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# Research Article
# Anthropometric Indicators for Blood Pressure and the Prevalence of Hypertension in Indonesian College Students Aged 18-25 Years

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## Abstract

**Background and Objective:** Anthropometric measures have been reported to be associated with elevated blood pressure. Understanding these factors may prevent the increasing level of hypertension. This study aimed to examine some anthropometric indicators for blood pressure and the prevalence of hypertension in Indonesian college students (18-25 years) in Yogyakarta. **Materials and Methods:** A total of 209 male and 258 female students (18-25 years) in Yogyakarta participated in this study. Weight, stature, circumferences at mid upper arm (MUAC), wrist, waist, hips, total of four skinfolds and systolic and diastolic blood pressure were measured. Body mass index (BMI), body frame index, waist-to-hip ratio (WHR) and waist-to-stature ratio (WSR) were determined. Analyses of t-test, chi-square test and simple and multiple linear regression analyses were conducted. **Results:** The prevalence of hypertension was low (14.0% in boys, 1.6% in girls), but that of prehypertension was high (43.0% in boys, 18.1% in girls). All anthropometric measures (weight, MUAC, wrist circumference, WC, HC, skinfold thickness, BMI and WSR) except for stature and WHR were significantly associated with systole and diastole in boys and systole in girls (r= 0.13 - 0.32, p<0.05, p<0.01, respectively). The BMI and MUAC were the strongest predictors of systole in boys and girls, respectively. Diastole was predicted better by weight and MUAC together and weight alone in boys and weight in girls. **Conclusion:** The prevalence of hypertension was higher in boys than in girls. All anthropometric measures except stature and WHR were significantly associated with systole and diastole in boys and systole in girls. The BMI in boys and MUAC in girls were the strongest contributors in systole, whereas, weight and MUAC in boys and weight in girls were the strongest predictors of diastole.

Key words: Anthropometric indicators, body weight, BMI, MUAC, systole, diastole, hypertension prevalence, college students

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Obesity has become a worldwide epidemic[1], including in Indonesia[2]. A concern for immediate health problems associated with obesity has been raised, including cardiovascular diseases (CVDs), which are the major cause of death globally. An estimated 17.5 million people died from CVDs in 2012, representing 31% of all global deaths[3]. The World Health Organization[4] indicated that over the past two decades, deaths from CVDs have been declining in high-income countries, but they have increased astoundingly in low- and middle-income countries. Over three-quarters of CVD deaths occurred in low- and middle-income countries[3,5]. In 2013, Indonesia reported that approximately 13.6% and 14% of adult men and women suffered from CVD, respectively[2].

The elevated blood pressure (hypertension) is the main risk factors for cardiovascular disease, which affects one billion people worldwide. Researchers have estimated that elevated blood pressure has recently killed nine million people annually[6]. Among Indonesians aged >18 years, the prevalence of hypertension is 22.8 and 28.8% in men and women, respectively. However, of individuals with hypertension, only 6.6% of men and 12.3% of women have been medically diagnosed with hypertension[2]. Hypertension rarely causes symptoms, therefore, increasing public awareness is important for early detection. Moreover, CVDs are largely preventable. Both population-wide measures and improved access to individual health care interventions can result in a major reduction in the health and socioeconomic burden caused by these diseases and their risk factors[4].

Obesity is a major risk factor for hypertension and CVD[7]. Anthropometry is a feasible method to assess obesity. Many studies have indicated that some anthropometric measures were significantly associated with CVDs[8,9] and their risk factors, including hypertension in adults[10-14] and adolescents[15]. However, the magnitude of the association varied amongst the population. For example, body mass index (BMI), waist circumference (WC) and waist-to-height ratio (WHR) can predict hypertension amongst North Indian Punjabi adolescents[15]. The study suggested that WC was a better predictor of elevated blood pressure in boys compared to girls. In adult studies, the use of waist circumference allowed screening people at risk of hypertension amongst a Brazilian adult population[14]. In Chinese adults, the incidence rate of hypertension and the odd ratios for having hypertension increased with BMI and WC[12]. A similar report was shown in Iranian adults[10]. However, amongst the Saudi adult population, WHR was the most important predictor for blood pressure level and hypertension disease[11].

Studies on anthropometric measurements as predictors of elevated blood pressure and hypertension disease are limited in the Indonesian population. However, evaluation of the role of anthropometric measurements on hypertension may help to better understand the pathogenesis and provide more specific action for prevention. The present study evaluates some anthropometric measurements including weight, stature, circumferences at mid upper arm (MUAC), wrist, waist (WC), hips (HC), the total of 4 skinfold thicknesses (biceps, triceps, subscapular, suprailiac), BMI, body frame index, WHR and WSR as indicators of blood pressure and the prevalence of hypertension amongst Indonesian college students aged 18-25 years old in Yogyakarta.

## MATERIALS AND METHODS

**Participants:** A total of 467 college students (209 boys, 258 girls) studying at Universitas Gadjah Mada (UGM) and Universitas Teknologi Yogyakarta (UTY) participated in this study. Male and female students who were apparently healthy and aged 18-25 years were recruited. Those who had physical disabilities or disproportional body segments and pregnant female students were excluded from the study. All participants provided written informed consent. The present study was approved by the Medical and Health Research Ethics Committees of the Faculty of Medicine, Universitas Gadjah Mada, Indonesia.

**Measurements:** Body weight, stature, MUAC, wrist circumference, WC, HC and the skinfold thickness at the triceps, biceps, subscapular and suprailiac of the participants were measured using the standard protocol of the International Society for the Advancement of Kinanthropometry (ISAK)[16]. Body weight was measured with a Seca weight scale (Seca 803, Seca Deutschland) to the nearest 0.1 kg while the participants were wearing light clothing. Stature was measured using an anthropometric set (GPM, Swiss, Ltd.) to the nearest 0.1 cm. Circumferences were measured using an anthropometric tape (Holtain Co. Ltd., Wales, UK) to the nearest 0.1 cm. The MUAC was measured at the level of the mid-acromiale-radiale site, perpendicular to the long axis of the arm. Wrist circumference was measured at the minimal circumference of the wrist, just distal to the styloid processes of the radius and ulna. The WC and HC were measured, respectively, at the narrowest point between the lower costal (10th rib) border and the top of the iliac crest and at the level of the greatest posterior protuberance of buttock. Total skinfold thickness was the sum of skinfolds taken using a skinfold caliper (Model 610ND, Holtain Co. Ltd.,Wales, UK) at the triceps, biceps (respectively, the point on the posterior and anterior surface of the arm in the mid-line at the level of the mid-acromial-radial), subscapular (the undermost tip of the inferior angle of the scapula) and suprailiac (the centre of the skinfold raised immediately above the marked iliocristale). The BMI was calculated as kg $m^{-2}$. The ratios of stature and wrist circumference (body frame index), WC and HC (WHR) and WC and stature (WSR) were evaluated. The participants were classified as underweight (<18.5 kg $m^{-2}$), normal (18.5-24.9 kg $m^{-2}$), overweight (25.0-26.9 kg $m^{-2}$) and obese ($\geq$27.00 kg $m^{-2}$) based on BMI classifications adopted from the World Health Organization.

Blood pressure was taken on the right arm at the level of the heart after 5 min of sitting using a standard mercury sphygmomanometer (Sphygmed™ Medical Product, Abadi Nusa Group Inc., Jakarta, Indonesia). Blood pressures were categorized into four groups following the guidelines of the 7th Report of the Joint National Committee on Prevention, Detection, i.e., normal blood pressure (systolic blood pressure less than 120 mmHg and diastolic blood pressure less than 80 mmHg), prehypertension (systolic blood pressure between 120-139 mmHg and/or diastolic blood pressure between 80-89 mmHg), hypertension stadium-1 (systolic blood pressure between 140-159 mmHg and/or diastolic blood pressure between 90-99 mmHg) and hypertension stadium-2 (systolic blood pressure more than or equal to 160 mmHg and/or diastolic blood pressure more than or equal to 100 mmHg).

**Statistical analysis:** Characteristics of anthropometrics and blood pressures were described as the mean and standard deviation (SD) and the differences between genders were observed using independent sample t-tests. The prevalence of BMI obesity and blood pressure levels were analysed using cross-tabulation and chi-square tests. In addition, differences among anthropometric characteristics and blood pressure levels in boys and girls were observed using t-test analyses. Simple and multiple regression analyses were used to evaluate the contribution of anthropometrics to systolic and diastolic blood pressures. A p<0.05 was considered significant. All statistical analyses were performed using SPSS (version 20.0, SPSS Inc., 2011 Chicago, IL)[17].

## RESULTS

A description of anthropometrics and blood pressure is presented in Table 1. The mean age of the participants was 20.8 (±1.20) and 20.7 (±1.16) years for boys and girls, respectively. There were no significant differences between boys and girls in age and HC, but the remainder of the anthropometric measures, indices and systolic and diastolic blood pressure were significantly higher in boys (p<0.01). Table 2 shows that the prevalence of obesity was significantly higher (p<0.001) in boys (7.6% overweight and 13.9% obese) than in girls (3.7% overweight and 5.2% obese). Boys also showed a higher (p<0.001) prevalence of prehypertension (43%) and hypertension stadium-1 (13.5%) than girls (18.1% prehypertension and 1.6% hypertension stadium-1).

Prehypertension appeared in all BMI category of obesity in boys (Fig. 1) and girls (Fig. 2), however, the prevalence was much lower in all BMI categories in girls (10.0-21.4 vs. 21.1-48.3%). Similarly, hypertension stadium-1 existed in all BMI categories in boys (8.3-28%) but not in girls (1-10% in normal, overweight and obese). The normal blood pressure level was consistently high in most of the BMI categories in girls (approximately 80%) but lower in boys (44-62%).

Table 1: Characteristics of the study participants

| | Boys (n = 209) | | Girls (n = 258) | | |
|---|---|---|---|---|---|
| Parameters | Mean | SD | Mean | SD | p-value |
| Age (years) | 20.79 | 1.20 | 20.66 | 1.16 | 0.238 |
| Weight (kg) | 62.61 | 14.12 | 50.92 | 8.60 | <0.001 |
| Stature (cm) | 167.35 | 5.86 | 155.25 | 5.09 | <0.001 |
| MUAC (cm) | 27.52 | 3.73 | 25.32 | 3.05 | <0.001 |
| Wrist circumference | 16.23 | 0.99 | 14.47 | 0.78 | <0.001 |
| Waist circumference (cm) | 75.71 | 9.70 | 68.12 | 5.97 | <0.001 |
| Hip circumference (cm) | 93.82 | 9.06 | 93.98 | 7.03 | 0.830 |
| Total SKF4 (mm) | 45.02 | 22.39 | 55.22 | 16.42 | <0.001 |
| BMI (kg $m^{-2}$) | 22.27 | 4.38 | 21.10 | 3.27 | 0.001 |
| Body frame index | 10.34 | 0.55 | 10.76 | 0.57 | <0.001 |
| WHR | 0.81 | 0.07 | 0.72 | 0.03 | <0.001 |
| WSR | 0.45 | 0.06 | 0.44 | 0.04 | 0.002 |
| Systole (mmHg) | 113.00 | 11.22 | 102.58 | 9.59 | <0.001 |
| Diastole (mmHg) | 77.17 | 9.25 | 70.67 | 7.59 | <0.001 |

p indicates differences between boys and girls using t-test analysis MUAC: Mid upper arm circumference, Total SKF4: Total skinfold thickness at triceps, biceps, subscapular and suprailiac, WHR: Waist-to-hip ratio, WSR: Waist-to-stature ratio, BMI: Body mass index, SD: Standard deviation, the results of ANOVA indicates p<0.001

Table 2: Prevalence of BMI obesity and hypertension level in boys and girls

| | Boys | | Girls | | |
|---|---|---|---|---|---|
| Parameters | N | % | N | % | p-value |
| BMI | | | | | <0.001 |
| Underweight | 19 | 9.1 | 50 | 18.6 | |
| Normal | 145 | 69.4 | 195 | 72.5 | |
| Overweight | 16 | 7.6 | 10 | 3.7 | |
| Obese | 29 | 13.9 | 14 | 5.2 | |
| Total | 209 | 100.0 | 269 | 100.0 | |
| Hypertension level | | | | | <0.001 |
| Normal | 90 | 43.3 | 202 | 80.2 | |
| Prehypertension | 89 | 42.8 | 46 | 18.2 | |
| Hypertension stage I | 25 | 12.0 | 4 | 1.6 | |
| Hypertension stage II | 4 | 1.9 | - | - | |
| Total | 208 | 100.0 | 252 | 100.0 | |

p: Significance of chi-square test, BMI: Body mass index, N: Number of cases

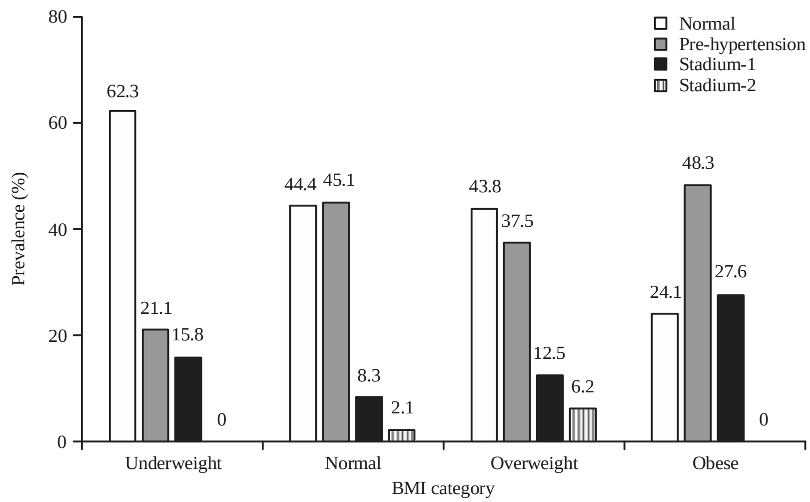


Fig. 1: Prevalence of hypertension levels amongst different BMI categories in boys

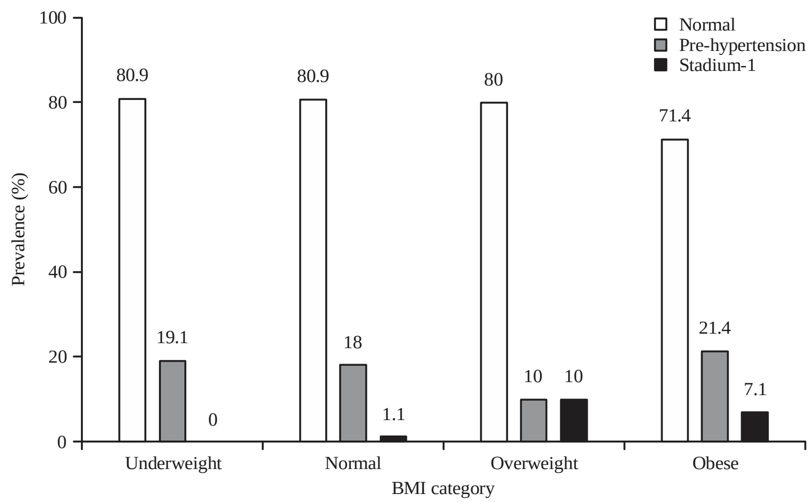


Fig. 2: Prevalence of hypertension levels amongst different BMI categories in girls

The simple linear regression analysis indicated a significant contribution ($p<0.05$, $p<0.001$) of weight, MUAC, wrist, waist and hip circumferences, total SKF4, body frame index, BMI and WSR to systolic blood pressure in boys and girls, as shown in Table 3. However, the magnitude of the associations was weak ($r = 0.18$-$0.32$). Multiple regression analyses indicated that BMI was the most significant predictor of systolic blood pressure in boys ($r = 0.32$, $p<0.001$), whereas MUAC showed a stronger predictor in girls ($r = 0.15$, $p<0.05$). The same anthropometric measures also had significant contributions ($p<0.001$) to diastolic blood pressure in boys (Table 4). In girls, stature, total skinfold, body frame index, WHR and WSR did not contribute significantly to diastolic blood pressure. Weight and MUAC together were the strongest predictor ($r = 0.32$, $p<0.001$) of diastolic blood pressure in boys in addition to weight alone ($r = 0.29$, $p<0.001$). Weight was also the strongest factor of diastolic blood pressure in girls ($r = 0.14$, $p<0.001$).

## DISCUSSION

The findings of the present study indicate that except for hip circumference, boys had significantly larger values than girls for all anthropometric measures (weight, stature, MUAC, wrist circumference, WC, HC, total skinfold, BMI, body frame index, WHR and WSR). Systolic and diastolic blood pressures were also higher in boys than in girls. The results confirmed the findings of studies in other countries, e.g., Iran[10] and China[12]. Prehypertension and hypertension stadium-1 were also more prevalent in boys than in girls. Present study also

Table 3: Regression analysis of anthropometrics and systolic blood pressure in boys and girls

| | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| Regression | β | 95% CI | p-value | r | β | 95% CI | p-value | r |
| **Simple linear regression** | | | | | | | | |
| Weight (kg) | 0.229 | 0.125-0.333 | <0.001 | 0.29** | 0.198 | 0.064-0.333 | 0.004 | 0.18** |
| Stature (cm) | 0.022 | -0.241-0.284 | 0.871 | 0.01 | 0.074 | -0.159-0.307 | 0.533 | 0.04 |
| MUAC (cm) | 0.924 | 0.531-1.317 | <0.001 | 0.31** | 0.615 | 0.238-0.992 | 0.001 | 0.20** |
| Wrist circumference (cm) | 1.984 | 0.464-3.504 | 0.011 | 0.18* | 1.936 | 0.440-3.433 | 0.011 | 0.16* |
| Waist circumference (cm) | 0.341 | 0.190-0.492 | <0.001 | 0.30** | 0.258 | 0.064-0.451 | 0.009 | 0.16** |
| Hip circumference (cm) | 0.328 | 0.164-0.492 | <0.001 | 0.27** | 0.231 | 0.067-0.395 | 0.006 | 0.17** |
| Total SKF4 (mm) | 0.143 | 0.077-0.209 | <0.001 | 0.29** | 0.074 | 0.003-0.144 | 0.041 | 0.13* |
| BMI (kg $m^{-2}$) | 0.815 | 0.483-1.148 | <0.001 | 0.32** | 0.524 | 0.172-0.875 | 0.004 | 0.18** |
| Body frame index | -4.006 | -6.741-1.272 | 0.004 | -0.20** | -2.153 | -4.220- -0.085 | 0.041 | -0.13* |
| WHR | 21.838 | -0.372-44.047 | 0.054 | 0.13 | 8.212 | -25.705-42.131 | 0.634 | 0.03 |
| WSR | 60.328 | 33.979-86.677 | <0.001 | 0.30** | 35.781 | 6.080-65.482 | 0.018 | 0.15* |
| **Multiple linear regression** | | | | | | | | |
| BMI | 0.815 | 0.483-1.148 | <0.001 | 0.32** | | | | |
| MUAC | | | | | 0.627 | 0.246-1.008 | 0.001 | 0.20** |

*p<0.05, **p<0.001, MUAC: Mid upper arm circumference, Total SKF4: Total skinfold thickness at triceps, biceps, subscapular and suprailiac, WHR: Waist-to-hip ratio, WSR: Waist-to-stature ratio, BMI: Body mass index, β: Unstandardized coefficient, 95% CI: 95% confidence interval (lower-upper bound), r: Coefficient of Pearson's correlation

Table 4: Regression analysis of anthropometrics and diastolic blood pressure in boys and girls

| | Boys | | | | Girls | | | |
|---|---|---|---|---|---|---|---|---|
| Regression | β | 95% CI | p-value | r | β | 95% CI | p-value | r |
| **Simple linear regression** | | | | | | | | |
| Weight (kg) | 0.177 | 0.096-0.257 | <0.001 | 0.29** | 0.125 | 0.019-0.232 | 0.021 | 0.14* |
| Stature (cm) | 0.175 | -0.026-0.377 | 0.088 | 0.12 | 0.094 | -0.091-0.278 | 0.318 | 0.06 |
| MUAC (cm) | 0.468 | 0.156-0.780 | 0.004 | 0.20** | 0.349 | 0.048-0.650 | 0.023 | 0.14* |
| Wrist circumference (cm) | 2.021 | 0.862-3.181 | 0.011 | 0.23** | 1.283 | 0.098-2.469 | 0.034 | 0.16* |
| Waist circumference (cm) | 0.219 | 0.100-0.337 | <0.001 | 0.25** | 0.151 | -0.003-0.304 | 0.009 | 0.12* |
| Hip circumference (cm) | 0.249 | 0.122-0.376 | <0.001 | 0.26** | 0.139 | 0.008-0.270 | 0.038 | 0.13* |
| Total SKF4 (mm) | 0.104 | 0.053-0.155 | <0.001 | 0.27** | 0.074 | 0.003-0.144 | 0.041 | 0.05 |
| BMI (kg $m^{-2}$) | 0.539 | 0.278-0.800 | <0.001 | 0.27** | 0.308 | 0.027-0.588 | 0.032 | 0.14* |
| Body frame index | -2.874 | -4.992- -0.756 | 0.008 | -0.18** | -1.169 | -2.807-0.469 | 0.161 | 0.09 |
| WHR | 5.531 | -11.763-22.824 | 0.529 | 0.04 | 1.446 | -25.401- -28.292 | 0.916 | 0.01 |
| WSR | 33.011 | 12.162-53.859 | 0.002 | 0.21** | 19.157 | -4.483-42.797 | 0.112 | 0.10 |
| **Multiple linear regression** | | | | | | | | |
| Weight[a] | 0.375 | 0.161-0.529 | <0.001 | 0.32** | | | | |
| MUAC[a] | -0.710 | -1.407-0.013 | 0.046 | | | | | |
| Weight | 0.177 | 0.096-0.257 | <0.001 | 0.29** | 0.124 | 0.016-0.231 | 0.024 | 0.14** |

*p<0.05, **p<0.001, a: Weight and MUAC together, MUAC: Mid upper arm circumference, Total SKF4: Total skinfold thickness at triceps, biceps, subscapular and suprailiac, WHR: Waist-to-hip ratio, WSR: Waist-to-stature ratio, BMI: Body mass index, β: Unstandardized coefficient, 95% CI: 95% confidence interval (lower-upper bound), r: Coefficient of Pearson's correlation

found that most of the anthropometric variables were associated with systolic blood pressure in boys and girls and with diastole in boys, except for stature and WHR. Amongst the anthropometric indicators, BMI and MUAC was the strongest predictors of systole in boys and girls, respectively, whereas, weight and MUAC in boys and weight in girls were the strongest predictors of diastolic blood pressure.

The prevalence of obesity (including overweight and obese categories) in the present study (boys: 21.5%, girls: 5.9%) did not represent the national prevalence of adult obesity in Indonesia, which was higher in women than in men, i.e., 32.9 and 19.7%[2], respectively. Nonetheless, a similar trend was found amongst Turkish individuals, of whom boys showed a higher obesity prevalence than girls[18]. The prevalence of high blood pressure (prehypertension and hypertension stadium-1) was also higher in boys. This has also been reported amongst Bangladeshi students[19]. The national prevalence of hypertension amongst adults (18 to >75 years) in Indonesia was 22.8% in men and 28.8% in women[2], contrary to the findings of this study, which had a higher prevalence in boys (13.5%) than in girls (1.6%). However, the prevalence of hypertension in boys was almost twice the national prevalence of hypertension amongst young Indonesians aged 18-24 years, i.e., 8.7%[2]. According to the national health survey in Indonesia, the hypertension prevalence increased with age, e.g., by the age of 35-44 years, the hypertension rate increased three-fold (24.8%) and was six-fold higher by the age of 65-74 years (57.6%). Physical and physiological development may predispose the increased blood pressure during ageing through several mechanisms, such as through genes[20] and hormones[21]. A cohort study in Korea found that a certain type of gene-GRSs derived from 4 SNPs was independently associated with an increased blood pressure or hypertension and was highly associated with an increased risk of incident hypertension[20]. The hormonal system controls hypertension through several systemic actions, such as the renin-angiotensin system (RAS)[21], finally, gender has an impact on the regulation of blood pressure[22].

Findings of current study are consistent with other reports in which anthropometric measures were significantly associated with blood pressure[10-13,15]. Most of the anthropometric variables were associated with systolic blood pressure in boys and girls and with diastolic in boys, except for stature and WHR. Some previous studies[10,11,23,24] indicated that WC and BMI contributed to the elevated blood pressure. According to Saeed and Al-Hamdan[11], the anthropometric indicators WC and BMI were predictors for elevated blood pressure amongst 4758 adults in Saudi Arabia. Similarly, Peymani *et al.*[10] reported in a study involving 1976 men and 1940 women aged 15-64 years in Iran that WC and BMI were strongly associated with systolic and diastolic blood pressure. In younger ages, the same association has been observed amongst adolescents in Turkey[25]. However, studies in Indian and Indonesian adolescents showed that BMI, WC and WSR can significantly predict high blood pressure[26,27]. Febriana and colleagues also indicated that Indonesian boys had a higher WSR than girls and proposed a WSR of 0.45 as an appropriate cut-off for high blood pressure in adolescents[27]. High blood pressure in children and adolescents is significant because it can result in adult hypertension[28].

Obesity may trigger hypertension through the mechanisms of adiposity tissue dysfunction, Renin-Angiotensin Aldosteron system (RAAS) activation and endothelial dysfunction[29]. Likewise, an increased WC may predispose an individual to hypertension directly via the physiological mechanism of visceral adipocyte and RAAS or indirectly via the increase of insulin resistance[23]. Seibert and colleagues[30] indicated that waist circumference was a better measure of visceral fat than the ultrasound method and can better predict cardiovascular disease risk including hypertension. Nonetheless, there may be potential racial/ethnic differences in the association between high WC and elevated blood pressure, which may influence the determination of preadolescents at risk for elevated blood pressure, as has been reported in non-Hispanic white pre-adolescent children[31]. A review study reported that Asians had higher odds ratios for hypertension in terms of BMI and WC compared to Caucasians[32]. However, in a meta-analysis study involving over 88 000 participants, Lee *et al.*[33] found that WC was superior to BMI in predicting hypertension. In the present study, waist and hip circumference, but not the subsequent index (WHR), had a significant association with systole and diastole. Body adiposity as reflected in skinfold thickness had an almost equal contribution as BMI and WC to blood pressure, particularly in boys. Conversely, Moser *et al.*[34] found that total body adiposity as reflected by BMI and triceps skinfold could better predict high blood pressure risk than abdominal fat in a sample of Brazilian adolescents.

The present study found that MUAC was also significantly correlated with blood pressure in both genders and was even the strongest predictor of systole in girls and diastole in boys (together with weight). The results are consistent with the study of Dua *et al.*[35], who reported that MUAC was strongly associated with blood pressure with an *r* of approximately 0.5. It was thought that MUAC corresponds to higher muscle mass in men and adiposity in women, therefore, MUAC may represent how body fat influences blood pressure in women[36]. This is consistent with the findings of this study in which MUAC was the strongest predictor of systolic blood pressure in girls. Amongst boys, however, MUAC was the strongest indicator of diastolic blood pressure in combination with body weight. It was suggested that MUAC may have a strong correlation with body weight since the prevalence of general obesity was higher in boys and may be associated with higher adiposity stored in MUAC. Mazigoglu *et al.*[37] indicated that MUAC was an important indicator that may reflect body adiposity and with WC can represent total body mass[37].

Interestingly, prehypertension existed almost proportionately in all obesity levels, even in underweight boys and girls. Hypertension stadium-1 even appeared amongst underweight boys. Nonetheless, the trend obviously showed that an increased level of blood pressure was more frequent in overweight and obese individuals of both genders. This raises concerns about blood pressure monitoring and controlling in all nutritional statuses. In a large cohort study in boys enrolling as undergraduates at Harvard University, Boston, Massachusetts, Gray *et al.*[38] indicated that higher blood pressure in early adulthood was associated with an elevated risk of all-cause mortality, CVD and CHD, but not stroke, several decades later. Lowering blood pressure in early adulthood may thus have benefits in reducing hypertension and the risk factors in later life.

The present study contains some limitations including the limited sample size, which prevents it from proposing cut-off points for the determination of hypertension and may not represent all Indonesian college students. There was also no follow-up to confirm hypertension. Nonetheless, despite extensive studies of anthropometrics in association with blood pressure in children and adults, studies on college students who are in the early adult life period are limited. Present study thus enhanced the knowledge of those associations amongst youths, particularly Indonesian youths. This study provides the additional recommendation that early identification and interventions to reduce blood pressure must occur earlier before adult life. Weight, MUAC, WC, HC, skinfold thickness, BMI and WSR are amongst the anthropometric variables that can be applied in the general population because they require only simple measurements that can easily be managed as a routine assessment. This study recommends the use of these measurements for the early detection of high blood pressure in Indonesian young adults.

## CONCLUSION

Boys showed a higher level and prevalence of high blood pressure than girls. The present study found that most of the anthropometric variables (weight, MUAC, wrist circumference, WC, HC, skinfold thickness, BMI and WSR) were associated with systolic blood pressure in boys and girls and with diastole in boys, except for stature and WHR. Amongst the anthropometric indicators, BMI and MUAC were the strongest predictors of systole in boys and girls, respectively, whereas weight and MUAC in boys and weight in girls were the strongest predictors of diastolic blood pressure.

## SIGNIFICANCE STATEMENT

This study discovers the usefulness of anthropometric measures as indicators of blood pressure that are beneficial for the identification of hypertension amongst Indonesian college students. This study will help researchers uncover critical areas of hypertension amongst young adults in Indonesia that many researchers were not able to explore. Thus, this study highlights a new theory on anthropometric indicators for high blood pressure in young adults.

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