THE RELATIONSHIP BETWEEN ENERGY INTAKE, MACRONUTRIENT INTAKE AND PHYSICAL ACTIVITY AND OVERNUTRITION IN ADOLESCENTS

Hermita Bus Umar[1], Aulia Izata[2], Marni Handayani[3]
[1,2,3] *Nutrition Departement, Health Ministry Polytechnic of Padang, Indonesia*

**Corresponding author: hermita1809@gmail.com*

Abstract

Background: Overnutrition among adolescents is a growing public health problem that increases the risk of various non-communicable diseases later in life. According to the 2023 Indonesian Health Survey, the prevalence of overnutrition among adolescents in Indonesia was 12.1%. In SMA N 6 Padang, the prevalence of overnutrition was reported to be 22.5% in 2023. This study aimed to determine the relationship between energy intake, macronutrient intake, and physical activity with the incidence of overnutrition among adolescents.**Methods:** A cross-sectional study was conducted among 56 students selected through simple random sampling. Dietary intake data were collected through interviews using a 24-hour food recall form, while physical activity data were assessed using the Physical Activity Level (PAL) questionnaire. Nutritional status was determined through anthropometric measurements using a weighing scale and microtoise. Data were analyzed using computerized statistical procedures, including univariate and bivariate analyses with the Chi-square test at a 95% confidence level. **Results:** The prevalence of overnutrition among students was 41.0%. The proportions of students with excessive intake were 33.9% for energy, 28.6% for protein, 46.4% for fat, and 28.6% for carbohydrates, 55.4% of students had low physical activity levels. Bivariate analysis showed significant associations between energy intake, macronutrient intake (protein, fat, and carbohydrates), and physical activity with the incidence of overnutrition among adolescents ($p \leq 0.05$).**Conclusion:** Energy intake, macronutrient intake, and physical activity were significantly associated with overnutrition among adolescents. Therefore, interventions promoting balanced dietary intake and adequate physical activity are needed to prevent overnutrition in this population.

Keywords: overnutrition, adolescents, energy intake, macronutrients, physical activity.

1. INTRODUCTION

Overnutrition among adolescents has become a major global public health challenge. The increasing prevalence of overweight and obesity during adolescence is associated with a higher risk of developing non-communicable diseases (NCDs) later in life, including type 2 diabetes mellitus, hypertension, cardiovascular diseases, and metabolic syndrome. According to the World Health Organization (WHO), more than 390 million children and adolescents aged 5–19 years were overweight in 2022, including over 160 million who were obese. Globally, the prevalence of overweight and obesity among children and adolescents increased from 8% in 1990 to 20% in 2022 [1, 2]

In Indonesia, overnutrition among adolescents also shows an increasing trend. Data from the 2023 Indonesian Health Survey reported that the prevalence of overnutrition among adolescents reached 12.1%. Based on Basic Health Research data from West Sumatra Province, the prevalence of overnutrition among adolescents aged 16-18 years continued to increase from 2013 to 2018, from 7.5% to 11.5%. Data from SMA N 6 Padang in 2023 showed that 22.5% of students were overweight. This prevalence is significantly higher than the National prevalence [3]

Energy intake is a major determinant of weight status in adolescents. Excessive consumption of energy-dense foods and beverages contributes to a positive energy balance and fat accumulation. In

addition to total energy intake, macronutrient composition also plays a significant role in the development of overnutrition. High fat intake is associated with increased energy density and adiposity, while excessive carbohydrate consumption, particularly from refined carbohydrates and sugar-sweetened beverages, can contribute to weight gain by increasing calorie intake. Excessive protein intake has been associated with increased body mass index (BMI) in adolescents due to its effects on growth factors and energy balance. Several studies have shown a significant association between excessive energy and macronutrient intake and the development of overweight and obesity in adolescents [4]

Physical activity is another important factor influencing nutritional status. Adolescents with low levels of physical activity expend less energy, increasing the likelihood of a positive energy balance and subsequent weight gain. The consequences of overnutrition during adolescence extend beyond physical appearance and have significant health implications. Overweight adolescents are more likely to remain overweight or obese in adulthood and face increased risks of cardiovascular disease, type 2 diabetes, musculoskeletal disorders, certain cancers, psychological problems, and premature mortality. Additionally, obesity may negatively affect academic performance, self-esteem, and overall quality of life [1,4]

Previous research has identified a link between dietary intake, physical activity, and excess nutrition among adolescents. Similarly, other studies have reported that risky dietary patterns and low levels of physical activity are key determinants of overweight and obesity among adolescents in Central Java [5,6]. This study examines the relationship between energy intake, macronutrient intake, and physical activity and the incidence of overweight among adolescents at SMA Negeri 6 Padang a school where the prevalence of overweight is 22.5%, a figure higher than that of several other high schools in the city. To date, there is no comprehensive data explaining the factors contributing to this high prevalence. The study's findings are expected to identify risk factors that can serve as a basis for developing school-based programs for the prevention and control of overweight. This study aimed to determine the relationship between energy intake, macronutrient intake, and physical activity with the incidence of overnutrition in adolescents

This study has received ethical approval (No. 911/KEPK.F1/ETIK/2024) from the Health Research Ethics Committee of Universitas Perintis Indonesia.

2. METHODS

This study used a cross-sectional design. The population was all 309 students of grade XI at SMA N 6 Kota Padang. The sample size was calculated using the Lemeshow proportion estimation formula, based on a population size (N) of 309, a case proportion of 22.5%, a precision of 10%, and a confidence level of 95%, resulting in a sample size of 56 students. To account for potential dropouts, a reserve of 10% of the sample size was added. The sampling technique used was simple random sampling. The data collected included: Anthropometric data to determine overnutrition (subjects' weight and height) were measured using a digital scale and microtoise. Intake data were measured using a 24-hour food recall format. Physical activity data were measured using the Physical Activity Level (PAL) instrument. Data categorization for overnutrition if the BMI z-score according to age > +1 SD and not overnutrition if the BMI z-score according to age ≤ +1 SD. Intake data was compared with the recommended dietary allowance (RDA).. Bivariate analysis used the chi-square test with a significance level of 0,05.

3. RESULTS

Distribution of students based on age, gender and nutritional status can be seen in table 1

Table 1. Student Distribution by Age and Gender at SMA N 6 Padang City

Variable	n	%
Age		
16	26	46,4
17	30	53,6
Gender		
Male	22	39,3
Female	34	60,7
Nutritional status		
Overnutrition	23	41,1
Not overnutrition	33	58,9

The students' ages are almost the same, 16 and 17 years old, while in terms of gender, there are more females than males. There are 41,1% of students with overnutritional status.

Distribution of students based on intake can be seen in table 2

Table 2. Distribution of students based on intake

Intake	More (n)	%	Better (n)	%	Less (n)	%	Total	%
Energy	19	33,9	7	12,5	30	53,6	56	100
Protein	16	28,6	10	17,9	30	53,6	56	100
Fat	26	46,4	6	10,7	24	42,9	56	100
Carbohydrate	16	28,6	8	14,3	32	57,1	56	100

Based on Table 2, it can be seen that the students' intake of energy (33,9%), protein (28,6%), fat (46,4%), and carbohydrates (28,6%) is more than the RDA. The average energy intake of students is 1845,64 kcal, protein 53,26 g, fat 63,51 g and carbohydrate 305,79 g.

Physical activity obtained from the results of interviews using the PAL (Physical Activity Level) questionnaire can be seen in table 3

Table 3. Distribution of students based on Physical activity

Physical activity	n	%
Light	31	55,4
Medium	14	25
Heavy	11	19,6
Total	**56**	**100**

Based on the grouping of physical activities, it appears that the most common are light activities (55,4%).

Table 4. The relationship between energy intake and macronutrients with overnutrition.

Energy intake	Nutritional status				Total		p value
	Overnutrition		No overnutrition				
	n	%	n	%	n	%	
More	16	84,2	3	15,8	19	100	
Better	2	28,6	5	71,4	7	100	<0,001
Less	5	16,7	25	83,3	30	100	
Protein intake	Nutritional status				Total		p value
	Overnutrition		No overnutrition				
	n	%	n	%	n	%	
More	15	93,8	1	6,2	16	100	
Better	2	20	80	10	7	100	<0,001
Less	6	20	24	80	30	100	
Fat intake	Nutritional status				Total		p value
	Overnutrition		No overnutrition				
	n	%	n	%	n	%	
More	18	69,2	8	30,8	26	100	
Better	3	50	3	50	6	100	<0,001
Less	2	8,3	22	91,7	24	100	
Carbohydrate intake	Nutritional status				Total		p value
	Overnutrition		No overnutrition				
	n	%	n	%	n	%	
More	14	87,5	2	12,5	16	100	
Better	3	37,5	5	62,5	8	100	<0,001
Less	6	18,8	26	81,2	32	100	

Table 4 shows that students with overnutrition have an intake of energy, protein, fat, and carbohydrates that exceeds the RDA. Statistically, there is a significant relationship between energy, protein, fat, and carbohydrate intake and overnutrition as indicated by a p-value of ≤ 0,05.

Table 5. The relationship between physical activity and overnutrition.

Physical activity	Nutritional status				Total		P Value
	Overnutrition		No Overnutrition				
	n	%	n	%	n	%	
Light	18	58,1	13	41,9	31	100	
Medium	5	35,7	9	64,3	14	100	
Heavy	0	0	11	100	11	100	0,003
Total	**23**	**41,1**	**33**	**58,9**	**56**	**100**	

From table 5 it can be concluded that the highest percentage of overweight students is in light physical activity, statistically there is a significant relationship between physical activity and the incidence of overweight.(p value = 0,003)

4. DISCUSSION

This study found a significant association between energy intake, protein intake, fat intake, carbohydrate intake, and overnutrition (p ≤ 0.001). These findings indicate that excessive consumption of energy and macronutrients contributes to the development of overweight and obesity among students.

Energy intake is one of the primary determinants of nutritional status. When energy consumption exceeds the body's requirements over a prolonged period, excess energy is stored as adipose tissue, resulting in weight gain and overnutrition. Students with higher energy intake are therefore more likely to experience positive energy balance and increased body fat accumulation. Recent studies have

consistently reported that excessive caloric intake is a major contributor to the rising prevalence of overweight and obesity among adolescents [8]

The significant association between fat intake and overnutrition may be explained by the high energy density of fat, which provides 9 kcal per gram, compared to 4 kcal per gram for protein and carbohydrates. Diets high in fat, particularly from ultra-processed foods, fried foods, and fast foods, can substantially increase total energy intake and promote fat storage. A recent systematic review reported that frequent consumption of energy-dense, high-fat foods is strongly associated with overweight and obesity among adolescents [9]

Protein intake was also significantly associated with overnutrition. Although protein plays an important role in growth and satiety, excessive protein intake may contribute to total caloric excess. In addition, protein-rich foods consumed by adolescents are often accompanied by high levels of fat and calories, especially when derived from processed meats and fast-food products. Therefore, high protein intake may indirectly contribute to excess body weight when overall energy intake exceeds expenditure [4,8]

Similarly, excessive carbohydrate intake was significantly related to overnutrition. High consumption of refined carbohydrates and sugar-sweetened beverages can increase total energy intake and stimulate fat storage through increased insulin secretion. Recent evidence suggests that diets rich in refined carbohydrates are associated with a greater risk of obesity and adverse metabolic outcomes among children and adolescents [10]

These findings are consistent with previous studies showing that excessive energy and macronutrient intake are important risk factors for overnutrition. A study found that adolescents with higher intakes of total energy, fat, and refined carbohydrates had a significantly greater likelihood of being overweight or obese. Likewise, the World Health Organization emphasizes that unhealthy dietary patterns characterized by excessive consumption of energy-dense foods contribute substantially to the global burden of adolescent obesity [11].

A meta-analysis concluded that excessive intake of macronutrients—particularly fats and carbohydrates—is associated with the incidence of obesity among adolescents. The study explains that dietary patterns high in energy and fat promote body fat accumulation, thereby increasing the risk of obesity. Overall, the results suggest that excessive intake of energy, protein, fat, and carbohydrates increases the risk of overnutrition among students. Therefore, promoting balanced dietary intake according to nutritional recommendations is essential to prevent overweight and obesity during adolescence [15].

This study found a significant association between physical activity and overnutrition ($p \leq 0.003$). Students with lower levels of physical activity were more likely to experience overnutrition than those who engaged in moderate or vigorous physical activity. Physical activity is an important component of energy balance because it increases energy expenditure and helps prevent excess fat accumulation. Conversely, insufficient physical activity reduces energy expenditure, leading to a positive energy balance and increased risk of overweight and obesity [12]

The finding that the majority of students engaged in light physical activity (55.4%) may explain the occurrence of overnutrition in this population Adolescents today spend increasing amounts of time engaging in sedentary behaviors, including smartphone use, social media, online gaming, and television viewing. Excessive screen time may reduce opportunities for physical activity, resulting in lower energy expenditure and an increased risk of overweight and obesity. Previous studies have identified low physical activity and high sedentary behavior as important modifiable risk factors for adolescent obesity [12,13,14]

This result is consistent with recent evidence indicating that regular physical activity is associated with lower body fat, healthier body weight, and reduced risk of obesity among children and adolescents. Physical activity interventions have also been shown to improve body composition and decrease adiposity in overweight and obese youth.

Furthermore, the 2020 WHO Guidelines recommend that children and adolescents perform at least 60 minutes of moderate-to-vigorous physical activity daily to maintain optimal health and prevent overweight and obesity. Adolescents who fail to meet these recommendations are more likely to develop excess body weight and related metabolic disorders [4]. Research on high school students in Jakarta indicates that low physical activity is a behavior associated with indicators of obesity in

adolescents. Less active adolescents tend to be at a higher risk of being overweight compared to those who actively engage in exercise [16].

Research on the determinants of nutritional status among Indonesian adolescents has found that nutritional status is largely influenced by various behavioral factors, including dietary habits, physical activity, and individual characteristics. The study underscores the multifactorial nature of overweight and obesity, highlighting the need for an approach that considers multiple risk factors [17].

Limitation study :This study has several limitations. First, the cross-sectional design does not allow researchers to establish a causal relationship between energy intake, macronutrient intake, physical activity, and the occurrence of overweight/obesity. Second, data on dietary intake and physical activity were obtained via self-report questionnaires, potentially introducing recall and reporting biases. Third, the study did not account for other factors that could influence the occurrence of overweight/obesity, such as genetics, sleep duration, screen time, sedentary behavior, and family socioeconomic status. Furthermore, the study was conducted solely among students at SMA Negeri 6 Padang, limiting the generalizability of the findings to the broader adolescent population.

5. CONCLUSION

This study demonstrated that a considerable proportion of students had energy and macronutrient intakes exceeding the Recommended Dietary Allowance (RDA), particularly fat intake. The majority of students were categorized as having light physical activity. Statistical analysis revealed significant associations between energy intake, protein intake, fat intake, carbohydrate intake, and physical activity with overnutrition ($p \leq 0.003$). Students with excessive energy and macronutrient intake and lower levels of physical activity were more likely to experience overnutrition. These findings indicate that both dietary intake and physical activity are important determinants of nutritional status among adolescents and play a crucial role in the development of overweight and obesity. It is hoped that adolescents will adopt balanced eating habits by limiting excessive consumption of foods high in energy, fat, and sugar, as well as sugary drinks. Increase participation in regular physical activity and reduce sedentary behavior to maintain a healthy weight.

ACKNOWLEDGEMENTS

Thanks are extended to the principal of SMA N 6, teachers and students who participated in this research, as well as all parties who helped with the research activities who cannot be mentioned one by one.

REFERENCES

[1] World Health Organization. (2025). *Obesity and Overweight*. Geneva: WHO. Available from: https:/ /www.who.int/ mediacentre /factsheets/fs311/ en/index.html.

[2] World Health Organization. (2025). *Prevalence of Overweight and Obesity Among Adolescents*. Geneva: WHO. Available from: https://www.who.int/data/gho.

[3] Kemenkes BKPK. Survei Kesehatan Indonesia (SKI) 2023 Dalam Angka. Kementrian Kesehatan Badan Kebijakan Pembangunan Kesehatan; 2023.

[4] World Health Organization. (2022). WHO European Regional Obesity Report 2022. Copenhagen: World Health Organization Regional Office for Europe.

[5] Widyastuti PA, Noer ER, Nuryanto, Margawati A, Pramono A. (2026). Socioeconomic, demographic, and lifestyle factors associated with adolescent obesity in Indonesia: Analysis of Indonesia Health Survey 2023 data. *AcTion: Aceh Nutrition Journal*, 11(1). DOI: 10.30867/action.v11i1.2553.

[6] Fathonah Y. (2025). Analysis of Determinants of Obesity and Overweight Risk Factors Among Adolescents in Central Java Province Based on the 2023 Indonesian Health Survey Data. *Sosioedukasi: Jurnal Ilmiah Ilmu Pendidikan dan Sosial*, 14(4).

[7] World Health Organization Regional Office for Europe. (2024). *The Challenge of Obesity*. Copenhagen: WHO Europe.

[8] Jebeile, H., Kelly, A. S., O'Malley, G., & Baur, L. A. (2022). Obesity in children and adolescents: Epidemiology, causes, assessment, and management. The Lancet Diabetes & Endocrinology, 10(5), 351–365.

[9] Askari, M., Heshmati, J., Shahinfar, H., Tripathi, N., & Daneshzad, E. (2020). Ultra-processed food and the risk of overweight and obesity: A systematic review and meta-analysis of observational studies. International Journal of Obesity, 44(10), 2080–2091.

[10] Lobstein, T., Brinsden, H., & Neveux, M. (2022). World Obesity Atlas 2022. London: World Obesity Federation.

[11] Naja, F., Itani, L., Hamadeh, R., & Sibai, A. M. (2021). Dietary patterns, energy intake, and overweight/obesity among adolescents: Findings from a national study. Nutrients, 13(8), 2784.

[12] Chaput, J. P., Willumsen, J., Bull, F., Chou, R., Ekelund, U., Firth, J., et al. (2020). 2020 WHO guidelines on physical activity and sedentary behaviour for children and adolescents aged 5–17 years: Summary of the evidence. *International Journal of Behavioral Nutrition and Physical Activity*, 17(141), 1–9.

[13] Katzmarzyk, P.T., Powell, K.E., Jakicic, J.M., Troiano, R.P., Piercy, K., & Tennant, B. (2022). Sedentary behavior and health: Update from the 2018 Physical Activity Guidelines Advisory Committee. *Medicine & Science in Sports & Exercise*, 54(2), 351–358.

[14] Jayasinghe, S., & Hills, A. P. (2023). Strategies to improve physical activity and nutrition behaviours in children and adolescents: A review. *Nutrients*, 15(15), 3370.

[15] Ainun, N., & Simbolon, D. (2024). *Macronutrient intake and obesity in adolescents: A meta-analysis study*. **Media Gizi Indonesia, 19** (1, Special Issue), 29–35. https://doi.org/10.20473/mgi.v19i1SP.29-3

[16] Lisetyaningrum, I., Pujasari, H., & Kuntarti. (2021). *A cross-sectional analysis of snacking habits, eating habits, physical activity, and indicators of obesity among high school students in Jakarta, Indonesia*. **Journal of Public Health Research**, 10(S1). https://doi.org/10.4081/jphr.2021.2402

[17] Sukoco, N. E. W., et al. (2021). *Determinants of late adolescent nutritional status in Indonesia: A nation-wide cross-sectional survey*. **Nutrition & Food Science, 52**(5), 801–813. https://doi.org/10.1108/NFS-07-2021-0235