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Elevated blood pressure and its relationship with bodyweight and anthropometric measurements among 8–11-year-old Indonesian school children

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Abstract

Objective: Increased prevalence of elevated blood pressure in children and adolescents was associated with increased body weight and measures. Also, prevalence of elevated blood pressure varies between countries. This study is to investigate the prevalence of elevated blood pressure in Indonesian children and its relationship with bodyweight and anthropometric measures.

Methods: This cross-sectional study involved 1010 elementary students aged 8 – 12 years (479 girls, 531 boys). The anthropometric measures and blood pressure were assessed. Elevated blood pressure (EBP) was determined if at the 90th percentile or above for gender, age, and height. Independent t-test, Chi-square, Pearson correlation, and multivariate logistic regression were applied. Significance was determined at $p<0.05$.

Results: Overall prevalence of EBP was 28.8% (35.9% in girls, 22.4% in boys). BMI, waist circumference (WC), waist to height ratio (WHtR), and abdominal skinfold had significant correlation with EBP. Elevated BP was higher in overweight and obesity than in normoweight (60.5% *vs* 39.5%, p=0.00). In girls, the OR of EBP for overweight and obesity were 2.33 (95% CI 1.40 - 3.87, p=0.03) and 3.44 (95% CI 1.98 - 5.99, p=0.00) whereas in boys were 4.26 (95% CI 2.20 - 8.28, p=0.00) and 8.82 (95% CI 5.10 - 15.38, p=0.00).

Conclusions: Prevalence of EBP in Indonesian school children aged 8 – 11 years was higher and more prevalent in overweight/obesity and in girls. Anthropometric measures were correlated with EBP.

Introduction

Childhood overweight and obesity is a real threat to the health of children and adolescents and has become a serious public health problem. The prevalence of childhood obesity and overweight has increased dramatically in the last two decades. The worldwide incidence of childhood overweight and obesity increased from 4.2% in 1990 to 6.7% in 2010, with the highest prevalence in developed and industrialized countries.[1] Worldwide study on overweight and obesity conducted by a large number of experts from across nations revealed the prevalence of overweight and obesity in 2013 was 23.8% in boys and 22.6% in girls in developed countries whereas in developing countries it was 12.9% in boys and 13.4% in girls.[2] However, from an estimated total of 43 million overweight or obese children worldwide, 35 million are in developing countries.[3] In Southeast Asia the prevalence of childhood obesity and overweight in 2010 is estimated to increase by two-fold (10.6 million in 2000 to 22.9 million in 2010).[3] With an ever-increasing prevalence, the WHO estimates that the number of children with obesity and overweight would reach 70 million by 2025.[4]

As well as in adults, prevalence of EBP in children and adolescent is higher in overweight and obesity children. A study by Dong *et al*. in China found the prevalence of elevated blood pressure in non-overweight, overweight and obese children were 11.4%, 24.9%, and 38.7%, respectively.[5] A study by Rosaneli et al also found the prevalence of elevated BP was higher in overweight and obesity (20.6% and 39.7%, respectively), compared to 11.2% in normal-weight children.[6] A systematic review study conducted in Africa revealed that the prevalence of elevated blood pressure was six times higher in obese than in normal-weight children.[7]

As with overweight and obesity, elevated BP correlates with anthropometric measures of obesity indicators, especially abdominal obesity.[8-11] However, the correlation of the anthropometric measures with elevated BP varies between studies. A study by Lu *et al*. in Chinese adolescents observed that waist circumference (WC) was a more sensitive indicator for elevated BP than BMI.[10] Two studies in China found additional measurements of WC could improve sensitivity to predict high blood pressure than BMI alone.[11,12] On the other hand, some studies observed waist-to-height ratio (WHtR) has strongest relationship with elevated BP.[13,14] However, a systematic review and meta-analysis investigation revealed that performance of those anthropometric measures in identifying BP was not so different.[15]

Indonesia is a developing country with a large population of 260 million and has been facing a double burden of malnutrition, either underweight and overweight.[16,17] Overall prevalence of

Significance for public health

Prevalence of elevated blood pressure in children is increasing worldwide. Overweight and obesity are at higher risk of hypertension. In addition, anthropometric indices had association with elevated blood pressure. Our study found prevalence of prehypertension and hypertension in 8-11-year-old school children in Indonesia were 5.0% and 24% in girls, and 7.3% and 14.5% in boys. The OR of overweight and obesity for elevated blood pressure were 2.33 and 3.44 in girls, and 4.26 and 8.82 in boys. Anthropometric indices in hypertension are greater than in normal blood pressure.

overweight and obesity in children and adolescents in Indonesia was about 11.5%.[18] Nevertheless, higher incidence could be found in elementary school (20.4-23.2%).[17,19] High prevalence of overweight and obesity causes Indonesian children to be at high risk of developing hypertension. To our knowledge, there is still a lack of information about elevated BP and its relationship with obesity and anthropometric measures in Indonesia. The purpose of this study was to determine the prevalence of high blood pressure and its relationship with overweight and obesity as well as anthropometric measures in elementary school children in Indonesia.

Materials and Methods

Subjects

The design of this study was cross-sectional. The study was conducted in two elementary schools in Jakarta, schools fostered by the School of Medicine and Health Sciences, Atma Jaya Catholic University of Indonesia, Jakarta. Participants were students of the third to sixth grade (aged 8-12 years). Permission and informed consent were obtained from principals and parents proceeded by proposal presentation and a written explanation. All measurements and clinical examinations were performed at schools. The study was approved by the Research Ethics Committee of Atma Jaya Catholic University of Indonesia, School of Medicine and Health Sciences, Jakarta.

Anthropometric measurements

Anthropometric measurements and BP examination were conducted from 07.00 to 10.00 AM on the first visit by trained research assistants. Students were examined by assistants of the same gender (male assistants for boy students, female assistants for girl students). Weight was measured using a digital calibrated scale (Seca Robusta 813, Germany) while the students wore minimal clothing and the result was recorded in kilograms to the nearest 0.1 kg. Height was measured in Frankfort position without shoes using a calibrated stadiometer (microtoise) and recorded in centimeters to the nearest 0.1 cm.[20,21] Body mass index (BMI) were calculated based on formula weight (kg) divided by square of height (m^2).

Age- and sex-specific BMI percentiles criteria of each student were determined according to the 2000 Centers for Disease Control and Prevention growth charts. Nutritional status of the students was categorized based on BMI percentile criteria as follows: underweight if BMI<5^{th} percentile, normal if $5^{th} \leq$ BMI $< 85^{th}$ percentiles, overweight if $85^{th} \leq$ BMI $< 95^{th}$ percentiles, and obese if BMI $\geq 95^{th}$, respectively.[22,23]

Waist and hip circumference were measured using a non-elastic tape laid in a horizontal plane with students in a standing position to the nearest 0.1 cm. Waist circumference (WC) was taken at midway between the lowest rib and the superior border of the iliac crest at the end of normal expiration. Waist-to-height ratio (WHtR) was calculated according to the measurement result. Abdominal skinfold was obtained from abdominal skinfold taken by caliper (at 3 cm right lateral to the midpoint of the umbilicus) and measured to the nearest 0.1 cm.[20,21] The measurements were performed until two similar results were obtained.

Clinical assessment of blood pressure

Blood pressure (BP) was taken by researchers in a comfort room with air condition on the second visit. Blood pressure was measured using a digital oscillometric blood pressure monitor (Omron T8 with Intellisense, Japan) on the right arm after subjects had rested for at least 5 min in a sitting position.[24,25] The cuff size was based on arm length and circumference of the upper arm of participants.[26] Blood pressure measurements were taken three times with 10-20 seconds intervals in-between. The average of three readings was recorded. Systolic and diastolic blood pressure (SBP and DBP) percentiles were classified according to sex, age and height percentile according to the 2000 CDC growth chart and on the fourth report on diagnosis, evaluation, and treatment of high BP in children and adolescents from the national high blood pressure education program working group on high BP in children and adolescents.[24] Blood pressure was categorized according to SBP and/or DBP as follows: normal if SBP and/or DBP $< 90^{th}$ percentile, pre-hypertension if $90^{th} \leq$SBP and/or DBP<95^{th} percentile, and hypertension if SBP and/or DBP$\geq 95^{th}$ percentile.[26] Elevated blood pressure was defined as SBP or DBP or both at $\geq$the 90th percentile.

Table 1. Characteristics of the participants.

Characteristic	All students (n=1010)	Normal BP (n=719)	Elevated BP (n=291)	p
Age (years)	9.6±1.2	9.6±1.1	9.6±1.2	0.870
Weight (kg)	35.7±11.6	33.8±10.4	40.4±13.1	0.000
Height (cm)	136.6±9.9	136.0±9.4	138.0±10.7	0.040
BMI (kg/m²)	18.8±4.2	17.9±3.8	20.8±4.6	0.000
Waist circumference (cm)	63a.1±10.5	61.4±9.6	67.4±11.2	0.000
Waist to height ratio (WHtR)	0.46±0.06	0.45±0.06	0.49±0.07	0.000
Abdominal skinfold (mm)	17.6±10.4	16.1±9.8	21.5±10.8	0.000
Gender				
Girls	479 (47.4%)	307 (42.7%)	172 (59.1%)	0.000
Boys	531 (52.6%)	412 (57.3%)	119 (40.9%)	
BMI Classification				
Underweight	77 (7.6%)	66 (9.2%)	11 (3.8%)	0.000
Normoweight	528 (52.3%)	424 (59.0%)	104 (35.7%)	
Overweight	166 (16.4%)	104 (14.5%)	62 (21.3%)	
Obesity	239 (2.7%)	125 (17.3%)	114 (39.2%)	

BMI, body mass index; BP, blood pressure; WHtR, waist to height ratio.

Statistical analyses

Numerical data for descriptive statistics for age and anthropometric measures were analyzed by BP classification and presented as the mean and standard deviation. The prevalence of elevated BP, overweight and obesity was presented as frequency (percentage) according to age, gender and BMI group. Numerical data from two groups were compared using independent samples of t-test or Mann-Whitney based on the normality of distribution. Association between categorical variables (age, BMI, SBP, and DBP) were analyzed using a chi-square or Kolmogorov-Smirnov test. Correlations between blood pressure (SBP and DBP) and anthropometric measures were analyzed separately for boys and girls using the Pearson or Spearman correlation test. Logistic regression was applied separately by gender to calculate the odds ratio (OR) and 95% confidence interval (CI) according to the BMI category for high BP after adjusting for age. Statistical significance was determined at p value <0.05. Statistical analyses were performed by using the SPSS 17.0 software for Windows (SPSS Inc., Chicago, IL, USA).

Results

Characteristics of the study subjects are presented in Table 1. The results are compared between normal BP and elevated BP. All numerical data had abnormal distribution. Mann-Whitney test showed only age was not different. Subjects with elevated BP had greater anthropometric measures than subjects with normal BP did (p<0.05). Chi-square test showed elevated BP had an association with gender and BMI (p<0.01 for gender and BMI). Girls were likely to have more elevated BP than boys (35.9% *vs* 22.4%). Elevated blood pressure in underweight, normoweight, overweight, and obesity were 14.3%, 19%, 37.3%, and 47.7%, respectively.

Distribution of subjects by group classification according to age, BMI, SBP, and DBP was presented separately by gender (Table 2). Statistical analysis showed gender has a relationship with BMI, SBP, DBP, and overall BP (p<0.01, p=0.01, p<0.01, p<0.01, respectively). The frequency of overweight between gender was comparable (16.3 in girls, 16.6% in boys) but obesity in boys was much higher than in girls (32.8% *vs* 13.6%, OR 3.10, 95% CI 2.26 - 4.27, p<0.01). However, frequency of elevated blood pressure within gender, in girls was higher than in boys

Table 2. Distibution of age, BMI, SBP, and DBP according to gender.

	Total (n=1010)	Girls (n=479)	Boys (n=531)	p
Age - n. (%)				
8	226 (22.4%)	123 (25.7%)	103 (19.4%)	0.194
9	288 (28.5%)	132 (27.6%)	156 (29.4%)	
10	253 (25.0%)	121 (25.2%)	132 (24.8%)	
11	243 (24.1%)	103 (21.5%)	140 (26.4%)	
BMI - n. (%)				
Underweight	77 (7.6%)	43 (9%)	34 (6.4%)	0.000
Normoweight	528 (52.3%)	293 (61.2%)	235 (44.2%)	
Overweight	166 (16.4%)	78 (16.3%)	88 (16.6%)	
Obesity	239 (23.7%)	65 (13.6%)	174 (32.8%)	
Systolic blood pressure - n. (%)				
Normal	782 (77.4%)	349 (72.9%)	433 (81.5%)	0.012
Prehypertension	75 (7.4%)	32 (6.7%)	43 (8.1%)	
Hypertension	153 (15.2%)	98 (20.4%)	55 (10.4%)	
Diastolic blood pressure - n. (%)				
Normal	781 (77.3%)	335 (69.9%)	446 (84%)	0.000
Prehypertension	70 (6.9%)	34 (7.1%)	36 (6.8%)	
Hypertension	159 (15.7%)	110 (23%)	49 (9.2%)	
Overall - n. (%)				
Normal	719 (71.2%)	307 (64.1%)	412 (77.6%)	0.000
Prehypertension	63 (6.2%)	24 (5.0%)	39 (7.3%)	
Hypertension	192 (19.0%)	115 (24.0%)	77 (14.5%)	

Table 3. Coefficient of correlation between blood pressure and anthropometric measures.

Girls	Weight	BMI	WC	WHtR	Abdominal fat
SBP	0.009	0.125**	0.094*	0.209**	0.033
DBP	0.217**	0.244**	0.246**	0.237**	0.176**
Overall	0.169**	0.239**	0.221**	0.264**	0.147*
Boys	**Weight**	**BMI**	**WC**	**WHtR**	**Abdominal fat**
SBP	0.309	0.351	0.328	0.319	0.306
DBP	0.398	0.430	0.409	0.390	0.385
Overall	0.380	0.414	0.382	0.366	0.355

*p<0.05; **p<0.01.

(35.9% *vs* 22.4%, OR 2.52, 95% CI 1.86 - 3.43, $p<0.01$).

Correlation between blood pressure and anthropometric measures was assessed separately according to gender (Table 3). The correlation between blood pressure and anthropometric measures were all positive except for height and SBP in girls (r=-(0.148), $p<0.01$). The correlations were mostly significant to a weak or moderate degree ($r<0.500$). Overall, BP has the strongest correlation with WHtR in girls and with BMI in boys. Diastolic BP had a stronger correlation with anthropometric measures compared with SBP, and the strongest correlation was with WC in girls ($r=0.246$, $p<0.01$) and with BMI in boys ($r=0.430$, $p<0.01$). Systolic BP was associated strongly with WHtR in girls ($r = 0.209$, $p<0.01$) and with BMI ($r=0.351$, $p<0.01$) in boys.

Comparison of elevated blood pressure according to age was presented in Figure 1. The frequency of elevated BP in girls was higher than in boys for all age groups. The trend of elevated BP between boys and girls was comparable. The frequency of elevated BP in girls decreased after the age of 8 (frequency of elevated BP at age 8-11 were 38.8%, 38.0%, 31.4%, and 34.0%, respectively) and then increased to highest at the age of 12 (45.5%). In boys, frequency of elevated BP also decreased after the age of 8 (frequency of elevated BP at age 8-10 were 21.9%, 19.3%, and 21.4%, respectively) and then increased at age 11 (25.4%) to reach the highest frequency at age 12 (32%) There was no association between age and elevated BP in girls ($p=0.672$) and boys ($p=0.575$).

Comparison of elevated blood pressure according to BMI was presented in Figure 2. In general, elevated BP increased as BMI increased. In addition, elevated BP in girls was much more than in boys at any BMI classification. Elevated SBP was also found in underweight girls but not in boys. The frequency of elevated SBP in underweight girls was 25.6%, increased according to BMI, and reached the highest in obesity (58.5%) ($p=0.000$). In boys, there was no elevated BP in underweight. As seen in girls, the frequency of elevated BP increases with increasing BMI and achieved the highest frequency in obesity (43.7%) ($p=0.000$).

Multivariate logistic regression models adjusted for age was applied to analyze the influence of BMI category on elevated BP separately for girls and boys (Table 4). Normoweight was determined as a reference. Effect of underweight on elevated BP was not significant. In the same BMI category, increased risk of elevated BP in boys was much higher than in girls. Overweight and obesity increase strikingly the risk of elevated BP in boys (OR for overweight = 4.26, 95% CI 2.20 – 8.28, $p<0.001$, OR for obesity = 8.82, 95% CI 5.10 – 15.38, $p<0.001$). In girls, increased risk of BP was not so striking (OR for overweight = 2.33, 95% CI 1.40 – 3.87, $p<0.05$, OR for obesity = 3.44, 95% CI 1.98 – 5.99, $p<0.001$).

Discussion

Overweight, obesity and association with high blood pressure in children and adolescents is a challenging topic. This study is one of a few studies that examined elevated blood pressure in childhood and its relationship with BMI and anthropometric measures. The overall prevalence of overweight and obesity was

Table 4. Multivariate logistic regression model for elevated blood pressure (>90th percentile).

	Girls OR (95% CI)	Boys OR (95% CI)	p value between genders
Normoweight	1 (reference)	1 (reference)	
Overweight	2.33 (1.40 - 3.87)*	4.26 (2.20 - 8.28)**	<0.01
Obesity	3.44 (1.98 - 5.99)**	8.82 (5.10 - 15.38)**	<0.001
Underweight	0.84 (0.41 - 1.75)	0.00	0.724

*$p<0.05$; **$p<0.01$.

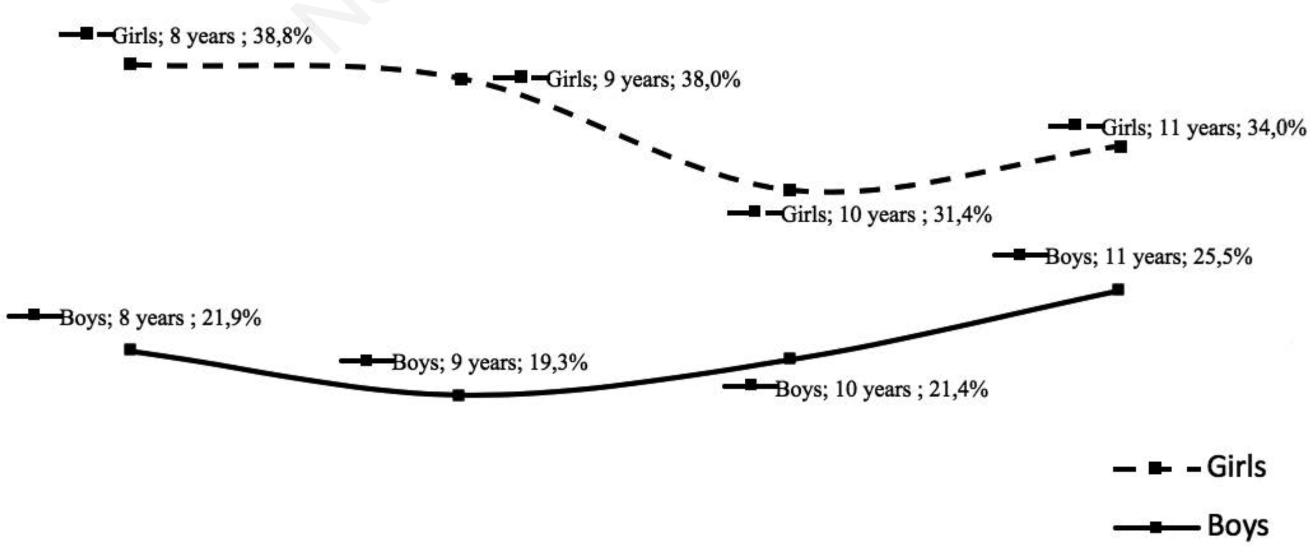

Figure 1. Comparison of the frequency of elevated blood pressure according to age.

16.4% and 23.7%. Elevated BP was found in 28.8% children, more prevalent in girls. Frequency of elevated BP across age was less conclusive. Anthropometric measures had correlation with BP but mostly with mild-to-moderate degree of correlation. The correlation in boys was stronger than in girls as well as DBP than SBP. Overweight and obesity increased risk of elevated BP 4.7 – 22.4 in boys and 1.7 – 3.2 in girls.

Prevalence of overweight and obesity in this study was comparable to global prevalence in children and adolescents.[2] The incidence is also similar with a previous study in Indonesia that used the same BMI category for children and adolescents from the CDC.[19] However, the prevalence was slightly different from that of another study which used BMI classification from the WHO.[17] Use of the different BMI category between studies has been shown to yield a difference in the prevalence of overweight/obesity.

Association of elevated BP to obesity is established. Most studies reported that elevated BP in was much more prevalent in overweight/obesity children.[10,27-29] The prevalence of elevated BP was 2 - 6 times higher in overweight/obesity.[5,7,30] Overweight or obesity also increased the risk of hypertension 2.0-10.6 times.[6,9,31,32] In addition, increased BMI increases blood pressure. A study in a large sample by Chorin et al found blood pressure increased for every increase of 1 unit BMI and the 10th BMI deciles was associated with SBP above 130 mmHg.[33] A longitudinal study for 3 years by Fuiano et al confirmed the influence of overweight and obesity on elevated blood pressure.[34] The recent study of overweight/obesity reported the increased prevalence of elevated BP 2–3 times and increased risk of hypertension 1.4 – 5 times. Even not significant, underweight tend to be a protective factor for EBP. The association of age and EBP was less conclusive. In our study, elevated BP tended to decrease after the age of eight and increases again at the age of 11 years. Prior studies also reported that increased age did not increase prevalence of hypertension in children.[5,7,35] Some possible explanation has been proposed but according to our observation might be caused by situation in room examination affecting the results such as reaction alert and children activity.

The discrepancy in the prevalence of elevated BP could be due to several factors such as difference in device used, number of BP measurements, subjects' condition during examination, and criteria for defining elevated BP. Blood pressure tends to be higher when taken with a digital device compared with aneroid or sphygmomanometer or condition is not comfort as recommended.[7,26] Definition of elevated BP varied between studies. Some studies defined elevated BP as SBP or DBP (or overall) ≥95th percentile, whereas other studies use ≥90th percentile, or even used criteria as in adults.[36]

Elevated BP in children must be confirmed by repeated visits.[26] Several previous studies demonstrated the prevalence of elevated blood pressure decreased by 4–5 times after being confirmed on subsequent visits.[30,37,38] A study by Steinthorsdottir *et al.* showed the prevalence of elevated BP in children aged 9–10 years decreased from 13.1% at the first visit to 3.1% at the third.[37] A similar result was obtained from the study by Arnaud *et al.* which found the prevalence of elevated blood pressure decreased from 11.4% at the first visit to 2.2% at the third.[38] Decreased BP on subsequent visits has been well-known as the so-called white collar effect.[37,39] The mechanism is still unclear but it may be related to stress response to medical activities, officers, devices, and the environment.[39] In children, this condition is aggravated by the absence of parents during examination.[37]

Male sex is supposed to be a risk factor for elevated blood pressure.[9,11,12,40] This study showed elevated BP was more pronounced in girls. The similar result was also reported by Fuiano *et al*. and Genovesi *et al*.[34,41] The gender disparity in prevalence of EBP might be caused by the white collar effect in which female students is more susceptible and considered as independent predictive factor.[42,43] Another explanation is related to early onset of puberty in girls that affect BMI. However, the latter explanation was not appropriate to this study as BMI and obesity prevalence was higher in males.

The correlation between BP and anthropometric measures in children and adolescent has been investigated previously.[10-15] Waist circumference (WC), waist-to-height ratio (WHtR), and subcutaneous fat thickness are mostly evaluated to identify the type of obesity.[12-15,44,45] The results showed the degree of correlation, sensitivity, and specificity of the indices varied widely between studies and gender. Our study showed the degree of correlation was weak-to-moderate. A study by Moser *et al.* also found a weak correlation between anthropometric measures and elevated BP.[46] Elevated BP was most closely related to WHtR in girls and with BMI in boys in this study. On the other hand, WC alone or both BMI and WC were shown to be more related to elevated BP.[10-12,45] The cause of the discrepancy could not be determined, but it might be influenced by subjects' characteristics, sample size, and data retrieval through measurements. Also, percentile for WC and WHtR has been developed to identify obesity-related health risk more appropriately.[14,33,47-51] However, the anthropometric measures should be used wisely as it is influenced by ethnicity, age and velocity of growth of children and adolescents.[51]

This study also has some limitations. First, blood pressure measurements were performed using a digital oscillometric. Besides practice and user-friendliness, this device has the disadvantage of a less consistent result compared with sphygmomanometer or aneroid. Therefore, three measurements with 10–15 seconds interval were expected to be able to reduce this shortcoming. Second, BP examination was performed only in one visit. Diagnosis of hypertension must be confirmed after three trips on different days. Third, family medical history, eating habit and physical activity which are important in determining risks and intervention for treatment was not available.

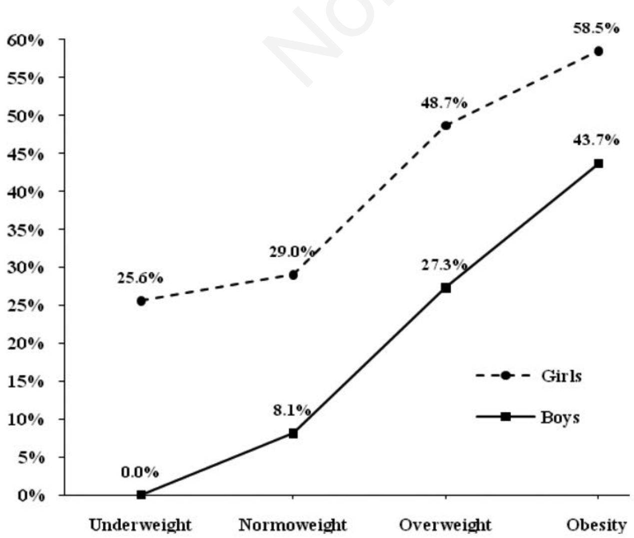

Figure 2. Frequency of elevated blood pressure according to BMI classification.

In conclusion, this study discovers a high prevalence of overweight/obesity and elevated BP in elementary school children. Elevated BP was more prevalent in overweight or obesity and in girls. Blood pressure was correlated with anthropometric measures. The results of this study should become a concern for parents, teachers, and they who care of children health. Plan to make an action for prevention and initial treatment of obesity and hypertension must be discussed involving medical experts.

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