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Body Mass Index is The Most Associated Anthropometry Indicators of Obesity with Insulin Resistance in Female College Students

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ABSTRACT

Background: Dysfunction of body tissues due to excessive food consumption is often referred to obesity. Excess storage of visceral fat can develop insulin resistance. Insulin resistance is associated with cardiovascular diseases. Anthropometric measurements can illustrate the early risk of insulin resistance. The aim of this study is to identify the association between anthropometric indicators and insulin resistance.

Materials and Methods: The participants in this study were 163 female students aged 19-24 years who live in Semarang. This is a cross sectional study with a purposive sampling method using the "google form". Anthropometric data that were collected in this study include weight, height, waist cirrcumference, hip, sagittal abdominal diameter. Biochemical data that were collected include blood sugar and insulin levels. The data were analyzed using Pearson Correlation test and Multiple Linear Regression test.

Results: Anthropometric indicators with high risk were 72.4% for Waist to Height Ratio (WHtR); 22.1% for Waist Hip Ratio (WHR); 35.6% for Body Mass Index (BMI); 12.2% for Sagittal Abdominal Diameter (SAD) and 55.2% for waist cirrcumference. Meanwhile, subjects with high Fasting Blood Glucose levels was 16.6%, subjects had the Conicity Index (C-Index) at risk was 74.8% and based on the Relative Fat Mass (RFM) it was 23.9% of the participants were at risk of obesity and high Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) levels were 74.2%. Anthropometric indicators of obesity, including Conicity Index, Relative Fat Mass, WHtR, WHR, BMI, SAD, and waist and hip ratio were all positively associated with insulin resistance. Therefore, multivariate analysis showed that an increase in body mass index is an indicator that is most associated with the insulin resistance ($p<0,001$).

Conclusion: Body Mass Index is the anthropometric indicator that is most associated with insulin resistance.

Keyword: waist-to-height ratio, waist hip ratio, body mass index, sagittal abdominal diameter, conicity index; relative fat mass; insulin resistance

BACKGROUND

Obesity prevalence continues to increase both in Indonesia and globally. Obesity occurs because of an energy imbalance caused by eating food that exceeds the body's function requirements. Physiologically, obesity is defined as a state of abnormal or excess fat accumulation in the tissue.[1] Based on Basic Health Survey (Riskesdas), the prevalence of obesity increased at >18 years of age from 14.8% in 2013 to 21.8% in 2018. Meanwhile, the prevalence of abdominal obesity at >15 years of age has increased by 26.6% in 2013 and 31% in 2018. The indicator used for abdominal obesity is the abdominal circumference with measurements of more than 80 cm for women and more than 90 cm for men [2,3] Meanwhile, the prevalence of obesity in Semarang on people >15 years old was 2.66% in 2018.

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Obesity is one of the factors that is closely related to the development of insulin resistance and type 2 diabetes mellitus.[5] A study in Semarang stated that the storage of visceral or abdominal fat is an implication of insulin resistance, cardiovascular, and other metabolic conditions associated with diabetes mellitus. Excess visceral fat is associated with an impaired insulin sensitivity.[6] A woman tends to be more at risk of fat accumulation in the abdominal and subcutaneous areas associated with insulin sensitivity.[7]

Insulin resistance is a risk factor for metabolic disorders such as impaired glucose tolerance, Non-Insulin Independent Diabetes Mellitus (NIDDM), hypertension, and dyslipidemia. Insulin resistance is when cells in your muscles, fat, and liver don't respond well to insulin and can't use glucose from your blood for energy. To make up for it, your pancreas makes more insulin. Over time, your blood sugar levels go up. Insulin resistance syndrome includes a group of problems like obesity, high blood pressure, high cholesterol, and type 2 diabetes.[8] Insulin resistance is a condition when a person experiences weight gain, especially in the subcutaneous fat tissue and there is accumulation of fat in the stomach, liver, muscles, and further conditions in the brain, arteries and intestines. Most of the fat is stored in the stomach between the organs. This visceral fat develops, contrary to subcutaneous fat, into an active endocrine organ. The adipocytes secrete an abundance of adipokines, which alter the metabolism. Insulin resistance may causes hypertension and increased insulin levels, which can lead to cardiovascular diseases and type 2 diabetes mellitus.[8] Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) is an efficient instrument used by most of the population to identify insulin resistance already in the pre-diabetes stage.[9] Research in 2014 stated that Asian-Indian individuals have higher insulin resistance compared to Europe which leads to type 2 diabetes mellitus. Insulin resistance reflects an obesity trend. The study also explained that hyperglycemia in Southeast Asian and Indian individuals showed a response 2-3 times higher than those in Europe.[10]

Obesity in a person can be measured using several indicators or parameters, including Waist to Height Ratio (WHtR), Waist to Hip Ratio (WHR), Body Mass Index (BMI), Sagittal Abdominal Diameter (SAG), and Waist circumference (WC). Waist to Height Ratio (WHtR) or the ratio of waist to body height is measured as one of the indicators of abdominal obesity and is considered to be more accurate than BMI.[11,12] WHtR was first used in the 1990s to detects abdominal obesity and the risk of obesity-related disease. Recent meta-analysis revealed that WHtR is a better indicator to detect hyperinsulinemia, diabetes, hypertension, dyslipidemia, metabolic syndrome, and other health problems. In addition, WHtR is rated as a sensitive, inexpensive and easy-to-use method for insulin resistance screening. Research conducted in Brazil explained that there is a strong relationship between WHtR and HOMA-IR.[13]

Body Mass Index (BMI) is an indicator for determining obesity by dividing body weight in kilograms by height (squared in meters). The World Health Organization (WHO) defines obesity as a person who has a BMI >30 kg/m^2 and a BMI of 25-30 kg/m^2 for overweight. The American Diabetes Association (ADA) recommends that diabetes assessment should be considered for all Asian-American adults with a BMI score of 23 kg/m^2.[5] The use of BMI has a weakness, as it cannot assess the distribution of fat in the body so that it is less sensitive to determine abdominal obesity. The results of a study in Japan indicated that the BMI cut-off point to predict insulin resistance in all populations was 23.5 kg/m^2. Meanwhile the cut-off point for non-diabetic people is 22.7 kg/m^2 and for diabetic people is 23.6 kg/m^2. This shows that a BMI >23 kg/m^2 is a risk factor for insulin resistance and diabetes mellitus.[5]

Sagittal Abdominal Diameter (SAD) is a measurement of the diameter of the abdomen in the sagittal or median plane, also known as the height of the abdomen. SAD is used to measure visceral fat by the subject lying in a supine position so that the subcutaneous fat is pointed to the side and the harder, stiffer visceral fat remains in place so that it can be measured using a caliper. SAD measurement is considered valid and is not influenced by body size. The US study explained that there was no significant difference between SAD, waist circumference, and BMI. However, SAD is the best anthropometric measurement of glucose metabolism compared to other anthropometric measurements when using Oral Glucose Tolerance Test (OGTT), Fasting Blood Glucose (FGB),

HbA1c, and HOMA-IR. Fasting Blood Glucose (FGB), HbA1c, and HOMA-IR. SAD is also the best anthropometric measurement for all sex, BMI, race and age.[14]

The waist-to-hip ratio is calculated by dividing the circumference of the waist divided by the circumference of the hip. Waist circumference measurement can be used to assess metabolic disorders and diagnose insulin resistance. This measurement is more sensitive to assess body fat distribution, particularly on the abdominal wall and can be used to identify the type of fat distribution. A person with a history of insulin resistance may has difficulty losing weight on a diet with a normal carbohydrate percentage. WHO defines a value of >0.90 in men and >0.85 in women as an indicator of the metabolic syndrome.[8,15]

Waist circumference can be used to measure subcutaneous and intra-abdominal fat tissue, additionally, waist circumference has a better correlation with visceral fat mass and is easy to interpret. Visceral fat tissue is closely associated with metabolic complications such as insulin resistance syndrome. Waist circumference has a stronger correlation with total body fat tissue as assessed by BMI compared to waist-to-hip ratio.[16]

Apart from these indicators, the Conicity Index (C-Index) was also found as an anthropometric indicator related to detect the obesity and the distribution of body fat. The C-Index is determined based on the measurements of body weight, height, waist circumference which are indicators of abdominal obesity. Several studies have shown the relationship between the C-Index and increased body fat in adolescent group. In addition, the C-Index is also associated with an increased risk of metabolic diseases, such as hypertension, dyslipidemia, and diabetes mellitus. However, the correlation between C-Index and insulin resistance in female students has not been widely investigated, especially in Indonesia.[17]

Another estimator which is also a simple anthropometric indicator that can be used to predict body fat percentage and has not been widely studied is Relative Fat Mass (RFM).[18] The relative fat mass equation was derived based on data from the National Health and Nutrition Examination Survey (NHANES) 1999-2004 (n = 12,581) and validated against the data from the 2005-2006 NHANES data (n = 3,456).[19] The RFM formula is obtained after analysis on 365 anthropometric indexes. The results showed that RFM predicted total body fat percentage correctly, measured by dual energy X-ray absorptiometry (DXA), among women and men. RFM shows a higher accuracy than BMI and has fewer false-negative cases of body fat-induced obesity among women and men.[20] Woolcott and Bergman (2020) determined the RFM cut off point for as 40% and 30% for women and men, respectively, diagnose obesity and a higher risk of death. RFM was more accurate than BMI to estimate whole-body fat percentage among women and men and improved body fat-defned obesity misclassifcation among American adult individuals of Mexican, European or African ethnicity. Tus, accurate estimation of body fat percentage is highly relevant from a clinical and public health perspective, an aspect that has been endorsed by the American Heart Association Obesity Committee.[21]

Based on these explanations, this study aims to analyze the association between Waist Height to Ratio (WHtR), Waist Hip Ratio (WHR), Body Mass Index (BMI), Sagittal Abdominal Diameter (SAG), Waist circumference (WC), Conicity Index (C-Index) and Relative Fat Mass (RFM) with Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) in female students.

MATERIALS AND METHODS

This is a cross sectional study with a total of 163 participants. The participants were female students aged 19-24 years who live in Semarang between May-July 2020. The data collection was carried out in collaboration with the Cito Banyumanik Laboratory, Semarang, Central Java. This study has received an Ethical Clearance from the Medical / Health Research Bioethics Commission, Faculty of Medicine, Sultan Agung Islamic University Semarang No. 296/IX/2020/Komisi Bioetik.

The target population in this study were all students in Central Java and the reachable population was students in Semarang. The determination of the sample size is based on the sample size calculation formula for the ratio scale in the cross-sectional study plus 10% of the total sample to anticipate drop outs. The total number of subjects was 163 students who were willing to have their

blood tested. Samples were selected based on inclusion criteria, namely willingness to be research subjects, female students in the city of Semarang, aged 19-24, did not consume alcohol, never smoke and were not pregnant. The subject search process starts from the researcher providing information about the research and the subject opportunities needed through flyers or announcements that can be shared via social media, then people who are interested in being the subject are asked to fill out a google form, which will later be selected according to the inclusion criteria. The sampling technique used was a purposive sampling using "google form" because this research was taken while Indonesia, especially Semarang city, was still under the Large-Scale Social Restrictions due to the COVID-19 pandemic.[16]

The independent variables in this study were Waist Circumference, Hip Circumference, Waist-to-Height Ratio (WHtR), Waist Hip Ratio (WHR), Body Mass Index (BMI), Sagital Abdominal Diameter (SAD), and waist circumference with cut-off points adjusted for Asian participants, namely the cut-off point for the waist circumference of women is > 80 cm.[6] Cut off point for ≥0,50 WHtR,[21] ≥0,85 for WHR,[16] >19,3 cm for SAD,[6] and nutritional status using BMI with the normal cut-off point (18,5 – 22,9 kg/m^2) and obesity (≥25,0 kg/m^2) .[22]

The WHtR measurement required body height to be measured using a *microtoise* with an accuracy of 0.1 cm and a waist circumference measured using a Medline with the accuracy of 0,1 cm. WHR measurement used waist circumference and hip circumference using a Medline. Measurement of body weight using digital scales with an accuracy of 0.1 kg. While the measurement of SAD uses an abdominal caliper with an accuracy of 1 mm, the participants had to be in a sleeping position on a straight surface with their legs forming an angle of 90^o, the feet were above the base. The hands were crossed over the chest and measured in a straight line of the hipbone (iliac crest). The subject inhaled and exhaled slowly and held their breath for a moment while they were measured by lowering the caliper arm on the surface of the abdomen just above the navel.[14]

Relative Fat Mass (RFM) was calculated using the equation for RFM = 64 - (20 x Height in meters / waist in meters) + (12 x S),[20] where S = 0 (men), S = 1 (women). Woolcott and Bergman (2020) determined the RFM cut off point for as 40% and 30% for women and men, respectively, diagnose obesity and a higher risk of death.[21] While the Conicity Index (C-Index) was calculated by the equation of waist circumference in meters / (0.109 x (weight in Kg / height in meters) x 0.5). [23,24] Meanwhile, the dependent variable was insulin resistance measured using fasting insulin and fasting blood glucose levels which was converted into HOMA-IR models. HOMA-IR calculated by multiplying fasting insulin (mol / L) by fasting blood glucose level (mmol / L) which is then divided by 22.5. The Cut off the normal value of HOMA-IR in adolescent was <1.65.[6]

Statistical analysis was performed using SPSS software version 22 to describe the characteristics of the subject and the variables investigated. A correlation test using Pearson Correlation was performed to see the association of each anthropometric indicator with insulin resistance. After the multiple linear regression test conditions are met, then multivariate analysis can be performed using followed by Linear Regression test to determine which anthropometric indicators are the most associated with insulin resistance.

RESULTS

Tables 1 and 2 presented the characteristics of the participants and the frequency distribution of studies conducted on female students in Semarang to determine the anthropometric indicators that correlated with insulin resistance.

Table 1. Subjects Characteristics

Variable	Minimun	Maximum	Mean	Mean ± SD
Waist Circumference (cm)	58,00	112,10	79,44	10,78
Hip Circumference (cm)	80,60	138,45	98,96	9,30
Waist Height Ratio (WHtR)	0,37	0,71	0,51	0,07
Waist Hip Ratio (WHR)	0,67	0,96	0,80	0,06
Conicity-Index (C index)	0,99	1,78	1,19	0,95
Relative Fatt Mass (RFM)	22,02	47,81	35,89	5,52
Body Mass Index (kg/m^2)	15,81	39,30	24,04	4,72
Sagital Abdominal Diameter (cm)	11,35	25,50	16,79	2,42

Variable	Minimun	Maximum	Mean	Mean ± SD
Fasting Blood Glucose Levels (mg/dL)	66,00	110,00	92,00	7,59
Insulin Levels (µg/mL)	0,84	173,00	12,28	13,87
HOMA-IR (ratio)	0,17	8,34	2,58	1,41

The mean value of the BMI was 24.04 kg/m^2, and there was a participant who had a BMI of 39.3 kg/m^2. The average waist circumference of the subjects was 79.44 cm, and it was lower than the average hip circumference, which reached 98.96 cm. Meanwhile, the mean fasting blood glucose level was 92 mg/dL, the mean insulin level was 12.28 µg/mL and the mean HOMA-IR level was 2.58.

Table 2. Subject Characteristics based on Anthropometric Indicators Waist Circumference WHtR, WHR, IMT, SAD, Fasting Blood Glucose Levels, Insulin Resistance

variables	n	%
C-Index		
Normal (>1,14)	41	25,2
At Risk (≤ 1,14)	122	74,8
Relative Fat Mass (RFM)		
Non Obese <40%	124	76,1
Obese (Risk)≥40%	39	23,9
WHtR		
Normal (<0,50)	45	27,6
Risk (≥0,50)	118	72,4
WHR		
Normal (<0,85)	127	77,9
Central Obesity (≥0,85)	36	22,1
Body Mass Index		
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
Sagital Abdominal Diameter		
Normal (≤19,3 cm)	143	87,7
Risk (>19,3cm)	20	12,3
Waist Circumference		
Normal (<80 cm)	73	44,8
Obese (≤80 cm)	90	55,2
Fasting Blood Glucose Level(FGB)		
Normal (<110 mg/dL)	136	83,4
High (≥110 mg/dL)	27	16,6
HOMA-IR		
Normal (<1,65)	42	25,8
Resistance (≥1,65)	121	74,2

An overview of the frequency distribution based on the anthropometric profile is shown in Table 2. The characteristics of the participants based on the C-Index, RFM, WHtR, WHR, BMI, SAD and The waist circumference displayed that most of the participants, according to the C-Index value, were 74.8% at-risk subjects, while based on the Relative Fat Mass (RFM), 23.9% of subjects were classified as obese. Furthermore, about 72.4% had a WHtR > 0.50 (at risk), whereas based on the WHR value, 22.1% of subjects had abdominal obesity (> 0.85). Subjects with a BMI >25 kg/m^2 or categorized as obese were accounted for 35.6% of the total participants. However, based on the waist circumference, more participants were found to be obese compared to calculation based on BMI, which was about 55.2%. Meanwhile, only 16.6% of subjects had fasting blood glucose levels above normal, it was significantly different from the HOMA-IR value which showed that most subjects had a risk of insulin resistance as much as 74.2%.

The results of statistical analysis in this study are shown in Table 3 and Table 4. Bivariate analysis using the Pearson Correlation test obtained significant results on all anthropometric indicators to insulin resistance with a significance of p <0.001. It shows that the higher Relative Fat Mass, waist circumference, hip circumference, WHtR, WHR, BMI, and SAD, will increase the score

of insulin resistance. However, the C-Index value in this study is not significantly associated with a significance of p <0.001.

Table 3. Correlation Anthropometric Indicators with Insulin Resistance

Variable	HOMA-IR	
	r[a]	*p*
C-Index	0,155	0,048
RFM	0,455	<0,001
WHtR	0,471	<0,001
WHR	0,270	<0,001
BMI	0,548	<0,001
SAD	0,485	<0,001
Waist circumference	0,485	<0,001
Hip Circumference	0,476	<0,001

[a]Pearson Correlation Test

Furthermore, a multivariate analysis was carried out using the Linear Regression test to analyze the most associated anthropometric indicators with insulin resistance. Multivariate analysis was carried out based on the bivariate analysis with independent variabels that have p-value <0.25 and normally distributed. The results showed that the body mass index (BMI) is the anthropometric indicator that was most closely associated to insulin resistance in the participants, whereas about 29,6 % of the increase in insulin resistance was simultaneously influenced by the high BMI value of the participants while the rest was influenced by unobserved variables. The HOMA-IR constant was -1,359 + 0,164 BMI, which states that each additional 1 kg/m^2 increase in BMI value will increase 0,164 HOMA-IR.

Table* 3. *The Most Associated Anthropometry Indicators of Obesity with Insulin Resistance in Students

Variables	HOMA-IR			
	SC[a]	*p*	p-Anova[c]	*Adjusted R Square*
Constant	-1,359			
Body Mass Index	0,164	<0,001[b]	<0,001[c]	0,296[d]

[a]*Unstandardized Coefficient*, [b]Significance, [c]Significance Test F (ANOVA), [d]Coefficient of determination

DISCUSSION

This study was conducted on female students in Semarang, 35.6% of the participants were categorized as obese based on BMI, and 55.2% of participants had abdominal obesity based on waist circumference measurements. Based on the Basic Health Survey (Riskesdas) in 2013, the prevalence of obesity in adults aged ≥18 years reached 14.8% and increased to 21.8% in 2018. Meanwhile, abdominal obesity at ≥15 years of age in 2013 and 2018 reached 26.6% and 31%, respectively.[3]

Obesity in female students is one of the risk factors of insulin resistance. Insulin resistance is a condition that arises due to weight gain, causing an accumulation of fat in the stomach, liver, muscles and at an advanced stage in the brain, arteries and intestines. Most of the fat is stored in the abdomen and between the organs. This visceral fat develops, contrary to subcutaneous fat, into an active endocrine organ. The adipocytes secrete an abundance of adipokines, which alter the metabolism. The major problem that induces insulin resistance is a rise in blood pressure and insulin levels which can lead to cardiovascular diseases and type 2 diabetes mellitus.[8] Furthermore, insulin resistance can go through various mechanisms that can contribute to the accumulation of macrophages in the walls of blood vessels, thereby increasing atherosclerosiss

Insulin resistance can be assessed using the HOMA-IR model from fasting insulin and fasting blood glucose levels. The results of HOMA-IR in this study indicated that 74.2% of subjects showed insulin resistance with a mean value of HOMA-IR >1,65. In line with the previous study from Dieny et al in female students, the prevalence of participants with high levels of HOMA-IR was 83.3%.[6] Bivariate analysis showed that all tested anthropometric indicators related to the levels of HOMA-IR. Followed by the multivariate test, it was found that the BMI had a strong correlation with HOMA-IR levels.

A research conducted on the Japanese population indicated that a person who has a BMI ≥23 has a risk of insulin resistance and diabetes mellitus. American Diabetes Association suggests that for diagnosing Diabetes Mellitus in an individual, BMI ≥23 kg/m^2 should be considered. Moreover, a study from Japan, non-diabetic people without hypertension, hyperglycemia, or dyslipidemia indicated that there is a risk of insulin resistance in Japanese people who have a BMI ≥23 without any cardiometabolic risk factors.[5] In this study, the average BMI of the participants was 24 kg/m^2 and BMI is one of the indicators most closely associated with insulin resistance.

Another indicator in this study that has a positive correlation with insulin resistance are the Waist to Hip Ratio (WHR) and Waist to Height Ratio (WHtR). These two indicators measure the waist circumference which can explain abdominal obesity in a person. Abdominal Obesity caused an increase in corticosteroid and adrenal hormones produced by the adrenal glands and can affect the level of glucose in the blood. Overweight people will have an increased lipids levels in their bodies. One type of lipid tissue is a fatty acid. Peripheral tissues that are exposed to the increase in free fatty acids will induce insulin resistance. Mechanically, the activation of the threonine kinase pathway by free fatty acids metabolism will reduce insulin receptors. Long-term exposure to fatty acids in the pancreas will damage the beta cells, this condition called lipotoxicity. It has an impact on fasting blood glucose which causes WHR and WHtR values as central parameters of obesity associated with insulin resistance and type 2 diabetes.7[25]

Another study reported that anthropometric measurements such as waist circumference, BMI, WHR and WHtR are easy and inexpensive methods in clinical and epidemiological fields.[29] Meanwhile, other studies suggest that WHtR can be a screening tool for markers of insulin resistance in children and adolescents by considering the ratio, costs and benefits.[30,31] Besides, a study conducted in Peru on women over 18 years of age with normal BMI reported that waist circumference and WHtR were associated with a high ratio of triglyceride levels and HDL cholesterol. Whereas triglycerides and HDL cholesterol are components of metabolic syndrome. Insulin resistance plays an important role in the pathophysiology of metabolic syndrome.[26]

Abdominal obesity and diabetes are closely related. However, there are different conclusions regarding the better abdominal obesity index that can predict insulin secretion. A study from China by Liu et al. on obese patients reported that anthropometric measurement of WHR was found to be the most relevant index of obesity at each phase of insulin secretion among obese patients and could be a good predictor of β-cell insulin secretion function.[27] In line with a study by Zapata et al. on female subject of normal weight without type 2 diabetes mellitus, stated that WHR can be an anthropometric indicator for early detection of insulin resistance, including the healthy subjects.[28] In China, a study by Song et al. on children and adolescents participants was using the Mendelian Randomization (MR) method which has been widely used for cardiometabolic observation studies. MR method is a controlled trial where the genotype is randomly distributed at conception, is less likely to be influenced by reverse causation and confounding factors. Single Nucleotide Polymorphisms (SNP) associated with BMI and WHR were selected from the Genome-Wide Association Studies (GWAS). They found that a genetic predisposition to a higher BMI or WHR was associated with altered cardiometabolic traits. When compared with general obesity, abdominal obesity might have stronger effects on glycemic traits and blood lipids.[29]

Abdominal obesity is usually assessed by waist circumference, but recent studies have reported that it can be assessed using the Sagittal Abdominal Diameter (SAD), also known as abdominal height. A study by Moller *et al.* stated that SAD was significantly correlated with several markers of cardiometabolic risk factors other than waist circumference and BMI.[30] While a cohort study in Sweden stated that SAD >25 cm in patients with type 2 DM could be used as an independent risk assessment to identify high risk of cardiovascular disease if confirmed in a larger study.[31] Accumulation of certain fat depots is related to poor metabolic outcomes. Visceral adipose tissue can locally affect the heart and coronary arteries vasocrine or paracrine secretion of proinflammatory cytokines. A study by Vasques et al. on female aged >20 years stated that the amount of stored fat is associated with cardiometabolic risk factors in various kinds of adiposity and tolerance levels. SAD measurements correlated with epicardial adipose tissue (EAT). Furthermore, SAD is strongly

associated with atherogenic lipoprotein subfraction insulin resistance and cardiovascular risk. The metabolic characteristics of EAT may explain the association with cardiometabolic risk parameters. Adiponectin expression was significantly higher in subcutaneous fat, which may explain the poor insulin sensitivity associated with fat tissue accumulation.[32]

One of the anthropometric indicators, Conicity Index (C-Index) is an assessment of the distribution of fat mass at risk of metabolic disease. It can describe the condition of total body fat. The higher the C-index value, the higher a person's risk for metabolic disease.[33] If the C-index value is more than 1.14, it is considered as being at risk for metabolic disease.[18] The results of other studies suggest that the C-index can detect levels of C-reactive protein (CRP) and fibrinogen which are associated with an increased risk of cardiovascular diseases compared to anthropometric indicators of BMI, WC, and WHR.[34] Cardiovascular disease is a complication that causes a lower quality of life and increased morbidity also mortality.[35] Moreover, the C-index is also positively associated with insulin resistance, HT, and dyslipidemia.[36] Nevertheless, according to the present study, C-index is not associated with HOMA-IR (p = 0,048. These results are consistent with a prospective study in China which showed that the predictive power of diabetes from the C-index was still below the Body Roundness Index, waist circumference, and abdominal volume index (AVI).[37]

This variation in results may be due to differences in body fat composition and distribution between ethnic groups. Obesity is considered a major cause of IR in general population. An increased adipose tissue induces a change in the release of free fatty acids and the secretion of adipokines and proinflammatory cytokines, which are involved in the modulation of insulin sensitivity.[38] A woman with a Relative Fat Mass (RFM) >35 is considered at risk of obesity and associated mortality. RFM is more specific than BMI because it considers the differences of gender in body adiposity.[21] In our study, high RFM was significantly associated with an increase in HOMA-IR levels with a 23.9% percentage at risk of obesity. This finding is in line with a study by Karava et al. which showed that RFM level is a risk factor for IR even in normal-weight children and patients with glucose and insulin metabolism disorders.[38] RFM measurements have been reported in other studies to estimate body fat percentage such as the use of dual-energy X-ray absorptiometry (DXA).[39] Another study suggests that using RFM in conjunction with BMI to provide additional information when assessing obesity in women can improve diagnostic accuracy.[40] Anthropometric measurements using RFM can represent obesity diagnostically and thus provide better predictability for a wide range of dyslipidemia (high LDL, low HDL, and high triglycerides) and metabolic syndrome, which are independent risk factors for coronary heart disease, peripheral artery disease, stroke, and death.[41]

Although BMI is widely used to determine weight categories, anthropometric parameters of central obesity are reported to be a better screening tool to identify prediabetes in Asian multiethnic populations.[42]

Likewise with the results of this study. The potential mechanism of central obesity in promoting the development of prediabetes is through the role of visceral fat which has more metabolic activity than subcutaneous fat, namely by secreting nonesterified free fatty acids and proinflammatory adipokines such as tumor necrosis factor (TNF)-α and interleukin (IL)-6 which can be causes insulin resistance and pancreatic beta cell damage, resulting in impaired glucose tolerance and eventually developing diabetes.[43,44]

Women are known to have a higher optimal cut-off BMI than men. This is due to differences in fat storage patterns between sexes, where women have a tendency to store fat in the subcutaneous area, especially in the gluteofemoral location so that it is better for large and long-term storage than men who have a tendency to store fat in the visceral area.[45]

Research shows that visceral fat is more closely associated with cardiometabolic risk in women than men. This suggests that although women have less visceral fat overall than men, the accumulation of visceral fat in women carries a greater risk of developing cardiometabolic disorders.[46]

However, in this study, women actually had an optimal cut-off value of anthropometric parameters markers of central obesity which was higher than men. This is probably because the majority of the male sample in this study were active smokers. Nicotine (the main bioactive

component of cigarette smoke) can activate the sympathetic nervous system leading to increased lipolysis in white adipose tissue thereby increasing the release of free fatty acids that contribute to insulin resistance and weight loss.[47]

Insulin resistance happens to cause a decline of tissue sensitivity to insulin which main function is to stimulate glucose uptake. If obesity resulted in insulin resistance, increased blood glucose and hyperinsulinemia, it will end with the development of type 2 diabetes mellitus and metabolic syndrome.[48] Thereby, anthropometric measurements can be used for screening to control obesity in early life, especially in abdominal obesity, to prevent cardiometabolic dysfunction later in life. However, no single anthropometric indicator is consistently superior in predicting markers of cardiometabolic risk.[30]

CONCLUSION

Insulin resistance can be identified significantly using anthropometric indicators namely Conicity-Index, Relative Fat Mass, waist circumference, hip circumference, WHtR, WHR, BMI, and SAD. However, results indicated that BMI is the anthropometric indicator that was most associated with the HOMA-IR among other indicators. Therefore, it can be used as a fast and efficient anthropometric measurement in identifying the occurrence of insulin resistance in female students.

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