Body mass index and waist-to-height ratio cut-offs as predictors of high blood pressure in adolescents

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ABSTRAK

Latar belakang: *Obesitas merupakan faktor risiko peningkatan tekanan darah. Meskipun pemeriksaan tekanan darah diindikasikan untuk setiap anak yang berobat, pengenalan dini risiko tekanan darah tinggi mungkin dapat membantu menghemat waktu. Penelitian ini bertujuan untuk mengetahui* cut-off *indeks massa tubuh dan rasio lingkar pinggang per tinggi badan untuk melakukan prediksi terhadap tekanan darah tinggi pada anak.*

Metode: *Penelitian ini menggunakan disain potong lintang pada 928 anak usia 11 sampai 16 tahun yang dipilih secara kluster acak dari sekolah menengah pertama di Yogyakarta. Teknik pemeriksaan tekanan darah sesuai dengan* The Fourth Report on The Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. *Indeks massa tubuh disesuaikan dengan usia dan jenis kelamin menurut standar WHO tahun 2007. Nilai* cut-off *didapatkan dengan menggunakan* Receiver Operating Characteristic *(ROC).*

Hasil: *Cut-off skor Z indeks massa tubuh sesuai usia untuk prediksi tekanan darah tinggi pada anak adalah 0,51 (sensitivitas 82%; spesifisitas 76% pada tekanan darah sistolik, dan sensitivitas 82%; spesifisitas 72% pada tekanan darah diastolik). Cut-off rasio lingkar pinggang per tinggi badan adalah 0,45 (sensitivitas 76%; spesifisitas 74% pada tekanan darah sistolik, dan sensitivitas 76%; spesifisitas 70% pada tekanan darah diastolik).*

Kesimpulan: *Indeks massa tubuh dengan nilai skor Z = 0,51 dan rasio lingkar pinggang per tinggi badan 0,45 merupakan nilai* cut-off *yang dapat menjadi prediktor tekanan darah tinggi pada anak dengan akurasi yang cukup baik.*

ABSTRACT

Background: Obesity is associated with increased risk for high blood pressure (BP). Although a routine BP measurement is indicated for all children visiting pediatric practice, recognition of children particularly at risk may save times. The aim of this study was to assess the cut-off point for body mass index (BMI) and waist-to-height ratio (WHtR) to predict high BP in adolescents.

Methods: We conducted a cross-sectional study on 928 children aged 11 to 16 years in Yogyakarta. BP were measured using standard technique described by The Fourth Report on The Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. BMI was adjusted for age and sex using the WHO 2007 growth reference. WHtR was ratio of waist circumference related to height in centimeters. Receiver operating characteristic (ROC) curves were used to estimate the best cut-offs.

Results: The best cut-off point for BMI-for-age Z-score (BMIZ) to predict high BP was 0.51 with sensitivity and specificity of 82% (95% CI = 78-86) and 76% (95% CI = 67-78) for systolic BP and sensitivity and specificity of 82% (95% CI = 78-86) and 72% (95% CI = 68-76) for diastolic BP. The best cut-off point for WHtR was 0.45, with sensitivity of 76% (95% CI = 67-78) and specificity of 74% (95% CI = 71-79) for systolic BP and sensitivity of 76% (95% CI = 72-80) and specificity of 70% (95% CI = 61-75) for diastolic BP.

Conclusion: BMIZ of 0.51 and WHtR of 0.45 are the best cut-off point to predict high BP in adolescents.

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Elevated blood pressure (BP) in children and adolescents is a risk factor for subsequent hypertension.[1] A population study showed that obese children had approximately five times higher risk for elevated BP compared to children with normal weight.[2] The risk was even higher in those with central distribution of body fat.[3-5] Several anthropometric indicators, e.g. body mass index (BMI) and waist-to-height ratio (WHtR), had been used to estimate the level and the distribution of body fat in children and adolescents.[4,5]

Although a routine BP measurement is indicated for all children visiting pediatric practice, awareness of the possibility of elevated BP through abnormal anthropometric indicators may be a good strategy to detect children particularly in need for BP measurement.[6] Cut-off points for BMI and WHtR as predictors for high BP has been developed in other countries, i.e. China, US, Japan, and Brazil.[7-9] They observed cut-offs of +1 for BMI-for-age z-scores (BMIZ) and 0.5 for WHtR as predictors for elevated BP.[9,10] The objectives of this study was to assess the cut-off points of BMIZ and WHtR for predicting high BP in adolescents of Indonesian people in Yogyakarta.

METHODS

We conducted a cross-sectional study in junior high school students aged 11-16 years from three junior high schools in Yogyakarta. The study was performed in August 2012. Exclusion criteria were diagnoses of heart and renal diseases, adrenal disorders, and use of steroids or sympathomimetic drugs. From 938 children identified, 928 (99%) accomplished the inclusion and exclusion criteria.

Measurement of weights, heights and waist circumferences were performed in triplicate, the means of the three measurements were used for subsequent data analysis. Body weight was calculated to the nearest 0.1 kg by a digital weight scale which had been calibrated in the Metrology Department.[10] Height was measured to the nearest 0.1 cm using portable stadiometer with the subject standing without shoes facing the examiner.[11] Waist circumference was measured at a point between iliac crest and costal angle, using a non-stretchable measurement tape, to the nearest 0.1 cm.[11]

BMI was a calculation of weight (in kilograms) divided by squared height (in meters). BMIZ was age and gender adjustment of BMI using the WHO 2007 reference curve.[12] WHtR was waist circumference related to height in centimeter.

Blood pressures were measured in classrooms by trained nurses using a calibrated ossilometer. Blood pressures were measured in two-different-day-visits.[13] Appropriate cuff's size for every children's right arm was used. The appropriateness of the cuff's size was checked by measuring the subjects' right arm circumference using a non-stretchable measurement tape, to the nearest 0.1 cm. The length of the manset should cover 80% of the right mid-upper-arm circumference and its width covering 40% of the right mid-upper-arm circumference, after at least 10 minutes rest from recent activity. The children were asked to sit in a comfortable sitting position with their right arm fully exposed and resting on a supportive surface at the heart level. The measurements were performed in triplicate, a 5 minute-rest were given before the subsequent measurement was performed.[2] High BP was defined as BP ≥ 90 percentile of the reference by the The Fourth Report on The Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents, which was based on age, sex and height.[2]

Data were collected by six trained personnels. Concordance for every measurements were assessed. The Kappa values were 0.94 for measurement of body weight and height, 0.84 for waist circumference, and 0.94 for BP measurement.

Data on age, sex, the presence of heart, kidney or adrenal diseases as well as information on medications used were obtained from questionnaires filled by parents. Parents signed informed consent for their children to participate in the study. Ethical approval was obtained by Medical and Health Research Ethics Committee, Faculty of Medicine, Gadjah Mada University, Dr. Sardjito General Hospital (No. Ref : KE/FK/625/EC).

Receiver operating characteristic (ROC) curves and their parameters, area under the curve (AUC), sensitivity and specificity were used to find cut-offs for BMI and WHtR associated with elevated BP.

RESULTS

We invited 490 boys (52.8%) and 438 girls (47.2%) to participate in the study. Characteristics of the study subjects were shown in table 1.

Figure 1 showed the sensitivities and specificities of each cut-off point for BMIZ to detect high systolic BP. In boys, the cut-off point varied between 0.43 to 0.98 with variations of sensitivities between 71% to 82%, and specificities between 75% to 84%. In girls, the cut-off point varied between 0.50 to 0.89, with sensitivities between 68% and 83%, and specificities between 74% and 81%. In all children (boys and girls), the variation of cut-off point were between 0.47 to 0.92, with the variation of sensitivities between 70% to 82%, and specificities between 75% to 82%. From the overall data, a BMIZ cut-off point that was the best predictor for high systolic BP was BMIZ of 0.51 with sensitivity of 82% (95% CI = 78-86) and specificity of 76%

Table 1. Characteristics of the subjects

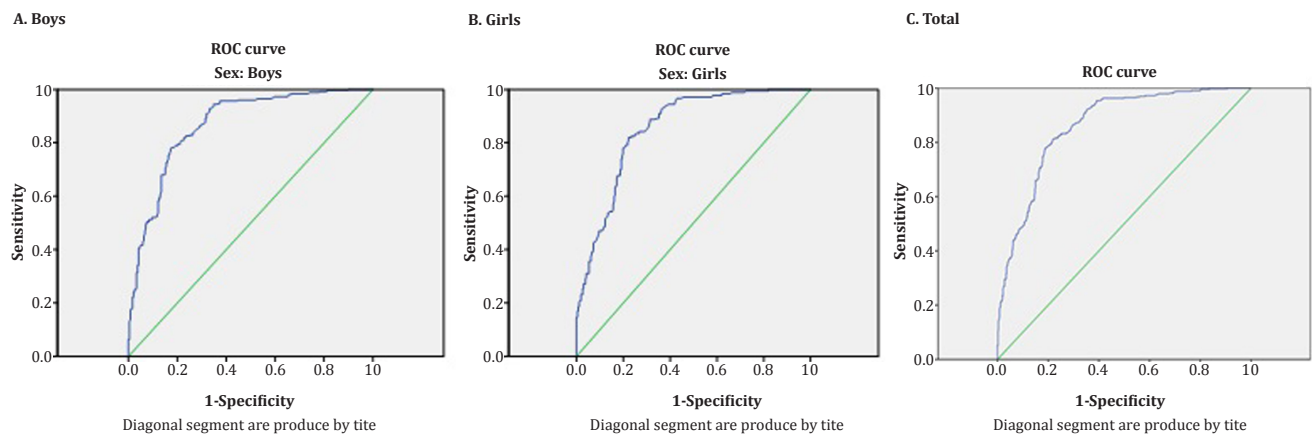| Characteristic	Boys (n=490) Mean (SD)	Girls (n=438) Mean (SD)	Total Mean (SD)
Age (years)	13.0 (1.1)	12.9 (1.0)	12.9 (1.0)
BMI-for-age Z-scores (BMIZ)	0.7 (1.6)	0.5 (1.3)	0.6 (1.5)
Waist to height ratio (WHtR)	0.47 (0.08)	0.45 (0.06)	0.46 (0.07)
Systolic BP (mmHg)	117.4 (13.4)	112.2 (10.7)	115.0 (12.5)
Diastolic BP (mmHg)	68.3 (10.5)	67.9 (9.6)	68.1 (10.1)

Figure 1. ROC curves and cut-offs for body mass index for age Z-scores (BMIZ) to detect high systolic BP in boys (A), girl (B) and total (C); sensitivity (sens), specificity (spes)
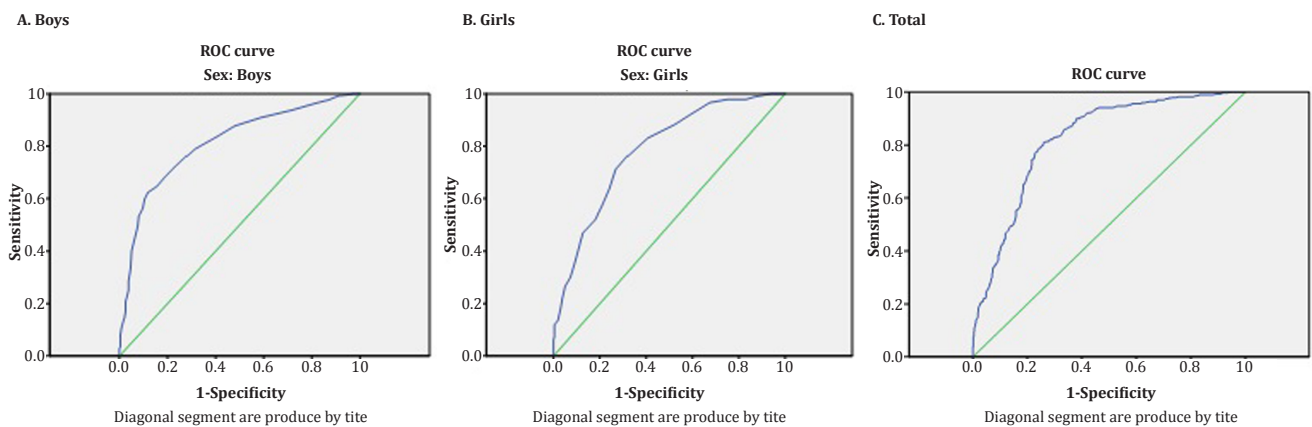

Figure 2. ROC curves and cut-offs of waist-to-height-ratio (WhtR) to detect high systolic BP in boys (A), girl (B) and total (C); sensitivity (sens), specificity (spes)

(95% CI = 72-83) (Table 2). This value had the best trade-off of sensitivity and specificity.

Figure 2 showed the sensitivities and specificities of every cut-off point of WHtR to detect high systolic BP. In boys, the cut-off point were between 0.41 to 0.50 with variation of sensitivities between 56% to 85%, and specificities between 52% to 90%. In girls, the cut-off point varied between 0.42 to 0.50, with sensitivities between 41% to 88%, and specificities between 47% to 88%. In all children (boys and girls), the variation of the cut-off point were between 0.42 to 0.5, with the variation of sensitivities between 50% to 85%, and specificities between 53% to 89%. From the overall data, WHtR cut-off point that was the best predictor for high systolic BP was 0.45 with sensitivity of 76 % (95% CI = 67-78) and specificity of 74% (95% CI = 71-79) (Table 2). This value had the best trade-off of sensitivity and specificity.

Table 2. Cut-off points and their sensitivities and specificities

	Cut-offs			
	Sensitivity	95%CI	Specificity	95%CI
Systolic BP BMIZ*: 0.51				
Boys	81%	77-86%	77%	72-83%
Girls	83%	78-89%	75%	70-80%
Total	82%	78-86%	76%	72-80%
Systolic BP WHtR**: 0.45				
Boys	72%	66-72%	77%	72-83%
Girls	72%	65-78%	73%	68-79%
Total	76%	67-78%	74%	71-79%
Diastolic BP BMIZ*: 0.51				
Boys	82%	77-87%	72%	67-77%
Girls	81%	75-87%	73%	66-77%
Total	82%	78-86%	72%	68-76%
Diastolic BP WHtR**: 0.45				
Boys	76%	67-78%	73%	67-78%
Girls	71%	60-74%	72%	64-73%
Total	76%	72-80%	70%	61-75%

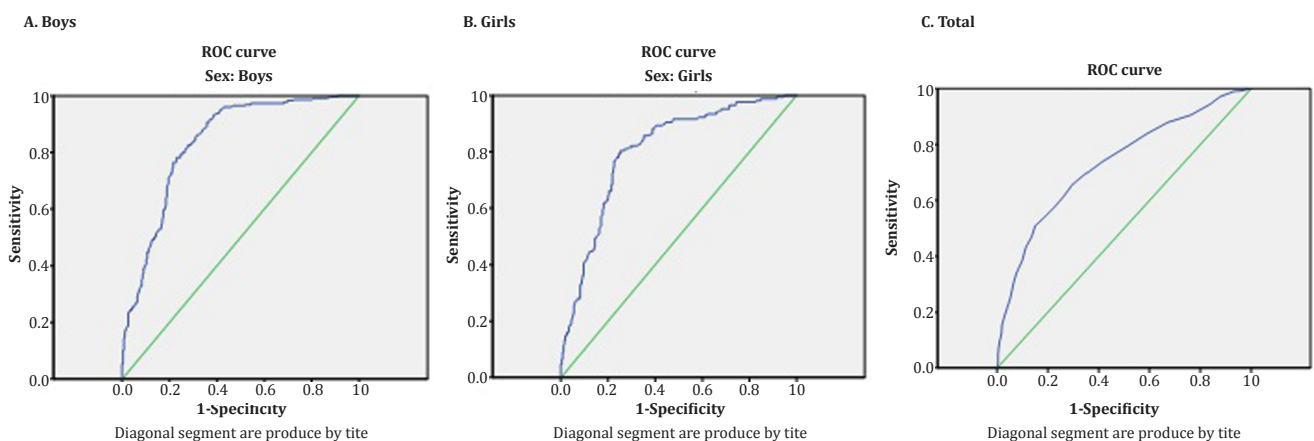*BMIZ=BMI-for-age z-score
** WHtR= waist-to-height-ratio

Figure 3. ROC curves and cut-offs for body mass index for age Z-scores (BMIZ) to detect high diastolic BP in boys (A), girl (B) and total (C); sensitivity (sens), specificity (spes)

Figure 3 showed the sensitivities and specificities of each cut-off point for BMIZ to detect high diastolic BP. In boys, the cut-off point were between 0.43 to 1.01 with a variation of sensitivities between 70% to 81%, and specificities between 68% to 80%. In girls the cut-off point varied between 0.46 to 0.86, with sensitivities varied between 68% to 81%, and specificities between 70% to 78%. In all children (boys and girls), the variation of the cut-off point were between 0.46 to 0.98 with the variation of sensitivities between 69% to 82%, and specificities between 69% to 79%. From the overall data, BMIZ 0.5 was the best cut-off point for predicting high diastolic BP, with sensitivity of 82% (95% CI = 78-86) and specificity of 72% (95% CI = 68-76) (Table 2). This value had the best trade off of sensitivity and specificity.

Figure 4 showed the sensitivities and specificity of each cut-off point of WHtR to detect high diastolic BP. In boys, the cut-off varied between 0.43 to 0.49 with a variation of sensitivities between 60% to 80%, and specificities between 65% to 84%. In girls, the cut-off point varied between 0.43 to 0.49, with sensitivities between 46% to 78%, and specificities between 55% to 85%. In all children (boys and girls), the variation of the cut-off point were between 0.43 to 0.49 with the variation of sensitivities between 54% to 79%, and specificities between 60% to 85%. From the overall data, WhtR cut-off point that was the best predictor for high diastolic BP was 0.45 with sensitivity of 76% (95% CI = 72-80) and specificity of 70% (95% CI = 61-75). This value had the best trade-off of sensitivity and specificity.

DISCUSSION

Boys showed higher mean distribution of WHtR than girls (0.47 vs 0.45). This is consistent with the theory that central fat accumulation is more common in men, whereas in women the fat will accumulate more in peripheral areas such as the thighs.[14]

Our study observed that both BMIZ and WHtR are fairly good predictors of high BP. Using appropriate cut-off point, both indicators gave high sensitivity and specificity to detect systolic and diastolic high BP. Compared to previous study in Mexico, cut-off point identified in this study were lower, although the sensitivity and specificity did not differ much.[15] In children aged 6-12 years, Elizondo-Montemayor, et al[15] observed a cut-off point for BMIZ of 1.92 with sensitivity of 85.5% and a specificity of 72.9%, while their cut-off point for WHtR was 0.59 with sensitivity of 81.8% and specificity 78.5%. Similar results were also observed by Motswagole, et al[16] suggested cut-off point 0.5 for WHtR a sensitivity of 68% and specificity of 98.6%, while Hara, et al[8] suggested 0.41 as the cut-off point for WHtR with sensitivity of 61.9 % and specificity of 53.6%.

In conclusion, cut-off point for BMIZ to detect high BP in adolescents was 0.51 with sensitivity of 82% and specificity of 76%, while the respective cut-off point for WHtR was 0.45 with sensitivity of 75% and specificity of 74%. The result of this study can be used to help deciding whether
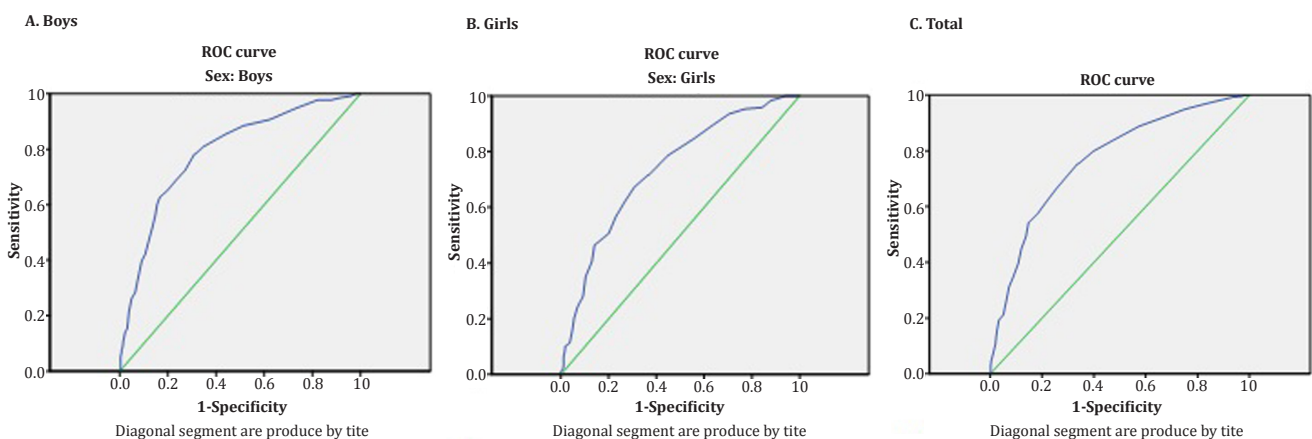

Figure 4. ROC curves and cut-offs of waist-to-height-ratio (WhtR) to detect high diastolic BP in boys (A), girl (B) and total (C); sensitivity (sens), specificity (spes)

certain obese patients are in need for screening for high BP.

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Conflict of interest

The authors affirm no conflict of interest in this study.

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