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Abstract

Metabolic syndrome is not a disease but is a set of several disorders and causes an increased risk of cardiovascular disease and diabetes mellitus complications. Several studies have shown that non-invasive approaches such as anthropometric measurements can be used for the early detection of metabolic syndrome. This study aimed to analyse the anthropometric indicators related to metabolic syndrome in female college students. The design of this research was cross sectional, with the number of subjects involved were as many as 163 female college students aged 19 to 24 years old. Purposive sampling was used in the sampling of this research. The independent variables in this study were the Waist-to-Height Ratio (WHtR), Waist-Hip Ratio (WHR), Body Mass Index (BMI), Sagittal Abdominal Diameter (SAD), and hip circumference. The dependent variable in this study is the metabolic syndrome component that has been converted into a metabolic syndrome score (cMetS). The analysis results showed that all anthropometric indicators, namely WHtR, BMI, SAD, waist circumference, hip circumference and WHR have a strong positive relationship with the metabolic syndrome score ($p<0.001$). BMI was the anthropometric indicator that is most associated with the metabolic profiles, such as systolic blood pressure ($p<0.001$), blood sugar ($p<0.05$), and HDL ($p<0.001$). Waist circumference was the anthropometric indicator that is most associated with triglycerides and metabolic syndrome score ($p<0.001$). Metabolic syndrome in female college students can be identified using anthropometric measurements, one of which is BMI and WHR which are very easy to measure and efficient. BMI and WHR have the strongest relationship and can be used to detect early risk of metabolic syndrome in female college students.

1. Introduction

Metabolic syndrome is a set of body metabolic disorders such as dyslipidemia, hyperglycemia, hypertension, and central obesity (Srikanthan *et al.*, 2016; Devi *et al.*, 2017; Christijani, 2019). Metabolic syndrome is not a disease but is a set of several disorders that causes an increased risk of cardiovascular disease and diabetes mellitus complications. Some epidemiological studies have shown that metabolic syndrome doubles the risk of cardiovascular diseases (Sri Rahayu and Maulina, 2017).

Indonesia as a developing country cannot be separated from the existing nutritional problems in the world, including the incidence of obesity and metabolic syndrome. Several studies found that the prevalence of metabolic syndrome keeps increasing every year. A study in China showed the prevalence of metabolic syndrome in adults was 24.2% (Li *et al.*, 2018). Another study indicated that the prevalence of metabolic syndrome in Indonesia was 21.66% (Herningtyas and Ng, 2019). In recent studies, metabolic syndrome can be assessed using the continuous value of metabolic syndrome (cMetS) or the metabolic syndrome score recommended by the American Diabetic Association of Diabetes. The metabolic syndrome score is a z-score resulting from the assessment of all components of the metabolic syndrome (Pratiwi, *et al.*, 2017). The advantages of using cMetS are (1) reducing dichotomization factors because cardiovascular disease is a progression of several components of the metabolic syndrome, (2) cMetS is more sensitive and less error-prone than categoric metabolic syndrome assessments, (3) increasing the statistical power (Okosun, Lyn, Smith *et al.*, 2010).

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Central obesity is one of the components of metabolic syndrome parameters. Central obesity is associated with increased blood pressure, serum triglycerides, decreased HDL, and glucose intolerance. Based on the National Basic Health Research (Riskesdas) in 2018, the prevalence of obesity in adults was 21.8%, and the prevalence of central obesity at age of more than 15 years increased from 26.6% in 2013 to 31% in 2018 (Badan Penelitian dan Pengembangan Kesehatan, 2018). Obesity is closely related to degenerative diseases. The prevalence of stroke, diabetes mellitus, heart disease, and hypertension is higher in women than men (Badan Penelitian dan Pengembangan Kesehatan, 2018).

Several studies have shown that non-invasive approaches such as anthropometric measurements can be used for the early detection of metabolic syndrome (Pratiwi, *et al.*, 2017). Anthropometric measurements are described as the measurements of body dimensions and body composition to assess nutritional status. The advantages of anthropometric measurements are relatively fast and easy, as they can be performed using portable and calibrated instruments with standardized methods (Rokhmah, *et al.*, 2015). Some anthropometric measurements that can be used for early detection of metabolic syndrome are Waist-to-Height Ratio (WHtR), waist-to-hip ratio (WHR), hip circumference, Body Mass Index (BMI), Sagital Abdominal Diameter (SAD).

One of the anthropometric measurements which can be a parameter for central obesity is the ratio of waist circumference to height (WHtR). The instruments used in the measurement are microtoise and measuring tape, which take a longer time. Studies on waist circumference have been shown to have a strong correlation with abdominal fat deposits (Zhou *et al.*, 2014). The distribution of abdominal adipose tissue (central obesity) in adults is associated with a component of the metabolic syndrome (Rodea-Montero, *et al.*, 2014). A study on adult subjects has shown that people who have the same waist circumference but are shorter in height have a greater risk of developing metabolic syndrome than taller people (Zhou *et al.*, 2014). Therefore, WHtR can be used as a simple and effective anthropometric index to identify the metabolic risk associated with obesity (Rodea-Montero, *et al.*, 2014).

The Waist-To-Hip Ratio (WHR) is a measurement that may indicate central obesity (Karimah, 2018). The higher the WHR value, the higher the risk level for several metabolic diseases. The Waist-To-Hip Ratio is calculated by dividing the measurement of the waist circumference by the circumference of the hip. The cut-off points for WHR are ≥1.0 for men and ≥0.85 for women (Rokhmah *et al.*, 2015). Individuals with a high waist and hip circumference will also have a higher distribution of fat in their abdominal area. Irregular fats distribution in the abdominal area indirectly causes higher triglyceride levels circulating in the blood, which will affect blood pressure (Sumardiyono *et al.*, 2018). WHR measurement is more sensitive in assessing the distribution of fat in the body, especially in the abdomen. This measurement is three times better than BMI in reflecting the presence of harmful fats in the abdomen. Measurement of waist circumference is performed by determining the lower part of arcus costae and crista iliaca (Sri Rahayu and Maulina, 2017).

Body Mass Index (BMI) is a practical and easy measurement to perform, but it cannot distinguish between fat mass, bone mass and muscle mass. BMI is calculated as body weight (kg)/height squared (m^2) (Okura *et al.*, 2018). BMI can be used as the first measurement before any other anthropometric measurements.

Sagittal Abdominal Diameter (SAD) or the height of the abdomen while the subjects are in a lying position. This anthropometric measurement has not been widely used to measure fat tissue in the abdominal area. SAD measurements using computed tomography or magnetic resonance imaging, and are associated with components of metabolic syndrome. The measurements of SAD are taken when the subject is lying down on the examination table with a naked upper body. SAD is related to central obesity in individuals with obesity and normal nutritional status. Furthermore, SAD is associated with diabetes mellitus and a predictor of cardiovascular disease incidence, even when SAD is measured in a standing position (Pajunen *et al.*, 2013). Based on the above-mentioned problems, our study aimed to analyze the anthropometric indicators related to metabolic syndrome in female college students.

2. Materials and methods

2.1 Design, location, and time

A cross-sectional study design and this research was conducted from March to July 2020. Anthropometric and biochemical data were collected at the Cito Laboratory, Banyumanik Semarang with health protocols applied. This study was approved by the Medical/Health Research Bioethics Commission, Faculty of Medicine, Sultan Agung Islamic University Semarang with Number No.296 /IX /2020 /Bioethical Commission.

2.2 Samplings

This study was conducted during the SARS-CoV-2 outbreak, which later was named COVID-19 by the WHO, hence the registration for study participants was done online. Purposive sampling was used in this study and the total number of subjects required was 163. Samples are selected based on inclusion criteria, such as voluntary to be research subjects, female college students in Semarang City, aged 19-24 years in Semarang, not consuming alcohol, not smoking, and voluntary to follow a series of study instructions. Exclusion criteria are subjects who withdraw and those who are ill during the research study. Based on the exclusion criteria mentioned, no subjects are included in the exclusion criteria. Subjects were asked to fill in personal data using a Google Form, and eligible subjects will be contacted by the researchers to plan a direct meeting.

The health protocol applied during the anthropometric and biochemical data collection process, consisted of the subject filling out a COVID-19 signs and symptoms screening questionnaire, the subject was checked for temperature, the subject washed hands before entering the room, the distance between subjects was at least 1 meter, the subject and researcher used a mask and face shield. Researchers used gloves and protective clothing. During the study, hand sanitisers were provided, and anthropometric tools that were on the subject's skin were wiped with alcohol.

2.3 Data collected

The independent variables in this study were the Waist-to-Height Ratio (WHtR), Waist-Hip Ratio (WHR), Body Mass Index (BMI), Sagittal Abdominal Diameter (SAD), and hip circumference. Weight and height data were obtained through direct measurements using a digital stamp scale GEA brand with an accuracy of 0.1 kg and microtoise with an accuracy of 0.1 cm. Waist circumference and hip circumference were measured using a measuring tape (Medline) to the nearest 1 mm and abdominal height was measured using the Abawerk Schaffenburg abdominal calliper to the nearest 1 mm. SAD measurements were performed with the subject in a supine position on a flat surface with both knees forming an angle of 90^o (Firouzi *et al.*, 2018). Anthropometric data were collected by trained enumerators.

The cut-off point used in this study refers to previous studies because it had been adjusted for the Asian race (Rose *et al.*, 2020). Each anthropometric measurement is stated as "at-risk" if the individuals have ≥0.50 for WHtR (Zhang *et al.*, 2016), ≥0.85 for WHR (Rokhmah *et al.*, 2015), >19.3 cm for Sagital Abdominal Diameter (SAD) (Dieny *et al.*, 2020), and have the normal to overweight BMI (18.5 - 25 kg/m^2) or obese BMI (≥25.0 kg/m^2) (Susetyowati, 2016).

The dependent variable in this study is the metabolic syndrome component that has been converted into a metabolic syndrome score (cMetS) with the cut-off point of cMetS >2.21 (Rose *et al.*, 2020). The guidelines for metabolic syndrome in this study are taken from the National Cholesterol Education Program-Adult Treatment Panel (NCEP-ATP III) 2005 which has been frequently used in Indonesia. There are 5 parameters to assess metabolic syndrome: (1) fasting blood glucose levels ≥110 mg/dL, (2) triglyceride levels ≥150 mg/dL (3) HDL cholesterol levels<50 mg/dL, (4) central obesity in women with waist circumference ≥80 cm, and (5) systolic and diastolic blood pressures ≥130 mmHg and ≥85 mmHg, respectively (Soewondo *et al.*, 2010). The calculation of the metabolic syndrome score (cMetS) was done in the following steps: (1) after measuring all parameters of the metabolic syndrome, standardisation was carried out to obtain a Z-score; (2) the blood pressure must be converted into Mean Arterial Blood (MAP) by dividing the difference between systolic and diastolic blood pressure by three and summed with the diastolic blood pressure; (3) the HDL cholesterol standardization results were multiplied by (-1) because the parameter was inversely related to the risk of metabolic syndrome; (4) All Z-scores were added to obtain the cMetS values; (5) The final step was to compare the cMetS values with the cut-off point of ≥2,21 (Eisenmann *et al.*, 2010; Okosun, Boltri, Lyn *et al.*, 2010; Rose *et al.*, 2020). The subjects were instructed to do fasting for at least 8 hrs, only drinking water was permitted.

Other than the cMetS score, metabolic syndrome risk can also be assessed from the classification of metabolic types. This classification combines the internal and external signs of the body such as biochemical parameters, the ratio of subcutaneous fat to abdominal fat, and blood pressure (Prybyla, 2020). The main phenotypes that reflect the possible combination of metabolic profile and the degree of obesity are metabolic healthy obese weight, metabolic healthy normal weight, metabolic unhealthy normal weight, and metabolic unhealthy normal weight.

2.4 Data analysis

All data were analyzed using computer programs and statistical analyses were performed using SPSS statistical software version 22. Univariate analysis was used to describe subjects characteristics. The normality test of the data using the Kolmogorov-Smirnov test was carried out before testing the hypothesis. The relationship of anthropometric indicators with metabolic profile (Blood Pressure, Triglycerides, Blood Sugar, HDL and metabolic syndrome scores) was determined using the Person correlation test. Furthermore, Anthropometric

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indicators that are most related to the metabolic component and metabolic syndrome score were analyzed using the Multiple Linear Regression test.

3. Results and discussion

The subject characteristics measured in female students aged 19-24 years include age, anthropometric indicators, and metabolic syndromes. Table 1 shows the characteristics of the study subjects. The mean WHtR value in this study was 0.51. Meanwhile, the mean WHR was 0.80; the mean BMI was 24.04 kg/m^2; the mean SAD was 16.79 cm, and the mean waist circumference was 79.44 cm.

Table 2 shows the various nutritional status of the subjects based on BMI. It was found that 43.6% of the subjects had normal BMI, 17.2% were overweight and 35.6% were obese. Based on the WHtR anthropometric indicator, 72.4% of subjects were at risk of having obesity, based on WHR, 22.1% had central obesity, based on BMI, 35.6% were obese, based on SAD 12.3% of the subjects were at risk, and based on waist circumference 55.2% had central obesity. According to the metabolic profile that was assessed, 16.6% had high Fasting Blood Glucose levels, 8.6% had hypertriglycerides, 17.2% had low HDL, and 16.6% had high systolic blood pressure, and 21.5% had high diastolic blood pressure. In addition, we found that 33.1% of the subjects had high metabolic syndrome (cMetS) scores. This proportion was similar to the assessment based on the metabolic type of unhealthy subjects (subjects who had ≥3 risk factors of the metabolic profile), which was 33.7%. Moreover, two subjects had five risk factors: abdominal obesity, hypertension, hyperglycemia, hypertriglycerides, and low HDL.

The objective of this study was to determine the anthropometric indicators associated with metabolic syndromes in female students. The study included 163 female students aged 19-24 years. The students are in their late adolescents who begin to have an independent life. Inappropriate and unhealthy eating behaviour will have an impact on the student's nutritional status. Excessive nutritional status and obesity will affect student's body metabolism. Based on the study results, 33.1% of the subjects had a high metabolic syndrome (cMetS) score. In line with the previous study conducted in 2019 on 18-to-21-year-old students at Universitas Diponegoro, 20% of the subjects had high cMetS (Rose *et al.*, 2020). Meanwhile, a study conducted by Pratiwi et al in 2017 using secondary data from the National Basic Health Research 2013 found that 19.98% of adolescents aged 15-24 years had high cMetS (Pratiwi, *et al.*, 2017). To conclude, there is a trend of Metabolic Syndrome Score (cMetS) among young women in Semarang.

The assessment of metabolic syndrome using a continuous type (scoring) rather than using a dichotomy or binary ("yes" and "no") is recommended (Christijani, 2019). An adolescent can be diagnosed with metabolic syndrome if their Metabolic Syndrome Score (cMetS) >2.21 (Pratiwi, *et al.*, 2017). Anthropometric indicators used in this study are Waist and Height Ratio (WHtR), Waist-to-Hip Ratio (WHR), Body Mass Index (BMI), Sagittal Abdominal Diameter (SAD), and Waist Circumference. Based on the correlation analyses, all anthropometric indicators have a significant positive relationship with the Metabolic Syndrome Score (cMetS). Furthermore, the multivariate analyses show that the anthropometric indicators of BMI and WHR are strongly associated with cMetS.

If the metabolic type is considered based on nutritional status (subjects with non-obese BMI (<25kg/m^2) with metabolic healthy and metabolic unhealthy and

Table 1. Minimum, maximum, average and standard deviation

Variable	Minimum	Maximum	Mean	SD
Anthropometric Indicators				
WHtR (ratio)	0.37	0.71	0.51	0.07
WHR (ratio)	0.67	0.96	0.80	0.06
BMI (kg/m^2)	15.81	39.30	24.04	4.72
Sagital Abdominal Diameter (cm)	11.35	25.50	16.79	2.42
Hip Circumference (cm)	80.60	138.45	98.96	9.30
Waist Circumference (cm)	58.00	112.10	79.44	10.78
Metabolic Profiles				
Blood Glucose Levels (mg/dL)	66.00	110.00	92.00	7.59
Trygliceride Levels (mg/dL)	29.00	309.00	88.35	44.68
Cholesterol HDL Levels (mg/dL)	36.00	109.00	61.73	26.43
Systolic Blood Pressure (mmHg)	84.00	144.00	114.63	11.13
Diastolic Blood Pressure (mmHg)	55.00	178.00	82.40	55.52
cMetS (Score of Metabolic Syndrome)	-7.10	11.93	0.01	2.90

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Table 2. Anthropometric overview and components of metabolic syndrome

Characteristics	n	%
Anthropometric		
Body Mass Index (BMI)		
Underweight (< 18.5 kg/m^2)	6	3.7
Normal (18.5 – 22.9 kg/m^2)	71	43.6
Overweight (23-24.9 kg/m^2)	28	17.2
Obese (≥25.0 kg/m^2)	58	35.6
Waist Height Ratio (WHtR)		
Normal (<0.50)	45	27.6
At Risk (≥0.50)	118	72.4
Waist Hip Ratio		
Normal (<0.85)	127	77.9
Central Obesity (≥0.85)	36	22.1
Sagital Abdominal Diameter (SAD)		
Normal (≤19.3 cm)	143	87.7
At Risk (>19.3 cm)	20	12.3
Waist Circumference		
Normal (<80 cm)	73	44.8
Obese (≤80 cm)	90	55.2
Metabolic Profiles		
Blood Glucose Levels		
Normal (<110 mg/dL)	136	83.4
High (≥110 mg/dL)	27	16.6
Triglycerides		
Normal (<150 mg/dL)	149	914.0
High (≥150 mg/dL)	14	8.6
Cholesterol HDL		
Normal (≥150 mg/dL)	135	82.8
Low (<150 mg/dL)	28	17.2
Sistolic Blood Pressure		
Normal (<130 mg/dL)	136	83.4
High (≥130 mg/dL)	27	16.6
Diastolic Blood Pressure		
Normal (<85 mg/dL)	128	78.5
High (≥85 mg/dL)	35	21.5
cMetS (Score of Metabolic Syndrome)		
Normal (<2.21)	109	66.9
At Risk (≥2.21)	54	33.1
Metabolic Types		
Metabolic Unhealthy Normal Weight (MUNW)	17	10.4
Metabolic Healthy Normal Weight (MHNW)	88	54.0
Metabolic Unhealthy Obese Weight (MUOW)	38	23.3
Metabolic Healthy Obese Weight (MHOW)	20	12.3

subjects with obese BMI (>25kg/m^2) with metabolic healthy and metabolic unhealthy), subjects are categorized as metabolic unhealthy (experiencing metabolic syndrome) if they fulfil ≥3 risk factors including high waist circumference, blood pressure, fasting blood glucose and triglyceride levels, and low HDL levels. Based on these criteria, it was found that 10.4% of the subjects had a metabolic unhealthy normal weight (MUNW) and 23.3% of the subjects had metabolic unhealthy obesity weight (MUOW). Of non-obese subjects, 54% of them were metabolic healthy. Our study also shows that 10.4% of the subjects were classified as metabolic unhealthy normal weight (MUNW). The subjects' BMI in this category is in the normal range but has a high percentage of body fat that makes them at high risk of developing metabolic disorders (Eckel *et al.*, 2015; Suliga *et al.*, 2015). Several recent cohort studies have shown a greater risk of type II diabetes mellitus in individuals with MUNW compared to individuals with MHNW (Ärnlöv *et al.*, 2011; Hadaegh *et al.*, 2011; Aung *et al.*, 2014; Jung *et al.*, 2014; Hinnouho *et al.*, 2015). Other studies have shown that women with the MUNW type have a long-term impact of an increased risk of cardiovascular diseases such as higher blood pressure, triglyceride and glucose levels as well as lower levels of adiponectin, HDL, and LDL compared to women with the MHNW type (Kim *et al.*, 2013).

In this study, 23.3% of the subjects belonged to the Metabolic Unhealthy Obese Weight (MUOW) type. Subjects with this metabolic type have an obese BMI and have a high risk of developing metabolic disorders. A study conducted in Japan on 29,564 subjects showed that individuals with MUOW had a greater risk of developing type II diabetes mellitus compared to individuals with MHOW (Heianza *et al.*, 2015).

It was also found that 12.3% of the subjects were categorized as metabolic healthy obese weight (MHOW). Individuals in this metabolic type have an obese BMI but do not show any metabolic risks. Given the impact of obesity in relation to the risk of metabolic diseases, various studies have been conducted to examine the long-term effects of MHOW. Individuals with MHOW had a different fat distribution pattern (less ectopic and visceral fat), and lower inflammatory markers (Samocha-Bonet *et al.*, 2014). Other studies also have shown that women with MHOW had lower blood pressure, triglyceride levels, and glucose levels, but higher levels of HDL, adiponectin, and LDL compared to women with MUNW (Kim *et al.*, 2013). This condition was associated with good diet quality in individuals with MHOW. Based on National Health and Nutrition Examination Surveys (NHANES) data, Camhi *et al.* (2015) examined the quality of diet in obese subjects and found that adolescents and adult women with the MHOW metabolic type had higher diet quality scores due to high intake of fruit, whole grains, meat, and nuts.

Table 3 and Table 4 show the results of statistical

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Table 3. The relationship between anthropometric indicators and metabolic profiles (blood pressure, triglycerides, blood sugar, HDL and metabolic syndrome scores)

Variable	Systolic BP		Diastolic BP		TG		Blood Glucose		HDL		cMetS	
	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*	r	*p*
WHtR	0.358	<0.001[s]	0.306	<0.001[s]	0.289	<0.001[s]	0.210	0.007[s]	-0.266	0.001[s]	0.599	<0.001[s]
BMI	0.370	<0.001[s]	0.313	<0.001[s]	0.315	<0.001[s]	0.221	0.005[s]	-0.292	<0.001[s]	0.600	<0.001[s]
SAD	0.352	<0.001[s]	0.284	<0.001[s]	0.278	<0.001[s]	0.191	0.015[s]	-0.264	0.001[s]	0.575	<0.001[s]
WC	0.377	<0.001[s]	0.284	<0.001[s]	0.295	<0.001[s]	0.212	0.005[s]	-0.243	0.002[s]	0.616	<0.001[s]
HC	0.369	<0.001[s]	0.332	<0.001[s]	0.302	<0.001[s]	0.179	0.002[s]	-0.273	<0.001[s]	0.581	<0.001[s]
WHR	0.244	0.002[s]	0.128	0.104	0.194	0.013[s]	0.172	0.028[s]	-0.149	0.048[s]	0.415	<0.001[s]

[s]Significant, p-value<0.05 indicates there is a significant relationship

Table 4. Anthropometric indicators most associated with metabolic components and metabolic syndrome scores

Variable	Systolic BP				
	Constant	USC[a]	p1[b]	p2[c]	[d]Adjusted R^2
BMI	91.759	0.951	<0.001	<0.001	0.158
	Blood Glucose Levels				
	Constant	USC[a]	p1[b]	p2[c]	Adjusted R^2
BMI	83.454	0.355	0.005	<0.001	0.043
	HDL				
	Constant	USC[a]	p1[b]	p2[c]	Adjusted R^2
BMI	81.429	-0.819	<0.001	<0.001	0.08
	Triglycerides				
	Constant	USC[a]	p1[b]	p2[c]	Adjusted R^2
WC	-6.614	1.195	<0.001	<0.001	0.078
	Score of Metabolic Syndrome				
	Constant	USC[a]	p1[b]	p2[c]	Adjusted R^2
WC	-13.163	0.166	<0.001	<0.001	0.375

[a]Unstandardized Coefficient, [b]p-value, [c] p F-Test (ANOVA), [d] coefficient of determination

analyses on anthropometric indicators related to metabolic syndromes. Table 3 shows the bivariate statistical analysis using the Pearson correlation test. The analysis results showed that all anthropometric indicators, namely WHtR, BMI, SAD, waist circumference, hip circumference and WHR have a strong positive relationship with the metabolic syndrome score ($p<0.001$), which means that the higher the anthropometric value, the higher the metabolic syndrome score. In addition, the analysis of the relationship between anthropometric indicators and each metabolic profile revealed that almost all of the independent variables (WHtR, waist and hip circumference, WHR, BMI, and SAD) were associated with each metabolic profile, such as baseline systolic pressure, diastolic blood pressure, triglyceride levels, blood sugar levels, and HDL. Only WHR was not associated with diastolic blood pressure ($p>0.005$).

Table 4 shows the results of the analysis using multiple linear regression to determine anthropometric indicators that are most associated with each metabolic profile and metabolic syndrome score. The results showed that BMI was the anthropometric indicator that is most associated with the metabolic profiles, such as systolic blood pressure ($p<0.001$), blood sugar ($p<0.05$), and HDL ($p<0.001$). In addition, waist circumference was the anthropometric indicator that is most associated with triglycerides and metabolic syndrome score ($p<0.001$). Based on the Adjusted R^2 value on the metabolic syndrome score, we found that 37.5% of the metabolic syndrome score was related to anthropometric indicators, such as WHtR, waist and hip circumference, WHR, BMI, and SAD. The rest may be influenced by other variables that are not included in this study.

The correlation test results indicated that all anthropometric indicators had a positive relationship with the metabolic syndrome scores with $p<0.001$. Meanwhile, the regression analyses show that BMI and WHR were inversely related to cMetS. This is in line with research that reported an increase in the WHR value could be associated with the risk of metabolic syndrome in children and adolescents in Florida (Moore *et al.*, 2015). Another study revealed that there was a strong relationship between overweight and obese adolescents with metabolic syndrome (Al-Bachir and Bakir, 2017). Furthermore, a study on adolescents in South Africa found that central obesity as measured by the hip circumference could lead to an increased risk of cardiovascular diseases and death. Therefore, hip circumference and waist circumference can be used to predict the risk of cardiovascular diseases and death in the future (Cameron *et al.*, 2012).

Body Mass Index (BMI) is the most widely used indicator of measurement in epidemiological studies and is used as a substitute for evaluating body composition. However, BMI cannot distinguish fat from fat mass and lean mass, and it fails to show the presence of adipose and body fat distribution (Ofer *et al.*, 2019; Leone *et al.*, 2020). However, the BMI cut-offs for metabolic syndrome have not yet been determined (Ofer *et al.*, 2019). Obesity in adolescents is generally assessed using a BMI of ≥25.0 kg/m^2. In this study, we only divided the subjects into normal nutritional status (18.5-25 kg/m^2) and obesity (≥25.0 kg/m^2), and we found that 35.6% of the subjects were obese. The finding is in line with the research on the subject of students at Universitas Diponegoro aged 18-21 years. They found that 40% of their study population had obesity level I and 36.3% had obesity level II (Rose *et al.*, 2020).

Abdominal obesity is often assessed to determine a metabolic syndrome in people. One of the indicators used to measure abdominal obesity is the Waist-to-Hip Ratio (WHR) which is calculated by dividing the waist circumference and the hip circumference. Measurement of waist circumference is more sensitive in assessing the distribution of body fat in the abdominal wall, which is also a component of metabolic syndrome. The limit of the WHR value for a female is ≥0.85 (Rokhmah, *et al.*, 2015). This study shows that every 1% increase in the WHR value will increase the cMetS value by 10.411. Hip circumference is also an indicator that has a strong correlation with cMetS, but many studies have used it as a ratio along with waist circumference for assessing a person's central obesity status.

4. Conclusion

Metabolic syndrome in female students can be identified using anthropometric measurements, one of which is BMI and WHR which are very easy to measure and efficient. BMI and WHR have the strongest relationship and can be used to detect early risk of metabolic syndrome in female college students.

Conflict of interest

The authors declare no conflict of interest.

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