ORIGINAL ARTICLE

The Components of Height and Blood Pressure in Javanese Children

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ABSTRACT

Introduction: Understanding the correlation between body height components and blood pressure in children can encourage proper investment in population-based primary prevention programs and gives benefits in terms of public health and economic well-being. This study aimed to investigate the prevalence of stunting and relationship between height, sitting height, leg length, and systolic and diastolic blood pressure (SBP and DBP) in Javanese children in Yogyakarta, Indonesia. **Methods:** This study used a cross sectional method which was conducted on 492 Javanese children aged 6-12 years old (237 boys and 255 girls). All children underwent anthropometric, SBP, and DBP measurements using standard procedures. Height-for-age based on WHO chart was used to define stunting, while leg length was based on the relative subischial leg-length. Statistical analysis was conducted using independent sample t-test and Pearson's correlation test with a significance of $p<0.05$. **Results:** It was found that around 22.3% of children were stunted with two thirds of girls. Height components were positively correlated with SBP in boys (r=0.19–0.32, $p<0.05$) and girls (r:0.22–0.37, $p<0.05$) as well as DBP in boys (r:0.18–0.24, $p<0.05$) and girls (r:0.22–0.33, $p<0.05$). The highest correlations were found between siting height and SBP in boys and girls (r:0.32 and r:0.37, respectively). **Conclusion:** In this study, the incidence of stunting in girls was higher than boys. A positive correlation was found between the components of height and blood pressure. The component of sitting height was better than leg length for predicting blood pressure in Javanese children aged 6-12 years.

Keywords: Height, Sitting height, Leg length, Blood pressure, Javanese children

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INTRODUCTION

The Indonesian National Health Research found that from 2013 to 2018, there was an increase in the prevalence of national hypertension in 18-year-old population from 25.8% to 34.4% instead a notable decrease in the overall prevalence of diagnosed hypertension from 9.5% to 8.4% (1, 2). In many countries, early detection of hypertension risk is not only conducted in adult groups but also in children. This approach is attributed to the fact that systemic hypertension in adults can begin in childhood (3). Lifestyle that leads to atherosclerosis can possibly start from childhood and the prevalence of risk factors will increase with age (4). In clinical settings, growth rate can serve as an early detection of growth abnormalities in children that can lead to cardiovascular disease in the future (5). Thus, early detection in children is expected to generate early intervention opportunities to prevent disease progression as early as possible.

Many studies have been conducted on the relationship between the components of height and blood pressure (6-11). In many countries, early detection of hypertension is conducted in children because a pro-atherogenic lifestyle and child growth monitoring is considered as potentially beneficial to encourage modifications of risk factors for hypertension (4). Generally, the earlier the risk is identified, the earlier the intervention can take place. Chen and Wang (12) found strong evidence that early detection of blood pressure changes from childhood can predict a patient's blood pressure problems during adulthood and provide better hypertension intervention. Height is an anthropometric profile that can be used to monitor body growth, obesity, metabolic disorders or hypertension in early life (13). The components of body height include sitting height, trunk length, and leg length, which are dominated by bone tissue originating from the mesoderm layer. The correlation between the components of body height and blood pressure can

possibly be traced to intrauterine life, where bone, heart muscle, blood vessels, and adipose tissue originate from the mesoderm lining (7). Robinson et al. (6) indicated that the lack of vascular endothelial growth factor due to impaired growth also explains why patients with stunting tend to have higher blood pressure. However, this correlation is still debatable because various previous research results indicate that this correlation can also be attributed to population heterogeneity (8-10).

Moreover, in relation to stunting, several studies suggest that individuals with stunting have a greater risk of cardiometabolic diseases, including a higher risk of blood pressure problems (8-9). However, research conducted by Rachmi et al. (10) in the Indonesian population revealed that there was no significant relationship between stunting in childhood and high blood pressure in adolescence. In Indonesian children, the component of body height has not been studied extensively, especially when related to blood pressure. According to Rao and Apte (14), the component of body height can describe the nutritional status and growth of the child, making it possible to see risk factors for children in the future.

This research is significant because in the near future, particularly by 2030, there will be demographic challenges in disease trends, since the current children will have reached their productive age and are expected to contribute to Indonesia's economic growth. Understanding the correlation between the components of body height and blood pressure in children can encourage proper investment in population-based primary prevention programs and produce the greatest possible benefits in terms of the burden on public health and economic well-being in the near future.

MATERIALS AND METHODS

Study population

This study used a cross-sectional method which was collected in July-December 2017 on 492 Javanese children (237 boys, 255 girls) aged 6-12 years living in the suburban areas (Bantul and Kulon Progo districts) Yogyakarta, Indonesia. All subjects had obtained parental consent as indicated by the signing of the required informed consent form. This study was approved by the Medical and Health Research Ethics Committee, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia.

Data collection

Measurements were taken for the height, sitting height, leg length and blood pressure of all subjects. Measurement of height was conducted using the straight stature method. The subject stood with an anatomical stance, and measurements were made from vertex to plantar with an anthropometer (GPM, 0.1 cm accuracy scale). Sitting height was measured from the vertex to the gluteal part that touches the chair when sitting (15) with an anthropometer (GPM, 0.1 cm accuracy scale). All anthropometric measurements were done by trained anthropometrists according to the methods of the International Society for the Advancement of Kinanthropometry (17). Blood pressure measurement data was performed by medicos using a calibrated (Riester) sphygmomanometer (19).

Study Variables

The dependent variables in this study were height, sitting height and leg length. Categories of normal height (≥-2 SD) and stunting (<-2 SD) were using the World Health Organization standard (Z-score) (18). The measurement of leg length according to Bogin et al is based on the relative sub ischial length. The formula is height minus sitting height, divided by height multiplied by 100 (16). The independent variables were systolic and diastolic blood pressure. Dependent variables of the study were the height components including height and leg length.
Statistical analysis

Statistical analysis was conducted using the SPSS program (SPSS Inc. Version 25) including independent sample t-test and Pearson's correlation test with a significance of $p < 0.05$.

Ethical clearance

This study was approved by Research Ethics Committee, Faculty of Medicine, Public Health and Nursing Universitas Gadjah Mada No. KE/FK/108/EC/2017.

RESULTS

Table I showed no difference in mean height and leg length between boys and girls in all age groups. It was found that the average sitting height of boys aged 8 years was greater (65.90 ± 2.81 cm) than girls (64.14 ± 2.91 cm). The mean systolic blood pressure for boys aged 8, 9 and 11 years was significantly higher than girls, and the average diastolic blood pressure for boys was significantly higher at ages 8 and 9 years. In this study, 22.3% of stunted children (110 children) were found, and 69 (2/3) of them were girls. The average systolic and diastolic blood pressure of Javanese children increased with age (Table I), especially in boys except at age 10 years. In girls, the blood pressure fluctuated across aged.

Table II showed that in Javanese children in Yogyakarta, there was a significant relationship ($p < 0.05$) between height for age, sitting height and leg length with blood pressure, for both systolic and diastolic blood pressure. Pearson's correlation analysis was conducted to seek the correlation between blood pressure and height components. Blood pressure was significantly and positively correlated with height for age, sitting height and leg length in both boys and girls, with a correlation range for boys ($r = 0.18 - 0.32$) and for girls ($r = 0.22 - 0.37$).

Table I: Descriptive statistics of components of height and blood pressure parameters of Javanese children aged 5–12 years in Yogyakarta, Indonesia

				Boys (X ± SD)			
Age (year)	6 (n=19)	7(n=42)	8 (n=36)	9 (n=42)	10 (n=39)	11 (n=38)	12 (n=24)
Stature (cm)	115.33 ± 4.88	119.60 ± 5.35	123.02 ± 4.67	127.43 ± 6.31	134.90 ± 7.62	138.55 ± 9.41	144.19 ± 9.03
SH (cm)	62.13 ± 2.29	62.13 ± 2.29	**65.90 ± 2.81	67.27 ± 3.19	70.32 ± 4.58	72.19 ± 4.75	74.85 ± 4.55
LL (cm)	61.43 ± 5.69	66.05 ± 5.69	69.44 ± 5.05	74.62 ± 6.77	82.78 ± 7.69	86.42 ± 9.95	92.25 ± 9.59
SBP (mmHg)	83.16 ± 7.66	86.37 ± 9.31	**91.21 ± 9.44	*91.87±14.37	87.99±14.38	*94.74±10.52	94.38±10.35
DBP (mmHg)	55.53 ± 7.79	57.38 ± 8.21	*62.88 ± 8.66	*62.26±12.35	61.96±12.59	64.80 ±9.70	65.06±12.31
Height-for-age							
Normal	16 (84.2%)	39 (92.9%)	29 (82.1%)	34 (80.9%)	34 (86.2%)	29 (76.3%)	18 (75.0%)
Stunting	3 (15.8%)	3 (7.1%)	7 (17.9%)	8 (19.1%)	5 (13.8%)	9 (23.7%)	6 (25.0%)
				Girls (X ± SD)			
Age (year)	6 (n=27)	7 (n=31)	8 (n=44)	9 (n=38)	10 (n=47)	11 (n=54)	12 (n=14)
Stature (cm)	113.24 ± 4.83	117.72 ± 5.35	117.72 ± 5.35	127.03 ± 5.88	135.83 ± 9.16	138.81 ± 7.88	144.41 ± 8.68
SH (cm)	61.31 ± 2.84	62.86 ± 3.28	**64.14 ± 2.91	66.66 ± 3.14	72.91±11.39	72.64 ± 4.68	75.50 ± 4.50
LL (cm)	59.09 ± 5.33	64.30 ± 6.37	68.51 ± 6.84	74.53 ± 6.33	82.10±12.86	86.73 ± 7.82	92.12 ± 8.88
SBP (mmHg)	84.63 ± 9.89	85.73 ± 9.34	**83.79±10.43	*85.91 ± 9.14	91.03±11.08	*89.86±11.09	91.07 ±8.59
DBP (mmHg)	56.85 ± 7.86	58.63 ± 6.25	*57.22 ± 7.09	*56.74 ± 7.92	64.20±10.94	61.94±11.47	63.93 ±7.88
Height-for-age							
Normal	24 (88.9%)	23 (74.2%)	32 (72.7%)	28 (72.7%)	36 (76.6%)	34 (63.0%)	9 (64.3%)
Stunting	3 (11.1%)	8 (25.8%)	12 (27.3%)	10 (27.3%)	11 (23.4%)	20 (37.0%)	5 (35.7%)

*p < 0.05; ** p < 0.01; Independent sample t-test to analyze differences between boys and girls.
SH = sitting height, LL = Leg length, SBP = systolic blood pressure, DBP = diastolic blood pressure
The data are partly taken from Kusila (20).

Table II: Correlation between height for age, sitting height and leg length to blood pressure among Javanese children in Yogyakarta, Indonesia

	Coefficient correlation	
	Systolic Blood Pressure (mmHg) r	**Diastolic Blood Pressure (mmHg) r**
Boys		
Height for age	0.20*	0.24*
Sitting height (cm)	0.32*	0.23*
Leg length (cm)	0.19*	0.18*
Girls		
Height for age	0.22*	0.22*
Sitting height (cm)	0.37*	0.31*
Leg length (cm)	0.32*	0.33*

*p<0.05; r: Pearson's correlation analysis.

DISCUSSION

Our study showed that the percentage of stunting of Javanese children in Yogyakarta was 22.3% and this result was greater when compared to the Indonesian Basic Health Research in 2018, with the prevalence of stunting children aged 5-12 years in Yogyakarta of 14.1%.

Research conducted in developing countries, including China, revealed that children in rural areas were more prone to stunting or nutritional problems than children in urban areas (10, 21-22). This fact must be considered in this study because Indonesian rural areas are occupied by 45.53% of the population or 118,896,312 people (23). But, the actual number of children in rural areas is not known. Although there are 72,205,147 children aged 0-14 years old in Indonesia with 25,885,053 children registered as primary school students (23). In addition, there may be an overestimation of height by age. Research conducted in Japan (24) and Indonesia (25) showed that the WHO reference for assessing child growth by standard deviation (SD) can lead to confusion whether these children actually fall into abnormal categories (-2 SD) such as stunting, underweight or overweight or not.

The results demonstrated that girls have approximately 10% higher of stunting than boys at aged 8 – 11 years. Several studies in Pakistan and China highlighted that families prioritize food for boys than girls, but it is not known why the results of these studies indicate that boys are more susceptible to stunting, even though sex discrimination is more common against girls (26-27). Research in China by Zhang (28) presented that before the age of 5 years, girls are more at risk of experiencing nutritional deficiencies, while boys are at risk of experiencing nutritional deficiencies at more than 5 years of age until adolescence.

However, there were limited studies to explain whether there is discrimination between boys and girls in Indonesia that can affect the nutritional intake of children of a certain sex. There was a higher prevalence of stunting in girls than boys in this study, possibly resulting from the lack of physical activity in girls. The

2013 Indonesian Basic Health Research stated that Indonesian girls have higher sedentary behavior for more than 6 hours than boys, and are predominantly in the 10–14-year age group, even though moderate intensity physical activity can increase bone density and become a protective factor in the occurrence of stunting (29-30). The highest percentage of stunting occurs in the 11-year age group. This result is probably due to the lowest level of physical activity occurring in the 10 – 14-year age group (1).

In this study, we found a correlation between height for age and systolic and diastolic blood pressure (Table 2). In particular, the greater the height for age, the higher the value of blood pressure. This result is different from the conducted study by Rachmi (10), that the prevalence of stunting had no significant relationship with blood pressure, while a study in China [31] showed that children with undernutrition had lower blood pressure than children with normal nutritional status.

Another study of immigrant children in Georgia USA, showed that these children had higher blood pressure with a greater prevalence of stunting compared to the nonimmigrant children population [32]. Various differences between the correlations of height for age with blood pressure in children should be widely studied, because studies on the correlation between height for age and blood pressure mostly involved adult subjects, which also showed that stunted people had higher blood pressure [33]. Ferreira et al. (8) suggested that association between stunting and blood pressure may be due to inefficient endocrine control, which is caused by decreased levels of insulin-like growth factor-1 and or altered expression of hormone receptors resulting from nutritional deficiencies in early life. Consequently, there is a negative effect on individual development in general and the vascular system in particular, thereby increasing the risk of hypertension. Furthermore, Rao and Apte (14) found that an increase in the diameter of the coronary vessels in line with the increase in body height which results in a decrease in the risk of luminal occlusion.

The average sitting height of Yogyakarta children is significantly correlated with blood pressure in both boys and girls, where the higher the sitting height, the higher the blood pressure (Table 2). These results are the same as the results of studies conducted on children in the USA, Brazil and South Africa (5, 34-35), while research by Dong et al. (31) showed that the greater the comparison value of leg length and sitting height, the lower the blood pressure. The relationship between sitting height and blood pressure can be explained by the concept of hydrostatic volume pressure. If a person has a sitting height of 50 cm and the mean arterial pressure at heart level measured in a standing position is 100 mmHg (the magnitude of the effect of gravity and the vertical distance above or below the heart is 0.77 mmHg/cm at normal blood density), the pressure in the large cranial and brain arteries are 100 (0.77 x 50), which is 62 mmHg (36). It can be concluded that the farther the heart is from the brain, the smaller the arterial pressure in the head. The body compensates by increasing the pressure in the arteries at the level of the heart to keep the adequate blood supply to the head. Hence, it is estimated that a person with a greater sitting height has a greater blood pressure than a person with a lower sitting height (37-38).

Our study also indicates that the average leg length of Yogyakarta children is significantly correlated with blood pressure in both boys and girls. It was obvious that the correlation between leg length and blood pressure showed different results in different age groups. Adulthood showed a negative correlation, while prepubertal age showed a positive correlation (15, 35, 38). In Indonesia, there are only a few studies that examined why there is a different correlation between leg length and blood pressure in children and adults, but there is a possibility that this is related to the onset of puberty (39), protein consumption (40), as well as economic changes (41).

The limitation of this study is the lack of variety of research subjects because the subjects only originate from one region with Javanese ethnicity despite the fact that Indonesia has more than 1,300 ethnic groups. However, Javanese represents the largest ethnic group in Indonesia [2]. Thus, it is necessary to conduct such studies covering some other ethnic groups and populations in Indonesia to enrich ethno-socio-cultural and geographical diversities of samples. Nevertheless, findings of this study give important insight for public health policy makers to consider assessment of stunting and height components in the evaluation of health in children to prevent future risk of cardiometabolic diseases due to evidence that individuals with stunting may pose a greater risk of cardiometabolic diseases, including high blood pressure and the importance of height components in identifying the predicted risks of future health.

CONCLUSION

This study concludes that the prevalence of stunting is higher in girls than boys, and the boys have a higher sitting height and blood pressure level than the girls. There is a positive correlation between the components of body height and blood pressure. The sitting height component is better than leg length in predicting blood pressure in Javanese children aged 6-12 years in Yogyakarta, Indonesia. The results of this study are essential in relation to public health for the prevention of disease risk factors and improvement of growth of children.

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