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Waist Circumference and Waist-to-Height Ratio as Indicators for Excess Adiposity in Indonesian Adolescents

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ABSTRACT

The aimed of study was to evaluate the accuracy of Waist Circumference (WC) and Waist-to-Height Ratio (WHtR) for identification of excess adiposity in adolescents. The study design was diagnostic study. The subjects consisted of 620 adolescents (283 boys and 337 girls) aged 14-18 years. The classification of excess adiposity termed as overfat and obese was based on age-and sex-specific percent body fat cut-off values of body fat reference curves for children from the Growth Foundation. Receiver-operating characteristic (ROC) curve analyses was used to assess the accuracy of WC and WHtR as diagnostic tests of excess adiposity in adolescent. Area under curve (AUC) of WC and WHtR for the diagnostic of overfat were over 0.8 for boys and over 0.9 for girls. Whereas for obese, the AUC of WC and WHtR were over 0.9 for both sexes. The thresholds for defining overfat were 75.25 cm for WC and 0.45 for WHtR (Sensitivity (Se) and Specificity (Sp) >0.8) for boys, and 73.85 cm for WC and 0.49 for WHtR (Se dan Sp >0.8) for girls. The thresholds for defining obese were 86.45 cm for WC and 0.51 for WHtR (Se=1; Sp>0.9) for boys, and 75.60 cm for WC (Se and Sp >0.8) and 0.55 for WHtR (Se>0.8; Sp >0.9) for girls. WC and WHtR are accurate for screening of excess adiposity in adolescents.

Keywords: adolescent, waist circumference, waist-to-height ratio

INTRODUCTION

The prevalence of overnutrition in adolescents aged 16-18 years in Indonesia has escalated from only 5.9% in 2007 to 7.3% (5.7% overweight and 1.6% obesity) in 2013 (Kemenkes 2014).

Overnutrition is a state of excessive accumulation of fat mass which has been associated with increased risk of morbidity. Percent body fat as indicator for fat mass in adolescents is classified by sex and age (Freedman *et al.* 2015; McCharty *et al.* 2006). Adolescents with overnutrion are more likely to stay obese as they grow into adulthood which mean they will also at increased risk to develop non-communicable diseases (WHO 2018). Thus, screening program is needed in the adolescents group, so early intervention can be done if problems of overnutrition are found. A study on Mexican adolescents aged 6-18 years found that cardiovascular diseases risk factors was higher at higher levels of percent body fat (above 20% fat in boys and above 30% fat in girls) (Going *et al.* 2011).

Regardless of its accuracy in defining excess adiposity compared to body mass index (BMI), percent body fat measurement is not practical in low resource setting. Nutrition screening requires a simple method with relatively inexpensive tools and covers many subjects. Anthropometry method is widely used as a method for nutrition screening and has been scientifically recognized (Supariasa *et al.* 2014). Percent body fat measurement using digital Body Impedance Analysis (BIA) requires data on weight, height, age, and sex (Manualslib 2012). Although digital BIA is relatively inexpensive but it is still more expensive compared to waist circumference (Kyle *et al.* 2014). Therefore, waist circumference (WC) has been used as an alternative to define body fat distribution. Recently, waist-to-height ratio (WHtR) has also became an alternative indicator for evaluation of overnutrition in adolescents. Yan *et al.* in 2007 found that WHtR was a better indicator to evaluate the incidence of obesity than WC in adolescents. WC has been used in adult group but there is no cut-off point available for WHtR in Indonesian adolescents. Hence, the aim of the study was to evaluate the accuracy of WC and WHtR in identifying excess adiposity termed "overfat" and "obese" in adolescent as well as to propose the optimal thresholds.

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METHODS

Design, location. and time

This study was a diagnostic study to assess WC and WHtR as an overnutrition indicators in adolescents based on percent body fat parameter. The study was conducted in SMA N 2 Ungaran, Central Java in November 2017. The school location is in an area close to various fast food restaurants that can be reached on foot. The school canteen provides high energy snacks such as sweet cakes and various fried foods. While on the other hand, most students use motorbikes to go to school.

Sampling

The subjects in this study were 620 students (283 boys, 337 girls) and was acquired from total sampling technique. The inclusion criteria were not suffering from fever and not during menstruation at the time of measurement. The study was ethically approved by Ethics Commision of Health Research, Public Health Faculty of Diponegoro University (No. 281/EC/FKM/2017).

Data collection

Data on the number of students were obtained from the school student service centre. Data on sex and date of birth of each student were recorded for sex. Anthropometry parameter measurements were performed on subjects wearing sports uniform and barefoot. Height was measured by microtoise (accuracy=0.1 cm), WC was measured using measuring tape to the nearest 0.1 cm, and digital percent body fat instrument Omron Body Composition Model HBF-358-BW(accuracy=0.1%) was used to collect percent body fat data. The subjects were standing straight for height measurement with heels, buttock, and shoulder blades in contact with the wall, the headboard were lowered on the highest point of the head with enough pressure to compress the hair (Gibson 2005). WC measurement was performed in closed room with the same sex enumerator to maintain the privacy and comfort of the subject. WC was measured at natural waist, mid-way between the tenth rib (the lowest rib margin) and the iliac crest (Gibson 2005). Subjects were asked to clean and dry their hands and feet before percent body fat measurement was done. Enumerators inputted sex, age, and height data of the subjects before the subject stand on the instrument, weight, and percent body fat were measured (Manuaslib 2012). Measurements were perfomed by trained nutrition lecturer and nutrition students.

Data analysis

Percent body fat, WC, and WHtR were expressed as mean ± standard devation (SD). The sensitivity (Se) and specificity(Sp) of WC and WHtR as indicators for overfat and obesity were determined with cut-off values based on percent body fat as gold standard. WHtR was calculated by dividing waist circumference with height. Percent body fat was classified using percentile scores for sex and age (<2nd percentile=underfat; 2nd-85th percentile=normal; >85th-95th percentile=overfat; >95th percentile=obese) (McCarthy *et al.* 2006). Receiver operating characteristics (ROC) curves and area under the curve (AUC) for ROC's were obtained by plotting sensitivity against the false-positive rate (1-specificity). The Youden index (J) was used to determine optimal cut-off values for WC and WHtR for identification overweight and obesity (J=sensitivity+ specificity-1).

RESULTS AND DISCUSSION

Total number of students was 732 students and 112 students did not meet the inclusion criterias thus 620 students participated in the study. The age range of the subjects was 14-18 years and the distribution of subjects based on sex were 283 (45.65%) boys and 337 (54.35%) girls. Subject characteristics are shown in Table 1.

There was positive correlation between WC and WHtR with percent body fat ($p<0.01$). The mean of percent body fat and WHtR were higher in girls than boys. There was difference of percent body fat and WHtR between the sexes, while the mean of WC was lower in girls.

This is in line with Yunieswati and Briawan study (2014) which found that WC was lower in girls than boys. After puberty, body fat

Table 1. Subject characteristics

Variables	Min - max	Boys (n=283)	Girls (n=337)	p
Age (y)	14.1-18.4	16.16±0.7	16.01±0.6	
Percent body fat (%)	5.0-38.1	14.28±6.5	24.57±4.1	0.0001
Waist circumference (cm)	52.0-114.0	70.75±1.1	69.08±1.1	0.5560
Waist to height ratio	0.33-0.71	0.43±0.1	0.45±0.1	0.0001

n= Total subject, *Significant for $p<0.01$

distribution differ between sexes. Boys have relatively greater central distribution of fat than girls (WHO 2011). However, the mean WHtR was higher in girls than boys due to the mean of height was higher in boys than girls (boys=166.18±5.7; girls=154.19±5.6). Peak growth occurs later in boys, coupled with their higher peak growth velocity. The difference between final heights is approximately 12.5 cm between sexes (Tylor-Miller & Simm 2017).

Anthropometry indexes accuracy for evaluating overfat and obese were measured using AUC (Area Under Curve). For overfat, results are shown in Table 2 and Figure 1.

WC and WHtR have good accuracy (AUC>0.8) in boys and excellent accuracy (AUC>0.9) in girls to determine overfat (Table 2). For obese, WC and WHtR have excellent accuracy (AUC>0.9) in both sexes (Table 3).

A study on subjects aged 8-18 years showed that percent body fat can be explained 31% by WC lower than WHtR (64%) (Brambilla *et al.* 2013). The widely used indicator for assessing obesity is BMI (Body Mass Index). BMI cannot describe body fat. There are subjects with "normal" BMI but high abdominal fat thus mean increased in excess adiposity as well as subjects with high BMI due to muscle growth but low in excess adiposity. High percent body fat, specifically in abdominal area is one of independent indicators for all cause of mortality in men and women (Leeds Beckett University 2017). WC describe fat deposit in abdominal area. Higher risk of obesity occurs with greater WC (Par'i *et al.* 2017). In addition, WHtR is an alternative to describe percent body fat and visceral adipose tissue. (Leeds Beckett University 2017).

Cut-off point WC is higher in boys than girls with sensitivity and specificity >0.8 (boys=75.25 cm and girls=73.83 cm). For WHtR, cut-off point is lower in boys than girls with sensitivity and specificity >0.8 (boys=0.45 and grils=0.49) (Table 4).

For determining obese, optimal cut-off point is higher in boys than girls for WC (boys=86.45 cm and girls=75.60 cm) and lower for WHtR (boys=0.51 and girls=0.55). Sensitifity and specificity are better in boys than girls (boys: Se=1, Sp>0.9; girls: Se=1, Sp>0.8) (Table 5).

Despite some research had shown high sensitivity and specificity for WC to determine obesity in adolescents, there is no universally

Table 2. Area under curve for waist circumference and waist to height ratio to determine overfat based on percent body fat in adolescents

Sex	Anthropometry indicators	AUC	SE	p	Lower	Upper
Boys	Waist circumference	0.84	0.033	0.0001	0.777	0.907
	Waist to height ratio	0.86	0.029	0.0001	0.800	0.914
Girls	Waist circumference	0.93	0.016	0.0001	0.901	0.965
	Waist to height ratio	0.95	0.015	0.0001	0.918	0.978

AUC=Area under curve, SE=Standard error,*significant for p<0.01

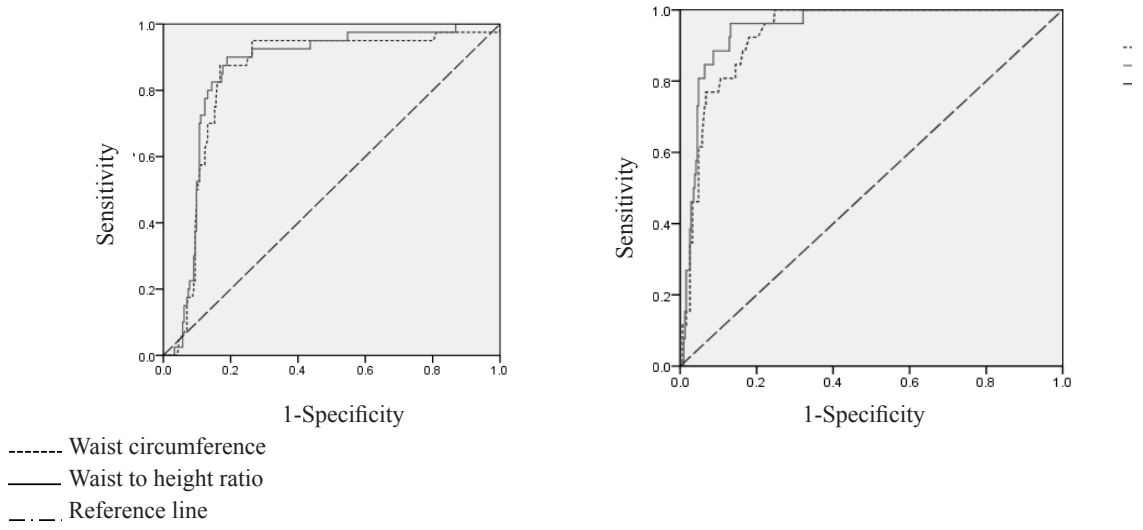

Figure 1. Receiver-operating characteristic (ROC) curves for overfat in boys (left) and girls (right)

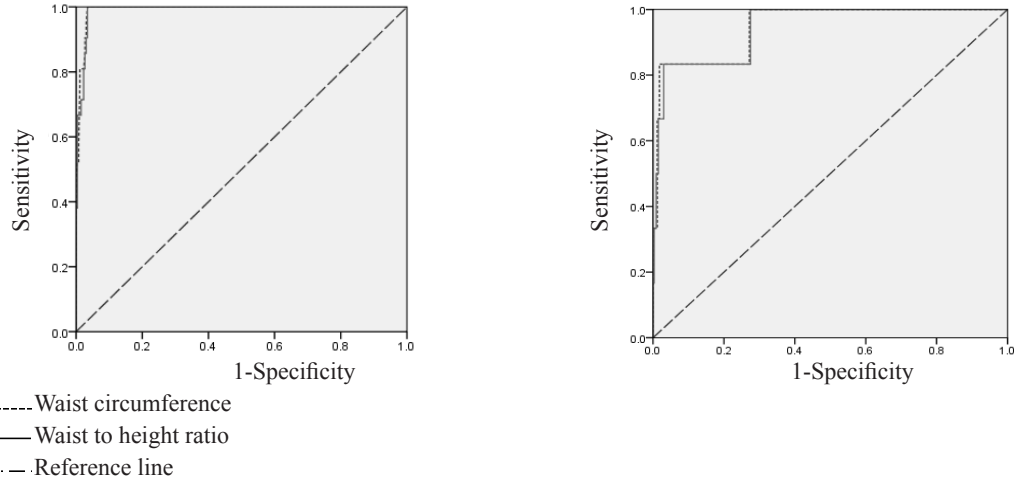

Figure 2. Receiver-operating characteristic (ROC) curves for obese in boys (left) and girls (right)

Table 3. Area under curve for wasit circumference and waist to height ratio to determine obese based on percent body fat in adolescents

Sex	Anthropometry indicators	AUC	SE	p	Lower	Upper
Boys	Waist circumference	0.99	0.040	0.0001	0.984	1.000
	Waist to height ratio	0.99	0.005	0.0001	0.981	0.999
Girls	Waist circumference	0.95	0.040	0.0001	0.869	1.027
	Waist to height ratio	0.95	0.041	0.0001	0.865	1.025

AUC=Area under curve, SE=Standard error,*Significant for p<0.01

accepted definition for WC classification for the age group. Mulyasari's study in 2016 had suggested WC cut-off point for adolescents aged 13-15 years as follow, for boys, ≥79.75 cm (Se=1; Sp=0.92) and ≥73.5 (Se=0.92; Sp=0.87) for girls. Another study had shown that WC 111.5 cm in boys and 104.6 in girls as cut-off point for metabolic syndrome incidence prediction in adolescents with obesity in Helsinki (Masquio *et al.* 2015).

Previous study in Greek adolescents aged 12-17 years in 2015, had shown that WHtR was a better predictor for obesity than Waist-Hip Ratio (WHR). Based on ROC analysis, WHtR had higher sensitifity to determine obesity than WHR. WHtR cut-off point was 0.5 with sensitivity 91% and specificity 95% for both sexes and all age. WHR cut-off point was 0.9 for boys (Se=22%; Sp=97%) and 0.85 for girls (Se=24%; Sp=99%) (Bacopoulou *et al*. 2015).

Table 4. Optimal cut-off point for waist circumference and waist to height ratio to determine overfat in adolescents

Sex	Anthropometry indicators	Cut-off	Se	Sp
Boys	Waist circumference	75.25	0.875	0.831
	Waist to height ratio	0.45	0.850	0.823
Girls	Waist circumference	73.85	0.885	0.832
	Waist to height ratio	0.49	0.885	0.874

Se=Sensitivity, Sp=Specificity

Table 5. Optimal cut-off point for waist circumference and waist to height ratio to determine obese in adolescents

Sex	Anthropometry Indicators	Cut-off	Se	Sp
Boys	Waist circumference	86.45	1	0.962
	Waist to height ratio	0.51	1	0.958
Girls	Waist circumference	75.60	0.833	0.831
	Waist to height ratio	0.55	0.833	0.952

Se=Sensitivity, Sp=Specificity

WHtR also had been shown as better indicator to detect cardiovascular disease than BMI in Asian ethnicity compare to non-Asia (Savva *et al.* 2013). Cut-off point to determine over nutrition using WHtR based on study in Indonesian adolescents aged 13-15 years was ≥0.46 for boys and ≥0.47 for girls (Nambiar *et al.* 2010; Savva *et al.* 2013; Mulyasari 2016).

WC and WHtR are anthropometry indicators that have been suggested in various studies to screen for over nutrition in adolescents which can also serve as predictor for non communicable disease risks such as cardiovascular disease. Both indicators had shown good sensitivity, faster, and easier than BMI. Due to the differences in growth pattern between girls and boys, body fat distribution and height in all age and both sexes might be bias in diagnosing overnutrition (Tybor *et al.* 2008). While to date, there is no consensus of overnutrition classification for both indicators especially for Indonesian adolescents.

This study results can be used as preliminary information that WC and WHtR have had good sensitivity for determining overnutrition in adolescents. Further research about both indicators is needed to include subject who represent all ethnic in Indonesia. The error measurement might occur in this research. Digital instrument for assessing percent body fat have hydration consideration. Recommended time for using the instrument are in well-hydrated condition of subject and two hours after main meal consumption. This study did not consider body fat distribution and growth velocity differences in adolescent related to their growth period. We are suggesting that future research about both indicators can be done with longitudinal design for better interpretation of the growth pattern. Cut-off point for diagnosing overnutrition should be developed for each age and sex.

CONCLUSION

This study suggests the potential use of WC and WHtR as indicators for excess adiposity in adolecents. Cut-off point for overfat and obese are higher in boys than girls. For WHtR, cut-off point of overnutrition was lower in boys than girls.

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