesterol, age, sex, and BMI-SDS were entered in the first block, and KIDMED adherence categories were added in the second block. Pubertal stage was not additionally entered as a covariate because eligibility had been restricted to cases at Tanner stage III or higher. Results are presented as unstandardized regression coefficients with 95% confidence intervals. The additional variance explained by KIDMED adherence categories was assessed using the change in R^2 and the corresponding F-change test. As a sensitivity analysis, the total KIDMED score was entered as a continuous variable in the second block of otherwise identical models to assess whether the findings were robust to the categorization of adherence.

Regression assumptions were evaluated by examining residual diagnostics and collinearity statistics. Multicollinearity was assessed using tolerance and variance inflation factor values. Analyses were based on available data. Lipid variables, visceral adiposity index, and dyslipidemia status were available for 241 cases. All tests were two-sided, and $p<0.05$ was considered statistically significant.

RESULTS

The study included 246 adolescents with overweight or obesity. The median age was 14.14 years (25th-75th percentile, 11.75-16.45), and 152 cases (61.8%) were female. Eighty-eight cases (35.8%) were in the overweight category and 158 (64.2%) were in the obesity category. Mediterranean diet adherence was classified as low in 80 cases (32.5%), moderate in 120 (48.8%), and high in 46 (18.7%).

Case characteristics according to KIDMED adherence category are presented in Table 1. Age and sex distributions did not differ among the low-, moderate-, and high-adherence groups (p=0.631 and p=0.625, respectively). The distribution of BMI categories differed significantly among the groups (p=0.002). In the high-adherence group, 58.7% of cases were in the overweight category and 41.3% were in the obesity category. In contrast, obesity accounted for 70.0% of the low-adherence group and 69.2% of the moderate-adherence group.

BMI-SDS differed among the adherence groups (p=0.006), with lower values in the high-adherence group than in both the low- and moderate-adherence groups. Waist circumference also differed overall (p=0.048). The only significant pairwise difference was between the moderate- and high-adherence groups; mean waist circumference was lower in the high-adherence group (86.27±13.87 vs 92.85±16.42 cm, p=0.044). Waist-to-height ratio and triponderal mass index were also lower in the high-adherence group than in both the low- and moderate-adherence groups (p=0.012 and p=0.007, respectively). Body fat percentage, trunk fat percentage, and visceral adiposity index did not differ among the groups.

LDL cholesterol differed significantly according to KIDMED adherence category (p=0.005). Mean LDL cholesterol was lower in the high-adherence group than in the low-adherence group (86.61±23.01 vs 100.34±22.77 mg/dL). The moderate-adherence group did not differ significantly from either group. No differences were found in total cholesterol, HDL cholesterol, or triglyceride concentrations. Dyslipidemia was present in 46.9% of cases, and its prevalence did not differ across KIDMED adherence groups (p=0.443).

Adjusted regression results are shown in Table 2. No evidence of multicollinearity was observed in the final regression models; tolerance values ranged from 0.748 to 0.958,

Table 1. Case characteristics according to KIDMED adherence category.

Variable	Total (n=246)	Low adherence (n=80)	Moderate adherence (n=120)	High adherence (n=46)	p value
Age, years	14.14 (11.75–16.45)	14.39 (11.70–16.47)	14.08 (11.99–16.54)	12.82 (11.11–16.27)	0.631[3]
Female sex, n (%)	152 (61.8)	46 (57.5)	77 (64.2)	29 (63.0)	0.625[4]
BMI category, n (%)					**0.002**[4]
Overweight	88 (35.8)	24 (30.0)	37 (30.8)	27 (58.7)	
Obesity	158 (64.2)	56 (70.0)	83 (69.2)	19 (41.3)	
BMI-SDS	2.36 ± 0.78	2.41 ± 0.77[a]	2.45 ± 0.79[a]	2.03 ± 0.66[b]	**0.006**[1]
Waist circumference, cm	91.45 ± 15.90	92.35 ± 15.78[ab]	92.85 ± 16.42[a]	86.27 ± 13.87[b]	**0.048**[1]
Waist-to-height ratio	0.570 (0.516–0.618)	0.574 (0.523–0.624)[a]	0.575 (0.525–0.624)[a]	0.532 (0.509–0.582)[b]	**0.012**[3]
Triponderal mass index, kg/m^3	18.15 (16.68–20.55)	18.85 (16.65–20.64)[a]	18.28 (17.03–20.75)[a]	16.99 (15.91–18.53)[b]	**0.007**[3]
Body fat, %	36.99 ± 6.81	37.39 ± 7.50	37.21 ± 6.79	35.72 ± 5.43	0.370[1]
Trunk fat, %	33.43 ± 7.42	33.98 ± 8.38	33.52 ± 7.32	32.26 ± 5.71	0.345[2]
Visceral adiposity index	1.37 (0.89–2.29)	1.36 (0.92–2.27)	1.33 (0.86–2.35)	1.38 (0.83–2.09)	0.840[3]
Total cholesterol, mg/dL	156.95 ± 27.00	158.44 ± 28.47	156.06 ± 25.26	156.70 ± 29.17	0.833[1]
LDL cholesterol, mg/dL	94.86 ± 23.11	100.34 ± 22.77[a]	94.44 ± 22.54[ab]	86.61 ± 23.01[b]	**0.005**[1]
HDL cholesterol, mg/dL	49.00 (41.00–58.25)	50.00 (41.45–56.00)	46.70 (39.00–59.20)	50.50 (43.65–61.00)	0.125[3]
Triglycerides, mg/dL	97.70 (75.65–135.00)	97.00 (78.75–132.85)	95.00 (74.00–135.00)	109.00 (84.75–136.83)	0.619[3]
Dyslipidemia, n (%)	113 (46.9)	39 (50.0)	50 (42.7)	24 (52.2)	0.443[4]

Note: Data are presented as mean ± standard deviation, median (25th–75th percentile), or n (%), as appropriate. [1] One-way analysis of variance; [2] Welch's analysis of variance; [3] Kruskal–Wallis test; [4] Pearson's chi-square test. Significant overall differences were followed by the appropriate post-hoc pairwise comparisons. Values in the same row with different superscript letters indicate a statistically significant pairwise difference; values sharing a superscript letter did not differ significantly. Lipid variables, visceral adiposity index, and dyslipidemia status were available for 241 cases: low adherence, n=78; moderate adherence, n=117; and high adherence, n=46.

BMI-SDS, body mass index standard deviation score; **HDL,** high-density lipoprotein; **KIDMED,** Mediterranean Diet Quality Index for Children and Adolescents; **LDL,** low-density lipoprotein.

Table 2. Adjusted associations between KIDMED adherence categories and anthropometric and lipid outcomes.

Outcome	Moderate adherence vs low, B (95% CI)	p value	High adherence vs low, B (95% CI)	p value	Final model R^2	ΔR^2	p for ΔR^2
BMI-SDS	0.019 (−0.193 to 0.232)	0.858	−0.386 (−0.659 to −0.114)	**0.006**	0.094	0.040	**0.005**
Waist-to-height ratio	<0.001 (−0.021 to 0.021)	0.998	−0.032 (−0.059 to −0.005)	**0.022**	0.127	0.025	**0.034**
Triponderal mass index, kg/m^3	−0.087 (−0.869 to 0.695)	0.828	−1.464 (−2.467 to −0.461)	**0.004**	0.084	0.038	**0.008**
LDL cholesterol, mg/dL	−5.958 (−12.539 to 0.624)	0.076	−12.986 (−21.495 to −4.476)	**0.003**	0.048	0.037	**0.011**

Note: Low KIDMED adherence was the reference category. Models for BMI-SDS, waist-to-height ratio, and triponderal mass index were adjusted for age and sex. The LDL cholesterol model was adjusted for age, sex, and BMI-SDS. B values are unstandardized regression coefficients. Final model R^2 represents the proportion of variance explained after the addition of KIDMED adherence categories. ΔR^2 represents the additional variance explained by KIDMED adherence categories, and the corresponding p value is based on the F-change test. The models for BMI-SDS, waist-to-height ratio, and triponderal mass index included 246 cases; the LDL cholesterol model included 241 cases.

BMI-SDS, body mass index standard deviation score; **CI,** confidence interval; **KIDMED,** Mediterranean Diet Quality Index for Children and Adolescents; **LDL,** low-density lipoprotein.

and variance inflation factor values ranged from 1.044 to 1.337. After adjustment for age and sex, high KIDMED adherence was associated with lower BMI-SDS compared with low adherence (B=−0.386, 95% CI −0.659 to −0.114, p=0.006). Adding KIDMED adherence categories to the model explained a further 4.0% of the variance in BMI-SDS (ΔR^2=0.040, p=0.005). Moderate adherence was not associated with BMI-SDS.

High adherence was also associated with a lower waist-to-height ratio (B=−0.032, 95% CI −0.059 to −0.005, p=0.022) and a lower triponderal mass index (B=−1.464, 95% CI −2.467 to −0.461, p=0.004). KIDMED adherence categories accounted for an additional 2.5% of the variance in waist-to-height ratio (ΔR^2=0.025, p=0.034) and 3.8% of the variance in triponderal mass index (ΔR^2=0.038, p=0.008). Moderate adherence was not associated with either outcome.

In the LDL cholesterol model, adjusted for age, sex, and BMI-SDS, high adherence was associated with a 12.99 mg/dL lower LDL cholesterol concentration than low adherence (B=−12.986, 95% CI −21.495 to −4.476, p=0.003). The addition of KIDMED adherence categories increased the explained variance by 3.7% (ΔR^2=0.037, p=0.011). The association between moderate adherence and LDL cholesterol did not reach statistical significance (B=−5.958, 95% CI −12.539 to 0.624, p=0.076).

In sensitivity analyses treating the total KIDMED score as a continuous variable, each one-point increase in KIDMED score was associated with lower BMI-SDS (B=−0.040, 95% CI −0.077 to −0.003, p=0.033; ΔR^2=0.018), lower triponderal mass index (B=−0.172 kg/m^3, 95% CI −0.307 to −0.038, p=0.012; ΔR^2=0.025), and lower LDL cholesterol (B=−1.736 mg/dL, 95% CI −2.859 to −0.614, p=0.003; ΔR^2=0.037). The association with waist-to-height ratio was not statistically significant when KIDMED score was modeled continuously (B=−0.003, 95% CI −0.006 to 0.001, p=0.129; ΔR^2=0.009).

Responses to the individual KIDMED items are presented in Figure 1. The most frequently reported behaviors were consuming cereals or bread at breakfast (85.8%), consuming two servings of yogurt and/or 40 g of cheese daily (70.7%), eating legumes more than once per week (67.5%), and consuming milk or dairy products at breakfast (65.4%). Fish consumption at least two to three times per week and vegetable consumption more than once daily were reported by 22.0% and 22.8% of cases, respectively. A second daily serving of fruit was reported by 31.3%. Among negatively scored behaviors, 60.2% reported eating sweets or candy

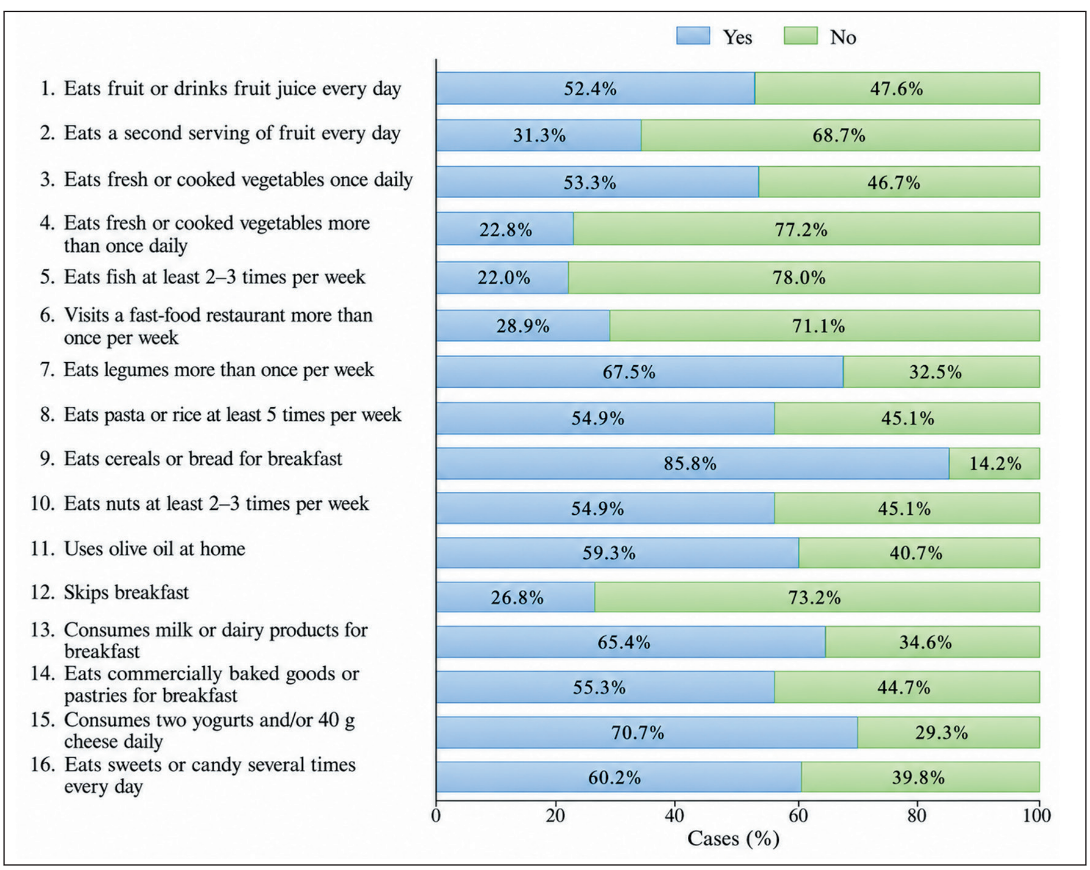


Figure 1: Distribution of “Yes” and “No” responses to individual KIDMED questionnaire items.

several times daily, 55.3% consumed commercially prepared pastries at breakfast, 54.9% consumed pasta or rice at least five times per week, 28.9% visited a fast-food restaurant more than once per week, and 26.8% skipped breakfast.

DISCUSSION

In this study, high Mediterranean diet adherence was associated with lower BMI-SDS, waist-to-height ratio, triponderal mass index, and LDL cholesterol compared with low adherence. The associations with the anthropometric outcomes remained statistically significant after adjustment for age and sex. For LDL cholesterol, the association also persisted when BMI-SDS was included in the adjusted model. Sensitivity analyses using the total KIDMED score as a continuous variable produced similar inverse associations with BMI-SDS, triponderal mass index, and LDL cholesterol. The result for waist-to-height ratio was different. It was no longer statistically significant when KIDMED was modeled continuously, suggesting that this association depended partly on how adherence was represented in the analysis and should be interpreted cautiously. Moderate adherence was not associated with these outcomes relative to low adherence. We also observed no significant differences in body fat percentage, trunk fat percentage, visceral adiposity index, total cholesterol, HDL cholesterol, triglycerides, or dyslipidemia prevalence. Overall, the more favorable anthropometric and LDL cholesterol profiles were mainly observed among adolescents with high adherence.

High adherence accounted for 18.7% of the sample, whereas roughly one case in three was classified as having low adherence. Studies from Türkiye also report that most adolescents fall within the low- or moderate-adherence categories, although the proportions differ according to age, sex, and study setting (7,15,16). In our sample, obesity was less common and overweight was more common among cases with high adherence. The lower mean BMI-SDS in this group was consistent with that distribution. Both the categorical and continuous findings point to the same difference in weight status.

The lower BMI-SDS and waist-to-height ratio associated with high adherence in our sample are similar to findings reported in earlier studies. Better Mediterranean diet quality has been related to lower BMI-SDS among European schoolchildren, and intervention studies have reported reductions in waist circumference and waist-to-height ratio after adherence improved (17,18). Results across the literature are not entirely consistent. A systematic review found an overall relationship between greater Mediterranean diet adherence and more favorable adiposity outcomes in children and adolescents, but the findings varied among the included studies (19).

This inconsistency is also evident in large observational studies. In the AdolesHealth Study, overall KIDMED adherence was not associated with overweight, excessive waist circumference, or excess body fat, despite associations between individual KIDMED behaviors and these outcomes (8). Similarly, a multicountry European study found associations between empirically derived healthy dietary patterns and adiposity-related measures but not with the KIDMED index itself (20). The available evidence therefore remains heterogeneous, as also noted in a recent umbrella review (4). Differences in weight-status distribution, geographic setting, physical activity, pubertal stage, and covariate adjustment may partly explain these discrepancies. The restriction of the present sample to adolescents with overweight or obesity may also have made differences within the upper range of adiposity more apparent.

Triponderal mass index was also lower in the high-adherence group and remained significant after adjustment. TMI has been proposed as a height-adjusted indicator that may reflect adiposity during adolescence more appropriately than BMI in some populations (10). However, its relationship with Mediterranean diet adherence has rarely been studied. The similar direction of the findings for BMI-SDS, waist-to-height ratio, and TMI suggests that the association with high adherence was not dependent on a single anthropometric measure. Waist circumference differed across adherence groups in the unadjusted analysis, but the pairwise difference was limited to the moderate- and high-adherence groups. Because absolute waist circumference varies with height and overall body size, waist-to-height ratio was selected as the more comparable indicator of central adiposity across the 10-19-year age range and was therefore included in the adjusted regression analysis instead of waist circumference.

In contrast, body fat percentage and trunk fat percentage did not differ across adherence categories. Previous studies have also reported weak or inconsistent associations between KIDMED and body fat measures (8,20). This may partly reflect the limited variation in body fat among cases who all had overweight or obesity. In addition, bioelectrical impedance provides an indirect estimate of body composition and may be less sensitive than imaging-based methods for detecting relatively small differences in regional adiposity.

Visceral adiposity index was likewise similar across KIDMED groups. VAI incorporates BMI, waist circumference, triglycerides, and HDL cholesterol and was originally developed as an indirect marker of visceral adipose dysfunction in adults (11). Although the formula was derived in adults, subsequent pediatric studies have reported associations of VAI with metabolic syndrome and metabolically unhealthy phenotypes in children and adolescents with obesity, supporting its exploratory use as a composite cardiometabolic indicator in this population (21,22). The absence of group differences in triglycerides and HDL cholesterol may partly explain the null VAI result. Nevertheless, the adult-derived formula has not been sufficiently validated against direct imaging-based measures of visceral adiposity in adolescents, and age- and puberty-specific reference values are not well established. The present finding should therefore be interpreted as a lack of association with this composite index rather than direct evidence that Mediterranean diet adherence is unrelated to visceral fat accumulation.

LDL cholesterol was the main metabolic finding related to KIDMED adherence. After adjustment for age, sex, and BMI-SDS, high adherence was associated with an LDL cholesterol concentration approximately 13 mg/dL lower than that observed with low adherence. The model did not account for pubertal stage, physical activity, familial or genetic susceptibility to dyslipidemia, or recent weight change. This estimate should therefore be viewed as a cross-sectional association, not as evidence that Mediterranean diet adherence directly lowered LDL cholesterol. Several features of the Mediterranean diet could contribute to such an association, including lower saturated fat intake and greater consumption of unsaturated fatty acids, fiber, plant sterols, and minimally processed foods (2). Pediatric intervention studies have also reported favorable changes in LDL cholesterol and other cardiometabolic markers (3). In children with primary dyslipidemia, improved KIDMED adherence following dietary counseling was accompanied by reductions in LDL and non-HDL cholesterol (13). That population differed from the present sample, and prospective studies are needed to examine this relationship further.

No differences were identified in total cholesterol, HDL cholesterol, triglycerides, or overall dyslipidemia prevalence. These lipid fractions are influenced by multiple determinants, including insulin sensitivity, physical activity, recent weight change, genetic factors, and the quantity and distribution of carbohydrate and fat intake. A 24-week training study in adolescent wrestlers reported changes in fasting glucose, insulin, and HOMA-IR without corresponding changes in BMI, total cholesterol, triglycerides, or LDL cholesterol, illustrating that physical activity may influence metabolic outcomes independently of weight-related measures (23). Such influences are not fully captured by the KIDMED score. In addition, the dyslipidemia definition combined abnormalities across several lipid fractions. An association limited mainly to LDL cholesterol may therefore not produce a significant difference in the prevalence of this composite outcome.

The item-level responses provide context for the predominance of moderate adherence. Consumption of cereals or bread at breakfast, dairy products, and legumes was relatively common. However, fish consumption and vegetable consumption more than once daily were reported by fewer than one-quarter of cases. Frequent intake of sweets or candy and commercially prepared breakfast pastries was also common. Thus, favorable traditional dietary practices coexisted with behaviors inconsistent with the Mediterranean pattern. Because KIDMED assigns fixed positive or negative scores to individual items, different dietary combinations may produce the same total score. The index should therefore be interpreted as an overall indicator of Mediterranean diet quality rather than a quantitative measure of nutrient intake (5). These findings also have implications for intervention design. A Turkish school-based 5210 weight-management program reported limited changes in BMI and nutrition-exercise behaviors, suggesting that longer and more intensive multicomponent approaches may be needed to achieve consistent outcomes in adolescents with overweight or obesity (24).

The strengths of this study include the specific focus on adolescents with overweight or obesity and the simultaneous assessment of conventional and newer anthropometric indices, body composition, visceral adiposity index, and fasting lipid parameters. The use of hierarchical regression allowed the contribution of KIDMED adherence to be assessed beyond age and sex, and the LDL cholesterol model was additionally adjusted for BMI-SDS.

Several limitations should be acknowledged. The cross-sectional design does not establish temporality or causality. KIDMED is based on self-reported behaviors and does not quantify energy intake, portion size, or nutrient composition. Physical activity, sedentary behavior, socioeconomic characteristics, familial or genetic susceptibility to dyslipidemia, and recent weight change were not available for inclusion in the adjusted models, leaving the possibility of residual confounding. Although eligibility was restricted to cases at Tanner stage III or higher to reduce heterogeneity related to early pubertal development, residual confounding across the later pubertal stages cannot be excluded because pubertal stage was not included as a covariate in the regression models. The primary models based on KIDMED adherence categories explained only 4.8% to 12.7% of the total variance in the outcomes, while KIDMED adherence categories contributed an additional 2.5% to 4.0%. Thus, although these contributions were statistically significant, their explanatory magnitude was modest, indicating that the outcomes were largely influenced by biological, behavioral, and environmental factors not captured in the present analyses. Body composition was assessed using bioelectrical impedance rather than a reference imaging method. In addition, VAI was calculated using adult-derived equations and was not validated against direct imaging-based measures of visceral adiposity in the present sample. Capping age at 18 years for three cases older than 18 years may have introduced some imprecision into their BMI-SDS estimates. Lipid and VAI data were unavailable for five cases, and the permitted interval of up to one month between the lipid measurements and the study assessment may have introduced some temporal variability. Finally, the single-center clinical sample may limit generalizability.

In conclusion, high Mediterranean diet adherence was associated with lower BMI-SDS, waist-to-height ratio, triponderal mass index, and LDL cholesterol in adolescents with overweight or obesity. However, KIDMED adherence categories explained only a small additional proportion of the variance in these outcomes, and the findings should therefore be interpreted as modest associations. These associations were not observed for moderate adherence and did not extend to body fat percentage, trunk fat percentage, visceral adiposity index, other lipid fractions, or dyslipidemia prevalence. Prospective and intervention studies are needed to determine whether improving Mediterranean diet adherence leads to sustained changes in adiposity and lipid-related risk in this population.

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Author Contributions

Conceptualization, methodology, data curation, interpretation of the results, literature review, visualization, project administration, and writing—original draft: **Didem Güneş Kaya;** formal analysis: **Gökçe Velioğlu Haşlak;** data collection: **Ece Doğan;** supervision: **Hande Turan;** writing—review and editing: **Didem Güneş Kaya, Gökçe Velioğlu Haşlak, Ece Doğan, Elvan Bayramoğlu, Saadet Olcay Evliyaoğlu,** and **Hande Turan.** All authors read and approved the final manuscript.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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Ethical Approval

The study protocol was approved by the Clinical Research Ethics Committee of Istanbul University-Cerrahpaşa (approval date: February 4, 2025; approval no: E-83045809-804.01-1225960). The study was conducted in accordance with the principles of the Declaration of Helsinki.

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