Relationship of Macronutrient Intake and Sedentary Activity with Overweight Status Among Primary School Children in Surabaya

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Abstract: The consequences of energy imbalance have resulted in a high prevalence of overweight students in primary schools, reaching 39.8%. Several factors contribute, including macronutrient intake and sedentary activity. This study aimed to analyze the relationship between macronutrient intake and sedentary activity among overweight primary school students. The study was conducted using a cross-sectional design. Proportional random sampling was employed to select a sample of 98 students from Pacar Kembang IV Surabaya Primary School. Data collection included parent and student characteristics, macronutrient intake (assessed using a semi-quantitative food frequency questionnaire), and sedentary activity (measured using a sedentary behavior questionnaire). Bivariate analysis was conducted using the Chi-Square test and the contingency coefficient relationship. Most respondents with high levels of sedentary activity (44.4%), excessive intake of energy (50%), protein (44.8%), fat (51.9%), and carbohydrates (46.2%) were overweight. The bivariate analysis revealed no relationship between energy intake ($p = 0.189$), fat intake ($p = 0.236$), carbohydrate intake ($p = 0.279$), and sedentary activity ($p = 0.414$) with overweight. However, a relationship was found between protein intake and overweight status ($p = 0.036$, $r = 0.252$). A higher protein intake is associated with an increased likelihood of being overweight. On the other hand, there is no relationship between intake of energy, fat, carbohydrate, and sedentary activity and being overweight.

1 INTRODUCTION

Obesity and overweight have become major health problems worldwide, with a huge increase in prevalence. Global obesity rates have tripled since 1975, according to the World Health Organization (WHO, 2021). This increase is due to changes in dietary patterns, lifestyles, and environmental impacts (Ermona & Wirjatmadi, 2018). Ng et al. (2014) conducted a study that highlighted the increasing prevalence of obesity in Indonesia and underlined the need for focused interventions. As one of the big cities in Indonesia, Surabaya illustrates the increasing obesity rates in Indonesia.

Overweight is not solely an issue affecting adults but has become a significant health concern among children as well. Based on data from the World Health Organization (WHO) for 2021, there were 340 million schoolchildren who were overweight. From 2010 to 2018, there was an increase in the prevalence of overweight in school-age children in Indonesia by 9.2%, 18.8%, and 20% (Kemenkes RI, 2018). Data from Riskesdas (2013) showed that the prevalence of obesity in East Java was higher than the national prevalence rate of 19.3% and reached 24.27% in 2018. This figure will continue to increase, especially among school-aged children in Surabaya.

Childhood overweight is a major public health concern, as it is associated with the onset of many health problems. Overweight children are more prone to developing chronic diseases such as type 2 diabetes, cardiovascular disease, and metabolic syndrome early in life (Singh et al., 2008). Childhood obesity may have an impact on academic achievement. Taras and Potts-Datema (2005) found that overweight and obese students had difficulty concentrating in class, leading to lower academic achievement. Childhood overweight and obesity have far-reaching consequences due to the risk of intergenerational transmission. Robinson et al. (2015)

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found that children who grow up to be obese have a higher likelihood of becoming obese adults, so the cycle continues. Thus, it is important to study the phenomenon of obesity in school-aged children.

The physical size of a person is closely tied to their nutritional health. As a result, anthropometric measurements are good and reliable for assessing nutritional status (Gibson, 2005). BMI for age can be used as a simple technique to assess nutritional status. According to the Indonesian Ministry of Health in 2020, overweight status is indicated by the body mass index according to age, which is > +1 SD. Based on the World Health Organization standard for 2021, the age of schoolchildren ranges from 7 to 15 years. Meanwhile, the Indonesian Ministry of Health's forecast for 2017 ranges from 7 to 12 years.

Maisyarah et al. (2021) state that the nutritional status of school-age children can be caused by direct and indirect factors. Direct factors such as environmental, economic, and socio-cultural factors. Meanwhile, indirect factors such as genetics, religion, medical history, and nutrient intake Suharsa & Sahnaz (2016) stated that most overweight children are caused by excessive macronutrient intake and a lack of physical activity.

Nutrient intake is a necessity for school-age children in the process of growth and development. Children who eat more frequently, in larger portions, less varied food, and are not nutritionally balanced tend to be overweight (Hardinsyah & Supariasa, 2016). Previous research at SDN Pacar Kembang I Surabaya showed that children with overweight status consumed more macronutrients than average, namely energy (24.3%), protein (28.8%), fat (24.24%), and carbohydrates (21.21%) (Qamariyah & Nindya, 2018). Therefore, school-age children are encouraged to consume foods that provide sufficient energy through protein, fat, and carbohydrate sources to grow and develop, as well as move well every day (Sutriani & Ngadiarti, 2013).

A systematic review by Tremblay et al. (2011) states that today's modern environment greatly reduces children's opportunities for physical activity. The convenience of transportation, computers, and television has encouraged lazy living habits. Sedentary activity is an activity that involves little or no body movement, which can affect nutritional status (Rahmad et al., 2021). It is explained that long-term inactivity can lead to an energy imbalance where energy input exceeds energy production, which can affect children's nutritional status (Amrynia & Prameswari, 2022).

While some literature has studied the relationship between macronutrient intake, physical activity, and overweight in children globally, few studies have specifically focused on the context of school-aged children, particularly primary schools. This research gap aims to identify the factors contributing to childhood overweight in this specific context, considering culture, environment, and lifestyle. Based on this description, this study aims to analyze the relationship between macronutrient intake, sedentary activity, and overweight in schoolchildren at Pacar Kembang IV Surabaya Primary School.

2 SUBJECTS & METHODS

This study was an analytic observational study with a cross-sectional design. The present study allowed for the examination of associations and relationships between variables within a specific timeframe from February to June 2022. The selection of Pacar Kembang IV Primary School in Surabaya as the research site was purposeful and based on a representation of the target population. This school was chosen due to the diverse composition of students in grades 3, 4, and 5, thus providing a comprehensive sample to draw meaningful conclusions.

Proportional random sampling was conducted exclusively at the school level to ensure a balanced representation of children across different grade levels. A sample size of 98 children was determined using this technique, with 37 children from grade 3, 37 children from grade 4, and 24 children from grade 5, contributing to the overall diversity of the group.

Data collected included characteristics of parents and schoolchildren, macronutrient intake, and sedentary activity. The independent variables studied were macronutrient intake (energy, fat, protein, and carbohydrate) and sedentary activity. Macronutrient intake was obtained from main meals and snacks obtained from the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ).

Before this study, the SQ-FFQ underwent validation procedures. The compilation of foods utilized in the questionnaire was curated through observations and discussions with several schoolchildren at Pacar Kembang IV Primary School, Surabaya. Macronutrient intake from SQ-FFQ was calculated through a Nutrisurvey application with the Indonesian Food Composition Database and then compared with the recommended Nutrition Adequacy Rate (RDA) according to age. The data were then grouped based on the WNPG in 2014, namely insufficient if <80% of the RDA, sufficient if 80–110% of the RDA, and excessive if >110% of the RDA.

Sedentary activity was measured through interviews using the Sedentary Behavior Questionnaire (SBQ), which was divided into two questionnaires (weekday and weekend) with a total of 18 questions. The dependent variable in this study was nutritional status. The nutritional status is determined by the calculation of the weight and height of school-age children, which is then calculated with an age-adjusted BMI to determine the Z-score. The measurement results were processed using the WHO AnthroPlus application, and then the data was grouped into BMI for age categories, including overweight if > +1SD and not overweight if ≤ +1SD (Kemenkes RI, 2020). Furthermore, the data was analyzed using the Chi-Square test and relationship of contingency coefficients in the SPSS application, then presented in tables and narratives to describe the study results.

3 RESULTS

3.1 Characteristics

The characteristics of school children studied included age, gender, and pocket money. Based on Table 1, the average age of school children was 10.2 (± 0.9) years old, with a range of 9–12 years old. Most of the school children were 10-year-old school children totaling 43.9%. More than half (54.1%) of the children were girls.

The average pocket money of school children was Rp. 5,000 (± Rp1,877.7), the minimum value was Rp. 2000, and the maximum value was Rp. 10,000. Then grouping was done based on the mean results consisting of school children's pocket money per day more if ≥ Rp. 5,000 and school children's pocket money per day less if < Rp. 5,000. Based on Table 1, almost all schoolchildren have pocket money ≥ Rp. 5,000, which is 77.6%.

Schoolchildren's nutritional status is obtained through measurements of body weight and height, then calculated using the WHO AnthroPlus application and viewed based on BMI/A. Nutritional status is categorized based on Permenkes RI 2020, namely underweight if the BMI/A Z-score is -3SD to <-2SD, normal if the Z-score is BMI/A -2SD to +1SD, overweight if the Z-score is BMI/A +1SD to +2SD, and obese if the BMI/A Z-score is >+2SD. The average nutritional status of schoolchildren was normal, with an IMT/U Z-score value of 0.15 SD ± 1.88 SD. Based on Table 1, most schoolchildren had normal nutritional status, which is 46.9%; 21.4% were overweight; 18.4% were obese; and 13.3% were underweight.

This study also examined the characteristics of parents, including their latest education, occupation, and family income. The latest education of parents is categorized into not going to school, primary school, junior high school, senior high school, and diploma or bachelor. Table 2 showed that most of the parents with the latest education were in senior high school, with 71.4% of fathers and 60.2% of mothers.

Furthermore, the types of employment of parents are grouped into does not work, civil servant, entrepreneur, and employee. It showed in Table 2 that most respondents' fathers' occupations were employees (57.1%). Meanwhile, more than half (52%) of the mothers were not working.

Income in this study is the income earned by the families of schoolchildren within one month. The family income was categorized based on the Surabaya city minimum wage. It was high if ≥ Surabaya minimum wage (≥ Rp. 4,375,479.00) and low if < Surabaya minimum wage (< Rp. 4,375,479.00). The average family income of schoolchildren was Rp. 4,061,377.5 (± Rp. 2,390,687.1). Table 2 shows that more than half (67.3%) of the schoolchildren's family income was lower than the Surabaya minimum wage (< Rp. 4,375,479.00).

Table 1: Distribution of Children Characteristics at Pacar Kembang IV Surabaya Primary School in 2022.

School Children Characteristics	n	%	Mean±SD
Age (year)			
9	23	23,5	
10	43	43,9	10,2 ± 0,9
11	25	25,5	
12	7	7,1	
Gender			
Boy	45	45,9	-
Girl	53	54,1	
Pocket Money			
< Rp. 5.000	22	22,4	Rp. 5.000 ± Rp. 1.877,7
≥ Rp. 5.000	76	77,6	
Z-Score (BMI for Age)			
- 3SD to - 2SD (*Underweight*)	13	13,3	0,15 ±1,88

School Children Characteristics	n	%	Mean±SD
- 2SD to + 1SD (Normal)	46	46,9	
+ 1SD to + 2SD (*Overweight*)	21	21,4	
> + 2SD (Obesity)	18	18,4	

Table 2: Distribution of Parent Characteristics at Pacar Kembang IV Primary School Surabaya in 2022.

Parent Characteristics	Father		Mother	
	n	%	n	%
Education				
Not going to school	0	0	3	3,1
Primary school	7	7,1	2	2
Junior high school	9	9,2	20	20,4
Senior high school	70	71,4	59	60,2
Diploma/Bachelor	12	12,2	14	14,3
Occupation				
Does not work	10	10,2	51	54
Civil servant	5	5,2	4	4,1
Entrepreneur	27	27,6	19	19,4
Employee	56	57,1	24	24,5
Family Income	**n**	%	**Mean**	
High (≥ UMK)	32	32,7	Rp. 4.061.377,5	
Low (< UMK)	66	67,3	(± Rp. 2.390.687,1)	

Table 3: Distribution of Nutritional Status, Macronutrient Intake, and Sedentary Activity of Pacar Kembang IV Primary School Surabaya Children in 2022.

Variable	n	%
Nutritional Status		
Overweight (BMI for Age > + 1SD)	39	39,8
Not Overweight (BMI for Age ≤ + 1SD)	59	60,2
Daily Food Intake	**Mean**	
Energy (kcal)	1876,77 ± 579,05	
Protein (gram)	71,89 ± 27,46	
Fat (gram)	53,65 ± 22,03	
Carbohydrates (gram)	277,75 ± 86,53	
Energy Intake (kcal)		
Insufficient (<80% RDA)	28	28,6
Sufficient (80-110% RDA)	30	30,6
Excessive (>110% RDA)	40	40,8
Protein Intake (gram)		
Insufficient (<80% RDA)	9	9,2
Sufficient (80-110% RDA)	22	22,4
Excessive (>110% RDA)	67	68,4
Fat Intake (gram)		
Insufficient (<80% RDA)	47	48,0
Sufficient (80-110% RDA)	24	24,5
Excessive (>110% RDA)	27	27,6
Carbohydrate Intake (gram)		
Insufficient (<80% RDA)	26	26,5
Sufficient (80-110% RDA)	33	33,7
Excessive (>110% RDA)	39	39,8
Sedentary Activity		
High (≥ 6 hours per day)	45	45,9
Low (< 6 hours per day)	53	54,1

3.2 Nutritional Status, Macronutrient Intake, and Sedentary Activity

The nutritional status of schoolchildren obtained from BMI for age is categorized into two categories. Overweight if the BMI/A Z-score was > +1SD and not overweight if the BMI/A Z-score was ≤ +1SD. Presented in Table 3, the nutritional status of schoolchildren at Pacar Kembang IV Primary School Surabaya was overweight, which was 39.8%.

The dietary intake of schoolchildren in this study was obtained from their daily food intake. Based on the results of interviews using SQ-FFQ, the average intake of energy, protein, fat, and carbohydrates from schoolchildren's daily meals was obtained. Based on Table 3, the average intake of energy, protein, fat, and carbohydrates from the daily diet of schoolchildren is 1876.77 kcal ± 579.05; 71.89 grams ± 27.46; 53.65 grams ± 22.03; and 277.75 grams ± 86.53.

Furthermore, macronutrient intake was obtained from the sum of daily food intake within the last 30 days using the SQ-FFQ method. Table 3 shows that most of the schoolchildren's energy, protein, and carbohydrate intake was excessive, which amounted to 40.8%, 68.4%, and 39.8%. Meanwhile, fat intake was mostly insufficient, at 48%.

The sedentary activity score of schoolchildren was obtained from sedentary activity during the past week in hours per day. This study showed that the average sedentary activity of schoolchildren was 5 hours and 57 minutes, so sedentary activity was categorized as high if ≥6 hours per day and low if <6 hours per day. Table 3 indicated that more than half of the schoolchildren, or 54.1%, had low sedentary activity.

3.3 Relationship Between Variables

Macronutrient intake is the total intake of energy, protein, fat, and carbohydrates from food per day. The nutritional status of schoolchildren was analyzed using the Chi-Square test. Based on Table 4, schoolchildren with excessive daily intakes of energy (50%), fat (51.9%), and carbohydrate (46.2%) were overweight. Meanwhile, children with insufficient daily intake of energy (71.4%), fat (68.1%), and carbohydrate (73.1%) were not overweight.

The p-values from the Chi-Square test described in Table 4 were energy (0.189), fat (0.236), and carbohydrate (0.279), where the p-value >0.05. This showed that there was no significant relationship between energy, fat, and carbohydrate intake and overweight among primary school children.

Schoolchildren with excessive daily protein intake (44.8%) were overweight. Meanwhile, schoolchildren with insufficient (100%) and adequate (59.1%) daily protein intake were not overweight. Table 4 below shows that the p-value of the protein Chi-Square test was (0.036), where the p-value was <0.05, so there was a significant association between protein intake and overweight status. In addition, the correlation value of the contingency coefficient (r) was shown to be 0.252, meaning that the protein intake variable had a low strength of association with the incidence of overweight status.

The last result in Table 4 showed that the difference in sedentary activity of children in the high and low groups was not much different, which were 20.4% and 19.4%, where both schoolchildren had an overweight status. The Chi Square test for sedentary activity and overweight status resulted in a p-value of 0.414, which was >0.05, so there was no significant relationship between sedentary activity and overweight status.

Table 4: Relationship between Macronutrient Intake and Sedentary Activity with Nutritional Status School Children at Pacar Kembang IV Primary School Surabaya in 2022.

Variable	Nutrition Status				Total		P-*value*	*r*
	Overweight		Not Overweight					
	n	%	n	%	N	%		
Energy Intake								
Insufficient (<80% RDA)	8	28,6	20	71,4	28	100	0,189	-
Sufficient (80-110% RDA)	11	36,7	19	63,3	30	100		
Excessive (>110% RDA)	20	50,0	20	50,0	40	100		
Protein Intake								
Insufficient (<80% RDA)	0	0,0	9	100	9	100	0,036	0,252
Sufficient (80-110% RDA)	9	40,9	13	59,1	22	100		
Excessive (>110% RDA)	30	44,8	37	55,2	67	100		
Fat Intake								
Insufficient (<80% RDA)	15	31,9	32	68,1	47	100	0,236	-
Sufficient (80-110% RDA)	10	41,7	14	58,3	24	100		
Excessive (>110% RDA)	14	51,9	13	48,1	27	100		
Carbohydrate Intake								
Insufficient (<80% RDA)	7	26,9	19	73,1	26	100	0,279	-
Sufficient (80-110% RDA)	14	42,4	19	57,6	33	100		
Excessive (>110% RDA)	18	46,2	21	53,8	39	100		
Sedentary Activity								
High (≥ 6 hours per day)	20	44,4	25	55,6	45	100	0,414	-
Low (< 6 hours per day)	19	35,8	34	64,2	53	100		

4 DISCUSSIONS

Schoolchildren at Pacar Kembang IV Surabaya Primary School have an average age of 10.2 years, in the range of 9–12 years. Children aged 9–12 years are in pre-adolescence, with an age division of 9–12 years for girls and 10–12 years for boys. This age is a crucial time to maintain a good intake to support growth and development (Brown et al., 2017).

In this study, it was found that most children had pocket money greater than Rp. 5,000. The higher the pocket money of schoolchildren, the higher their ability to buy food, thus affecting their intake (Desi et al., 2018). This can be influenced by the occupation of parents, which is related to the amount of family income. If the family income is high, then the pocket money given to children is also high. However, this does not necessarily fulfill the food intake given to children according to their needs (Wicaksana & Nurrizka, 2019). The latest education of parents indirectly affects the nutritional status of school children. The higher the education of the parents, the more favorable the variety and amount of food given to the family (Jannah & Utami, 2018).

In this study, 60.2% of schoolchildren had overnutrition or were overweight. Compared to the obesity rate of 18% reported by the WHO in 2021, the nutritional status rate in this study was higher at 39.8%. 6 Abnormal nutritional status occurs due to an imbalance between nutrient intake and the body's needs (Par'i et al., 2017).

Dietary intake in this study showed that schoolchildren with overnutrition and undernutrition had less fat intake and more protein intake. The mean daily energy intake from food was 1876.77 kcal, which was less than the Energy Adequacy Rate required for boys and girls aged 10 to 12 years (2000 kcal and 1900 kcal, respectively) but more than the Energy Adequacy Rate for children aged 7-9 (1650 kcal). The daily protein requirement of school-age children was 71.89 grams, higher than the recommended protein adequacy rate for boys and girls aged 9 to 12 years (40 grams, 50 grams, and 55 grams). A total of 53.65 grams of fat were consumed by the children daily, which is less than the Fat Adequacy Intake of 55 grams and 65 grams for both boys and girls aged 9 to 12 years. Carbohydrate intake from the daily diet of schoolchildren is 277.7 grams, which exceeds the needs of schoolchildren aged 7-9 years (250 grams) but is still less than the needs of the Carbohydrate Adequacy Rate for children aged 10 to 12 years for both boys and girls, which is 300 grams and 280 grams.

This study shows that there is no relationship between energy, fat, and carbohydrate intake and overnutrition status, and there is a relationship between protein intake and overnutrition status. This happened because the SQ-FFQ instrument questionnaire has limitations so that the results of energy, protein, fat, and carbohydrate intake from daily meals depend on memory and do not describe the actual food consumption of schoolchildren. The physical activity of schoolchildren in this study mostly had low sedentary activity, meaning moderate to high activity levels. There was no relationship between energy, fat, and carbohydrate intake and overnutrition because energy derived from food is used for physical activity. This means that energy is obtained through food consumption and expended through physical activity (Sari et al., 2018).

Meanwhile, there is a relationship between protein intake and overnutrition because protein is used for growth and development as well as physical activity. The types of proteins that support children's activity are actin, myosin, dynein, and tubulin. Protein plays a role in converting chemical energy into mechanical energy involved in movement. The protein acts as a catalyst in the decomposition of ATP as an energy source for activity (Suhartono, 2017). Physical activity is all body movement due to muscle contraction, and one of the functions of protein is to play a role in muscle contraction. Muscle contraction occurs due to the interaction between actin and myosin muscle proteins that require ATP with the help of enzymes known as ATPase enzymes (Welis & Rifki, 2013). So, protein intake affects nutritional status through growth and development.

This study shows there is no significant relationship between sedentary activity and overweight status. The results of the study are not related because schoolchildren who are overweight or not overweight have moderate to high levels of physical activity. Schoolchildren go to school and return home from school on foot, play soccer on the sports field, and do extracurricular activities such as dance, poetry, and samroh. When doing activity, calories are burned, which can affect the basal metabolic system (Tanjung & Bate'e, 2019). Therefore, sedentary activity is not associated with overweight status because schoolchildren still engage in high- to moderate-level physical activity in their daily lives. As a result, the basal metabolism of schoolchildren increased.

This study certainly has both strengths and weaknesses. Its main strengths lay in its comprehensive approach, using a large and diverse sample population, and using standardized

measurement tools. However, the weaknesses of this study may be due to the limited dietary data, which may lead to recall bias among schoolchildren. In addition, the cross-sectional design of this study made it challenging to determine cause-and-effect relationships. The lack of association between macronutrient intake and obesity could be attributed to the complexity of individual metabolic responses, genetic factors, or the need for a more nuanced analysis of diet rather than isolated macronutrients. Similarly, the absence of a significant association between sedentary activity and obesity could be influenced by factors such as compensatory physical activity at other times, individual variation in metabolic rate, or the need for a more nuanced exploration of sedentary behavior beyond a simple dichotomy. These limitations underscore the importance of considering different approaches and recognizing the intricacies of dietary and activity influences on overweight and obesity.

5 CONCLUSIONS

Macronutrient intake of energy, fat, carbohydrate, and nutritional status did not have a significant correlation with overweight in this research. However, there was a substantial correlation between protein intake and overweight. Being overweight results from a higher intake of protein from the daily diet, which is a macronutrient. There was no significant correlation between sedentary activity and overweight.

The study suggests that protein intake, rather than overall macronutrient composition or sedentary activity, is significantly correlated with overweight in school-age children. This highlights the importance of considering protein consumption as a potential factor in understanding childhood overweight and obesity, while emphasizing the need for further investigation into a broader range of variables.

Further research is needed into variables that may be associated with the prevalence of overweight in school-age children, ranging from internal variables that influence nutritional status, such as genetics and family history of obesity, to external variables that influence sedentary activities, such as technology, physical activity, and sedentary hobbies.

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