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ANALYSIS OF DETERMINANTS OF OBESITY IN ADOLESCENT GIRLS IN BOGOR DISTRICT: A CASE-CONTROL STUDY

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ABSTRACT

Adolescent obesity is a growing public health issue globally and in Indonesia, particularly among girls aged 16–18 in the Bogor district. Despite this trend, the determinants of obesity in this population remain underexplored. This study aims to identify and analyze the risk factors associated with obesity among adolescent girls in the Bogor district using a case-control approach. An observational analytical study with a case-control design was conducted from May to September 2024, involving 104 adolescent girls aged 16–18 selected through simple random sampling. Data on anthropometry, dietary intake, physical activity, sleep duration, and family socioeconomic status were collected via validated questionnaires and analyzed using chi-square and logistic regression tests. Multivariate analysis identified five significant risk factors for obesity: excessive energy intake (OR=12.566), high family income (OR=3.494), low maternal education (OR=0.246), short sleep duration (OR=0.183), and low fiber intake (OR=0.087). Energy intake emerged as the most influential determinant. Other factors like physical activity, maternal employment, and protein intake were not statistically significant. The findings emphasize the need for targeted interventions focusing on balanced nutrition education, particularly among families with higher incomes and lower maternal education levels. Future research should explore the effectiveness of school-based and parent-involved nutritional interventions tailored to socioeconomic differences to prevent obesity from persisting into adulthood.

KEYWORDS Adolescent girls, obesity, risk factors

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INTRODUCTION

Obesity in adolescence is a significant ongoing public health problem that affects both developing and developed countries (Shrivastava et al., 2014). The incidence of obesity rises sharply during adolescence, particularly between the ages of 10 and 19 years (Habbab & Bhutta, 2020). Adolescents with obesity are five

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times more likely to develop obesity in adulthood compared to adolescents without obesity (Simmonds et al., 2016). Furthermore, adolescent obesity strongly predicts increased mortality risk in adulthood (Nicolucci & Maffeis, 2022). It is estimated that the global prevalence of adolescent obesity will increase by 60% over the next decade, reaching 250 million by 2030, which will negatively impact global public health systems (Ma et al., 2022). Adolescent obesity is rapidly rising, especially in East, South, and Southeast Asia (Lai et al., 2022).

Indonesia is the country ranked fourth with the highest prevalence of adolescent obesity worldwide (Allegranzi et al., 2021). According to the National Basic Health Research (Riskesdas) in 2018, the prevalence of obesity among adolescents aged 16-18 in Indonesia was 4%, showing an upward trend compared to 1.6% in 2013. One of the provinces with a relatively high prevalence of obesity in adolescents aged 16-18 is West Java. The population of West Java is approximately 49 million people, with a significant portion residing in the Bogor district. Most of the population in the Bogor district falls within the adolescent age group, namely aged 15-24 years. Bogor district has a higher than the national average prevalence of obesity among adolescents aged 16-18 years, reaching 5.72%. Obesity prevalence in adolescents aged 16-18 is higher among girls, at 5.72%, compared to boys, at 3.31% (Riskesdas, 2018). Adolescent girls are at 0.5 times greater risk of obesity than boys (Nugroho, 2020). Adolescent girls are at a greater risk of obesity compared to boys, mainly due to the influence of hormones, particularly estrogen. During puberty, girls experience significant hormonal changes that affect body composition and fat distribution. Estrogen promotes the accumulation of subcutaneous fat, which is generally less harmful than visceral fat but can still contribute to overall obesity. Additionally, hormone fluctuations can lead to increased appetite and altered metabolism (Leeners et al., 2017).

Despite its increasing prevalence each year and its detrimental impact on health, adolescent obesity in girls is caused by multiple factors. In general, the risk factors contributing to obesity in adolescent girls are classified into two categories: modifiable and non-modifiable risk factors (Ang et al., 2013)Adolescent obesity is associated with modifiable risk factors, including physical activity, dietary intake, sleep duration, family socioeconomic status, and pocket money. On the other hand, non-modifiable risk factors include a family history of obesity.

Although cross-sectional studies have been conducted on the prevalence of overweight and obesity among adolescents, research examining the determinants using a case-control study design remains limited (Kedir et al., 2022). Moreover, the risk factors for overweight and obesity vary across regions due to differences in socioeconomic, cultural, ethnic, and geographical characteristics (Strugnell et al., 2020). No documented reports exist on the determinants of obesity among adolescent girls in the Bogor district area.

This study analyzed the factors associated with overweight/obesity in adolescent girls in the Bogor district. The novelty of this research lies in its regional specificity, study design, and comprehensive risk factor analysis. While previous studies have addressed adolescent obesity in broader or international contexts (e.g., Lai et al., 2022; Kedir et al., 2022), this study is the first to conduct a case-control analysis focusing specifically on adolescent girls in Bogor district, a region with

one of the highest obesity rates in Indonesia. Unlike other studies that predominantly use cross-sectional designs, this study applies a case-control method, enabling a more accurate identification of causal risk factors. Moreover, it integrates nutrient-specific intake analysis (energy, fat, carbohydrate, protein, and fiber) and socioeconomic variables (family income, mother's education, sleep duration, and physical activity) to assess their combined and individual effects. The identification of energy intake as the primary determinant with an odds ratio of 12.566 provides strong, localized evidence supporting targeted intervention strategies in the region, which was previously undocumented.

METHODS

This study was observational, analytical research with a case-control design. This study was conducted from May to September 2024, at a Senior High School in the Bogor district. This study has been conducted based on the Health Research Ethics Commission of the Faculty of Nursing Universitas Airlangga, Number 3252-KEPK. The sample size was counted using the case-control formula based on Ismail et al., 2022 (Ananda Ismail et al., 2022). The number of potential dropouts was increased by 10%, resulting in a total sample size. The total number of subjects in each case and control group of 52 participants was 104. The sample was taken using simple random sampling. The inclusion criteria included adolescent girls aged 16-18 years old with approval from themselves and no comorbidities. Subjects with BMI-for-age z-score >+1SD (obesity) as the case group and subjects who did not have obesity (-2SD < z-score < +1SD) as a control group. The independent variables in this study were age, physical activity, sleep duration, pocket money, parents' education, job status, family income, family history of obesity, and nutrient intake. The dependent variable in this study was the incidence of obesity in adolescent girls.

Collected data were subject characteristics (age, height, weight, nutritional status, pocket money, sleep duration, physical activity), family characteristics (education, employment status, income, and history of obesity), and nutrient intake. Data collection involved direct anthropometric measurement using a digital scale with an accuracy of 0.1 kg for weight and a microtoise with an accuracy of 0.1 cm for height. Data on physical activity were collected through an interview using the *Physical Activity Questionnaire for Adolescents* (PAQ-A). Activity level was categorized based on the PAQ-A Scoring Protocol, in which physical activity score 1 -2,3 was categorized as light physical activity, 2,4 – 3,7 were categorized as medium physical activity, and 3,8 – 5 were categorized as high physical activity. Data on nutrient intake were obtained through an interview using the Semi-Quantitative *Food Frequency Questionnaire* (SQ-FFQ). Analysis of energy, carbohydrate, fat, protein, and fiber intake using the Nutrisurvey 2005 application. The cut-off point of fiber intake is based on the recommended dietary allowance *(RDA) from the Ministry of Health of the Republic of* Indonesia. The level of macronutrient intake was divided into two categories: over intake (>100% of individual need) and adequate (<100 % of individual need). Meanwhile, the level of fiber intake was divided into two categories: inadequate (<19 g/day) and normal

(≥19 g/day)(Kurdanti1 & , Isti Suryani , Nurul Huda Syamsiatun , Listiana Purnaning Siwi , Mahardika Marta Adityanti , Diana Mustikaningsih, 2015).

Data was entered in Microsoft Excel and analyzed using SPSS software version 22. Bivariate analysis used the chi-square test, and multivariate analysis used the logistic regression test. Multivariate analysis was performed to determine the most significant obesity risk factors using logistic regression.

RESULTS AND DISCUSSION

The study was conducted on 104 adolescent girls aged 16-18, consisting of 52 obese and non-obese adolescent girls. The characteristics of the subjects studied in this research include age, pocket money, sleep duration, and physical activity. The distribution of subjects based on these characteristics can be seen in Table 1.

Table 1. Bivariate analysis of the characteristics of subjects by group

Characteristics	n(%)		*p-value*
	Control	Case	
Age			
16	18(35)	13 (25)	0.142
17	32 (61)	33 (63)	
18	2 (4)	6 (12)	
Sleep duration			
< 7 hours	25 (48)	38 (73)	0.009*
≥ 7 hours	27 (52)	14 (24)	
Pocky money			
< Rp. 20.000	11 (21)	7 (13)	0.302
≥ Rp. 20.000	41 (79)	45 (87)	
Physical activity			
Low	19 (36)	34 (65)	0.006*
Medium	30 (58)	18 (35)	
High	3 (6)	0 (0)	

Based on **Table 1,** it can be seen that the majority of participants were 17 years old in both the control (61%) and case groups (63%). Regarding the pocket money variable, most participants received more than Rp. 20.000 in the control (79%) and case groups (87%). Statistical analysis using the chi-square test revealed no significant association between age or pocket money and the incidence of obesity ($p>0.05$). This finding is consistent with other studies that reported no association between the amount of pocket money and nutritional status. Adolescents do not always spend all their pocket money on snacks; a large portion is allocated for savings or school-related needs. Therefore, the amount of pocket money received does not necessarily influence adolescents' nutritional status (Kasmarini et al., 2023)**.**

However, there is a significant relationship between sleep duration and physical activity with the incidence of obesity in adolescent girls ($p<0.05$). In the control group, most participants slept 7 hours or more (48%), whereas in the case group, most participants slept less than 7 hours (73%). Additionally, the case group had a higher proportion of participants with low physical activity levels (65%) compared to the control group, which had a higher proportion of participants with moderate activity levels (58%). Sleep duration

plays a crucial role in regulating leptin and ghrelin hormones, where short sleep disrupts this balance, increasing appetite through elevated ghrelin and reduced leptin levels, which leads to a greater likelihood of consuming junk food and contributes to obesity (Rachmania Eka Damayanti et al., 2019). Furthermore, physical activity plays a key role in fat metabolism and weight loss, as it helps the body use stored energy, reducing the risk of obesity and preventing sedentary-related diseases (Bourdier et al., 2023). In contrast, low physical activity slows metabolism, leading to fewer calories being burned and more being stored, which further contributes to obesity (Suha & Rosyada, 2022).

Table 2. Bivariate analysis of the characteristics of the family by group

Characteristics	n(%)		*p-value*
	Control	Case	
Father's education			
Unschooled	2(4)	1(2)	0.524
Elementary school	3(6)	2(4)	
Junior high school	4(8)	3(6)	
Senior high school	21(40)	15(28)	
Graduate degree	22(42)	31(60)	
Mother's education			
Unschooled	1(2)	1(2)	0.013*
Elementary school	7(14)	11(21)	
Junior high school	10(19)	23(44)	
Senior high school	23(44)	9(17)	
Graduate degree	11(21)	8(16)	
Father's employment status			
Employed	48(92)	50(93)	
Unemployed	4 (8)	2(7)	
Mother's employment status			
Employed	8(15)	17(33)	
Unemployed	44(85)	35(67)	
Family income			
< Rp. 2.000.000	1(2)	5(10)	
Rp. 2.000.001 – 5.000.000		16(31)	
Rp. 5.000.001 – 7.500.000	3(6)	18(35)	
Rp. 7.500.001 – 10.000.000	9(17)	34(65)	0.039*
> Rp. 10.000.000	43(83)	11(21)	
Maternal history of obesity			
Yes	10(19)	41(79)	0.044*
No	42(81)		
Paternal history of obesity			
Yes	7(14)	8(15)	0.400
No			

			0.044*
			0.807

Based on **Table 2**, there was no association between father's education, father's employment status, and paternal history of obesity with the incidence of obesity in adolescent girls ($p>0.05$). On the other hand, there is a significant association between mother's education, mother's employment status, maternal history of obesity, and family income with the incidence of obesity in adolescent girls ($p<0.05$). lower maternal education and employment were linked to higher obesity risk, as mothers with lower education levels may have less access to health-related information, and employed mothers may have less time to monitor their children's eating habits, leading to unhealthy behaviors (Kamaruddin et al., 2023).

Additionally, adolescent girls with a maternal history of obesity were at higher risk of obesity, suggesting both genetic and environmental influences. Shared dietary habits, physical activity patterns, and health behaviors within the family likely contribute to this relationship. The study highlights how family dynamics, such as maternal health and employment, can play a role in shaping adolescents' obesity risk (Ainun & Simbolon, 2024).

The study also revealed that higher family income is associated with an increased risk of obesity in adolescent girls. In the case group, many families earned more than Rp. 10.000.000 compared to the control group. This correlation between income and obesity may be due to greater access to energy-dense foods and sedentary lifestyles (Ali & Nuryani, 2018). These findings emphasize the importance of public health strategies aimed at improving dietary practices and promoting healthier lifestyles, particularly among higher-income families (Mesawa et al., 2020).

Table 3. Bivariate analysis of energy, fat, carbohydrate, and fiber intake by group

Nutrient intake	n(%)		*p-value*
	Control	Case	
Energy intake			
Adequate	38(73)	15(29)	0.001*
Excessive	14(27)	37(71)	
Protein intake			
Adequate	37(71)	27(52)	0.044*
Excessive	15(29)	25(48)	

Fat intake			
Adequate	32(62)	20(38)	0.019*
Excessive	20(38)	32(62)	
Carbohydrate intake			
Adequate	45(87)	30(58)	0.001*
Excessive	7(13)	22(42)	
Fiber intake			
Adequate	42(81)	49(94)	0.038*
Excessive	10(19)	3(6)	

Nutrient intake among adolescent girls is detailed in **Table 3**. The study found that 71.2% of obese adolescent girls had a high energy intake, with a significant correlation between energy intake and obesity ($p<0.05$). This finding aligns with research by Lulu et al. (2024), which also identified a relationship between energy intake and central obesity ($p=0.04$) (Luthfiya et al., 2024). Theoretically, obesity arises from a long-term energy imbalance between intake and expenditure, where excess energy results from low physical activity and the consumption of high-energy foods like fast food, ultimately leading to fat storage (Zou et al., 2023).

Additionally, fat intake was correlated with obesity ($p<0.05$), as 61.8% of obese adolescent girls consumed more than the *recommended daily allowance* (RDA) for fat. In contrast, 61.8% of non-obese adolescent girls consumed less than the RDA for fat. The study indicated that high-fat consumption was common among the participants, with many consuming fried foods and snacks. This is consistent with Ago et al. (2022), who reported a significant relationship between fat consumption and obesity ($p=0.035$) (Harlim et al., 2022). Adolescents with higher fat intake levels are 2.34 times more likely to be overweight or obese (Muriyati et al., 2023). Fat provides more energy than carbohydrates or proteins. A high-fat diet can cause increased fat stores as a metabolic response to increase fat oxidation. Thus, fat imbalance is a main correlate of energy balance, making fat imbalance a primary factor in energy imbalance (Alfieri et al., 1997).

The study found a relationship between carbohydrate intake level and obesity ($p<0.05$). Obese adolescent girls had significantly higher intake of carbohydrate compared to non-obese adolescent girls. The findings of this study are consistent with research conducted by Fajriyah et al., 2020, where as many as 65.7% of adolescents with excess carbohydrate intake are found in adolescents with obesity. Adolescents with excess carbohydrate intake are 5.5 times as likely to be obese (Fajriyah et al., 2020). Excessive consumption of carbohydrates will cause obesity. Carbohydrates consumed will be broken down into glucose and stored in glycogen in the liver and as fat. When needed, for example, in a state of hypoglycemia, glycogen will be broken down through gluconeogenesis. Carbohydrates are the primary source of macronutrients for the body; if the intake of carbohydrates is excessive, the cells can convert carbohydrates into fat. Carbohydrates that enter through food intake must be balanced with the body's needs. An imbalance in carbohydrate intake that enters the body can last for a long time, causing nutritional problems, including obesity (Ainun & Simbolon, 2024).

There was also a significant relationship between protein intake and obesity ($p<0.05$), supporting findings from Roba et al. (2023), which indicated a correlation between protein intake and obesity ($p<0.05$) (Roba et al., 2023). Protein is a protective factor and energy source, particularly when insufficient fat and carbohydrate intake. Excess protein can lead to the breakdown of cellular proteins into amino acids for energy or fat storage. The deamination of amino acids in the liver converts them into acetyl-CoA, which contributes to fat tissue formation and can lead to obesity (Ainun & Simbolon, 2024).

Finally, the chi-square test indicated a significant relationship between fiber intake and obesity in adolescent girls ($p<0.05$), which corroborates the findings of Shifa et al. (2021), who reported a relationship between dietary fiber and nutritional status ($p=0.001$) (Yuliani Rambe et al., 2021). Subjects with low fiber intake were 5.81 times more likely to be obese or overweight compared to those with sufficient fiber intake. Dietary fiber can be categorized into water-soluble and insoluble types. Water-soluble fiber can slow down the absorption of food, thereby lowering cholesterol absorption because it has a higher viscosity. Water-soluble fiber fermentation can produce short-chain fatty acids (SCFA), reducing hunger and having a lower glycemic level, reducing insulin response, and preventing insulin resistance. Water-insoluble substances can increase fecal mass, decreasing the transit time of food in the intestine. Both play a role in weight management and overall health.

Table 4. Multivariate logistic regression results

Variables	B	OR	95%CI for OR		*p-value*
			Lower	Upper	
Sleep duration	-	0.183	0.041	0.811	0.025*
Physical activity	1.697	0.475	0.141	1.609	0.232
Mother's education	-	0.246	0.106	0.570	0.001*
Mother's employment status	0.743	0.791	0.107	5.860	0.819
Family income	-	3.494	1.670	7.309	0.001*
Maternal history of obesity	1.404	0.228	0.041	1.285	0.094
Energy intake	-	12.566	1.079	146.325	0.043*
Protein intake	0.234	0.236	0.025	2.186	0.236
Fat intake	1.251	5.698	0.965	33.634	0.055
Carbohydrate intake	-	8.240	0.873	77.730	0.066
Fiber intake	1476	0.087	0.010	0.749	0.026*
	2.531				
	-				
	1.446				
	1.740				
	2.109				
	-				
	2.438				

Multivariate analysis explained the effect of more than one independent variable on one dependent variable. **Table 4** shows the results of the logistic regression test for risk factors for obesity in adolescent girls. The results of multivariate analysis showed that risk factors for obesity in adolescent girls include sleep duration, physical activity, mother's education, mother's employment status, family income, maternal history of obesity, energy intake, protein intake, fat intake, carbohydrate intake, and fiber intake. The factors significantly associated with obesity in adolescent girls were sleep duration, energy intake, mother's education, family income, and fiber intake. Other variables unrelated to obesity

were physical activity, mother's employment status, maternal history of obesity, protein intake, fat intake, and carbohydrate intake. Energy intake exhibited the strongest association with obesity in adolescent girls, as indicated by the highest odds ratio (OR=12.566; 95%CI=1.079-146.325; p=0.043), followed by family income (OR=3.494; 95%CI=1.670-7.309; p=0.001), mother's education (OR=0.246; 95%CI=0.106-0.570; p=0.001), sleep duration (OR=0.183; 95%CI=0.041-0.811; p=0.025) and fiber intake (OR=0.087; 95%CI=0.010-0.749; p=0.026). This finding was identical to previous research that total energy intake was the most dominant factor towards obesity in teenagers in Semarang (Fajriyah et al., 2020). Excess energy intake in adolescent girls occurs when calorie consumption exceeds the body's energy expenditure. The surplus calories are stored as fat, leading to gradual weight gain. Over time, this energy imbalance can result in obesity (Romieu et al., 2017).

CONCLUSION

This study identified key risk factors for obesity among adolescent girls in the Bogor district, with energy intake emerging as the most significant determinant, followed by family income, maternal education, sleep duration, and fiber intake. To prevent the progression of obesity into adulthood, comprehensive interventions focusing on balanced nutrition are essential. These should include collaborative efforts between schools and parents to promote healthy eating habits and supervised food choices. Moreover, public health strategies should address socioeconomic disparities and promote physical activity, especially in higher-income families. Building on these findings, future research is recommended to evaluate the effectiveness of school-based and parent-involved nutrition education programs, particularly how family income and maternal education may influence outcomes. Longitudinal or experimental designs could provide insight into behavioral and health improvements across diverse socioeconomic groups.

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