The Correlation between Macronutrient Intake and Physical Activity with Overnutrition among Fifth-Grade Students at Banjarbendo State Elementary

Hubungan Asupan Makronutrien dan Aktivitas Fisik terhadap Kelebihan Gizi pada Siswa Kelas 5 di Sekolah Dasar Negeri Banjarbendo

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ABSTRACT

Background: Overweight status, which falls under the category of overweight and obesity, has become a serious and growing global health problem, especially among school-aged children. Unbalanced nutrition and low physical activity are the main factors contributing to the increasing prevalence of malnutrition among children in Indonesia.

Objectives: This study aims to analyze the correlation between macronutrient intake and physical activity with nutritional status (overweight and obesity) in fifth-grade students at Banjarbendo State Elementary School, Sidoarjo.

Methods: This study employed an observational analytical method with a cross-sectional design. The sample consisted of 64 fifth-grade students who were randomly selected through simple random sampling. Data were collected through anthropometric measurements to determine nutritional status based on body mass index-for-age (BMI-for-age) as well as interviews to assess food intake using a 2x24 hour food recall and physical activity using a 2x24 hour physical activity recall. Data analysis was carried out using Spearman's correlation test with a 95% confidence level ($\alpha = 0.05$).

Results: The results indicated a significant correlation between macronutrient intake, physical activity, and nutritional status. Most students with excessive macronutrient intake and low physical activity were found to be overweight or obese

Conclusions: A significant correlation between macronutrient intake, physical activity level, and nutritional status was observed. It is important to raise awareness of balanced nutrition and encourage physical activity in children to prevent overnutrition and its associated health problems in the future.

INTRODUCTION

Nutritional status is a condition resulting from the balance between nutrient intake from food and the body's nutritional needs for metabolic processes. Nutritional needs vary among individuals, depending on factors such as age, weight, gender, and physical activity[1,2]. Currently, overnutrition is a global health problem that requires urgent attention[3–10]. Overnutrition can affect individuals at any age and is commonly categorized into overweight and obesity.

To support growth and development, especially in school-aged children, a balanced diet with adequate nutrients is essential[11]. Nutrition plays a critical role during childhood[12–16], directly impacting optimal growth and development[17]. Children's nutritional adequacy can be assessed by examining their nutritional status, as insufficient intake can lead to various health problems[18,19]. According to the World Health Organization (WHO), the prevalence of overweight and obesity in

children and adolescents aged 5-19 years was 340 million, with 19% males and 18% females[20]. Nutritional problems in school-aged children are health problems that affect the future and intelligence of children, thereby requiring urgent attention[21]. Obesity is one of the nutritional problems that occurs in children and becomes a public health problem[22,23].

According to the 2018 Basic Health Research, the prevalence of overweight in children increased to 21.8%, with 10.8% overweight and 9.2% obese[24]. Environmental factors are the main contributors to overweight and obesity in children[25,26], including imbalanced diets, eating habits, and physical inactivity[27]. Physical activity has been found to correlate significantly with obesity in children[28–35].

Eating habits have also been found to correlate significantly with obesity in children[36–39]. Obesity results from excessive fat accumulation due to imbalance between energy intake and energy expenditure for a long

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time[40,41]. Individuals with obesity are at risk for diseases such as diabetes mellitus, hypertension, cancer, asthma, coronary heart disease, stroke, gout, and sleep apnea[42]. The prevalence of overweight and obesity among school-aged children (6-12 years) is 9.2%. The prevalence of overweight and obesity among school-aged children (6-12 years) in eleven provinces in Indonesia exceeds the national average, namely 11.6% in Nanggroe Aceh Darussalam, 10.5% in North Sumatra, 11.4% in South Sumatra, 10.9% in Riau, 11.6% in Lampung, 9.7% in Riau Islands, 12.8% in the Special Capital Region of Jakarta, 10.9% in Central Java, 12.4% in East Java, 14.7% in Southeast Sulawesi, 14.4% in and West Papua[43]. The 2018 Basic Health Research revealed the prevalence of non-communicable diseases among children aged 5–14 years, including asthma (1.9%), cancer (0.031%), diabetes mellitus (0.004%), and heart disease (0.7%). Among those aged 15 years and above, the prevalence of central obesity increased from 18.8% in 2007 to 26.6% in 2013 and 31% in 2018[44].

The prevalence of adult obesity reached 16.09% by 2020 and 19.61% in 2021. In response, the Health Office of East Java Province has launched initiatives such as the Healthy Living Community Movement (GERMAS) and the Nusantara Movement to Reduce Obesity Rates (GENTAS) to address these trends. During the COVID-19 pandemic, the Health Office of East Java Province faced challenges in meeting obesity handling targets, with only 65% of active integrated service posts (*posyandu*). Factors contributing to overweight include genetic factors, environmental factors (e.g., access to fast food and lack of physical activity*)*, and hormonal factors (e.g., consumption of appetite-stimulating drugs). The short-term effects of being overweight include reduced immunity, growth disorders, and respiratory problems, while the long-term impact of excess weight include the risk of developing non-communicable diseases such as coronary heart disease, diabetes mellitus, cancer, and pregnancy complications[45–48]. According to data from the Central Bureau of Statistics (BPS), the East Java Province ranks the third lowest levels of physical activity, a situation that is quite alarming.

The aforementioned background led to the implementation of this study. This study aims to determine the correlation between macronutrient intake, physical activity, and overweight status among fifth-grade students (10-12 years) at Banjarbendo State Elementary School, Sidoarjo. The nutritional status of the students were assessed using body mass index-for-age.

METHODS

This study employed an analytical observational method with a cross-sectional design. This method allows the exploration of the how and why behind health phenomena. It is followed by the examination of the dynamics of the correlation between phenomena or between risk factors and effect factors by collecting data at a single point in time. In this study, both risk and effect variables for the study population were measured simultaneously[49].

Participants

The study population consisted 75 students with the following criteria: active fifth-grade students, students in good health, and students who consented to participate. The sample size was determined using Slovin's formula (1960) as follows:

$$n = \frac{N}{1 + N\,(e)^2}$$

$$n = \frac{75}{1 + 75(0.05)^2}$$

$n = 63{,}16$ (rounded up to 64 respondents)

Variables:
n = Total Sample Required
N = Population Size
(e) = Error Rate (5% of Population Size)

Sampling was performed through simple random sampling, in which each member of the population was assigned a number and selected randomly. This resulted in a total sample size of 64 respondents.

Data Collection

Data collection was carried out over six months, from September 2023 to March 2024. Initially, consent forms were distributed to the respondents or their guardians to obtain their agreement to participate in this study. Upon obtaining consent, anthropometric measurements were taken. Height was measured using a stadiometer accurate to 0.1 cm, while weight was measured using a digital scale accurate to 0.1 kg. These measurements were essential for calculating the body mass index-for-age (BMI-for-age), which was then used to determine the nutritional status of the students. The classification of overnutrition status was based on the WHO 2007 standards. Students with a BMI-for-age between >1SD and 2SD were classified as overweight, while those with BMI greater >2SD were classified as obese.

Following the anthropometric measurements, interviews were conducted with the respondents to assess their dietary intake through a 2x24-hour food recall, which included one weekday and one weekend day. Additionally, a 2x24-hour physical activity recall was conducted to capture their activity levels during both weekdays and weekends. Food intake data were categorized into three groups based on the Recommended Dietary Allowance (RDA): deficit (<90% RDA), normal (90-119% RDA), and excessive (≥120% RDA). Meanwhile, physical activity data were grouped into three categories based on Metabolic Equivalent of Tasks (MET) values: low (1.40-1.69), moderate (1.70-1.99), and high (2.00-2.40).

Data Analysis

Data analysis was performed in two stages. First, a univariate analysis was conducted to describe the frequency distribution of each variable, including macronutrient intake, physical activity, and overnutrition status. The data were presented as frequency

distributions, cross-tabulations, and percentages to provide a clear overview of the findings. Following this, a bivariate analysis was carried out to determine the correlation between the independent and dependent variables using Spearman's correlation test. This statistical method was chosen due to the ordinal nature and non-normal distribution of the variables. The correlation test was conducted at a 95% confidence level (α=0.05).

Ethical Considerations

This study received ethical approval from the Health Research Ethics Committee of the Surabaya Health Polytechnic, Ministry of Health of the Republic of Indonesia, with an approval number EA/2931/KEPK-Poltekkes Sby/V/2024. This study adhered to ethical guidelines as outlined by the 2011 WHO standards and the 2016 CIOMS guidelines, ensuring respect for the rights and welfare of the participants. Therefore, this study is expected to provide valuable insights into the correlation between macronutrient intake, physical activity, and overnutrition status in children.

RESULTS AND DISCUSSIONS

This section details the correlation between variables based on the results, which are presented in the following tables. The results of previous research compared to this study are also explained in this section. Table 1 summarizes the characteristics of fifth-grade students at Banjarbendo State Elementary School, Sidoarjo who participated in this study.

Table 1. Frequency Distribution of the Characteristics of Fifth-Grade Students at Banjarbendo State Elementary School, Sidoarjo

Characteristics	n	%
Gender		
Male	37	57.81
Female	27	42.19
Age (Years)		
10	25	39.06
11	37	57.82
12	2	3.12
Energy Intake		
Severe Deficit	4	6.25
Moderate Deficit	3	4.69
Mild Deficit	7	10.94
Normal	37	57.81
Excessive	13	20.31
Protein Intake		
Severe Deficit	2	3.13
Moderate Deficit	4	6.25
Mild Deficit	6	9.37
Normal	23	35.94
Excessive	29	45.31
Fat Intake		
Severe Deficit	3	4.69
Moderate Deficit	4	6.25
Mild Deficit	8	12.5
Normal	26	40.62
Excessive	23	35.94
Carbohydrate Intake		
Severe Deficit	9	14.06
Moderate Deficit	12	18.75
Mild Deficit	11	17.19
Normal	29	45.31
Excessive	3	4.69
Physical Activity		
Light	31	48.44
Moderate	25	39.06
High-Intensity	8	12.5
Nutritional Status		
Very Skinny	1	1.56
Skinny	3	4.69
Normal	38	59.37
Overweight	8	12.5
Obese	14	21.88

Classification according to the Indonesian Ministry of Health of 1996 and 2010

The analysis revealed the age and gender distribution among the 64 respondents. In terms of age, the majority of respondents were 11 years old, accounting for 57.82% of the sample, followed by 10-year-olds at 39.06%, and 12-year-olds at 3.12%. This distribution suggests that the sample primarily included younger students, potentially reflecting specific enrollment patterns at the primary school. In terms of gender, 57.81% of the respondents were male, while 42.19% were female, indicating a notable predominance of male students. This gender imbalance may influence the study's outcomes, especially if the variables are affected by gender differences.

Overall, the majority of students were 11 years old and predominantly male. This demographic skew has implications for the study's results and highlights the importance of considering age and gender in further analyses. Future research should aim to stratify samples by age and gender to enhance representativeness and generalizability, as well as to investigate the underlying causes of this demographic distribution, such as school admission policies or socioeconomic factors.

In terms of nutritional status, the analysis revealed that most respondents fell within the normal category, while a smaller but significant proportion fell within the overweight category. These results suggest that overnutrition is a health problem at the primary school. The existing nutritional problems are also reflected in physical activity data, where most respondents fell into the light category. At the time of data collection, the researchers found that overnourished students tended to spend more time buying food and drinks or sitting and socializing with friends.

Further analysis of nutritional status revealed that the majority of respondents fell within the normal category, followed by the obese category with a total of 21.88%. Obesity remains a serious health problem that occurs in elementary school students. Overall, these findings highlight the need for targeted nutritional interventions and educational programs to improve dietary habits and physical activity among school-aged children, aiming to reduce the risk of overweight and obesity.

The analysis of dietary intake and nutritional status of the 64 students revealed important insights. For energy intake, 57.82% of respondents met recommended levels, while 21.88% had a deficit and 20.3% exceeded recommendations. This indicates that while most students meet their energy needs, a notable portion is at risk of undernutrition. For protein intake, 45.32% exceeded recommended amounts, 35.93% were within the normal range, and 18.75% had a deficit, suggesting

potential dietary imbalances. For fat intake, 39.07% of students met recommended levels, 37.49% exceeded recommended amounts, and 23.44% had a deficit, highlighting concerns about overall dietary balance. Carbohydrate intake is particularly alarming, with 50% of respondents having a deficit, which is critical for meeting energy needs, especially in growing children. Physical activity levels showed that 48.45% of students engaged in light activities, 39.06% in moderate activities, and only 12.49% in high-intensity activities, indicating a need for increased physical engagement. Lastly, the nutritional status of the respondents showed that 59.37% were classified as normal, while 21.88% were obese and 12.5% were overweight, raising concerns about long-term health implications. Overall, these findings highlight the need for targeted nutritional interventions and educational programs to improve dietary habits and physical activity among school-aged children, aiming to reduce the risk of overweight and obesity.

Correlation between Energy Intake and Overnutrition

The findings indicated that the majority of students had normal energy intake, with a total of 37 students (57.82%). Among respondents with normal nutritional status, 27 students (42.19%) normal energy intake. Conversely, among overnourished respondents, five students (7.81%) with overweight nutritional status and eight students (12.5%) with obesity had excessive energy intake. The 2x24-hour food recall interviews revealed unhealthy eating patterns among most overweight children, such as consuming excessive calories, eating fast food and foods containing saturated fats, as well as foods and drinks high in sugar. Additionally, overnourished children were less active than their friends. During breaks, they typically sat and ate until the bell rang, while children with normal nutritional status engaged in active play, such as ball games, with their friends. The pattern of excessive consumption and low physical activity leads to ongoing fat accumulation in the body and limited calorie expenditure, resulting in unwanted weight gain. This finding is consistent with a study which found that the average energy consumption of students with obesity was 1917.64 kcal, while that of students with normal nutritional status was 1600.13 kcal. Statistical analysis showed that energy intake had a significant correlation with the nutritional status of primary school children (ρ=0.000). Excessive macronutrient intake can increase the body's capacity to accumulate energy. However, this may result in weight gain and an increased risk of obesity[50]. A similar study at Dukuhsari Elementary School in Sidoarjo Regency also reported a correlation between energy adequacy and children's nutritional status[51].

Table 2. Correlation Between Macronutrient Intake and Physical Activity with Overnutrition Among Fifth-Grade Students at Banjarbendo Elementary School, Sidoarjo

Variables	Very Skinny		Skinny		Normal		Overweight		Obese		p-value
	n	%	n	%	n	%	n	%	n	%	
Energy Intake											
Severe Deficit	0	0	0	0	4	6.25	0	0	0	0	
Moderate Deficit	0	0	0	0	3	4.69	0	0	0	0	
Mild Deficit	0	0	1	1.56	4	6.25	0	0	2	3.13	<0.001
Normal	1	1.56	2	3.13	27	42.19	3	4.69	4	6.25	
Excessive	0	0	0	0	0	0	5	7.81	8	12.5	
Protein Intake											
Severe Deficit	0	0	0	0	2	3.13	0	0	0	0	
Moderate Deficit	0	0	1	1.56	3	4.69	0	0	0	0	
Mild Deficit	0	0	0	0	5	7.81	0	0	1	1.56	<0.001
Normal	1	1.56	1	1.56	18	28.12	0	0	3	4.69	
Excessive	0	0	1	1.56	10	15.63	8	12.5	10	15.63	
Fat Intake											
Severe Deficit	0	0	0	0	2	3.13	1	1.56	0	0	
Moderate Deficit	0	0	0	0	4	6.25	0	0	0	0	
Mild Deficit	1	1.56	1	1.56	6	9.38	0	0	0	0	<0.001
Normal	0	0	2	3.13	18	28.13	0	0	5	7.81	
Excessive	0	0	0	0	7	10.93	7	10.93	10	15.63	
Carbohydrate Intake											
Severe Deficit	1	1.56	0	0	7	10.93	0	0	1	1.56	
Moderate Deficit	0	0	2	3.13	8	12.5	0	0	2	3.13	
Mild Deficit	0	0	0	0	7	10.93	2	3.13	2	3.13	0.005
Normal	0	0	1	1.56	16	25	6	9.38	6	9.38	
Excessive	0	0	0	0	0	0	0	0	3	4.69	
Physical Activity											
Light	0	0	2	3.13	14	21.88	5	7.81	10	15.63	
Moderate	1	1.56	1	1.56	17	26.56	3	4.69	3	4.69	0.045
High-Intensity	0	0	0	0	7	10.93	0	0	1	1.56	

*) Significant at p-value<0.05 (Spearman's test)

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Correlation between Protein Intake and Overnutrition

The findings indicated that the majority of students had normal protein intake, with 23 students (35.93%) falling into this category. However, among those with overnutrition status, significant figures emerged: 10 students (15.63%) were classified as obese and eight students (12.5%) as overweight status, suggesting excessive protein intake. This pattern indicates a potential correlation between excessive protein consumption and adverse nutritional outcomes. Food recall interviews further revealed that overnourished children frequently consumed two to three servings of protein-rich side dishes and snacks, such as sausages and meatballs. This increase in protein intake often accompanied higher carbohydrate consumption, leading to the accumulation of excess protein stored as fat and contributing to unwanted weight gain.

These findings are consistent with previous research, which also established a significant relationship between protein intake and nutritional status (ρ=0.000). Excessive protein intake may lead to weight gain, as surplus protein is converted into triglycerides through deamination, a process that releases nitrogen and transforms the carbon chain into acetyl-CoA. Acetyl-CoA then facilitates lipid formation, further increasing body mass[51]. Additional research found similar correlations in overweight children, with 85% of overweight respondents having adequate protein intake, suggesting a need for dietary balance[52].

Correlation between Fat Intake and Overnutrition

Among respondents with overnutrition status, seven students (10.93%) with overweight status and 10 students (15.63%) with obesity had excessive fat intake. The Spearman's correlation test revealed a ρ-value<0.001. This value indicates a significant correlation between fat intake and overnutrition among fifth-grade students at Banjarbendo State Elementary School, Sidoarjo.

Food recall interviews revealed that children with overnutrition status mostly consumed high-fat snacks such as fried foods, while only a small proportion of students consumed fat from sources such as grains and vegetables. Diets high in fried and high-fat foods may increase the risk of overnutrition. Frying methods involve the process of cooking and drying food items using oil as a heat-conducting medium. One commonly used frying technique is deep-fat frying, where food is cooked at high temperatures and submerged in oil[53].

These findings are consistent with the research by Amalia et al., which identified a correlation between fat intake and children's nutritional status (ρ-value<0.05)[54]. Ernawati et al. also reported a significant correlation between fat intake and nutritional status based on BMI-for-age in Indonesian children aged six months to 12 years[55]. Similarly, Fadillah et al. found a correlation between fat intake and nutritional status in children aged 7-12 years in Semarang City[56].

Correlation between Carbohydrate Intake and Overnutrition

This study found that the majority of students had normal nutritional status but insufficient carbohydrate intake, with a total of 22 students (34.36%). Among respondents with overweight nutritional status, six students (9.38%) with overweight nutritional status and six students (9.38%) with obesity had normal carbohydrate intake. Meanwhile, among students with obesity, three students (4.69%) had excessive carbohydrate intake. The Spearman's correlation test revealed a ρ-value of 0.005, indicating a significant correlation between overnutrition and carbohydrate intake among fifth-grade students at Banjarbendo State Elementary School, Sidoarjo.
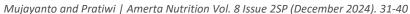
The 2x24-hour food recall interviews revealed that children with overnutrition status consumed more complex and simple carbohydrates than specified in the Nutritional Adequacy Score. The recommended fiber intake for children aged 7-12 years is 23-28 grams. Complex carbohydrates are high in fiber, minerals, and vitamins that are essential for the body, while simple carbohydrates provide quick energy. Low fiber intake and high simple carbohydrate intake indicate an imbalance in the consumption of carbohydrate types. Therefore, excessive consumption of sugary foods can increase the risk of unwanted weight gain in children. These findings are consistent with the North African Food and Nutrition Study and other studies that report a correlation between carbohydrate intake and overweight status[57–59].

Correlation between Physical Activity and Overnutrition

The findings indicated that the majority of students engaged in light physical activities, with a total of 31 students (48.45%). Among the respondents, five students (7.81%) with overweight nutritional status and 10 students (15.63%) with obesity engaged in light physical activity. The Spearman's correlation test revealed a p-value of 0.045, indicating a significant correlation between physical activity and overnutrition among fifth-grade students at Banjarbendo Elementary School, Sidoarjo. Lifestyle changes often lead to changes in diets rich in calories, fats, and cholesterol, which, without adequate physical activity, result in overnutrition problems. A diet high in calories, fats, and cholesterol needs to be balanced with physical activity to maintain a balanced nutritional status.

Active physical activity in children can affect their BMI and reduce the risk of overnutrition, as there is a balance between energy intake and expenditure. Physically active children tend to have good health as physical activity helps strengthen muscles and bones, prevents excessive weight gain, and reduces the risk of chronic diseases. Exercise does not only benefit the physical health, but also the mental health of children[60].

Most of the respondents only engaged in physical activities organized by the school once a week, especially during physical education classes. During breaks, the respondents tended to buy snacks available inside and outside the school, and spend time chatting with classmates. Outside of school hours, most respondents spent their time watching television, using gadgets, playing games, or studying. This finding is consistent with research noting that the increasing prevalence of obesity in school children is due to their tendency to spend their leisure time with activities that do not involve much energy, such as watching television. This condition lowers

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their physical activity level, which in turn contributes to an unbalanced diet[52].

The use of electronic devices is not only common among adults, but has also spread among young children. Prolonged use of these devices can lead to gadget addiction in children, visible through signs such as ignoring calls from parents and declines in academic performance. In addition, frequent gadget use can also interfere with children's development, especially in terms of physical, psychological, and social aspects. Physical development includes the growth of the body in terms of weight, height, and strength, which are the basis of later development. This study found that the physical development of children who frequently used gadgets were hindered compared to those who rarely used them. The effects include impaired brain development, red eyes due to exposure to high radiation, laziness affecting muscle growth, and weight gain that can lead to childhood obesity[61,62].

CONCLUSIONS

This study showed a significant correlation between macronutrient intake, specifically energy, protein, fat, and carbohydrate, and overweight status among fifth-grade students at Banjarbendo State Elementary School, Sidoarjo. The prevalence of overweight and obese students was higher among those with excessive energy (34.38%), protein (34.38%) and fat (35.93%) intake, with ρ-values of less than 0.001. Carbohydrate intake was also associated with overnutrition, as evidenced by 34.4% of students categorized as overnourished and a ρ-value of 0.005. In addition, physical activity level significantly influenced overnutrition status, with 48.45% of students doing light activity (Physical Activity Index=1.4) and a ρ-value of 0.045. These findings underscore the urgent need for regular monitoring of students' nutritional status and implementation of increased physical activity, such as morning exercises, to promote healthier dietary practices and reduce the risk of obesity.

AUTHOR CONTRIBUTIONS

MM: methodology, formal analysis, writing-original draft, writing-review, and editing; ERP: conceptualization, investigation, methodology, supervision, writing-original draft, writing-review, resources, and editing.

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