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Relationship Between Central Obesity and The Risk of Hypertension in Obesity Adolescents

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ABSTRACT
The study aims to analyze the relationship between central obesity and the risk of hypertension in obese adolescents, including both male and female subjects. The study was a retrospective observational study that utilized medical record data from a previous research project entitled "Polimorfisme Gen Adiponectin ADIPOQ +45 T>G, ADIPOQ – 11377 C>G with Adiponectin Levels in Obese Adolescents and Risk of Metabolic Syndrome." This data was obtained from research conducted on obese adolescents aged 13-18 years in junior and senior high schools in Surabaya and Sidoarjo who met the criteria. The sample comprised 140 obese adolescents, who were then categorized into two groups: those without central obesity and those with central obesity. Statistical data were analyzed using SPSS with the Chi Square test. There is a very strong and significant relationship between central obesity and the risk of hypertension in obese adolescents (p = 0.000; r = 0.373); central obesity and the risk of hypertension in obese male adolescents (p = 0.001; r = 0.587); and central obesity and the risk of hypertension in obese female adolescents (p = 0.003; r = 0.300). The study found a significant relationship between central obesity and hypertension risk in obese adolescents. Adolescents with central obesity were 3.6 times more likely to develop hypertension than those without. Male adolescents with central obesity were 6.5 times more likely to develop hypertension than those without. Female adolescents with central obesity were 2.9 times more likely to develop hypertension

Introduction

Based on data from the National Health and Nutrition Examination Survey in the United States, it was found that the central obesity rate in the population was 57.2% in 2013-2014 and increased to 58.9% in 2015-2016. Meanwhile, in Indonesia's population, the central obesity rate is 31%, and in Central Java Province, 29.3% of the population was found to have central obesity. The prevalence of central obesity in adolescents increased by 4.4%, rising from 26.6% in 2007 to 31.0% in 2018 (Riskesdas, 2013). Obesity in adolescents has been associated with comorbidities such as dyslipidemia, nonalcoholic steatohepatitis, type 2 diabetes mellitus, obstructive sleep apnea, and hypertension(Zhao et al., 2021).

The national prevalence of hypertension among individuals aged 15-17 years is 5.3%, with rates of 6.0% for men and 4.7% for women. In a study conducted at SMA Negeri 2 Semarang with 47 participants, 10 of them had systolic blood pressure ≥ 122 mmHg, and 5 other teenagers had diastolic blood pressure ≥ 77 mmHg. Adolescents with elevated blood pressure are at an increased risk of developing coronary heart disease or heart failure in adulthood. Approximately 7% of adolescents with pre-hypertension experience hypertension each year (Probosari, 2017).

Hypertension is linked to central obesity through several mechanisms. An increase in fat around the abdomen leads to a reduction in adiponectin, facilitating the occurrence of atherosclerosis. Another mechanism involves the elevation of sympathetic activity, attributed to the impaired function of baroreceptor sensitivity. Increased levels of free fatty acids, angiotensin II, insulin, and leptin contribute to heightened vascular resistance, thereby causing hypertension (Seravalle & Grassi, 2017).

According to Asia-Pacific standards, central obesity is defined as waist circumference >90 cm for men and >80 cm for women5. The cut-off points for the waist circumference for girls are 104.6 cm and 111 (Harbuwono et al., 2018). cm for boys can predict the presence of metabolic syndrome. Waist circumference is one of the best types of anthropometric measurements to identify central obesity (Dâmaso et al., 2015).

Previous research on adolescents aged 10-18 years showed that waist circumference has a very close relationship with the risk of hypertension (Cheng et al., 2022). This study also shows that waist circumference can be an accurate predictor of hypertension. Furthermore, previous study showed that adolescents with hypertension have a large waist circumference (Meitei et al., 2022) (Çam & Top, 2021). Meanwhile, another research reported that waist circumference was not associated with the risk of high blood pressure in 18 students aged 6 to 14 years with normal weight (Xu et al., 2018).

As previously explained that central obesity has been recognized as a risk factor for cardio-metabolic disease and is also a component of the metabolic syndrome which plays an important role in the pathogenesis of cardiovascular disease (Drozdz et al., 2021). However, there is still a lack of research that discusses the relationship between central obesity in adolescents and the risk of hypertension. Therefore, the study titled "Relationship between Central Obesity and the Risk of Hypertension in Obese Adolescents" was conducted using anthropometric measurements, specifically waist circumference, as a reference to determine the occurrence of central obesity in adolescents. This measurement was then associated with the risk of hypertension. Additionally, this research was undertaken to pave the way for further studies on the relationship between central obesity and hypertension in adolescents.

Research Methods

The study was a retrospective observational study utilizing medical record data from previous research titled "Polimorfisme Gen Adiponectin ADIPOQ +45 T>G, ADIPOQ – 11377 C>G dengan Kadar Adiponektin Pada Remaja Obesitas dan Resiko Sindrom Metabolik." The data were obtained from research on obese adolescents in junior and senior high schools in Surabaya and Sidoarjo, meeting the criteria for central obesity. The sample comprised 140 obese adolescents, with 112 samples exhibiting central obesity, and only 28 samples (25%) without central obesity. The sample was then categorized into obese adolescents without central obesity and those with central obesity. The variables considered were waist circumference and blood pressure, with inclusion criteria being adolescent obesity and central obesity in individuals aged 13-18 years, criteria for central obesity included a waist circumference ≥ 88 cm for male adolescents and ≥ 85 cm for female adolescents) who were willing to participate as research subjects. Exclusion criteria involved individuals who had taken corticosteroids in the 6 months prior to the study, consumed dyslipidemia drugs within 3 months before the study, had diabetes mellitus, hypertension, or consumed alcohol. Data analysis employed the Chi-Square test and association coefficient using Statistical Package for Social Science (SPSS) software version 26. Ethical approval for the research was obtained from the Ethics Committee of the Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.

Results and Discussions

Demographics of obese adolescents by sex and the incidence of hypertension are presented in table 1, while the characteristics of the sample are presented in table 2.

Table 1 Demographic Characteristics of the Sample

Demograhic	Central Obesity	No Central Obesity
	n (%) = 112	n (%) = 28
Gender distribution		
Male	32 (28,57%)	8 (28,57%)
Female	80 (71,43%)	20 (71,43%)
Hypertension		
Yes	72 (64,29%)	5 (17,86%)
No	40 (35,71%)	23 (82,14%)

Table 2 Characteristics of the Sample

Characteristics	Central Obesity (Mean ± SD)	Obesity (Mean ± SD)
	n = 112	n = 28
Age	179.47 ± 18.38329	177.07 ± 18.85604
Weight	84.63 ± 11.85553	69.49 ± 9.77290
Height	160.50 ± 7.20757	157.27 ± 7.61149
BMI	32.82 ± 4.47517	28.00 ± 2.54629
Waist circumferences	95.94 ± 8.88205	81.29 ± 5.07979
Hip circumferences	109.79 ± 9.57173	95.53 ± 7.18479
Fasting glucose	86.04 ± 6.29017	93.29 ± 36.44565
Total cholesterol	176.52 ± 31.74334	172.39 ± 44.61385
HDL	44.06 ± 7.47763	45.86 ± 11.06451

Characteristics	Central Obesity (Mean ± SD)	Obesity (Mean ± SD)
	n = 112	n = 28
LDL	116.45 ± 28.87183	112.39 ± 36.60939
Triglycerides	111.56 ± 59.48363	108.43 ± 61.05822
Systolic blood pressure	128.66 ± 14.36309	116.07 ± 11.33310
Diastolic blood pressure	85.98 ± 11.87091	77.86 ± 7.38223

The relationship between central obesity and the risk of hypertension in obese adolescents is presented in table 3.

Table 3 Relationship between Central Obesity and Risk of Hypertension in Obese Adolescents

	Central Obesity	No Central Obesity	Phi Coefficient (r)	P Value
	n (%) = 112	n (%) = 28		
Hypertension	72 (64,29%)	5 (17,86%)	0,373	0,000[a]
No Hypertension	40 (35,71%)	23 (82,14%)		

a. Pearson chi- square

From the 112 adolescents with central obesity, 72 (64.29%) had hypertension, and 40 (35.71%) did not. Meanwhile, of the 28 obese adolescents without central obesity, 5 (17.86%) had hypertension, and 23 (82.14%) did not. After statistical analysis using the Pearson chi-square test, a p-value of 0.000 was obtained with an association coefficient of r = 0.373. The value of p = 0.000 (p < 0.05), and the value of r = 0.373 (r > 0.25), means that there is a very strong and significant relationship between central obesity and the risk of hypertension in obese adolescents. Adolescents with central obesity are 3.6 times more at risk of developing hypertension than obese adolescents without central obesity. The relationship between central obesity and the risk of hypertension in obese male adolescents is presented in Table 4.

Table 4 Relationship between Central Obesity and the Risk of Hypertension in Obese Male Adolescents

	Central Obesity	No Central Obesity	Phi Coefficient (r)	P Value
	n (%) = 32	n (%) = 8		
Hypertension	26 (81,25%)	1 (12,5%)	0,587	0,001[b]
No Hypertension	6 (18,75%)	7 (87,5%)		

b. Fisher's exact test

From 32 male adolescents with central obesity, 26 (81.25%) had hypertension, and 6 (18.75%) did not. Meanwhile, out of 8 obese male adolescents without central obesity, 1 (12.5%) had hypertension, and 7 (87.5%) did not. After statistical analysis using Fisher's exact test, a p-value of 0.001 was obtained with an association coefficient of r = 0.587. The value of p = 0.001 (p < 0.05), and the value of r = 0.587 (r > 0.25) means that there is a very strong and significant relationship between central obesity and the risk of hypertension in obese male adolescents. Male adolescents with central obesity are 6.5 times more at risk of developing hypertension than obese male adolescents without central obesity. The relationship between central obesity and the risk of hypertension in obese female adolescents is presented in table 5.

Table 5 Relationship between Central Obesity and the Risk of Hypertension in Obese Female Adolescents

	Central Obesity	No Central Obesity	Phi Coefficient	P Value
	n (%) = 80	n (%) = 20	(r)	
Hypertension	46 (57,5%)	4 (20%)	0,300	0,003[a]
No Hypertension	34 (42,5%)	16 (80%)		

c. Pearson chi square

From 80 female adolescents with central obesity, 46 (57.5%) had hypertension, and 34 (42.5%) did not. Meanwhile, out of 20 obese female adolescents without central obesity, 4 (20%) had hypertension, and 16 (80%) did not. After statistical analysis using the Pearson chi-square test, a p-value of 0.003 was obtained with an association coefficient of r = 0.300. The value of p = 0.003 (p < 0.05), and the value of r = 0.300 (r > 0.25) means that there is a very strong and significant relationship between central obesity and the risk of hypertension in obese female adolescents. Adolescent girls with central obesity are 2.9 times more at risk of developing hypertension than obese adolescent girls without central obesity.

Discussion

Central obesity is characterized by excess fat deposits in the stomach and waist area, resembling the shape of an apple (Dixon & Peters, 2018). This condition, identified as a determinant of arteriosclerosis development (Sturm et al., 2009), is associated with an atherogenic risk profile, elevating cardiometabolic risk factors like lipid profile, systolic hypertension, and abnormal fasting blood glucose in children and adolescents (Kelishadi et al., 2015). Previous studies have shown an association between visceral fat and total fat with high blood pressure in children and adolescents with central obesity. Consistent with these findings, the current study establishes a relationship between central obesity and the risk of hypertension in obese adolescents (Genovesi et al., 2008). This is in line with the results obtained from this study that there is a relationship between central obesity and the risk of hypertension in obese adolescents. In addition, according to research conducted by Abdus Sukkur at the heart polyclinic at Sidoarjo Hospital in 2009, central obesity will be very at risk of developing hypertension because it is followed by increased cholesterol and will more easily cause blockages in blood vessels. Previous study reported that central obesity can trigger high blood pressure/hypertension. This is because in central obesity, the most fat accumulation is in the abdominal area (stomach) (Sulastri et al., 2012). This accumulation of fat in the abdomen will lead to a decrease in adiponectin levels and the uptake of intracellular free fatty acids by mitochondria which will lead to reduced oxidation. This can lead to an increase in the accumulation of free fatty acids in cells which can lead to insulin resistance. This hyperinsulinemia condition can lead to narrowing of blood vessels and absorption of sodium in the kidneys which will then trigger the risk of hypertension more quickly. In line with this, another research stated that of the mechanisms that may be involved in the relationship between central obesity and increased blood pressure in adolescents is a decrease in insulin sensitivity, then hyperinsulinemia as further compensation (Castro et al., 2014). Excess insulin secretion associated with the presence of intra-abdominal fat will increase sodium retention, this will stimulate sympathetic activity which ultimately increases blood pressure, which will then increase the risk of hypertension in adolescents. In addition, the mechanism of increasing blood pressure in adolescents correlates with the development

of puberty (Li et al., 2021). Children who have the onset of puberty or go through puberty early have higher blood pressure.

The risk of hypertension was estimated to be 3-fold greater in male adolescents with central obesity compared with their non-obese counterparts, whereas in female adolescents the risk of hypertension was 2.5 times greater in adolescents with central obesity. Then taking into account both sexes, the overall risk of hypertension is 2.7 times greater in adolescents with central obesity. Several other studies have also shown that the relationship between central obesity and the risk of hypertension is stronger in obese male adolescents than in obese female adolescents. This is consistent with the results of this study that there is a relationship between central obesity and the risk of hypertension in obese male adolescents.

Sex hormones are involved in regulating adolescent blood pressure. In this case, estrogen in female adolescents stimulates the release of endothelium-derived vasodilator factors, can inhibit the renin-angiotensin system, and is associated with a decrease in blood pressure. Meanwhile, male adolescents produce the hormone testosterone which can stimulate the renin-angiotensin-aldosterone system which can then result in an increase in blood pressure in male adolescents. There is significant evidence that testosterone plays an important role in gender-related differences in blood pressure regulation. Studies using outpatient blood pressure monitoring techniques in children have shown that blood pressure increases with age in both boys and girls. However, after puberty, boys have higher blood pressure than girls of the same age. At ages 13 to 15 years, systolic blood pressure is approximately 4 mm Hg higher for boys than girls, and at ages 16 to 18 years, boys have systolic blood pressure higher than girls by 10 to 14 mm Hg. These data clearly show that during adolescence and puberty, when androgen levels increase, blood pressure in boys is higher than in girls. In addition, Hypertension is more common in men than women of the same age, this indicates gender differences in the physiological control mechanisms of blood pressure (Khalil, 2005). Previous study demonstrated that average blood pressure value is higher in male adolescents than in female. However, to date, there is limited data available on gender differences in adolescent hypertension (Juhász et al., 2010). In a recent study, the probability of having high systolic blood pressure values among adolescent boys was only slightly higher than that of female adolescents (Dasgupta et al., 2006).

It can be seen from previous studies that male adolescents have a higher risk of hypertension than female adolescents. However, another study reported that the blood pressure of female adolescents increased during puberty. This is due to earlier maturation in female adolescents compared to male adolescents. Previous research also found that children who experience early pubertal maturation have lower physical activity which is inversely related to blood pressure (Baker et al., 2007). Pubertal development can also affect blood pressure levels by regulating physical activity (Gidding et al., 2006). Several studies have also shown that the relationship between pubertal development and early puberty with hypertension only occurs in female adolescents (Boyne et al., 2014). The onset of puberty increases blood pressure in adolescent boys and girls, but after adjusting for covariates, the relationship between pubertal development and increased blood pressure is stronger in female adolescents than male adolescents. Several studies have shown that the effect of pubertal development on blood pressure is mediated by body fat (Devonshire et al., 2015). This is also in line with the results of this study that there is a relationship between central obesity and the risk of hypertension in obese female adolescents. Previous studies have also shown that female adolescents have more body

fat than male adolescents (Guo et al., 2016). However, women will be better protected from cardiovascular disease before menopause. Women who have not experienced menopause are protected by the hormone estrogen which plays a role in increasing HDL (high density lipoprotein). High HDL cholesterol levels are a protective factor to prevent atherosclerosis which can also be one of the causes of hypertension.

Strength and Limitations

Strengths of this study include its comprehensive exploration of the relationship between central obesity and hypertension risk in obese adolescents, a substantial sample size of 140 participants, and robust statistical analysis revealing significant associations, especially gender-specific correlations. However, limitations include the retrospective design relying on existing data, potential biases from the original research project, a cross-sectional nature restricting causal inference, and regional specificity (Surabaya and Sidoarjo) limiting generalizability. Despite these constraints, the study provides valuable insights, emphasizing the need for further prospective research to validate and extend these findings

Conclusion

Based on the results, it can be concluded that there are a significant relationship between central obesity and hypertension risk in obese adolescents. Adolescents with central obesity were 3.6 times more likely to develop hypertension than those without. Male adolescents with central obesity were 6.5 times more likely to develop hypertension than those without. Female adolescents with central obesity were 2.9 times more likely to develop hypertension.

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