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Dietary Quality and Body Composition on Lipid Profile in Endurance Athletes Aged 13-18 Years in Central Java Province

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Abstract

Diet quality and body composition are critical determinants of lipid metabolism and cardiovascular health in adolescent athletes. However, the relationship between these factors and lipid profiles in this population remains underexplored. This study aimed to examine the association between anthropometric indicators, diet quality, and lipid profile parameters in adolescent athletes. A cross-sectional study was conducted on 72 adolescent athletes. Univariate analysis described participants' characteristics, including anthropometric measures, diet quality using the Alternative Healthy Eating Index (AHEI), blood pressure, lipid profiles, and physical activity levels. Data normality was tested using the Kolmogorov–Smirnov test. Pearson or Spearman correlation tests were applied for bivariate analysis, and logistic regression was used for multivariate analysis. Statistical significance was set at $p < 0.05$. Participants had a mean BMI of 21.9 ± 2.1 kg/m², body fat percentage of 19.3 ± 5.5%, and AHEI score of 51.1 ± 10.6, indicating moderate diet quality. Most lipid parameters were within normal ranges. Bivariate analysis revealed no significant associations between BMI, waist circumference, or AHEI score with lipid parameters. Waist-to-hip ratio was positively associated with HDL ($p = 0.017$). Body fat percentage showed significant associations with total cholesterol ($p = 0.001$), HDL ($p = 0.001$), LDL ($p = 0.007$), and triglycerides ($p = 0.010$). Multivariate analysis confirmed body fat percentage as the strongest predictor of lipid profile alterations. Body fat percentage is a more sensitive indicator of lipid metabolism changes than BMI in adolescent athletes.

INTRODUCTION

Adolescence, which lasts between the ages of 10 and 18, marks a period of accelerated growth and development in the physical, psychological, social, and intellectual dimensions. Rapid physical changes can affect eating habits, create a diet that is not always optimal, and give rise to nutritional problems in adolescents. In Indonesia, one of the groups of adolescents who are vulnerable to experiencing nutritional problems is adolescent athletes (Hapsari, 2019).

Exercise supports healthy bone and muscle development, cognitive function, and emotional well-being, even if it doesn't directly accelerate height. Evidence suggests that targeted exercise may boost growth via hormonal pathways (IGF-1) in short-stature cases. Given Indonesia's high stunting prevalence (20–30%), promoting active lifestyles in adolescents, especially girls, can be a strategic component to combat undernutrition and build healthier future generations (Proia et al., 2021).

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Athletes need to consume nutrients to meet their needs in quantity and quality. Athletes' eating habits that vary in each sport can affect the quality of an athlete's diet. The quality of an athlete's diet impacts preparation, appearance, and post-match recovery. A diet that includes the right amount of macro and micronutrients, accompanied by the right time of consumption, affects performance in training or competition, accelerates the recovery process, and improves the function of the immune system. In endurance sports, athletes require a large Intake of energy and carbohydrates to maintain muscle glycogen reserves and optimize performance, given the high intensity and duration of training (Santos et al., 2016; Janiczak et al., 2022; Isanejad et al., 2023).

The relationship between body composition and sports performance enhances the adjustment of consumption habits and activity levels among athletes to reduce body fat and increase the proportion of muscle mass. Previous studies showed variations in body fat percentage between athletes from different sports. Sports involving high-intensity sprints and agility (e.g., track, soccer) show lower BF%, while sports focused more on power (e.g., baseball, volleyball) show higher BF%. Sprinters had lower BF% (12.3%) than distance swimmers (16.3%) (Dassanayake, 2016; Fields et al., 2018).

Evaluating dietary quality and body composition characteristics in adolescent athletes can be a significant source of information to understand variations in diet, fulfillment of needs, and intake of macro and micronutrients. The lack of dietary quality, which can be recognized through high cholesterol and saturated fat intake, may contribute to an increase in body mass index (BMI) and body fat percentage. The relationship between fat intake and body structure tends to be positive with most fat profile indicators, except for HDL indicators in the adult age group. This lipid profile is a significant risk factor for developing cardiovascular diseases. Suboptimal conditions of lipid profiles are also associated with decreased physical performance and body fitness.

In previous studies, researchers analyzed adolescent athletes' dietary intake of energy, protein, fat, and carbohydrates (Mardiana et al., 2022; Dion et al., 2024; Moussavi Javardi et al., 2020; Zhou et al., 2021; Momma et al., 2021). The results indicated that energy intake met 85% of the recommended dietary allowance (RDA), protein intake reached 124% of the RDA, fat intake 110%, and carbohydrate intake only 76.8%. This pattern suggests that protein and fat intake exceeded the requirements, whereas carbohydrate intake was insufficient to meet the high energy demands of athletes. Such imbalances in macronutrient intake may compromise diet quality, as adequate carbohydrate availability is crucial for glycogen replenishment and sustained performance. In contrast, excessive fat intake can contribute to unfavorable lipid profiles (Logue et al., 2018; Kripp et al., 2024). Previous research has shown that inadequate diet quality in athletes can lead to suboptimal recovery, increased fatigue, and alterations in biomarkers such as total cholesterol, LDL, and triglycerides, which may ultimately impair athletic performance and long-term health (Buga et al., 2022).

However, despite the physiological importance of balanced macronutrient intake, limited studies have explored diet quality specifically among adolescent athletes and its relationship with biomarker indicators, particularly lipid profiles. This knowledge gap underlines the need for the present study to assess dietary patterns and lipid profile outcomes in adolescent athletes to provide evidence-based recommendations for optimizing performance and health.

METHODS

Study designs

This study used a Cross-sectional research design with the purposive sampling technique. The research was conducted at KONI Central Java (Indonesian National Sports Committee) in Semarang. The population used in this study is all athletes in KONI Central Java. The sample in this study is endurance athletes who are in KONI. The research sample was determined based on the following criteria (inclusion): 1) 16 to 18 years old, 2) good nutritional status, 3) willing to be a research subject, and 4) athletes who pursue endurance sports. The exclusion criteria in this study were: 1) athletes who were sick at the time of data collection, and 2) athletes who were in the race period. The minimum sample was 64+ 10% = 70 respondents, and the number of participants was 72 people (Lemeshow).

Data collection techniques and data sources

Data collection is carried out through: First stage was the research licensing process and the management of ethical clearance at FK UNNES are carried out. The Second step, measurement of nutritional status and body composition, the nutritional status in this study was obtained from the weight and height measurements with an anthropometric index of BMI/U (age 16 to 18 years). Body composition is used to look at the body fat percentage of athletes. Weight measurement using a digital scale with an accuracy of 0.1 kg and height using a microtome with an accuracy of 0.1 cm. Body composition is known using BIA (Bioimpedance Analysis).

The third stage, physical activity measurements are carried out for one time using the IPAQ (International Physical Activity Questionnaire) questionnaire. Physical activity categories are based on a composite calculation of activity types (days per week and minutes per day). Physical activity considers work, travel, leisure/leisure, and sitting/lying down factors. Heavy activities have eight times the weight; moderate activities have four times the weight, and light activities have two times the weight. Respondents who are included in the lack of physical activity if they have a total physical activity (related to work, travel, or leisure time) <600 Metabolic Equivalent (MET) in one week.

The fourth step, Diet quality is measured using the AHEI (Alternate Healthy Eating Index). The dietary quality assessment refers to AHEI-2010, which comprises 11 food components. The AHEI used has been modified by the 2014 Indonesian Balanced Nutrition Guidelines (PGS), especially in the portion of food components, which include components of vegetables, fruits, grains, nuts, sweetened drinks, red/processed meat, trans fats, omega 3, PUFAs, alcohol consumption and sodium; omega three components adjusted to the Indonesian Nutritional Adequacy Number (AKG); other components still use AHEI cut-offs. Each element of AHEI is given a score of 0 to 10. The total AHEI score ranges from 0 to 110. The total AHEI score is categorized into two categories: if it is ≥80, and if it needs improvement if it is <80 (Putri et al., 2018; Kinasih et al., 2024). The data was taken using a 24-hour recall form to get the AHEI score. The recall is carried out 2 times by taking weekdays and holidays. Then, the data is changed by a household size portion unit, grams (g), or percentage (%) of contribution to total energy consumption, which is then adjusted to AHEI provisions.

The last step measured Lipid Profile Rate. The respondents were told to fast for about 8-9 hours (only mineral water was allowed) before the blood samples were taken. Health workers carried out 5 mL plasma blood sampling through a vein using a syringe. Blood samples are taken once and will be analysed using automated techniques. This will be seen for total cholesterol, triglycerides, LDL, and HDL. The Cito laboratory, Semarang, carried out blood Tests.

Method of data analysis

Univariate analysis was conducted to describe the characteristics of the respondents, presented in both tabular and narrative form. Data normality was assessed using the Kolmogorov–Smirnov test, as the sample size exceeded 30 participants. The Pearson correlation test was applied to variables with normally distributed data for bivariate analysis. In contrast, the Spearman rank correlation test was used for variables that did not meet normality assumptions. Multivariate analysis was performed to identify factors influencing the quality of athletes' diets, using linear regression analysis. All statistical tests were conducted with a 95% confidence level, and results were considered statistically significant when $p < 0.05$. The null hypothesis was rejected when the p-value was less than the alpha level (0.05) and accepted when the p-value was greater than 0.05.

This research has received a research ethics license from the Health Research Ethics Commission, Faculty of Medicine, State University of Semarang, with number No. 375/KEPK/FK/KLE/2024.

RESULT AND DISCUSSION

The univariate analysis results describe the mean and standard deviation (SD) of participants' anthropometric measurements, dietary quality, blood pressure, lipid profile, and physical activity levels. The average body mass index (BMI) was 21.9 ± 2.1 kg/m², indicating a normal weight range on average. Mean waist circumference was 74.2 ± 8.9 cm, while at the abdominal level, it was 94.2 ± 9.0 cm. The waist-to-hip ratio (WHR) averaged 0.79 ± 0.05. Mean body fat percentage was 19.3 ± 5.5%. Regarding lipid profile, the mean total cholesterol was 166.8 ± 30.8 mg/dL, the mean HDL cholesterol was 57.9 ± 14.1 mg/dL, and the mean LDL cholesterol was 92.2 ± 25.9 mg/dL. The mean triglyceride level was 109.8 ± 64.3 mg/dL. This aligns with research conducted by Rashid et al. (2023) in youth athletes, which resulted in the mean percentage of fat mass 23.22%; HDL 47.24 mmMol/dL; LDL 71 mmMol/dL. This research also showed a positive association between HDL levels and self-reported general and cardiorespiratory fitness, which has been linked to better blood vessel function and a lower risk of heart disease, thanks to its anti-inflammatory, antioxidant, and blood vessel–relaxing properties.

The mean diet quality score was 51.1 ± 10.6, suggesting moderate diet quality. The quality of the athlete's diet will undoubtedly affect the nutritional status and performance of athletes. This study assessed diet quality using AHEI, also done by the NCAA (National Collegiate Athletic Association). The results of previous study (Werner et al., 2024) involving athletes from the NCAA showed an average AHEI score of 59.2, whereas only 9 out of 94 had a score above 80. Meanwhile, in this study, the average AHEI score was 51.1, which means almost all athletes still need to improve the quality of their diet. Maximum score for each component in AHEI consisting of; vegetables (3-4 portions), fruits (≥5 portions), grains (≥100 g/day), sugar-sweetened beverages (0 portion), legumes and nuts (≥3 portions), red meat (0 portion), trans-fat (≤ 0.5% energy), Omega 3 (≥110 mg for women; ≥160 mg for men), PUFA (≥10% Energy), Sodium (≤2000 mg), Alcohol (0.5–1.5 portion for women; 0.5–2.0 for men). Total points of AHEI are 110; if the subjects get less than 80 points, they need improvement, but more than 80 points is considered good. Meanwhile, the needs of adolescent athletes are generally different from those of adolescents. The requirement for estimated energy expenditure is about 3640 ± 830 for males, 3100 ± 720 for females. Protein requirement at 1.5 g/kg/day; fat at 20–35% of total energy, with saturated trans fatty acids providing no more than 1% of total energy and the rest for CHO (Desbrow, 2021). Diet can balance these lipid profile components, reducing cardiovascular disease risk. The main food components that affect lipid profiles and can be modified through diet are saturated and trans fats, unsaturated fats, cholesterol, phytosterols, vegetable proteins, and water-soluble fiber (Feingold, 2021).

The results showed that body mass index (BMI) had no significant association with any lipid profile component. This result was aligned with the research conducted by Pano-Rodriguez et al. (2025), who found no correlation between BMI and TG, LDL, and HDL, whether in athletes and non-athlete participants. High BMI (mean = 21.9 kg/m²) in participants could be one of the reasons that lead to this result (Pano-Rodriguez et al., 2025). Waist-to-hip ratio (WHR) had a considerable positive association with HDL levels (p = 0.017). At the same time, no significant relationship was observed between WHR and total cholesterol, LDL, TG, or the cholesterol ratio. Despite many results showed a correlation between AHEI and some lipid profiles that used adults as

Table 1. Characteristics of respondents

Characteristic	Mean	SD
Body Mass Index (kg/m²)	21.9	2.1
Waist Circumferences (cm)	74.2	8.9
Hip Circumferences (cm)	94.2	9.0
Waist-to-Hip Ratio	0.79	0.05
Body Fat Percentage (%)	19.3	5.5
Total Cholesterol (mg/dL)	166.8	30.8
HDL Cholesterol (mg/dL)	57.9	14.1
LDL Cholesterol (mg/dL)	92.2	25.9
Triglycerides (mg/dL)	109.8	64.3
Diet Quality Score	51.1	10.6

Table 2. Correlation between body composition and lipid profile

Variable	Cholesterol	HDL	LDL	TG	Cholesterol/ HDL ratio
	p-value	p-value	p-value	p-value	p-value
Body Mass Index	0,181[a]	0,772[b]	0,271[b]	0,098[b]	0,772[b]
Waist-to-Hip Ratio	0,055[a]	0,017[*b]	0,068[b]	0,339[b]	0,799[b]
Waist Circumferences	0,080[b]	0,058[b]	0,183[b]	0,762[b]	0,864[b]
Body Fat Percentage	0,001[*b]	0,001[*b]	0,007[*b]	0,010[*b]	0,199[b]
Diet Quality Score	0,156[a]	0,853[b]	0,161[b]	0,925[b]	0,095[b]

[a]Pearson correlation; [b]Spearman rank; *p-value < 0,05 = significant

Table 3. Multivariate analysis of body composition and lipid profiles

Outcomes	Lipid Profiles			
	Cholesterol B (p-value)	Tryglicerides B (p-value)	LDL B (p-value)	HDL B (p-value)
Body Fat Percentage	2.332(0,001)	-2.914 (0,037)	1.387 (0,013)	1.201 (0,001)

participants (Faraji et al., 2024), in this research, the dietary quality and waist circumference (WC) were not significantly related to any lipid profile parameter. In contrast, body fat percentage exhibited significant associations with multiple lipid parameters, namely total cholesterol (p = 0.001), HDL (p = 0.001), LDL (p = 0.007), and TG (p = 0.010), but not with the cholesterol ratio. Previous studies highlight that visceral adiposity is metabolically active and perpetually releases free fatty acids (FFAs) into circulation, contributing to dyslipidemia characterized by elevated triglycerides and LDL, alongside reduced HDL concentrations (Potter et al., 2025). In contrast, BMI often misclassifies adiposity in athletes, as it cannot distinguish lean mass from fat mass, leading to significant overestimation of obesity prevalence in this group (Wati et al., 2024).

Based on Table 3, the factor that most significantly influences the four lipid profiles is the percentage of body fat. This finding is important because it suggests that body fat percentage may be a more sensitive indicator of lipid metabolism alterations than other commonly used anthropometric measures, particularly in adolescent athletes. This result is in line with research conducted by Sun et al. (2022), which states that there is a positive relationship between total body fat and cholesterol, triglycerides, and LDL, and a negative relationship with HDL (p < 0.001). The mechanism by which body fat affects the lipid profile is related to the incidence of insulin resistance. People with excess fat in the abdominal area are likely to experience insulin resistance, which causes visceral fat cells to release excess free fatty acids. The liver then absorbs these fatty acids to synthesize triglycerides (TG). Increased insulin resistance also decreases lipoprotein and liver lipase activity, leading to reduced maturation and increased HDL cholesterol breakdown. Other possible mechanisms include adipokine imbalances or inflammatory cytokines, which accelerate abnormal metabolism in the endothelium, as well as the adverse effects of insulin on sympathetic nerve activity (Kuwano et al., 2017; Karbowska & Kochan, 2025; Caprio et al., 2017).

CONCLUSION

This study found that among various anthropometric and dietary quality indicators, body fat percentage was the most significant and consistent predictor of lipid profile components in adolescent athletes, showing positive associations with total cholesterol, LDL, and triglycerides, and a negative association with HDL. These findings underscore the importance of monitoring body fat percentage, rather than relying solely on BMI, in assessing cardiovascular risk and guiding targeted nutrition interventions for adolescent athletes.

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