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## Case-Control Study: Evaluation of the Correlation between Obesity and Hypertension in South Jakarta Adolescents

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### ABSTRACT

**Introduction:** The prevalence of hypertension in adolescents has increased in recent years. Initially, hypertension was rare in adolescents, but now hypertension is showing a trend of prevalence at a younger. Hypertension in adolescents is multifactorial, and there is no single cause. However, some studies suggest that high blood pressure or hypertension is more common in overweight or obese adolescents.

**Objective:** To determine the correlation between obesity and hypertension in adolescents in South Jakarta in 2023.

**Method:** This research is an analytical study with a case-control design, using secondary data from the Non-Communicable Disease Information System (SIPTM) of DKI Jakarta Provincial Health Office in 2023. The sample size used the Lemeshow formula, hypothesis tests for two proportions (two-sided test), with 1124 respondents divided by 562 cases and 562 controls, by purposive sampling technique. Statistical tests included univariate, stratification, and multivariate analysis (logistic regression causal model).

**Result:** The obesity proportion was 29.8%, primarily female, at 58.45%, with the highest being 16 years (25.8%). After evaluating confounding, found a significant correlation between obesity and hypertension in adolescents, namely aOR 3,6 (95% CI 2.72 - 4.73), which means that obese adolescents are statistically proven to have a 3,6 times greater risk of developing hypertension than non-obese adolescents.

**Conclusion:** This finding indicates a prevalence increase of hypertension in the future if there is no obesity control in adolescents. Need screening or early detection in adolescents, especially in obese adolescents. Hypertension screening in adolescents to involve parents so that they get enough attention in the screening routine. In addition, there will be collaborative efforts between schools and healthcare providers to provide education and health promotion for school children, especially adolescents, to control hypertension and other non-communicable diseases.

**Keywords:** Adolescent; Hypertension; Obesity

## INTRODUCTION

Obesity is a chronic, multifactorial condition characterized by increased body fat, leading to adverse health consequences (1). Several developed countries around the world have shown childhood and adolescent obesity to be a significant health problem, putting children and adolescents at risk of poor health. Based on statistics from 2017 to 2020, obesity prevalence is about 19.7% and affects about 14.7 million children and adolescents aged 2-19 years, while in the adolescent group aged 12-19 years, the prevalence of obesity is 22.2% (2). World Health Organization (WHO) reports that the prevalence of overweight and obesity among adolescents is increasing dramatically. This increase occurred in both sexes, with 18% of girls and 19% of boys classified as overweight in 2016 (3).

In recent years, significant changes have been observed in the leading causes of hypertension (high blood pressure) in children and adolescents (4). This change is due to the global obesity epidemic observed over the past decade (5). An increase in obesity rates leads to an increase in the incidence of hypertension, making it one of the most common health problems in children. Studies have found that obesity indicators, such as body mass index (BMI) and other obesity indices, can help identify children and adolescents with high blood pressure levels (6).

Initially, hypertension was rare in children and adolescents, but now hypertension shows a trend of prevalence at younger ages (7). The results of a study by the CDC show that about 1 in 25 adolescents, or as many as 1.3 million adolescents aged 12 to 19 years, suffer from hypertension (8). Hypertension experienced by adolescents is associated with multifactorial that cannot be ascertained as a single cause. In adolescents, high blood pressure is more common in overweight or obese adolescents, and there is a strong relationship between obesity and hypertension in adolescents (9,10). Research by Zhao, et al (2021) found that the prevalence of hypertension in adolescents was 14.1%. The prevalence of hypertension was significantly higher in adolescents with obesity than in adolescents with normal weight (11). Simbolon, et al (2019), in their research looking at the risk of hypertension in adulthood due to obesity in adolescence, found that the risk of developing hypertension in adulthood based on overweight and obesity in adolescent boys is three times and girls are two times (12).

A cross-sectional study of 500 adolescent girls and boys in India found that among obese adolescents, 8.8% had hypertension. In contrast, the remaining 91.2% were not hypertension, with a p-value <0.0001, indicating a significant association between hypertension and obesity (13). In a Meta-Analysis study, overweight adolescents were 2.44 times more likely to have hypertension than adolescents with normal weight (aOR= 2.44; 95%CI= 1.87 - 3.19; p<0.001), and adolescents with obesity were 4.53 times more likely to have hypertension than adolescents with normal weight (aOR= 4.53; 95%CI= 3.10 - 6.61) (14).

Hypertension, also known as high blood pressure, is a chronic medical condition characterized by increased arterial blood pressure. Hypertension in adolescents is a risk factor for cardiovascular and cerebrovascular disease, and this can progress to hypertension in adults (15). Hypertension is often dubbed the silent killer because it usually presents with no symptoms. Hypertension is more common in the elderly, and its prevalence increases. However, several studies have shown that hypertension can occur as early as adolescence and its prevalence has been increasing in recent years. Most people do not understand that hypertension that occurs in adolescence will continue into adulthood and increase the risk of morbidity and mortality (10).

The South Jakarta City is an administrative city located in the southern part of DKI Jakarta Province. This region is the third city with the largest population in DKI Jakarta Province (16). According to Riskesdas (2018), the prevalence of hypertension in DKI Jakarta is higher than the national average (8.4%), which is 10.47% and ranks fifth in Indonesia, while the prevalence of hypertension in the South Jakarta City area is 11.01% and ranks third highest in DKI Jakarta (17). Moreover, the research results by Widiyanti (2019) showed that the proportion of hypertension in DKI Jakarta Province was 26.2%, and obesity was 17.4% (18).

This measurement is a useful tool to assess the risk of hypertension, especially in the adolescent age group of 15-19 years. It is important to address the relationship between obesity and hypertension in adolescents, as early identification and intervention can play an important role in preventing long-term health complications.

## METHOD

This study is an analytic study with a case-control design approach. This study was conducted in April 2023 using secondary data from the Non-Communicable Disease Information System (SIPTM) of the DKI Jakarta Provincial Health Office in 2023. The study population was all adolescents who participated in screening for NCD risk factors in the South Jakarta City work area in 2023. The sample is part of the population that meets the criteria. Sample size calculation used the Lemeshow formula, a two-sided test with a 95% confidence interval (CI) and a 90% power of the test. The sample size was 1124 respondents, divided into 562 cases and 562 controls, with a ratio of 1:1. Cases were defined as adolescents diagnosed with hypertension by a doctor or health worker, while controls were adolescents who were not hypertension. The sampling technique was purposive sampling. Inclusion criteria were adolescents aged 15-19 years and diagnosed with hypertension as cases, while controls were adolescents aged

15-19 years and not hypertensive as controls. Exclusion criteria had other chronic disease diagnoses and incomplete or invalid databases. Data were analyzed using STATA version 15.1. Statistical tests included univariate, stratification, and multivariate analysis (logistic regression causal model). The dependent variable was hypertension, the independent variable was obesity, and the covariate variables were gender, central obesity, family history of hypertension, physical inactivity, and cigarette consumption.

## RESULTS

### Univariate Analysis

Based on Table 1, the proportion of adolescents with obesity was 29.8%, mostly female, at 58.45%, with the highest age being 16 years (25.8%). Other risk factors include 45.46% of respondents having central obesity, having a family history of hypertension (7.74%), physical inactivity (35.59%), and smoking (14.59%).

**Table 1.** Respondent Characteristics

Variables	Frequency (n=1124)	Percentage (%)
<b>Obesity</b>		
Obesity	335	29,8
Not Obese	789	70,2
<b>Hypertension</b>		
Hypertension	562	50
No Hypertension	562	50
<b>Age</b>		
15 years	119	10,59
16 years	290	25,80
17 years	222	19,75
18 years	214	19,04
19 years	279	24,82
<b>Sex</b>		
Female	657	58,45
Male	467	41,55
<b>Central Obesity</b>		
Yes	511	45,46
No	613	54,54
<b>Family History of Hypertension</b>		
Yes	87	7,74
No	1037	92,26
<b>Lack of Physical Activity</b>		
Yes	400	35,59
No	724	64,41
<b>Cigarette Consumption</b>		
Yes	164	14,59
No	960	85,41

### Stratification Analysis

A stratification analysis was conducted to identify the existence of confounding variables and the effects of modification. A change in  $\Delta\text{OR} > 10\%$  indicates the existence of confounding variables, and a Test of Homogeneity value  $< 0.05$  suggests modifying effects. The analysis identified central obesity as a confounding variable and family history of hypertension as a modifying variable.

**Table 2.** Results of Stratification Analysis of Covariate Variables on Obesity and Hypertension in Adolescents

Variables	Case (n=562)	Control (n=562)	OR Strata (95% CI)	OR Crude	OR Adjusted	$\Delta\text{OR}$	Test of Homogeneity
<b>Sex</b>							
Female							
Not Obese	181	262	3.46	3.59	3.60	0.2805	0.734
Obesity	151	62					

Male							
Not Obese	142	204					
Obesity	88	33	3.83				
<b>Central Obesity</b>							
No Central Obesity							
Not Obese	231	237					
Obesity	115	30	3.93				
				3.59	4.31	<b>16.741</b>	0.56
Central Obesity							
Not Obese	92	229					
Obesity	124	66	4.67				
<b>Family History of Hypertension</b>							
No family history							
Not Obese	305	440					
Obesity	199	93	3.08				
				3.59	3.44	-4.2383	<b>0.0077</b>
Has a Family History							
Not Obese	18	26					
Obesity	40	3	19.25				
<b>Lack of Physical Activity</b>							
Not lacking physical activity							
Not Obese	202	296					
Obesity	165	61	3.96				
				3.59	3.58	-0.2519	0.3282
Lack of Physical Activity							
Not Obese	121	170					
Obesity	74	35	2.97				
<b>Cigarette Consumption</b>							
Not Smoking							
Not Obese	278	387					
Obesity	212	83	3.55				
				3.59	3.56	-0.6840	0.9517
Smoking							
Not Obese	45	79					
Obesity	27	13	3.64				

### Multivariate Analysis

Multivariate analysis was conducted to evaluate the correlation between obesity and the occurrence of hypertension in adolescents. This analysis used the logistic regression-causal model. The study was first conducted using modeling involving all variables. The analysis results in the following table were used to evaluate confounding variables.

Based on Table 3, the analysis results with a full model involving all covariates showed that the risk of hypertension in adolescents due to obesity was four times greater than in adolescents who were not obese (OR= 4,207; 95% CI 3,13-5,64).

**Tabel 3.** Full Model Analysis of the Correlation between Obesity and Hypertension in Adolescents

Variables	OR	95% CI	p-value
Obesity	4,207	3.133006 - 5.64976	<0,001
Sex	0,775	0.5832594 - 1.030753	0.080
Central Obesity	0,361	0-.2716182 - 0.4816259	<0,001
Family History	1,957	1.181966 - 3.243418	0,009
Lack of Physical Activity	0,952	0.7281731 - 1.244722	0,719

Cigarette Consumption	0,661	0.4551408 - 0.9615246	0,030
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In the next step, the final modeling was carried out using the backward method: removing variables one by one from the variables with OR values closest to 1 and comparing the OR after removal (reduced model) with the OR of Obesity in the initial modeling. If there is a change in  $\Delta\text{OR} > 10\%$  in the next model, the variable is a confounder and re-entered into the model (retained). The results of the analysis on confounding selection are presented as follows:

**Tabel 4.** Confounding Variables Selection on the Correlation between Obesity and Hypertension in Adolescents

Variables	Full Model	Reduced Model	$\Delta\text{OR} (\%)$
	OR* (95% CI)	OR* (95% CI)	
Sex	4.207 (3,133 – 5,649)	4.204 (3.1344 - 5.6386)	-0,075
Central Obesity		3.481 (2.637 - 4.5957)	-17,24
Family History		3.591 (2.7252 - 4.7338)	-14.62
Lack of Physical Activity		4.221 (3.1453 - 5.6664)	0,344
Cigarette Consumption		4.209 (3.14183 - 5.6405)	0,058

\*) OR full model: OR of obesity in initial modeling;

\*) OR reduced model: OR of obesity after one-by-one exclusion of covariates from confounding evaluation

The results of the confounding evaluation were that by considering the change in OR in all categories of obesity, it was evident that no covariate variables had the effect of changing  $\text{OR} > 10\%$ . Therefore, the final modeling of the association of obesity with hypertension only included the obesity variable as the main independent.

**Tabel 5.** Final Model of the Correlation between Obesity and Hypertension in Adolescents

Variabel	<i>p-value</i>	OR (95% CI)
Obesity		
Obesity	<0.001	3.591 (2.725 - 4.733)
No Obesity	Ref.	1

Based on the final logistic regression analysis results, the aOR and 95% CI of correlation between obesity and hypertension were 3.6 (95% CI 2.72 - 4.73). It means that obese adolescents are statistically proven to be at a 3.6 times greater risk of developing hypertension than adolescents who are not obese.

## DISCUSSION

In the results of the study, it was found that the difference between the crude OR and adjusted OR did not reach  $\geq 10\%$ . Thus, it was stated that there were no variables that met the assumptions as confounders of the association between obesity and hypertension in adolescents in this research.

The results showed that there is a significant correlation to the occurrence of hypertension in adolescents who are obese. Adolescents with obesity are almost four times more likely to develop hypertension than adolescents who are not obese or have a normal body mass index. These results are in line with research by Zaen, et al (2023) which showed a significant relationship between obesity and hypertension in adolescents (aOR = 4.53; 95% CI = 3.10-6.61;  $p < 0.001$ ), which means that obesity can increase the risk of hypertension in adolescents (14). The results were also corroborated by the finding of a significant association between obesity and hypertension (aOR = 6.64; 95% CI 4.65-9.49) among Lithuanian adolescents aged 12 to 15 years after adjusting for age and sex (19).

Obesity has been associated with a higher prevalence of hypertension. A study analyzing trends in adolescent obesity found a consistent association between body mass index and systolic and diastolic blood pressure in both genders. The study found mean systolic and diastolic blood pressure increased as BMI increased (systolic blood pressure by 10 mmHg and diastolic blood pressure by 3-4 mmHg,  $p < 0.001$  for both). In multivariate analysis, every

1 unit increase in BMI was associated with an increased risk of systolic blood pressure above 130mmHg in both men (OR=1.108, 95% CI 1.107-1.110,  $p<0.001$ ) and women (OR=1.114, 95% CI 1.139-1.146,  $p<0.001$ ). BMI in adolescents was significantly associated with systolic blood pressure and diastolic blood pressure in both sexes, both in the normal weight and overweight groups (20). BMI in the obese category during adolescence significantly affects blood pressure in adulthood, with a higher risk of hypertension in adulthood in obese individuals (21). Several studies have also shown a high prevalence of hypertension in Portuguese adolescents, at 22% (22) and 34% (23).

Overweight and obesity in adolescents is a worldwide epidemic problem. An estimated 32% of adolescents are overweight or obese (24). Adolescent overweight has been associated with comorbidities such as dyslipidemia, nonalcoholic steatohepatitis, type 2 diabetes mellitus, obstructive sleep apnea, and hypertension (25). The causative mechanisms of obesity-related hypertension include increased sympathetic nervous system activity, increased renal sodium retention due to insulin resistance, or obesity-mediated inflammatory hyperinsulinemia (26). Overweight adolescents show several traits, including levels of hormones and enzymes in the respiratory system, related to lipid metabolism and inflammation that contribute to the development of hypertension (27). Factors such as dyslipidemia, hyperinsulinemia, and family history of hypertension are indicative of the high risk of hypertension in obese adolescents (28).

Hypertension is one of the ten most common chronic diseases in children, and the rate has been steadily increasing in recent decades. Increasing evidence suggests that elevated blood pressure in childhood or adolescence is associated with intermediate phenotypes and adverse cardiovascular disease in adulthood (11). The primary treatment for obesity-related hypertension is weight loss with lifestyle changes in diet and physical activity. When lifestyle changes are insufficient for control, pharmacologic therapy is needed to reduce cardiovascular morbidity and mortality (26).

## CONCLUSION

The results of this research indicate a significant correlation between obesity and hypertension in adolescents aged 15-19 years in South Jakarta. This finding suggests an increase in the prevalence of hypertension in the future if there is no obesity control for adolescents. Routine screening or early detection for hypertension should be done in adolescents, especially in obese adolescents. Hypertension screening in adolescents is expected to involve parents getting enough attention in routine screening activities. In addition, it is hoped that there will be collaborative efforts or cooperation programs between school administrators and health service providers in providing education and health promotion for school children, especially adolescents, to control hypertension and other non-communicable diseases.

## SUGGESTION

Obesity is one of the risk factors that can be modified, namely through lifestyle changes to maintain an ideal body weight or in the normal body mass index category. Adolescents must pay attention to the daily consumption of sugar-salt-fat as recommended by the Indonesian Ministry of Health, which is 50 grams (4 tablespoons) - 5 grams (1 teaspoon) of salt - 67 grams (5 tablespoons). In addition, daily calorie burning is also needed through physical activity or exercise, at least 30 minutes per day or 150-300 minutes per week. In addition, it is highly recommended to avoid smoking behavior and cigarette smoke, as well as adequate rest.

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