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Original Article

The Association between Waist-Hip Ratio and Body Fat Composition, and Metabolic Syndrome: A Study at RSUP Dr. Kariadi

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Abstract

Background : Metabolic syndrome, which is a collection of symptoms which are usually include of hypertension, hyperglycemia, dyslipidemia, and central obesity, has various fatal complications. Fat composition is known to have a close relationship with complications of metabolic syndrome. However, measurement of fat usually requires expensive tools and methods. Meanwhile, anthropometric indicators such as waist-to-hip ratio (WHR) have links with metabolic syndrome and central obesity. This study examines whether there is a significant relationship between WHR and body fat composition in patients with metabolic syndrome. This study examined relationship between WHR and body fat composition as described in fat percentage, fat mass, visceral fat rating, and degree of obesity in patients with metabolic syndrome.
Methods : Cross-sectional observational analytic study was conducted on 51 metabolic syndrome patients at Endocrine Polyclinic, RS dr. Kariadi. Respondents filled out informed consent and questionnaires and measured WHR and body fat composition using Tanita scales. Data analysis was performed by univariate test and bivariate test (Pearson test, Spearman test, or Mann-Whitney test).
Results : There is a weak significant negative correlation between WHR and body fat percentage (p = 0.023; r = -.0.318). There is no correlation between WHR and fat mass (p=0.312). There is a weak positive significant correlation between WHR and visceral fat rating (p=0.001; r=0.441). And there is no correlation between WHR and the degree of obesity (p=0.785).
Conclusion : WHR has a weak significant correlation with body fat percentage and visceral fat rating in NCEP ATP III metabolic syndrome patients.

Keywords : Waist to hip ratio, body fat composition, metabolic syndrome.

INTRODUCTION

World Health Organization defines metabolic syndrome as a pathological condition characterized primarily by central obesity, hypertension, insulin resistance, and hyperlipidemia.[1] Metabolic syndrome has various definitions depending on the criteria used, WHO, National Cholesterol Education Program (NCEP) ATP III, European Group for the Study of Insulin Resistance (EGIR), and International Diabetes Federation (IDF) criteria.[2,16] The impact/complications caused by metabolic syndrome can be fatal to health and life-threatening, such as sudden cardiac death and other atherosclerotic cardiovascular diseases,[3] as well as cerebrovascular diseases like stroke.[4] Central obesity, which is the accumulation of fat in the visceral area, is closely related to metabolic syndrome.[5] Therefore, studies on body fat in patients with metabolic syndrome need to be developed with the hope of finding variables that can be used as predictors to predict the risk of metabolic syndrome and its complications earlier. Meanwhile, body fat composition is described both as the degree of fat cells present in the body, which can be illustrated in body fat percentage, total body fat mass, visceral fat rating, and degree of obesity. Excess fat in the body is closely related to complications of metabolic syndrome, such as atherosclerotic cardiovascular disease.[6] Therefore, early detection of changes in body fat composition is expected to indicate the complications, such as cardiovascular diseases, complications in patients with metabolic syndrome as early as possible.

There are several methods of measuring body fat composition that are considered valid. For this research, the researchers used the bioelectrical impedance analysis (BIA) method because this technique is known to be quite fast, simple, inexpensive, and easy to perform.[15] However, not all healthcare facilities have body composition measurement tools like BIA. In addition to fat composition measurement techniques like BIA, there are several anthropometric indicators that are believed to have a strong correlation with metabolic syndrome, such as the waist-to-hip ratio (WHR).[9] Anthropometric measurement techniques like WHR have several advantages, such as simple, inexpensive, and easy to perform without requiring special skills. This study was conducted on patients with metabolic syndrome with the aim of assessing the correlation between WHR and body fat composition measured by the BIA technique. It is hoped that WHR measurement can become an alternative method that is simple, accurate, inexpensive, and easy for measuring body fat composition in patients with metabolic syndrome, if BIA is not feasible. With the discovery of an alternative method that is cheaper and easier to perform, it is hoped that fat composition screening and the prediction of related complication risks in patients with metabolic syndrome can be done as early as possible.[9]

METHODS

This research is an observational analytic study with a cross-sectional design involving samples of metabolic syndrome patients according to the NCEP ATP III criteria with Asian modifications at the Endocrine Clinic of Merpati at Dr. Kariadi Hospital. The study was conducted at the Endocrine Clinic of Merpati, Dr. Kariadi Hospital, from September to October 2022. The samples in this study were metabolic syndrome patients according to the NCEP ATP III criteria with Asian modifications at the Endocrine Clinic of Merpati, Dr. Kariadi Hospital, who met the inclusion criteria (aged 25–65 years and agreed to participate in the study) and exclusion criteria (pregnant or postpartum, using hormonal contraception, consuming alcohol, having conditions that prevent direct measurement, or choosing not to continue to participate in the study). Sample collection was carried out using consecutive sampling, and 51 samples that met the inclusion and exclusion criteria including already assigning informed consent were obtained.

The independent variable in this study was the waist-to-hip ratio based on the measurement guidelines from the Centers for Disease Control and Prevention (CDC). The dependent variable in this study was body fat composition. The components of body fat composition measured include body fat percentage, body fat mass, visceral fat rating, and degree of obesity. Data analysis consists of univariate and bivariate tests.

The univariate test was used to determine the general characteristics of respondents and the distribution of each variable studied, including age, gender, smoking history, nutrition, physical activity, resting metabolic rate, waist-to-hip ratio, body fat percentage, body fat mass, visceral fat rating, and degree of obesity descriptively in the form of frequency and percentage tables.

The bivariate or hypothesis test aims to determine the relationships between variables. The Pearson test was used to analyze the relationship between WHR, age, and resting metabolic rate variables (numeric ratio scale) and the dependent variables such as body fat percentage, body fat mass, visceral fat rating, and degree of obesity (numeric ratio). Prior to this, a normality test was conducted using the Kolmogorov-Smirnov test. The Spearman test was used to analyze the relationship between fat consumption and physical activity (ordinal categorical scale) and the dependent variables such as body fat percentage, body fat mass, visceral fat rating, and degree of obesity (numeric ratio). The Mann-Whitney-test was used to analyze the relationship between gender and smoking history variables (nominal categorical variables) and the dependent numerical variables such as body fat percentage, body fat mass, visceral fat rating, and degree of obesity.

The study was conducted after obtaining ethical clearance from the Health Research Ethics Committee of the Faculty of Medicine, Diponegoro University, under approval number 299/EC/KEPK/FK-UNDIP/VIII/2022. In addition, this study had got the ethical clearance from Dr. Kariadi Hospital's ethics committee. Participants who agreed to take part in the study provided their consent by signing an informed consent form.

RESULTS

General Characteristics of the Sample

The researchers collected data from 51 samples of patients with metabolic syndrome NCEP ATP III criteria at the Endocrine Polyclinic Merpati, Dr. Kariadi Hospital. The distribution of the population characteristics shown at Table 1.

Based on Table 1, the most prevalent component was excessive waist measurement or central obesity (96.1%); the second most prevalent was hyperglycemia (86.3%); hypertension was in the third place at 78.4%; low HDL stands at 58.8%; and the least prevalent component was high triglycerides at 43.1%. General characteristics of other variables can be observed in the Table 2.

Based on Table 2, out of 51 respondents, only 1 (2%) had a normal WHR, while the remaining 50 (98%) had an excessive WHR or above the cut off. In terms of age, the study was participated by 2 (3.9%) early adulthood respondents, 12 (23.5%) late adulthood respondents, 17 (33.3%) early elderly respondents, and 20 (39.2%) late elderly respondents. Regarding gender, the study was participated by 16 (31.4%) male samples and 35 (68.6%) female samples. Therefore, the number of female samples exceeds male samples by more than twice. Among the 51 samples, only 9 individuals (17.6%) had a history of smoking, whether active or passive, while the remaining 42 individuals (82.4%) did not have a smoking history. In terms of physical activity, there were 13 (25.5%) samples classified as light physical activity, 13 (25.5%) as moderate physical activity, and 25 (49%) as heavy physical activity. Meanwhile, in terms of fat consumption category, out of 51 samples, 2 (3.9%) were classified as severe deficit, 7 (13.7%) as moderate deficit, 5 (9.8%) as severe deficit, 10 (19.6%) as normal category, and 27 (52.9%) as excess fat category. In terms of RMR, 21 (41.2%) respondents had RMR in the low range, while 30 (58.8%) respondents had RMR in the medium range.

Regarding body fat composition variables such as fat percentage showed that 12 (23.5%) respondents had normal values or below the cutoff, while 39 (76.5%) respondents had excessive values. In terms of fat mass, 23 (45.1%) respondents had normal fat mass values, while 28 (54.9%) respondents had excessive values. In terms of visceral fat rating, 34 (66.7%) respondents had normal or below cut off values, while 17 (33.3%) respondents had excessive values. Finally, in terms of the degree of obesity (DO), 7 (13.7%) respondents were in the normal category, 32 (62.7%) were in the overweight category, and 12 (23.4%) were in the obesity category.

Relationship between General Characteristics and Body Fat Composition

Based on Table 3, the relationship between age and fat percentage resulted in a *p*-value of 0.152 ($p>0.05$), indicating that the two variables were not significantly related. The relationship between age and fat mass resulted in a *p*-value of 0.097 ($p>0.05$), indicating no significant relationship between the two variables. Spearman's test between age and VFR resulted in a

TABLE 1
Characteristics of Patients with Metabolic Syndrome

NCEP ATP III Criteria for Metabolic Syndrome	Sample that meets the criteria
Fasting blood glucose	44 (86.3%)
Blood pressure	40 (78.4%)
Triglycerides	22 (43.1%)
HDL	30 (58.8%)
Waist measurement	49 (96.1%)

*Criteria for metabolic syndrome based on modified NCEP ATP III for Asians are as follows:
a. Fasting blood glucose ≥ 100 mg/dL
b. Blood pressure ≥ 130/85 mmHg
c. Triglycerides ≥ 150 mg/dL
d. HDL ≤ 50 mg/dL in females dan ≤ 40 mg/dL in males
e. Waist measurement ≥ 80 cm in females dan ≥ 90 cm in males

TABLE 2
General Characteristics of Variables

Variables		Frequency	Percentage (%)
Waist-Hip Ratio	Normal	1	2
	Excessive	50	98
Age	Early Adulthood	2	3.9
	Late Adulthood	12	23.5
	Early Elderly	17	33.3
	Late Elderly	20	39.2
Gender	Female	35	68.6
	Male	16	31.4
Smoking History	No	42	82.4
	Yes	9	17.6
Physical Activity Score	Light	13	25.5
	Moderate	12	23.5
	Heavy	26	51.0
Fat Consumption Score	Mild Deficit	2	3.9
	Moderate Deficit	7	13.7
	Severe deficit	5	9.8
	Normal	10	19.6
	Excessive	27	52.9
Resting Metabolic Rate	Low	21	41.2
	Medium	30	58.8
	High	0	0
Fat Percentage	Normal	12	23.5
	Excessive	39	76.5
Fat Mass	(No universal category)	–	–
Visceral Fat Rating (VFR)	Normal	34	66.7
	Excessive	17	33.3
Obesity Degree (OD)	Normal	7	13.7
	Overweight	32	62.7
	Obesity	12	23.5

p-value of 0.010 ($p<0.05$), indicating a significant relationship with r=0.360, implying a weak positive correlation. Meanwhile, age with obesity degree (OD) resulted in a *p*-value of 0.374 ($p>0.05$), indicating no significant relationship between the two variables.

The relationship between gender and fat percentage resulted in a *p*-value of <0.001 ($p<0.05$), indicating a significant relationship between the two variables. The relationship between gender and fat mass resulted in a *p*-value of 0.008 ($p<0.05$), indicating a significant relationship between the two variables. The test of the relationship between gender and VFR resulted in a *p*-value of <0.001 ($p<0.05$), indicating a significant relationship. Meanwhile, gender with OD resulted in a

TABLE 3
Relationship between General Characteristics and Body Fat Composition

Variables		Fat Percentage	Fat Mass	VFR (Visceral Fat Ratings)	OD (Obesity Degree)
Age	p	0.152[a]	0.097[a]	0.010[b*]	0.374[a]
	r	-0.204[a]	-0.235[a]	0.360[b]	-0.127[a]
Gender	p	<0.001[c*]	0.008[c*]	<0.001[c*]	0.903c
Smoking History	p	0.648[c]	0.739[c]	0.970[c]	0.408[c]
Physical Activity Score	p	0.105[b]	0.195[b]	0.625[b]	0.522[b]
	r	0.230[b]	0.184[b]	-0.070[b]	0.092[b]
Fat Consumption Score	p	0.699[b]	0.936[b]	0.505[b]	0.339[b]
	r	0.055[b]	0.011[b]	0.096[b]	0.137[b]
RMR	p	0.039[b*]	0.413[b]	<0.001[b*]	0.009[b*]
	r	-0.290[b]	0.117[b]	0.720[b]	0.362[b]

Notation:
a : Pearson Test
b : Spearman Test
c : Mann-Whitney Test
* : Significant Relationship (*p*<0.05)

TABLE 4
Relationship between WHR and Body Fat Composition

Variables		Fat Percentage	Fat Mass	VFR (Visceral Fat Ratings)	OD (Obesity Degree)
WHR	p	0.023[a*]	0.312[a]	0.001[b*]	0.785[a]
	r	-0.318	-0.145	0.441	0.039

Notation:
a : Pearson Test
b : Spearman Test
* : Significant relationship (*p*<0.05)

p-value of 0.903 (*p*>0.05), indicating no significant relationship between the two variables.

The relationship between smoking history and fat percentage resulted in a *p*-value of 0.648 (*p*>0.05), indicating that the two variables were not significantly related. The relationship between smoking history and fat mass resulted in a *p*-value of 0.739 (*p*>0.05), indicating a non-significant relationship between the two variables. The test of the relationship between smoking history and VFR resulted in a *p*-value of 0.970 (*p*>0.05), indicating a non-significant relationship. Meanwhile, smoking history with OD resulted in a *p*-value of 0.408 (*p*>0.05), indicating no significant relationship between the two variables.

The relationship between physical activity and fat percentage resulted in a *p*-value of 0.105 (*p*>0.05), indicating that the two variables were not significantly related. The relationship between physical activity and fat mass resulted in a p-value of 0.195 (*p*>0.05), indicating a non-significant relationship between the two variables. The test of the relationship between physical activity and VFR resulted in a *p*-value of 0.625 (*p*>0.05), indicating a non-significant relationship. Meanwhile, the test of the relationship between physical activity and OD resulted in a *p*-value of 0.522 (*p*>0.05), indicating no significant relationship between the two variables.

The relationship between fat consumption and fat percentage resulted in a *p*-value of 0.699 (*p*>0.05), indicating that the two variables were not significantly related. The relationship between fat consumption and fat mass resulted in a *p*-value of 0.936 (*p*>0.05), indicating a non-significant relationship between the two variables.

The test of the relationship between fat consumption and VFR resulted in a *p*-value of 0.505 ($p>0.05$), indicating a non-significant relationship. Meanwhile, fat consumption with OD resulted in a *p*-value of 0.339 ($p>0.05$), indicating no significant relationship between the two variables.

The relationship between RMR and fat percentage resulted in a *p*-value of 0.039 ($p<0.05$), indicating a significant relationship between the two variables. However, the value of r=-0.290 indicates a very weak negative correlation. The relationship between RMR and fat mass resulted in a *p*-value of 0.413 ($p>0.05$), indicating a non-significant relationship between the two variables. The test of the relationship between RMR and VFR resulted in a *p*-value of <0.001 ($p<0.05$), indicating a significant relationship with r=0.720, indicating a strong positive correlation. Meanwhile, RMR with OD resulted in a a *p*-value of 0.009 ($p<0.05$), indicating a significant relationship between the two variables with r=0.362, indicating a weak positive correlation.

Relationship between WHR and Body Fat Composition

The relationship between WHR and fat percentage resulted in a *p*-value of 0.023 ($p<0.05$), indicating a significant relationship between the two variables. This relationship has an r-value of -0.318, indicating a weak negative correlation. The relationship between WHR and fat mass resulted in a *p*-value of 0.312 ($p>0.05$), indicating no significant relationship between the two variables. The Spearman test between RLPP and VFR resulted in a *p*-value of 0.001 ($p<0.05$), indicating a significant relationship with an r-value of 0.441, implying a weak positive correlation. Meanwhile, RLPP with OD resulted in a *p*-value of 0.785 ($p>0.05$), indicating no significant relationship between the two variables.

DISCUSSION

The Pearson test shows a significant relationship between WHR and fat percentage ($p=0.023$) with a weak negative correlation (r=-0.318). This result aligns with Verma *et al*.' (2017) study, which also found a significant relationship between WHR and fat percentage ($p=0.01$) but with a very weak positive correlation (r=0.075).[7] This may be due to the majority of respondents being female (68.6%). Theoretically, in females, excess fat tends to accumulate in the hip and thigh areas, while in males, it tends to accumulate in the abdominal area.[10] This may explain the significant negative correlation between WHR and fat percentage in the population of metabolic syndrome patients.

The Pearson test shows no significant relationship between WHR and fat mass ($p=0.312$). Previous studies specifically examining the relationship between WHR and absolute body fat mass were not found. The non-significant result may be due to variations in fat distribution in the body. The majority of respondents in this study were females, who genetically and hormonally tend to accumulate fat in the hip and thigh areas. In contrast, in males, fat is more likely to be distributed in the abdominal or waist area.[11] Therefore, excess fat mass in an individual may not necessarily be distributed in the waist area, leading to an increase in WHR.[8] However, why does this result differ from the relationship between WHR and fat percentage? Fat mass represents the absolute mass of fat in the body, whereas fat percentage was obtained by dividing fat mass by total body mass. This difference may explain why fat mass does not have a significant relationship with WHR as fat percentage does.[12]

The Spearman test shows a significant relationship between WHR and VFR ($p=0.001$) with a weak positive correlation (r=0.441). This result was consistent with Gadekar *et al*.'s (2018) study, which found a significant strong relationship between WHR and visceral fat score ($p<0.05$; r=0.920) in adults in India.[9] Many factors can cause an increase in WHR, one of which was the accumulation of fat in the visceral area. With this result, WHR can be used as an indicator of visceral fat level in the population of metabolic syndrome patients.

The Pearson test shows no significant relationship between WHR and OD ($p=0.785$). Previous research on the relationship between OD and WHR was not found. However, there was research on the relationship between BMI and RLPP, where BMI was a value that also indicates whether someone was obese or not (Basically, OD was a value that indicates how far someone was from the BMI value of 22). Previous research by Doustjalali (2020) found a significant relationship between BMI and WHR ($p\leq0.01$; r=0.498) in a population of elementary school students. This can happen for several reasons. First, the variables used were not exactly the same, where this study uses OD while previous research uses BMI. Second, the sample in this study consists of metabolic syndrome patients with a range of ages from adults to the elderly, while previous research was conducted on elementary school students. The non-significant result may also be due to the fact that the OD value indicates how far someone was from the BMI value of 22. The BMI value does not fully indicate whether someone with a high BMI has more fat than someone with a low BMI (an athlete can have a high BMI due to high muscle mass).[13,14] Moreover, each person's fat distribution was different, especially since the majority of respondents were females whose fat distribution tends to be in the hip and thigh areas.[8] Therefore, someone's high OD because of fat or other substances may not necessarily increase their WHR. Although the research results were not significant, further research is needed to further confirm the relationship between WHR and OD.

Based on the correlation tests between WHR and body fat composition variables, significant results were found between WHR and fat percentage and VFR. However, between WHR and fat mass and OD, non-significant relationships were found. Therefore, among the tested body fat composition parameters, only fat percentage and VFR can be described with WHR. Although further research is needed, WHR can be considered to represent fat percentage and VFR in the population of metabolic syndrome patients.

This study has several strengths, including its focus on a well-defined patient population of metabolic syndrome patients using the NCEP ATP III criteria with Asian modifications, ensuring relevance to the targeted demographic. Additionally, the inclusion of comprehensive variables, such as waist-to-hip ratio and detailed body fat composition metrics, provides a holistic understanding of the relationships being studied. However, the study has some limitations. Its cross-sectional design restricts the ability to establish causal relationships. Some variables, such as nutrition and physical activity, rely on self-reported data, which may be subject to recall bias. Furthermore, being a single-center study conducted at one clinic, the findings may not be fully generalizable to other populations or settings.

CONCLUSION

WHR has a weak but significant relationship with body fat percentage and visceral fat rating in patients with NCEP ATP III metabolic syndrome at the Endocrine Polyclinic Merpati, dr. Kariadi Central General Hospital, Semarang. However, the WHR does not have a significant relationship with body fat mass and the degree of obesity in this sample. Therefore, since the relationship between the WHR and body fat percentage was negative, it can be concluded that the WHR is not a good tool for describing body fat percentage. However, it can still be relied upon to describe visceral fat rating.

DECLARATION OF INTERESTS

The authors declare no conflict of interest

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