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Original article

Cut-off value of Waist-to-Hip Ratio as a predictor of metabolic syndrome in adolescents with obesity

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Abstract. *Background and aim:* Metabolic syndrome is present in 7% of adolescents and 19 to 35% in obese adolescents, and the cause of this condition has not been fully understood. Early identification of the risk involved could be an initial step in preventing a metabolic syndrome. Increased waist circumference, which is a parameter of central obesity, is also risk factor for this condition. This study aims to determine the possibility cut-off value of waist-to-hip (WHR) as a predictor of metabolic syndrome. *Methods:* We studied 208 obese adolescents between the ages of 13 to 18 years from junior and senior high schools who living in rural dan urban areas in East Java. These obese adolescents were divided into two groups, namely with and without a metabolic syndrome. Anthropometric measurements, including waist-to-hip ratio (WHR), were carried out to analyze the cut-off values between the two groups. *Results:* 208 obese adolescents (51.4% males and 48.6% females) without the metabolic syndrome and 104 obese adolescents with metabolic syndrome were evaluated. There was a significant relationship between WHR and metabolic syndrome in obese adolescents ($r = 0.203$, $P = 0.003$). Those adolescents with a high WHR value > 0.891 had twice risk to develop metabolic syndrome compared to those with lower (OR 2.033; 95% CI = 1.165-3.545). *Conclusions:* Increased waist-to-hip ratio > 0.89 in adolescents was associated with higher risk to develop metabolic syndrome and can be proposed as a predictor for metabolic syndrome in obese adolescents. (www.actabiomedica.it)

Key words: Waist-to-hip ratio, Metabolic Syndrome, Adolescence, Risk Factors

Introduction

Metabolic syndrome (MetS), also known as "Insulin Resistance Syndrome" or "Syndrome X", has an increasing prevalence in children and adolescents. The cause of this condition has not been fully understood (1). Therefore, early identification of MetS risk factors and adopting suitable preventive measures is an essential step in preventing its occurrence (2,3). One of the components of MetS is central obesity, which can be measured using various anthropometric parameters, such as waist and hip circumferences, and waist-hip ratio (WHR). Furthermore, the periodic measurement of these parameters can be used for early identification of MetS (4). The cut-off value of WHR can be used as a predicting indicator of metabolic syndrome in obese children (5). However, this value varies among different countries (6). This study aims to determine the cut-off value of WHR as a predictor of metabolic syndrome in obese adolescents in Indonesia.

Materials and methods

Study population and design

This is an observational case-control study performed between January to May 2020 on obese adolescents with and without the metabolic syndrome. The cut-off value that discriminates those with versus those wthout the metabolic syndrome was searched.

The correlation of WHR with the metabolic syndrome in all obese adolescents aged 13 to 18 years in Surabaya and Sidoarjo was measured. This study was approved by the Ethical Committee of the Faculty of Medicine, Airlangga University (No. 65/EC/KEPK/FKUA/2020).

Diagnosis of obesity and metabolic syndrome

Obesity was diagnosed based on the CDC 2000 criteria and body mass index (BMI) for age and gender above the 95th percentile. The metabolic syndrome was diagnosed based on the IDF criteria for diagnosing this condition in children and adolescents.

Physical and laboratory examination

Body weight was measured using a digital weight scale (Seca, Germany No ref. 224 1714009) with a precision of 0.1kg. The subjects were standing barefoot and putting on thin clothes during the measurement. Furthermore, the heights were measured using stadiometers (Seca, Germany No ref. 224 1714009), with an accuracy of 0.1cm. The stadiometer was used to measure the height from heel to vertex and the results were presented in 'meter'. Waist circumference was measured midway between the lowest rib and the iliac crest at the end of expiration. The measurements were made on the skin and recorded to the nearest 0.1cm. Furthermore, the waist-hip ratio (WHR) was calculated using the Bjorntorp formula (7). The subjects had fasted for 12 hours before the blood samples were taken. Fasting blood sample was collected for measuring triglyceride, HDL, and blood glucose levels. The blood samples were centrifuged and the serum was stored at -70° C for further analysis.

Data analysis

The correlation between waist-to-hip ratio and metabolic syndrome in obese adolescents was analyzed using the Mann-Whitney comparative test. The cut-off value of WHR was based on the receiver operating characteristic (ROC). The correlation between WHR (WHR>0.891 vs. WHR<0.891) with the component of metabolic syndrome (central obesity, low level HDL-c, hypertriglyceridemia, hyperglyceridaemia, and hypertension) was calculated with chi square test.

Results

An examination was conducted on adolescents with obesity in junior and senior high schools in Surabaya and Sidoarjo. The characteristics of the subjects are listed in the table below (Table 1).

The Mann-Whitney test was used to show the correlation between WHR and metabolic syndrome in obese adolescents with a P-value of 0.003 (95% CI = 0.689-1.071). There was a significant correlation between WHR and metabolic syndrome in obese adolescents as seen in Table 2. The backward multivariate regression analysis showed that the WHR was the most influential parameter on metabolic syndrome compared to other central obesity parameters, such as waist and hip circumference. Based on table 2, waist circumference has stronger correlation with metabolic syndrome compared to WHR (r = 0.296 vs. 0.203 respectively, P: < 0.05).

A diagnostic power test of the WHR for metabolic syndrome in obese adolescents was performed using ROC to determine the cut-off value (Figure 1). The cut-off value of WHR 0.891 on the ROC curve showed a sensitivity value of 63.72% and a specificity of 52.99%. The analysis showed that adolescents with WHR > 0.891 would be x 2.033 times higher risk to develop metabolic syndrome than a low WHR (< 0.891). Furthermore, a chi-square analysis was performed based on the mean waist-to-hip ratio of 0.891 for the components of the metabolic syndrome, including decreased HDL-c, increased triglyceride, and increased fasting blood sugar levels, and increased blood pressure. A high WHR (> 0.891) had a significant correlation with increased blood pressure in obese adolescents, (P: 0.027). It was found that in obese adolescents with WHR > 0.891, the WHR was not correlated with the other components of metabolic syndrome (increased triglycerides, decreased in HDL-c, and increased fasting blood sugar levels (P: >0.05).

Discussion

Gender is one of the factors that play a major role in adolescents suffering from metabolic syndrome. The metabolic syndrome was more common in obese male adolescents compared to females. Similar results were also obtained from studies in Malaysia (8)

Table 1. Demographic characteristics, biochemical and diagnostic parameters.

Characteristic	Metabolic syndrome + SD	Non metabolic syndrome	Total (n=208)	P
Sex				
Male, n (%)	64	37	101 (48.5%)	<0.0001[1]
Female, n (%)	40	67	107 (51.4%)	
Age, month	181.13 + 18.96	179.23 + 18.98	180.18 + 18.95	0.470[2]
≤ 16 years	80	80	160 (76.9%)	0.565[1]
> 16 years	24	24	48 (23.1%)	
Triglyceride level	150.70 + 68.27	92.21 + 47.87	121.46 + 65.72	<0.0001[2]
≥ 150 mg/dl	70	20	90 (43.3%)	<0.0001[1]
< 150 mg/dl	34	84	118 (56.7%)	
HDL level	38.72 + 6.79	45.74 + 7.29	42.23 + 7.86	<0.0001[2]
< 40 mg/dl	98	60	158 (75.9%)	<0.0001[1]
≥ 40 mg/dl	6	44	50 (24.1%)	
Fasting glucose level	86.74 + 9.42	87.31 + 19.46	87.02 + 15.26	0.789[2]
≥ 100 mg/dl	18	4	22 (10.5%)	<0.0001[1]
< 100 mg/dl	86	100	186 (89.5%)	
Systolic blood pressure	130.87 + 11.44	119.52 + 12.50	125.19 + 13.24	<0.0001[2]
Diastolic blood pressure	87.11 + 9.65	78.65 + 8.47	82.88 + 9.998	<0.0001[2]
≥ 130/85 mmHg	72	21	93 (44.7%)	<0.0001[1]
< 130/85 mmHg	32	83	115 (55.3%)	

[1]Fischer's exact test; [2]Independent sample T-test; Significant of P: <0.05

Table 2. Regression analysis of central obesity parameters in correlation to the metabolic syndrome in adolescents with obesity.

Variable	r	P	OR
Waist circumference	0.296	0.001	0.825[1]
Hip circumference	0.181	0.014	1.238[1]
WHR	0.203	0.003	1.248[1]
Hip circumference	0.181	0.014	1.045[1]
WHR	0.203	0.003	762.115[2]

[1]bivariate regression analysis; [2]multivariat regression analysis. Significant of P: <0.05

and Norway (9) which showed that male adolescents had a greater prevalence of metabolic syndrome. This relationship was not significant for ages above 18 years (10).

The different components of the metabolic syndrome had variable prevalence in our obese adolescents. A decrease in HDL levels was detected in (75.9%), while an increase in blood pressure occured in (44.7%). Similar results were reported from a study in Virginia on 78 children aged 3 to18 years with obesity. In their study, high blood pressure was the most prevalent component , followed by a decrease in HDL levels (11).

This study documented a significant correlation between WHR and metabolic syndrome in obese adolescents. Similarly, a cross-sectional studies conducted

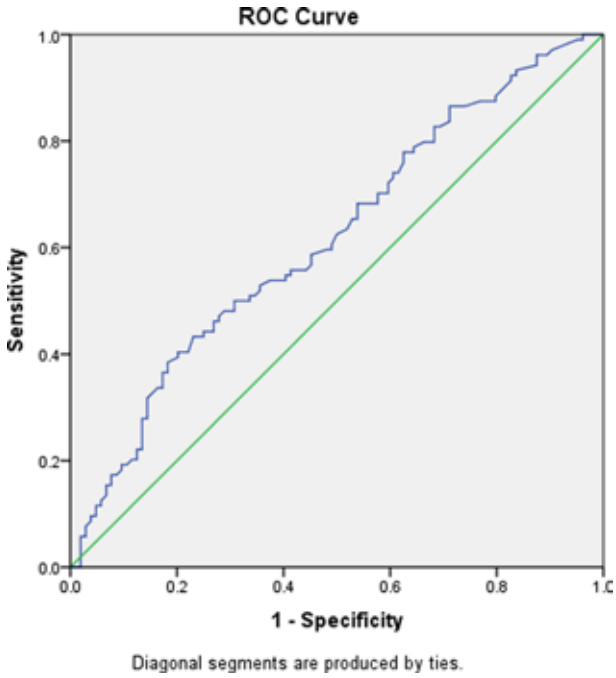

Figure 1. ROC curve for the value of WHR as a predictor of metabolic syndrome.

in Brazil (109 children), Turkey (1194 children, mean age: 9 years), and USA (764 children, aged 5 to 12 years) found significant relationship between the waist-hip ratio and the metabolic syndrome in obese children (2). Another study showed that WHR had a significant relationship with components of the metabolic syndrome in obese children (2,12,13). Furthermore, Moore et al. (13), retrospectively showed that the waist-to-hip ratio was associated with the occurrence of metabolic syndrome.

Central obesity has also been associated with the risk of metabolic syndrome in children along with other variables such as waist (WC) and hip circumference (HC), and waist-to-hip ratio (WHR). Furthermore, according to the multivariate regression analysis, the most influential variable in obese adolescents is the waist-to-hip ratio. A study in Spain involving 1001 adolescents with an average age of 13.1 years also showed that WHR was the best predictor of this condition compared to WC and BMI. Furthermore, a cross-sectional study that was conducted in 18 secondary schools showed that WHR had the highest predictive value compared to WC and BMI (14). The results of a retrospective study in Iran which was conducted on 2064 children and adolescents aged 6 to18 years showed that WHR has the weakest association with metabolic syndrome when compared to other parameters such as WC, and BMI (15).

Currently, there is no consensus of the best cut-off value for WHR to the risk of metabolic syndrome in obese adolescents. The cut-off value of WHR 0.891 on the ROC curve showed a sensitivity value of 47.1% and a specificity of 35.6% in relation to metabolic syndrome, which was in contrast with this result.

A study involving 958 adolescents in Brazil showed a limiting WHR value of 0.87 on the ROC curve with an AUC of 0.43 and suggested that a WHR value of 0.87 can be used as a predictor of metabolic syndrome in adolescents (sensitivity value of 46.1% and a specificity of 51.2%) (2). A study from Spain on 1001 adolescents (median age of 13 years) suggested a cut-off value of WHR - 0.89 to be a good predictor of metabolic syndrome (14). Other studies in Asia propose a mean value of 0.8 to indicates higher risk of metabolic disorders.

There was a decrease on WHR value at the age of 9 to 15 years, and then stagnant (flat) at the age of 16, which was occurred on males and females in this study. A large cohort cross-sectional study involving 21,111 children aged 8 to 15 years, it was found that the WHR curve declined and then came to a plateau at the age of 15 years (16). In addition, the cut-off value associated with the metabolic syndrome also decreased above 15 years of age with a value of 0.84 in females and 0.91 in males representing the 95th percentile (17).

To our knowledge, no previous research in Indonesia has searched the WHR cut-off value associated with the metabolic syndrome in adolescents. However, Istiqomah et al. (18) analyzed the WHR cut-off value associated with hypertension, a component of the metabolic syndrome, in a large cohort (n = 325) and suggested that WHR > 0.94 could be used for screening hypertension in children, (AUC value of 0.724 (95% CI 0.672-0.72; P<0.001). In their study, the WHR value > 0.94 had a sensitivity of 59.6% and a specificity of 77.0% (18). In our study whereby the high WHR (> 0.891) had a significant correlation to the occurrence of increased blood pressure (a component of the metabolic syndrome), in obese adolescents

with a P: <0.05. In support to our findings, Widjaja et al. (19) studied 59 Indonesian obese adolescents and reported a significant correlation between WHR and insulin resistance, another component of the metabolic syndrome (p value 0.008 and r value 0.343).

Conclussion

The waist-to-hip ratio significantly correlated with the occurrence of metabolic syndrome in obese adolescents compared to the other central obesity parameters. Therefore, the WHR values of more than 0.891 can be used as a predictor of metabolic syndrome in obese adolescents.

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