Comparison of Obesity Indices in Predicting Diabetes Mellitus, Heart Disease, Chronic Kidney Disease, and High Blood Pressure among Adults in Kalimantan, Indonesia

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Abstract: There has been evolving evidence that waist-to-height ratio (WtHR) may be a better obesity index compared to body mass index (BMI) and waist circumference (WC). We would like to compare the performance of those indices in identifying the risk of several chronic diseases among the adult population in Kalimantan, Indonesia. This is a cross-sectional study using data from the latest Basic Health Research (Riskesdas). Multivariate logistic regression analysis was performed to investigate the odds ratios (OR) relating three obesity indices (BMI, WC, and WtHR) to diabetes mellitus (DM), heart disease, chronic kidney disease (CKD), and high blood pressure (HBP). High WtHR (≥0.5) was found to have significant relationships with the aforementioned diseases. Among the investigated indices, high WtHR had the highest OR in relation to DM (3.365; 95% CI 2.707-4.182), CKD (1.935; 95% CI 1.309-2.861), and HBP (2.008; 95% CI 1.866-2.160). Its OR for heart disease (1.549; 95% CI 1.247-1924) was just slightly lower than the OR of high WC (1.589; 95% CI 1.277-1.979). Meanwhile, BMI was significant only for DM and HBP. High BMI consistently showed the lowest OR values among the three indices. These results suggest that chronic diseases can be predicted better by the measurement of WtHR.

1 INTRODUCTION

Obesity can be defined as excessive fat accumulation that may impair health (World Health Organisation (WHO), 2006). Indonesia is experiencing a severe problem of double burden of malnutrition due to the rise of obesity and overweight (Popkin, Corvalan and Grummer-Strawn, 2020). According to data from the biggest national health survey, Riskesdas or the Basic Health Research year 2007 and 2018, the prevalence of general and central obesity had been increasing by over 10% (Kementerian Kesehatan RI, 2007, 2018). Kalimantan, referring to the Indonesian part of Borneo Island, follows a similar trend. The prevalence of general and central obesity in two of its provinces, North and East Kalimantan, are bigger than the national prevalence (Kementerian Kesehatan RI, 2018).

Consequently, the rise of non-communicable chronic diseases or NCDs in the region should also be anticipated. The Framingham Heart Study showed obesity as an independent risk factor for cardiovascular diseases (Hubert, Mcnamara and Castelli, 1983). Obesity status is traditionally determined by calculating body mass index (BMI). However, other anthropometric measures reflecting abdominal adiposity have been endorsed as being superior to BMI in predicting the risk of cardiovascular diseases (CVD) (World Health Organisation (WHO), 2008). This is based basically on the justification that increased visceral adipose tissue is related to a range of metabolic abnormalities which become the risk factors for type 2 diabetes and CVD (Frank *et al.*, 2019).

Waist circumference (WC) as the discriminator of central obesity is shown to be a reliable proxy of visceral adiposity across a wide age range in a population with a high incidence of metabolic syndrome (Onat *et al.*, 2004). Central obesity is officially recognized as a core component in

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diagnosing metabolic syndrome (International Diabetes Foundation, 2006).

More recent studies have found that waistline measurement shows better correlations with chronic diseases when used in conjunction with body height, which also became the hypothesis of our present study. Waist-to-height ratio (abbreviated as WtHR, WHtR, or W/Ht) with a general cut-off value of 0.5 has been proposed as a novel obesity index (Ashwell and Gibson, 2014). This study would like to compare the three obesity indices, namely BMI, WC, and WtHR; in predicting the risk of several chronic diseases that are increasingly prevalent in Kalimantan, Indonesia.

2 METHODS

2.1 Study Design and Population

This is a cross-sectional study using secondary data from the latest Basic Health Research (Riskesdas 2018) directed by the Ministry of Health of Indonesia. The population of interest was adults residing in Kalimantan, Indonesia. The sample in this study was adults aged 18 years old and older in Kalimantan who were selected as the 2018 Riskesdas participants and met the inclusion criteria. The inclusion criteria were adults aged $\geq$ 18 years whose blood pressure was measured at least once and answered survey questions about their chronic disease history. Since we would like to compare differences associated with obesity status, all pregnant respondents were purposively excluded in this study.

2.2 Data Collection

All subjects were interviewed and physically examined for survey purposes. The interview included questions about whether they had been diagnosed having certain diseases, such as diabetes mellitus, heart disease, and chronic kidney disease. Measurement of blood pressure, body weight, body height, and waist circumference (WC) were part of the physical examination.

2.3 Variables

High BMI is defined following the Asia-Pacific definition for general obesity, which is having a body mass index (BMI) $\geq$ 25 kg/m^2 (Kanazawa *et al.*, 2005). High WC is defined according to the central obesity criteria for the South Asian ethnic group, which is WC $\geq$ 90 cm for men and $\geq$ 80 cm for women (International Diabetes Foundation, 2006). Waist-to-Height Ratio (WtHR) is calculated by dividing the WC by the body height. High WtHR is defined as WtHR $\geq$ 0.5 (Browning, Hsieh, and Ashwell, 2010).

Diabetes mellitus (DM), heart disease, and chronic kidney disease (CKD) are determined by the relevant report provided by the subjects for the interview on the questions about their history of being diagnosed with the aforementioned diseases. High blood pressure (HBP) is defined as having systolic blood pressure $\geq$ 140 mmHg and/or diastolic blood pressure $\geq$ 90 mmHg when examined in the Riskesdas survey (Kementerian Kesehatan RI, 2018).

2.4 Ethical Consideration

For the primary data collection of Riskesdas 2018, the Ethical Committee of Health Research, NIHRD, Ministry of Health of Indonesia had given their approval with the reference number LB.02.01/2/KE.267/2017. All subjects were asked for their consent and signed the informed consent form in the survey. No additional ethical clearance is required for secondary analysis of the obtained data.

2.5 Statistical Analysis

The statistical analyses were performed using the International Business Machines Statistical Package for the Social Sciences (IBM SPSS) version 25. Multivariate logistic regression analyses with a complex samples analysis design were performed to calculate the odds ratios (OR) relating obesity status to DM, heart disease, chronic kidney disease (CKD), and HBP.

3 RESULTS

Subjects included in this study had a total number of 61,140. The prevalence of general obesity, central obesity, and high WtHR among the subjects who were recorded as having DM, heart disease, CKD, and HBP are presented in Table 1. Over 60% of subjects who suffered any disease of concern were categorized as having high WtHR. On the other hand, only up to 55.5% were categorized as having central or general obesity.

Table 1: Percentages of obesity status of subjects having DM, heart disease, CKD, and HBP.

	WtHR >= 0.5		Central obesity		General Obesity	
	Yes	No	Yes	No	Yes	No
DM (n = 1,320)	78.1	21.9	55.5	44.5	45.5	54.5
Heart disease (n = 1,143)	67.3	32.7	47.4	52.6	44.4	55.6
CKD (n = 270)	62.2	37.8	35.2	64.8	36.7	63.3
HBP (n = 13,763	71.2	28.8	48.7	51.3	29.4	70.6

Table 2: Multivariate analysis between DM, heart disease, CKD, and HBP with obesity indices*).

DM			
Variable	p-value	OR	95% CI
High WtHR	< 0.001	3.365	2.707-4.182
High WC	< 0.001	1.800	1.470-2.205
High BMI	< 0.001	0.611	0.509-0.734
Heart disease			
Variable	p-value	OR	95% CI
High WtHR	< 0.001	1.549	1.247-1.924
High WC	< 0.001	1.589	1.277-1.979
High BMI	0.725	0.964	0.786-1.183
CKD			
Variable	p-value	OR	95% CI
High WtHR	0.001	1.935	1.309-2.861
High WC	0.543	1.140	0.747-1.740
High BMI	0.116	0.717	0.473-1.085
HBP			
Variable	p-value	OR	95% CI
High WtHR	< 0.001	2.008	1.866-2.160
High WC	< 0.001	1.440	1.341-1.546
High BMI	< 0.001	1.367	1.277-1.464

*) Reference category for each index:
WtHR: < 0.5
WC: < 90 cm for men, < 80 cm for women
BMI: < 25

Table 2 shows that WtHR was the only index showing significant relationships with all the aforementioned diseases (p-value < 0.001 except for CKD). Compared to other indices, high WtHR also had the highest OR in relation to DM (3.365; 95% CI 2.707-4.182), CKD (1.935; 95% CI 1.309-2.861), and HBP (2.008; 95% CI 1.866-2.160). Its OR for heart disease (1.549; 95% CI 1.247-1.924) was just slightly lower than the OR of high WC (1.589; 95% CI 1.277-1.979). Meanwhile, the ORs from high BMI were consistently the lowest among the three indices. General obesity also showed negative associations (OR < 1) for the concerned diseases except in relation to HBP (Table 2).

4 DISCUSSION

Hypertension is known to happen more commonly in obese than in lean individuals at practically every age (Thakur, Richards and Reisin, 2001). Obesity status, especially central obesity, increases sodium reabsorption in the kidneys and affects the renin-angiotensin-aldosterone hormone production system that regulates blood pressure (Hall, 2003). In our analyses, high BMI showed a positive association (OR > 1) only with HBP. There is indeed a significant linear relationship between blood pressure and BMI found among Indonesian population (Peltzer and Pengpid, 2018). It has also been established general and central obesity were associated with hypertension in Indonesian women (Nurdiantami *et al.*, 2018).

However, BMI alone is not appropriate to properly assess the cardiometabolic risk associated with increased adiposity in adults (Ross *et al.*, 2020). In those who are not classified as obese based on BMI, abdominal fat accumulation is associated with HBP and predisposes people to diseases associated with metabolic syndrome (Frank *et al.*, 2019). Looking at the subjects having HBP in our present study, only less than a third of them were categorized as having high BMI (Table 1). Additionally, our analysis showed that with ORs < 1, high BMI failed to predict the occurrence of DM, heart disease, and CKD.

Although BMI is popularly used to describe obesity, WC has emerged as a more specific indicator of metabolic risk. Centralized obesity measures, especially WtHR, have been proved to be superior to BMI for detecting cardiovascular risk factors (Lee *et al.*, 2008; Schneider *et al.*, 2010). Not only it does not differentiate between lean and fat mass, but BMI also does not indicate the distribution of the body fat. For assessing obesity, BMI has high specificity but low sensitivity (Okorodudu *et al.*, 2010).

The result from our analyses shows that concerning heart disease, WC was the best predictor while WtHR performed just almost the same based on their ORs (Table 2). Prospective studies and meta-analyses of adults have revealed that the WtHR is comparable to WC and superior to BMI in predicting advanced cardiometabolic risk (Yoo, 2016).

Unfortunately, WC and BMI do not have universal obesity thresholds. They are ethnic-specific, while WC is gender-specific as well. The boundary values are relatively lower for the Asian population. As such, Asians pose a higher risk of getting diabetes and dying prematurely at lower levels of BMI and WC, from cardiovascular problems (Naser, Gruber and Thomson, 2006). Use of Asian BMI threshold improved detection of DM and hypertension in Filipino-American women (Battie *et al.*, 2016).

WtHR has been endorsed as a novel obesity index with a cut-off value of 0.5 that can be applied globally, across age groups and genders (Ashwell and Hsieh, 2005; Browning, Hsieh and Ashwell, 2010; Ashwell, Gunn and Gibson, 2012; Ashwell and Gibson, 2016). Besides its simple boundary value, it is more sensitive than BMI or WC alone to evaluate clustering of coronary risk factors among non-obese men and women (Hsieh and Muto, 2005). WtHR also performed better than BMI and WC for the association with hypertension and diabetes (Cai *et al.*, 2013). Table 1 shows that people having history of DM, heart disease, CKD, or HBP were dominated by those having high WtHR.

This index was shown to be the best anthropometric measure than BMI and WC in identifying the risk of diabetes among Indonesian population and suitable for both genders (Djap *et al.*, 2018). In our present analyses, WtHR was superior not only to BMI but also to WC in predicting the risk of DM, CKD, and HBP.

Another remark from our study is that WtHR was found to be the only index having a significant relationship with CKD. Although the biological mechanism is not fully understood, obesity is a risk factor for the development and progression of kidney disease. It may promote kidney damage directly over hormonal and hemodynamic effects or indirectly by favoring the progress of diabetes and hypertension, and disorders with strong kidney involvement (Wang *et al.*, 2008). A cohort study of hypertensive patients found that overweight and obesity were associated with a 20–40% increased risk for the development of CKD (Kramer *et al.*, 2005). A recent meta-analysis reported that WtHR appears to be the best predictor of CKD compared to other physical measurements (Liu *et al.*, 2019).

With these findings of the usefulness of WtHR as an index for obesity, keeping waistline to be less than half of the body height is worth being a treatment target in preventing adverse health risks for adults. Dietary interventions, as well as routine, moderate-intensity exercise, have been suggested to reduce WC (Ross *et al.*, 2020) and ultimately, WtHR.

5 CONCLUSION

Our results suggest that chronic diseases can be predicted better by the measurement of WtHR. WtHR has better performance than BMI and WC in identifying the risk of developing DM, CKD, and HBP; while for identifying the risk of heart disease, its performance was similar to WC. Despite its widespread use, BMI was found to be a weak predictor of chronic diseases as it only showed a positive correlation with HBP but not with other chronic diseases of interest. We support the measures of centralized obesity, especially WtHR, to detect the risk of non-communicable chronic diseases.

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