

Waist circumference and waist-hip ratio as screening tools for hypertension in children aged 6-11 years

Esti Istiqomah, Dida A. Gurnida, Dany Hilmanto, Dzulfikar Djalil Lukmanul Hakim, Prima Nanda Fauziah

Abstract

Background Hypertension in children is associated with obesity. The renin-angiotensin-aldosterone system has been associated with intra-abdominal fat tissue. Many studies have shown that waist circumference and waist-hip ratio are more precise to determine overweight or obese.

Objective To determine the usefulness of waist circumference and waist-hip ratio as hypertensive screening tools for children aged 6-11 years.

Methods This analytical study with cross-sectional design and multistage cluster sampling method was conducted in August-September 2017 at a primary school in Bandung, West Java, Indonesia. Subjects underwent height, weight, waist circumference, hip circumference, and blood pressure measurements. Receiver operating characteristic (ROC) curve analysis was done to obtain the area under curve (AUC), cut-off point, sensitivity, specificity, and prevalence ratio.

Results Subjects were 325 children consisting of 187 males and 138 females. Hypertension was diagnosed in 47 children (37 males and 10 females). Mean waist circumference and waist-hip ratio were significantly higher in the hypertensive group than in the normotensive group. The hypertensive group had a mean waist circumference of 72.6 (SD 12.8) cm, AUC 0.779 (95%CI 0.730 to 0.823; $P < 0.001$), cut-off point > 65 cm, sensitivity 66.0%, specificity 76.3%, and prevalence ratio 4.55. This group had mean waist-hip ratio of 0.94 (SD 0.10), AUC 0.724 (95%CI 0.672 to 0.772; $P < 0.001$), waist-hip ratio cut-off > 0.91 , sensitivity 59.6%, specificity 77.0%, and prevalence ratio 3.73.

Conclusion Waist circumference > 65 cm or waist-hip ratio > 0.91 can be used to screen for hypertension in children aged 6-11 years with negative predictive values of 92.0% and 91.8%, respectively. [Paediatr Indones. 2019;59:265-70; doi: <http://dx.doi.org/10.14238/pi59.5.2019.265-70>].

Keywords: hypertension; waist circumference; waist-hip ratio

The prevalence of hypertension in children and adolescents has increased in recent years, possibly related to the increased prevalence of obesity in children and adolescents.^{1,2} Hypertension in children frequently has no symptoms so it often goes undiagnosed. Hypertension in adults begins in childhood.¹ Childhood hypertension increases the risk of cardiovascular disease, stroke, and death from cardiovascular disease during adulthood.^{3,4} Likewise, childhood obesity increases the risk of cardiovascular disease in adulthood.⁵

Studies have shown that overweight or obese children are at risk of hypertension.^{6,7} The renin-angiotensin-aldosterone system has been associated with intra-abdominal fat tissue compared to other sites, and may ultimately have an effect on blood pressure elevation.⁸⁻¹¹ This association between intra-abdominal fat tissue and the renin-angiotensin system has led some researchers to conclude that the anthropometric parameters of waist circumference and waist-hip ratio more precise determining overweight or obese nutritional status than other measurements.^{5,7,12}

Various studies have been conducted to determine the relationship between body mass index and the

Department of Child Health, Universitas Padjadjaran Medical School/ Dr. Hasan Sadikin Hospital, Bandung, West Java, Indonesia.

Corresponding author: Esti Istiqomah, Department of Child Health, Universitas Padjadjaran Medical School/Dr. Hasan Sadikin Hospital, Jln. Pasteur no. 38, Bandung 40161, West Java, Indonesia. Email: estiistiqomah52@yahoo.co.id.

Submitted April 14, 2019. Accepted October 11, 2019.

incidence of hypertension in children aged 12 years or more.¹³ Blood pressure in children aged 6-7 years was considered not to change more until adulthood,^{13,14} if hypertension occurs, it will be known immediately, so our study was done in children aged 6-11 years. The purpose of this study was to evaluate waist circumference and waist-hip ratio as hypertensive screening tools for children aged 6-11 years.

Methods

The inclusion criteria were children aged 6 years 0 months to 11 years 1 month, and written informed consent from parents/guardians. Exclusion criteria were children with known kidney disease, hypertension, congenital heart disease, or hormonal abnormalities, as well as those who received corticosteroid medications, had a family history of hypertension, or low birth weight. The selection of study subjects was done gradually with a multi-stage cluster sampling method based on the population of a primary school in Bandung, West Java.

Subjects underwent body height, body weight, waist circumference, hip circumference, and blood pressure measurements which were performed by physicians at school in the morning hours (8.00 am to 11.00 am). Blood pressure was measured three times with a 5 minute interval between each measurement. Before the blood pressure measurement, subjects were asked to sit still for 5 minutes. Body height was measured using a portable stadiometer to the nearest 0,1 cm and weight was measured with a balance beam scale (SECA measuring equipment) to the nearest 0,1 kg. To determine nutritional status, we used the 2000 Center for Disease Control and Prevention (CDC) chart,¹⁵ while blood pressure interpretation was based on *The National High Blood Pressure in Children and Adolescents* tables.^{4,16}

The unequal numerical difference test was used to analyze waist circumference and waist-hip ratio usefulness as screening tools for hypertension in children. Data normality was analyzed using Kolmogorov-Smirnov test. Unpaired t-test was used for normally-distributed data and Mann-Whitney test was used for non-normally distributed data. Receiver operating characteristic (ROC) curve analysis was used to obtain area under the curve (AUC), as well

as to determine cut-off points, sensitivity, specificity, and prevalence ratio for waist circumference and waist-hip ratio. All analyses were processed with SPSS for Windows version 21.0 software. Results with P values ≤ 0.05 were considered to be statistically significant.

This study was approved by the Health Research Ethics Commission of the Ministry of Research, Technology, and Higher Education Universitas Padjadjaran Medical School, Bandung.

Results

During the August-September 2017 study period, there were 329 children aged 6-11 years at the primary school. One child was excluded because of previously diagnosed hypertension and taking routine medication, 2 children because of premature birth, and 1 child because of nephrotic syndrome and taking routine prednisone, so the total number of subjects was 325. The characteristics of the study subjects are shown in **Table 1**. Of the 325 subjects, 47 (14.5%) had hypertension and 278 had normal blood pressure. Children with obese nutritional status had a higher percentage of hypertension compared to those with overweight, normal, and underweight nutritional status.

The analysis of relationships between hypertension and waist circumference as well as waist-hip ratio are shown in **Table 2**. Higher waist circumference and waist-hip ratio had significant associations with hypertension.

To determine the use of waist circumference and waist-hip ratio as screening tools for hypertension in children, ROC analysis was performed to assess the AUC as shown in **Table 3**. A waist circumference cut-off point of >65 cm was most valid with NPV of 92%. A waist-hip ratio cut-off point of >0.91 was most valid, with NPV of 91.8%.

The hypertension prevalence ratios based on waist circumference and waist-hip ratio is shown in **Table 4**. Children with a waist circumference >65 cm potentially have a 4.55 times higher risk of hypertension compared to those with waist circumference <65 cm. In addition, children with waist-hip ratio >0.91 have a 3.73 times higher risk of hypertension compared to those with waist-hip ratio <0.91 .

Table 1. Characteristics of study subjects

Characteristics	Total (N=325)	Hypertensive (n=47)	Normal (n=278)
Sex, n (%)			
Male	187 (57.5)	37 (19.8)	150 (80.2)
Female	138 (42.5)	10 (7.2)	128 (92.8)
Mean age (SD), years	9.3 (1.8)	10.0 (1.1)	9.2 (1.9)
Age range, years	6-11	7- 11	6-11
Age by year, n (%)			
6	35 (10.8)	0 (0.0)	35 (100.0)
7	34 (10.5)	1 (2.9)	33 (97.1)
8	50 (15.4)	4 (8.0)	46 (92.0)
9	32 (9.8)	12 (37.5)	20 (62.5)
10	28 (8.6)	9 (32.1)	19 (67.9)
11	146 (44.9)	21 (14.4)	125 (85.6)
Mean height (SD), cm	134.5 (12.5)	139.9 (10.3)	133.6 (12.6)
Height range, cm	103-164	117-162	103-164
Nutritional status, n (%)			
Underweight	57 (17.5)	6 (10.5)	51 (89.5)
Normal	193 (59.4)	15 (7.8)	178 (92.2)
Overweight	44 (13.5)	12 (27.3)	32 (72.7)
Obese	31 (9.5)	14 (45.2)	17 (54.8)

Table 2. Analysis of waist circumference and waist-hip ratio to hypertension

Variables	Total (N=325)	Hypertensive (n=47)	Normal (n=278)	P value
Waist circumference, cm				
Mean (SD)	62.1 (10.4)	72.6 (12.8)	60.3 (8.8)	<0.001*
Range	45.0-100.0	53.0-100.0	45.0-87.0	
Waist-hip circumference ratio				
Mean (SD)	0.88 (0.08)	0.94 (0.10)	0.87 (0.07)	<0.001*
Range	0.70-1.30	0.78-1.30	0.70-1.20	

*T-test

Table 3. ROC analyses of waist circumference and waist-hip ratio against hypertension

Variables	AUC (95% CI)	Cut-off point	P value	
Waist circumference, cm	0.779 (0.730 to 0.823)	>65	<0.001	Sensitivity= 66.0% Specificity = 76.3% PPV = 32.0% NPV = 92.0%
Waist-hip circumference ratio	0.724 (0.672 to 0.772)	>0.91	<0.001	Sensitivity = 59.6% Specificity = 77.0% PPV = 30.4% NPV = 91.8%

PPV= positive predictive value, NPV=negative predictive value

Table 4. Prevalence of waist circumference and waist hip ratio to hypertension

Variables	n	Hypertension (n=47)	Normal (n=278)	Prevalence ratio (95% CI)	P value
Waist circumference					
≥ 65 cm	97	31 (32.0)	66 (68.0)	4.55 (2.63 to 7.88)	<0.001
<65 cm	228	16 (7.0)	212 (93.0)		
Waist-hip ratio					
≥ 0.91	92	28 (30.4)	64 (69.6)	3.73 (2.20 to 6.30)	<0.001
<0.91	233	19 (8.2)	214 (91.9)		

Discussion

In children aged 6-11 years, waist circumference and waist-hip ratio was significantly higher in the hypertensive group than the normotensive group ($P < 0.001$). Previous studies have also shown a correlation between waist circumference and hypertension.^{8,17-20} Waist circumference is a reflection of morbidity in obesity and closely related to levels of intra-abdominal fat.³ Waist circumference and waist-hip ratio represent the distribution of body fat, both intracutaneously and intra-abdominally.^{5,14,17,18,22} Intra-abdominal fat is thought to produce mineralocorticoid-releasing factor that induces aldosterone synthesis. Aldosterone increases blood pressure through mineralocorticoid receptors located in various tissues such as the kidneys and vasculature,^{5,10,11} so measurement of waist circumference and waist-hip ratio should be considered as screening tools to predict hypertension in children.

Using ROC curve analysis, the waist circumference AUC was 77.9% (95%CI 0.730 to 0.823; $P < 0.001$) indicating a moderate level of accuracy. The AUC value of 77.9% means that if waist circumference is used to predict hypertension in children there are 77/100 children who have hypertension. The waist circumference cut-off point was > 65 cm, with PPV 32.0% and NPV 92.0%. The waist circumference can be used as a tool to predict probability of a healthy child/normal blood pressure. The waist-hip ratio cut-off point of > 0.91 had a PPV of 30.4% and NPV of 91.8%. This finding suggests that waist-hip ratio can be used as a tool to predict the true likelihood of a healthy child/normal blood pressure (among all children who show normal blood pressure). With the negative predictive value, waist circumference and waist-hip ratio can be used as a screening tool for the

possibility of hypertension.

The results of this predictive value validity study were similar to those of another study with increased waist circumference correlating to the incidence of hypertension and metabolic disorders such as hyperlipidemia, in which waist circumference cut-off point of 59 cm for boys (PPV 34.5% and NPV 86.9%) and 57 cm for girls (PPV 22.6% and NPV 90.9%).¹⁸ We were unable to determine the cut-off points on the basis of sex, as the number of subjects was not as large and we had unequal numbers of males and females.

A previous study reported that waist circumference with percentile > 90 correlated to the occurrence of hypertension.²² However, another study differed slightly, concluding that increased waist circumference correlated significantly with an increase in BMI and increased systolic or diastolic blood pressure. But increased waist circumference showed a weak correlation to elevated triglycerides or total cholesterol. In addition, the waist-hip ratio did not correlate with an increase in BMI, and only slightly correlated to the incidence of hypertension as well as increased triglycerides or total cholesterol.¹⁷

The prevalence of hypertension in our study was high at 14.5%, which differed from the 2-5% prevalence of hypertension in children estimated by the *World Health Organization* (WHO).^{1,18} Studies that calculated weight and height reported hypertension prevalence of 4.5%.^{14,19}

In our study, the prevalence ratio for waist circumference > 65 cm was 4.55, indicating that children with waist circumference > 65 cm had 4.55 times risk of hypertension compared to those with waist circumference < 65 cm. We also noted a prevalence ratio of 3.73 for waist-hip ratio > 0.91 , indicating that children with a waist-hip ratio > 0.91 had 3.73 times the risk of hypertension compared to those with waist-hip ratio < 0.91 . As such, parents of

children who have waist circumference >65 cm or waist-hip ratio >0.91 should be aware of the possibility of hypertension in future life. Various efforts should be made to prevent the occurrence of hypertension in children, such as a good diet, weight reduction, and regular exercise.

Waist circumference and waist-hip ratio in our study showed the highest validity of the NPV, whereas sensitivity, specificity, and PPV were not as high. To further assess the validity of the latter parameters, further study is needed with a larger sample size. Studies should be done from different regional and ethnic areas so that these parameters can be thoroughly explored.

In conclusion, waist circumference cut-off point >65 cm and waist-hip ratio cut-off >0.91 in children aged 6-11 years can be used as hypertensive screening tools with negative predictive values of 92.0% and 91.8%, respectively.

Conflict of Interest

None declared.

Funding Acknowledgment

The authors received no specific grants from any funding agency in the public, commercial, or not-for-profit sectors.

References

1. Supartha M, Suarta IK, Winaya IDA. Hipertensi pada anak. MKI. 2009;59221-30.
2. Hansen ML, Gunn PW, Kaelber DC. Underdiagnosis of hypertension in children and adolescents. JAMA. 2007;298:874-9.
3. Fujita Y, Kouda K, Nakamura H, Nishio N, Takeuchi H, Iki M. Relationship between height and blood pressure in Japanese schoolchildren. *Pediatr Int*. 2010;52:689-93.
4. Ejike C. Blood pressure to height ratios as simple, sensitive, and specific diagnostic tools for adolescent (pre)hypertension in Nigeria. *Ital J Pediatr*. 2011;37:30.
5. Garnet SP, Baur LA, Srinivasan S, Lee JW, Cowell CT. Body mass index and waist circumference in midchildhood and adverse cardiovascular disease risk clustering in adolescence. *Am J Clin Nutr* 2007;86:549-55.
6. Sahoo K, Sahoo B, Choudhury AK, Sofi NY, Kumar R, Bhadoria AS. Childhood obesity: causes and consequences. *J Family Med Prim Care*. 2015;4:187-92.
7. Salman Z, Kirk GD, Deboer MD. High rate of obesity-associated hypertension among primary schoolchildren in Sudan. *Int J Hypertens*. 2010;2011:629492.
8. Ramoshaba NE, Monyekei KD, Zatu MC, Hay L, Mabata LR. The relationship between blood pressure and anthropometric indicators in rural South African children: Ellistras Longitudinal Study. *J Obes Weight Loss Ther*. 2015;5:243.
9. Kotsis V, Stabouli S, Papakatsika S, Rizos Z, Parati G. Mechanisms of obesity-induced hypertension. *Hypertens Res*. 2010;33:386-93.
10. Davy KP, Hall JE. Obesity and hypertension: two epidemics or one? *Am J Physiol Regul Integr Comp Physiol*. 2004;286:803-13.
11. Aregullin-Eliqio EO, Alcorta-Garza MC. Prevalence and risk factors of high blood pressure in Mexican school children in Sabinas Hidalgo. *Salud Publica Mex*. 2009;51:14-8.
12. Dulskiene V, Kuciene R, Medzioniene J, Benetis R. Association between obesity and high blood pressure among Lithuanian adolescent: a cross-sectional study. *Ital J Pediatr*. 2014;40:102.
13. Chen B, Li HF. Waist circumference as an indicator of high blood pressure in preschool obese children. *Asia Pac J Clin Nutr*. 2011;20:557-62.
14. The National Center for Health Statistics in Collaboration with The National Center for Chronic Disease Prevention and Health Promotion (2000). Available from: <http://www.cdc.gov/growthcharts>.
15. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics*. 2004;114:555-76.
16. Lubis G, Oyong N. Hubungan lingkaran pinggang dengan faktor risiko penyakit kardiovaskular pada anak obesitas usia sekolah dasar. *Sari Pediatri*. 2006;8:147-53.
17. Liu A, Hills AP, Hu X, Li Y. Waist circumference cut-off values for the prediction of cardiovascular risk factors clustering in Chinese school-aged children: a cross-sectional study. *BMC Public Health*. 2010;10:82.
18. Choy CS, Chan WY, Chen TL, Shih CC, Wu LC, Liao CC. Waist circumference and risk of elevated blood pressure in children: a cross-sectional study. *BMC Public Health*. 2011;11:613.
19. Allamanda E, Prawirohartono EP, Mulyani NS. Predicting

- hypertension using waist circumference in obese Indonesian adolescents. *Paediatr Indones.* 2010;50:300-4.
20. Dwivedi GN, Sethi S, Singh R, Singh S. Association of blood pressure with body mass index and waist circumference in adolescents. *Int J Contemp Pediatr.* 2016;3:3971-6.
21. Xiao YQ, Liu Y, Zheng SL, Yang Y, Fan S, Yang C, *et al.* Relationship between hypertension and body mass index, waist circumference and waist-hip ratio in middle aged and elderly resident. *Zhonghua Liu Xing Bing Xue Za Zhi.* 2016;37:1223-7.
22. Zhang YX, Wang SR. Comparison of blood pressure levels among children and adolescents with different body mass index and waist circumference: study in a large sample in Shandong, China. *Eur J Nutr.* 2014;53:627-34.