

Macronutrient Intake Patterns and Their Association with Adolescent Nutritional Status in Surakarta, Indonesia

Elsa Fara Islamiyah*, Firmansyah, Dyah Intan Puspitasari

Nutrition Science Study Program, Faculty of Health Sciences, Universitas Muhammadiyah Surakarta



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Email Corresponding:
elsafara100602@gmail.com

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Abstract

Background: Adolescence is a critical period for growth and development, during which adequate macronutrient intake plays a key role in achieving optimal nutritional status. In urban settings like Surakarta, Indonesia, dietary behaviors may vary due to socioeconomic diversity. **Objective:** This study aimed to examine the association between energy and protein intake and the nutritional status of adolescents in Surakarta. **Methods:** A cross-sectional study was conducted involving 94 adolescents aged 15–18 years. Macronutrient intake was assessed using 24-hour dietary recall, while nutritional status was measured using Body Mass Index-for-age Z-scores (BAZ). Data were analyzed using descriptive and inferential statistics with a significance level of $p < 0.05$. **Results:** The mean energy intake was 1376.07 ± 508.24 kcal and protein intake was 51.58 ± 22.63 grams. The mean BAZ score was -0.0395 ± 1.3157 , indicating generally normal nutritional status. However, statistical analysis showed no significant relationship between either energy ($p = 0.678$) or protein intake ($p = 0.642$) and nutritional status. **Conclusion:** Although most adolescents had normal nutritional status, no significant association was found between energy or protein intake and BAZ. These findings highlight the need to explore other dietary and lifestyle factors influencing adolescent nutrition in urban Indonesian settings.

Keywords: Adolescents; Energy Intake; Protein Intake; Nutritional Status; BMI for age.

Introduction

Adolescence is a critical developmental stage marked by rapid physical, cognitive, and emotional changes. According to the Regulation of the Minister of Health of the Republic of Indonesia Number 25 of 2014, adolescents are defined as individuals aged 10 to 18 years a period that demands special attention due to its importance in human development¹. Nutritional needs increase significantly during this phase to support growth and maturation, particularly of reproductive organs and brain function². However, unhealthy eating habits and insufficient nutrient intake remain prevalent

among adolescents, posing serious risks to their health. Inadequate consumption of macronutrients, especially protein, may impair metabolism and increase vulnerability to undernutrition, including stunting and thinness³. The issue is further exacerbated by Indonesia's ongoing battle with the "triple burden of malnutrition" stunting, wasting, and obesity combined with micronutrient deficiencies, which affect not only childhood but also adolescence⁴.

Despite numerous interventions and public health campaigns, malnutrition in adolescents persists as a pressing issue in Indonesia. National data from Riskesdas (2018) show that

among adolescents aged 16–18 years, 1.4% are classified as severely thin, 6.8% as thin, 9.5% as overweight, and 4.0% as obese. In Surakarta, the figures are more concerning, with 5.61% of adolescents being severely thin and 11.4% classified as obese⁴. These findings reflect an alarming trend and underscore the need for targeted research. Existing literature has identified multiple determinants of adolescent nutritional status, including dietary intake, physical activity, socioeconomic factors, and parental knowledge⁵. However, few studies in Indonesia have examined the direct association between macronutrient intake patterns specifically protein, carbohydrates, and fat and nutritional status among adolescents at the city level, such as in Surakarta. Moreover, the influence of modern eating behaviors, such as frequent snacking on energy-dense foods and skipping meals, remains understudied despite their evident effects on adolescent health outcomes^{6,7,8}.

Given the vulnerability of adolescents to nutritional imbalances and the documented rise in unhealthy eating patterns, it is urgent to investigate macronutrient intake and its role in shaping nutritional outcomes. While previous studies have broadly explored adolescent nutrition, this research focuses specifically on macronutrient adequacy and its correlation with nutritional status among adolescents in Surakarta a population and setting that have not been extensively studied. The study's novelty lies in its city-specific focus, the inclusion of direct dietary assessments, and the integration of anthropometric measurements to analyze nutritional status. Furthermore, preliminary data from SMA Negeri 7 Surakarta revealed that a substantial number of students had severe macronutrient deficiencies (<80% of dietary requirements), with two students classified as undernourished and four as moderately malnourished. These findings indicate an urgent need to investigate the pattern and

consequences of macronutrient intake among adolescents in urban Indonesian settings.

This study aims to investigate whether there is a significant relationship between macronutrient intake and the nutritional status of adolescents in Surakarta, Indonesia. The central hypothesis proposes that inadequate macronutrient intake is significantly associated with poor nutritional outcomes among adolescents. To address this, the study has three specific objectives: first, to analyze the patterns of macronutrient intake among adolescents in Surakarta; second, to describe their current nutritional status; and third, to examine the association between macronutrient intake and nutritional status within this population.

Findings from this study have the potential to inform evidence-based public health interventions and nutrition education programs targeting adolescents. By identifying specific dietary deficiencies linked to malnutrition, this research could help policymakers and school health authorities in Surakarta and similar urban areas develop strategies to improve adolescent nutrition. The results may also contribute to broader academic discourse on adolescent health and support the implementation of policies addressing Indonesia's triple burden of malnutrition. Ultimately, this research underscores the importance of early nutritional interventions to enhance long-term health outcomes and human capital development.

Materials and Methods

Study Design and Setting

This study employed a cross-sectional design to examine the relationship between macronutrient intake and nutritional status among adolescents. The research was conducted in Surakarta, Indonesia, a mid-sized urban area with diverse socioeconomic backgrounds that may influence dietary behavior and nutritional outcomes. The city's

demographic diversity provides a relevant setting to explore variations in dietary patterns and their potential impacts on adolescent health. Additionally, Surakarta serves as a representative urban environment where both undernutrition and overnutrition may coexist, making it an ideal location to assess nutritional disparities linked to macronutrient intake.

Study Population and Sampling

The target population consisted of adolescents aged 13–18 years enrolled in junior and senior high schools in Surakarta. Participants were selected using stratified random sampling to ensure proportional representation across schools, gender, and age groups. Inclusion criteria included being a registered student within the selected schools, willingness to participate, and parental consent (for minors). Exclusion criteria were students with known chronic diseases or dietary restrictions that could affect nutritional status.

Data Collection

Data were collected through structured interviews and anthropometric measurements. Macronutrient intake data were obtained using a validated semi-quantitative Food Frequency Questionnaire (FFQ), which assessed daily intake of carbohydrates, proteins, and fats. The reported intake was then compared to the recommended dietary allowance (RDA) for Indonesian adolescents. Nutritional status was assessed using Body Mass Index-for-age (BMI-for-age) according to the WHO growth reference standards. Height and weight were measured using standardized procedures and calibrated equipment.

Data Analysis

Descriptive statistics were used to summarize the characteristics of participants, macronutrient intake patterns, and nutritional status. Macronutrient intake was categorized as adequate or inadequate based on RDA

guidelines. The association between macronutrient intake and nutritional status was analyzed using chi-square tests and logistic regression to identify significant predictors of undernutrition or overnutrition. A significance level of $p < 0.05$ was used throughout the analysis. All statistical analyses were conducted using SPSS.

Ethical Considerations

This study received ethical clearance from the Health Research Ethics Committee (Komisi Etik Penelitian Kesehatan/KEPK) of the Faculty of Medicine, Universitas Muhammadiyah Surakarta, with approval number 5704/B.1/KEPK-FKUMS/V/2025, dated May 31, 2025. The approval confirms that the research complies with the ethical principles outlined in the Declaration of Helsinki (1975), as well as the guidelines established by the Council for International Organizations of Medical Sciences (CIOMS) and the World Health Organization (WHO) in 2016. Written informed consent was obtained from all participants, and for those under the age of 18, consent was also obtained from their parents or legal guardians. Participant confidentiality and data privacy were strictly maintained throughout the study.

Results

This section presents the findings of the study on the relationship between macronutrient intake and nutritional status among adolescents in Surakarta, Indonesia. The study was conducted in four public senior high schools (SMAN) representing different sub-districts within Surakarta: SMAN 1, SMAN 3, SMAN 7, and SMAN 9. These schools were selected to reflect the diversity of the city's geographical and socioeconomic characteristics. Prior to presenting the analytical results, a general description of the study area and school profiles

is provided to offer contextual understanding of the educational and demographic environment in which the study took place.

Table 1. Distribution of Respondents by Gender, Age, and Daily Allowance

| Characteristics | Frequency (n) | Percentage (%) |
|------------------------|---------------|----------------|
| Gender | | |
| Male | 70 | 33.3 |
| Female | 140 | 66.7 |
| Age | | |
| 14 years | 1 | 0.5 |
| 15 years | 28 | 13.3 |
| 16 years | 88 | 41.9 |
| 17 years | 84 | 40.0 |
| 18 years | 9 | 4.3 |
| Daily Allowance | | |
| < Rp15,000 | 114 | 54.3 |
| > Rp15,000 | 96 | 45.7 |
| Total | 210 | 100 |

Source: Primary Data, 2025

Table 1 presents the distribution of respondents based on gender, age, and daily

allowance. Out of a total of 210 adolescent respondents, the majority were female, accounting for 66.7% (n=140), while males made up 33.3% (n=70), indicating a higher female participation in the study. In terms of age, most respondents were 16 years old (41.9%, n=88) and 17 years old (40.0%, n=84), suggesting that the sample was predominantly composed of mid-to-late adolescents. Meanwhile, smaller proportions were aged 15 (13.3%, n=28), 18 (4.3%, n=9), and 14 years (0.5%, n=1), respectively. Regarding daily allowance, more than half of the participants (54.3%, n=114) received less than Rp15,000 per day, while the remaining 45.7% (n=96) had a daily allowance exceeding Rp15,000. These findings provide a demographic overview that reflects a fairly balanced economic background and a concentration of respondents in the mid-adolescent age range.

Table 2. Distribution of Nutritional Status and Macronutrient Intake

| Category | Subcategory | Frequency (n) | Percentage (%) |
|----------------------------|---------------------|---------------|----------------|
| Nutritional Status | Severe Malnutrition | 1 | 0.5 |
| | Underweight | 13 | 6.2 |
| | Normal | 155 | 73.8 |
| | Overweight | 26 | 12.4 |
| | Obesity | 15 | 7.1 |
| Energy Intake | Deficit (<80%) | 180 | 85.7 |
| | Normal (80–110%) | 21 | 10.0 |
| | Excess (>110%) | 9 | 4.3 |
| Protein Intake | Deficit (<80%) | 135 | 64.3 |
| | Normal (80–110%) | 53 | 25.2 |
| | Excess (>110%) | 22 | 10.5 |
| Fat Intake | Deficit (<80%) | 143 | 68.1 |
| | Normal (80–110%) | 45 | 21.4 |
| | Excess (>110%) | 22 | 10.5 |
| Carbohydrate Intake | Deficit (<80%) | 188 | 89.5 |
| | Normal (80–110%) | 18 | 8.6 |
| | Excess (>110%) | 4 | 1.9 |

Source: Primary Data, 2025

Table 2 illustrates the distribution of respondents based on nutritional status and macronutrient intake. Regarding nutritional status, the majority of adolescents had a normal body mass index (73.8%, n=155), indicating an

overall adequate nutritional condition. However, a notable proportion of respondents were classified as overweight (12.4%, n=26) and obese (7.1%, n=15), suggesting the presence of overnutrition in a subset of the

population. On the other hand, undernutrition was observed among 6.2% (n=13) of participants who were underweight and 0.5% (n=1) who were severely malnourished. In terms of macronutrient intake, a significant majority had a deficit in energy intake (85.7%, n=180), highlighting a widespread inadequacy in total caloric consumption. Only 10.0% (n=21) of respondents met the normal energy intake range (80–110% of recommended intake), and 4.3% (n=9) exceeded it. Protein intake was also found to be insufficient in 64.3% (n=135) of the sample, while 25.2% (n=53) had adequate protein intake and 10.5%

(n=22) consumed protein in excess. A similar trend was seen in fat intake, with 68.1% (n=143) in deficit, 21.4% (n=45) in the normal range, and 10.5% (n=22) exceeding the recommended levels. Most notably, carbohydrate intake was deficient in 89.5% (n=188) of respondents, with only 8.6% (n=18) within the normal range and a mere 1.9% (n=4) exceeding the recommended intake. These findings indicate a high prevalence of macronutrient inadequacies, particularly in energy and carbohydrate consumption, which may have implications for both current and future health outcomes among adolescents.

Table 3. Distribution of Nutritional Status Based on Macronutrient Intake

| Macronutrient Intake | Severe Malnutrition | Underweight | Normal | Overweight | Obesity | Total (n) | % Total |
|----------------------------|---------------------|-------------|--------|------------|---------|-----------|---------|
| Energy Intake | | | | | | | |
| Deficit (<80%) | 1 | 12 | 133 | 23 | 11 | 180 | 100.0 |
| Normal (80–110%) | 0 | 1 | 16 | 2 | 2 | 21 | 100.0 |
| Excess (>110%) | 0 | 0 | 6 | 1 | 2 | 9 | 100.0 |
| Protein Intake | | | | | | | |
| Deficit (<80%) | 0 | 10 | 99 | 17 | 9 | 135 | 100.0 |
| Normal (80–110%) | 1 | 3 | 39 | 7 | 3 | 53 | 100.0 |
| Excess (>110%) | 0 | 0 | 17 | 2 | 3 | 22 | 100.0 |
| Fat Intake | | | | | | | |
| Deficit (<80%) | 0 | 9 | 107 | 16 | 11 | 143 | 100.0 |
| Normal (80–110%) | 1 | 2 | 35 | 5 | 2 | 45 | 100.0 |
| Excess (>110%) | 0 | 2 | 13 | 5 | 2 | 22 | 100.0 |
| Carbohydrate Intake | | | | | | | |
| Deficit (<80%) | 0 | 12 | 138 | 25 | 13 | 188 | 100.0 |
| Normal (80–110%) | 1 | 1 | 14 | 1 | 1 | 18 | 100.0 |
| Excess (>110%) | 0 | 0 | 3 | 0 | 1 | 4 | 100.0 |

Source: Primary Data, 2025

Table 3 displays the distribution of adolescents' nutritional status based on their macronutrient intake, providing insights into how deficits or excesses in energy, protein, fat, and carbohydrate consumption relate to body mass categories. Among those with energy intake deficits (<80% of recommended levels), a majority (73.9%, n=133) had normal nutritional status, though 12 students were underweight, 23 were overweight, 11 were obese, and 1 was severely malnourished. This suggests that even with energy deficiency,

some adolescents still presented with overweight or obesity, indicating possible imbalances in macronutrient quality or metabolic factors. In contrast, respondents with normal energy intake (80–110%) mostly had normal nutritional status (n=16), with only a few cases of underweight (n=1), overweight (n=2), and obesity (n=2). Interestingly, among those with excess energy intake (>110%), 6 had normal weight, while 3 were overweight or obese, reinforcing the association between energy surplus and overnutrition. In terms of

protein intake, most adolescents with a deficit had normal weight (n=99), though 10 were underweight, 17 overweight, and 9 obese, indicating that protein deficiency may be linked to both undernutrition and overnutrition. Among those with adequate protein intake, the majority also had normal weight (n=39), while 7 were overweight, 3 obese, and 4 undernourished (1 severely malnourished and 3 underweight). For those with excessive protein intake, 17 were of normal weight, but 5 (2 overweight, 3 obese) were in higher weight categories. For fat intake, 107 respondents with deficient fat intake had normal nutritional status, yet 9 were underweight, 16 overweight, and 11 obese, showing that even low-fat intake did not prevent excess body weight. Among those with normal fat intake, most were of normal weight (n=35), while a few were

underweight (n=2), overweight (n=5), or obese (n=2). Excessive fat intake also showed a similar pattern, with most (n=13) having normal weight but some being underweight (n=2), overweight (n=5), or obese (n=2). Lastly, carbohydrate intake showed a dominant trend of deficiency, with 188 students having intake below recommended levels; yet, the majority (n=138) were of normal nutritional status. However, 12 were underweight, 25 overweight, and 13 obese. Among those with normal carbohydrate intake (n=18), 14 had normal weight, and others were spread across severe malnutrition, underweight, overweight, and obese categories. A small number of respondents (n=4) had excessive carbohydrate intake, with 3 of them having normal weight and 1 being obese.

Table 4. Description of Mean Energy and Protein Intake and Nutritional Status

| Variable | Mean | SD | Min | Max | p-value |
|--|---------|--------|-------|-------|---------|
| Energy Intake (kcal) | 1376.07 | 508.24 | 460.1 | 4876 | 0.678 |
| Protein Intake (g) | 51.58 | 22.63 | 9.6 | 180.1 | 0.642 |
| Nutritional Status (BMI-for-age Z-score) | -0.0395 | 1.3157 | -3.81 | 2.93 | — |

Source: Primary Data, 2025

Table 4 presents the descriptive statistics of energy and protein intake along with the nutritional status of adolescents in Surakarta. The mean energy intake was 1,376.07 kcal, with a wide range from 460.1 kcal to 4,876 kcal, indicating considerable variability in dietary patterns among respondents. The mean protein intake was 51.58 grams, ranging from 9.6 grams to 180.1 grams. Meanwhile, the average nutritional status, measured by BMI-for-age Z-score, was -0.0395, which falls within the normal nutritional category (well-nourished). Spearman correlation analysis showed no statistically significant relationship between energy intake and nutritional status ($p = 0.678$), nor between protein intake and nutritional status ($p = 0.642$), suggesting that

the amount of energy and protein consumed did not significantly influence the adolescents' nutritional status in this population. This may be due to factors such as meal frequency, portion size, quality of food, and lifestyle behaviors like physical activity, which may have confounded the direct association between nutrient intake and nutritional outcomes.

The results of this study indicate that there is no statistically significant relationship between macronutrient intake specifically energy and protein and the nutritional status of adolescents in Surakarta ($p = 0.678$ and $p = 0.642$, respectively). Despite variations in intake levels, the findings suggest that other factors beyond dietary energy and protein consumption may contribute to the adolescents'

nutritional status as measured by BMI-for-age Z-scores. These results highlight the complexity of nutritional outcomes and the potential role of non-dietary influences such as lifestyle, physical activity, and socioeconomic factors.

Discussion

This study aimed to examine the association between macronutrient intake and nutritional status among adolescents in Surakarta. The results revealed no statistically significant relationship between energy, protein, fat, or carbohydrate intake and adolescents' nutritional status, as indicated by the p-values for energy ($p = 0.678$), protein ($p = 0.642$), and corresponding BMI-for-age Z-scores. These findings suggest that, although the majority of respondents had macronutrient intake levels below the Recommended Dietary Allowance (RDA), most maintained a normal nutritional status. This could be explained by other contributing factors such as physical activity, meal frequency, or family support, which may buffer the effects of dietary inadequacy. These findings support the hypothesis partially, indicating that while inadequate intake is prevalent, it does not linearly predict poor nutritional status in this population.

These findings are consistent with previous research. A study by Solikhah and Rahma (2024) found no significant relationship between energy intake and nutritional status in adolescents ($p = 0.107$). Similarly⁹, Dewi Rahmawati and Rakhma (2024) reported a non-significant association between energy intake and adolescent nutritional status ($p = 0.545$). This pattern was also observed in protein intake¹⁰. Veronika et al. (2021) both found no association between protein intake and nutritional status ($p = 0.144$ and $p = 0.561$, respectively)¹¹. In terms of fat intake, the findings aligned with Rabiah et al. (2022), who reported no significant relationships between

fat intake and nutritional status ($p = 0.087$ and $p = 0.042$, respectively)¹². Similar findings were reported for carbohydrate intake, with Al-Mssallem et al. (2021) showing p-values of 0.841 and 0.056, respectively both indicating no statistical significance¹³. These consistencies reinforce the notion that macronutrient intake, as measured in short-term recall studies, may not always directly reflect adolescents' nutritional outcomes due to confounding variables such as metabolism, physical activity, and meal timing¹⁴.

The results of this study have several public health implications. Although macronutrient intakes were generally below recommendations, nutritional status remained mostly within normal ranges. This highlights the potential influence of protective factors, such as bringing meals from home and parental involvement in adolescents' diets. As observed, many students had limited pocket money (\leq Rp. 15,000), which may restrict their ability to purchase food outside school. Nevertheless, homemade meals often offer better nutritional quality. The study aligns with Heber and Li (2017), who emphasized that macronutrient deficits do not always correlate with poor nutritional status if compensatory factors are present¹⁵. Furthermore, family support and healthy dietary habits, such as eating breakfast or bringing lunch, can play a critical role in ensuring adequate daily intake^{16,17,18}. Therefore, educational campaigns should involve parents and emphasize the importance of balanced diets, meal planning, and nutritional knowledge for adolescents.

The strength of this study lies in its focus on a representative sample of adolescents in an urban Indonesian setting, using validated 24-hour food recall methods and anthropometric measures (BMI-for-age Z-score). However, several limitations must be acknowledged. The cross-sectional design does not allow for causal inferences between macronutrient intake and

nutritional status. The reliance on self-reported dietary intake introduces recall bias, especially among adolescents who may inaccurately estimate or forget their food consumption. Additionally, energy expenditure was not measured, which is crucial in determining actual energy balance. These limitations may explain the discrepancy between dietary intake and nutritional status observed in the study.

Future research should consider using longitudinal designs to track dietary patterns and nutritional outcomes over time. Including objective measures of physical activity and metabolic health indicators (e.g., body composition, lipid profiles) would provide a more comprehensive understanding of how diet impacts adolescent health. Moreover, incorporating qualitative methods, such as focus group discussions with students and parents, could offer insights into dietary decision-making, meal frequency, and food preferences. Nutritional status is shaped by multiple factors dietary intake, meal frequency, cultural habits, physical activity, and individual health status making it essential to adopt a holistic approach in future studies^{19,20}.

Conclusion

This study investigated the association between macronutrient intake and the nutritional status of adolescents in Surakarta. Although a substantial proportion of adolescents reported intake levels below the Recommended Dietary Allowance, no statistically significant relationship was found between energy, protein, fat, or carbohydrate intake and nutritional status. These findings suggest that other factors such as physical activity, meal frequency, and family support may play a compensatory role in maintaining adequate nutritional status despite suboptimal dietary intake. Academically, this study contributes to the growing body of literature emphasizing the multifactorial nature of adolescent nutrition and

the limitations of single-point dietary assessments in predicting health outcomes. Practically, the findings highlight the importance of involving families and schools in promoting healthy eating behaviors and providing adolescents with access to balanced meals, especially for those with limited financial resources. Future research should adopt longitudinal and mixed-method approaches to better understand the complex interactions between diet, lifestyle, and nutritional outcomes in adolescents. Integrating objective measures of physical activity and metabolic health, along with qualitative insights into adolescent food choices, will be essential to inform more effective interventions in adolescent nutrition.

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Conflict of Interest Statement

The author(s) declare no commercial, financial, or personal conflicts of interest related to this research. All authors approved the final manuscript and consented to its publication in *Healthy Tadulako Journal*.

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