Berita Kedokteran Masyarakat
(BKM Journal of Community Medicine and Public Health)

Volume 36 **Nomor** 2, 2020
Pages 49-54
DOI: 10.22146/bkm.52439

Diagnostic value of waist-height ratio to predict cardiovascular disease risk in adults

Laeli Ardiani Putri[1]*, Neni Trilusiana Rahmawati[2], Hasanah Mumpuni[3]

Abstract

Purpose: This study aimed to determine the diagnostic strength, optimal cutoff point, and diagnostic value of waist circumference/body height ratio in detecting cardiovascular disease risk in adults with Framingham Risk Score (FRS). **Method:** This study used a cross-sectional research design using secondary data from the Fourth Wave of the Indonesian Family Life Survey 4 (IFLS 4). Subject selection uses the total sampling method so that the entire study population that matches the inclusion and exclusion criteria will be the subject of this study. The number of research subjects that fit the inclusion and exclusion criteria was 9,103 people. This research uses ROC analysis, with the gold standard is the risk of cardiovascular disease based on FRS, and the independent variable is WtHR. **Results:** The risk of cardiovascular disease in the moderate category was higher in men (80.54%) compared to women (30.23%). AUC WtHR value in male subjects was 0.5817 (95% CI 0.5610-0.624), while the AUC value in female subjects was 0.5904 (CI 0.5727-0.6084). The optimal cutoff point in male subjects is 0.5249 (sens = 0.3549; spe = 0.7626), while the cut point in female subjects is 0.5796 (sens = 0.4382; spe = 0.7024). **Conclusion:** The WtHR cutoff value based on this study is 0.5249 and 0.5796, so the health message that can be given to the public to prevent the risk of cardiovascular disease is to keep the waistline less than half the height.

Keywords: diagnostic test; waist circumference/height ratio; cardiovascular disease; IFLS

Submitted:
December 10th, 2019

Published:
February 25th, 2020

[1] Public Health Master Program, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada

[2] Laboratorium of Bio- & Paleoanthropology, Faculty of Medicine, Public Health, and Nursing Universitas Gadjah Mada, Yogyakarta

[3] Cardiovascular Department, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada

*Correspondence:
laeliardiani@gmail.com

INTRODUCTION

Cardiovascular disease is a disease caused by malfunctioning of the heart and blood vessels—data from WHO shows that deaths caused by cardiovascular disease in 2015 were approximately 17.7 million. Of the 17.7 million deaths globally in 2015, 82% of deaths came from developing countries where 37% of the deaths were due to cardiovascular disease [1]. The prevalence of stroke in 2018 increased to 10.9% from 7% in 2013. Based on the 2013 and 2018 Riskesdas data, many people with heart disease and stroke were adults over 40 years old [2,3]. The Ministry of Health (MoH) and the Research and Development Agency (2014) estimated that cardiovascular disease deaths would increase every year. The MoH also predicted that in 2030, deaths from cardiovascular disease would increase to 23.3 million [4].

Early prevention is needed to prevent cardiovascular disease in the future. One of the existing guideline recommendations is knowing the risk of cardiovascular disease in the future for each individual. Health workers can determine the magnitude of the risk of cardiovascular

disease by several scoring methods. One of which is the Framingham Risk Score (FRS) Cardiovascular Disease. FRS was developed from a population cohort study in America. However, the study by Selvarajah et al. (2014) conducted in an Asian population showed that the prediction model for FRS Cardiovascular Disease was more applicable in predicting the risk of cardiovascular disease compared to other risk scoring models [5].

In addition, knowing the risk of cardiovascular disease in the future for each individual using the scoring method, it is necessary to control risk factors to prevent cardiovascular disease. One of the risk factors for cardiovascular disease that needs controlling is obesity [4]. Body mass index (BMI), waist/hip ratio, waist circumference, and waist circumference/height are several anthropometric measurements for measuring obesity. According to Ashwell et al. (2014) and Bastien et al. (2014), BMI is considered insignificant in predicting mortality due to cardiovascular disease because BMI cannot distinguish whether fat mass or muscle mass causes body weight gain [6,7]. The waist/hip ratio is also considered less valid in measuring abdominal obesity. Waist circumference and hip circumference will both change if there is a bodyweight change so that the ratio results tend to look unchanged [8]. Measurement of waist circumference alone is also considered insufficient to describe body fat mass because body height influences the distribution and accumulation of fat in the body [9]. There needs to be a type of anthropometry that can identify obesity more validly. Several studies have shown that the waist to height ratio (WtHR) measurement can describe the mass of body fat compared to other measurements. This study aims to determine the diagnostic power, optimal cutoff, and WtHR diagnostic value in detecting cardiovascular disease risk in adults.

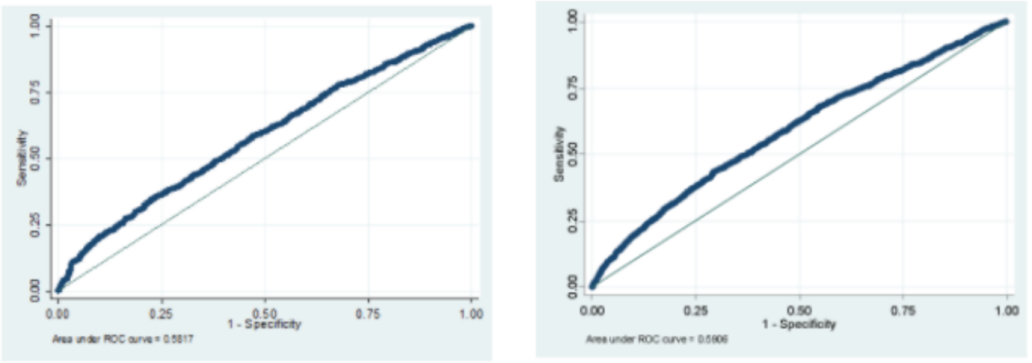
METHODS

This type of research is a diagnostic study in the form of secondary data analysis with a cross-sectional study design using data from the research of The Fourth Wave of the Indonesia Family Life Survey 4 (IFLS 4). IFLS 4 contained information regarding health measurement data (systolic blood pressure, total cholesterol, HDL cholesterol, history of the disease, history of drug consumption, smoking history), and anthropometric measurement data (waist circumference and height).

IFLS4 data includes 13,995 households and 73,016 individuals. The population of this research was Indonesian, aged 40-74 years who live in 13 selected provinces. In this study, the inclusion criteria were aged 40-74 years, had no history of heart disease and stroke, and were not pregnant. Meanwhile, the exclusion criteria were incomplete data.

The dependent variable of this study was the risk of cardiovascular disease according to the Framingham 10 year Risk of General Cardiovascular Disease score, and the independent variable was WtHR. Risk of cardiovascular disease. The scoring used data on risk factors for atherosclerosis such as sex, age, mean systolic blood pressure, total cholesterol, HDL cholesterol, consumption of hypertension drugs, smoking, and a history of diabetes mellitus. We categorized the Framingham 10 year Risk of General Cardiovascular Disease score as <10% and ≥ 10%.

The WtHR was a comparison of waist circumference and height data. We measured the waist circumference at the midpoint of the lower margin at the last rib and the very top of the iliac crest. In comparison, the measurement of body height is a measurement of the perpendicular distance between the vertex's transverse plane to the plantar pedis, using a measuring board.



A B

Figure1. ROC WtHR curve to FRS (A) male (B) female

This analysis uses a diagnostic test with the Receiver Operating Characteristic (ROC) curve analysis. The ROC curve is the curve resulting from the trade-off between sensitivity and specificity at various intersection points. We then measured the Area Under Curve (AUC) and the recommended cut off point from this procedure. In this analysis, the AUC value was between 50% -100%. A score of 50% is a bad AUC, while 100% is the best. In addition to the AUC value, we used ROC analysis to determine the cut off point based on the combination of the highest sensitivity and specificity [10]. Moreover, cut off point, and diagnostic value, this study also looked for positive predictive value (NDP) and negative predictive value (NDN) of waist circumference/height ratio to the risk of cardiovascular disease using a 2x2 table.

RESULTS

Table 1 presents the characteristics of the research subjects. The number of research subjects after cleaning was 9.103. There were more female (52.08%) subjects than male (47.92%). The mean age of the research subjects was 52.17 ± 9.12 years. The mean waist/body height ratio of the subjects was 0.53 ± 0.07. Table 2 shows that low cardiovascular disease risk was higher in men (80.54%) than women (30.23%).

Table 1. Characteristics of the respondents

Variables	n (%)
Sex	
Male	4362 (47.92)
Female	4741 (52.08)
Age ± sd (years old)	52.17 ± 9.12
Hip circumference ± sd (cm)	81.30 ± 11.11
Height ± sd (cm)	154.64 ± 8.16
WtHR ± sd	0.53 ± 0.07
Systolic blood pressure ± sd (mmHg)	136.38 ± 20.85
Total cholesterol ± sd	186.10 ± 54.42
HDL cholesterol ± sd	38.79 ± 15.61
FRS risk score ± sd	15.63 ± 13.94
Use of blood pressure medication	
Yes	146 (1.60)
No	8957 (98.40)
Smoking,	
Yes	3332 (36.60)
No	5771 (63.40)
History of diabetes	
Yes	248 (2.72)
No	8855 (97.28)

Table 2. Characteristics of the subject based on the risk for cardiovascular disease

Variables	Risk for Cardiovascular Disease		P-Value
	<10%	>10%	
Sex			0.000[a]
Male, n (%)	849 (19.5)	3513 (80.54)	
Female, n (%)	3308 (69.77)	1433 (30.23)	
Age ± sd (tahun)	47.82 ± 6.75	55.83 ± 9.25	0.000[b]
Systolic blood pressure ± sd (mm/hg)	127.49 ± 16.16	143.85 ± 21.42	0.000[b]
Total cholesterol ± sd	179.46 ± 49.92	191.67 ± 57.36	0.000[b]
HDL cholesterol ± sd	42.98 ± 15.52	35.26 ± 14.81	0.000[b]
FRS risk factors ± sd	5.04 ± 2.39	24.26 ± 13,82	0.000[b]
Use of blood pressure medication			0.000[a]
Yes	22 (15.07)	124 (84.93)	
No	4135 (46.17)	4822 (53.84)	
Smoking, n(%)			0.000[a]
Yes	3710 (64.29)	2061 (35.71)	
No	447 (13.42)	2885 (86.59)	
History of diabetes, n (%)			0.000[a]
Yes	4125 (46.58)	4730 (53.42)	
No	32 (12.9)	216 (87.10)	
Waist circumference ± sd (cm)	80.70 ± 10.97	81.79 ± 11.22	0.0001[b]
Body height ± sd (cm)	152.29 ± 7.27	156.62 ± 8.33	0.000[b]
Waist to height ratio ± sd	0.53 ± 0.07	0.52 ± 0.07	0.000[b]

The AUC WtHR value in male subjects was 0.5817 (95% CI 0.5610-0.624), while the AUC value in female subjects was 0.5904 (CI 0.5727-0.6084). From the two AUC values, the diagnostic values of both are in the very weak category. The optimal cut-off point value of WtHR against the risk of cardiovascular disease based on the FRS was found to be 0.5249 in male subjects (cents = 0.3549; spe = 0.7626), while the cut-off point for female subjects was 0.5796 (cents = 0.4382; spe = 0.7024).

Table 3. The Diagnostic value of waist-to-height ratio

Variables	AUC	95% CI	Cutoff	Sen	Spe
Male	0.5817	.56 -.60	0.52	0.35	0.7626
Female	0.5904	.57-.61	0.58	0.44	0.7028

In female subjects, the WtHR cut-off value was 0.5796 divided into WtHR <0.5796 and WtHR ≥0.5796. The sensitivity value was 46.4%, the specificity is 71.8%, the positive predictive value was 41.4%, and the negative predictive value was 75.8% as shown by the tabel 4.

Tabel 4. Cutoff Prediction Value of WtHR to the Risk of CVD

CVD	CVD Risk		Sen	Spe	NDP	NDN
	(>10%)	(<10%)	(%)	(%)	(%)	(%)
Male (>0,5249)	1247	2266	37.1	79.3	87.9	23.3
Male (<0,5796)	200	649				
Female (>0,5796)	628	805	46.4	71.8	41.4	75.8
Female (<0.5796)	983	2325				

DISCUSSIONS

Based on sex characteristic, men are more at risk of cardiovascular disease than women. The risk of cardiovascular disease was higher in men due to higher life expectancy. At the same time, the hormone testosterone will decrease as the age increases. The decrease in testosterone is further associated with increased fasting blood sugar, fasting insulin, and type 2 diabetes, which are risk factors for cardiovascular disease [11]. Moreover, adipocytes that accumulate in the visceral area have a metabolic rate that is biologically more active than other areas. This metabolic rate then causes the accumulated adipocytes to release more pro-inflam- matory fatty acids and adipokines, causing insulin resistance, endothelial dysfunction, and metabolic disorders in various organs.

Therefore, indirectly, this condition also increases blood pressure and the incidence of hypertension [12]. The AUC value in this study indicates if the WtHR has weak diagnostic power. The intersection point of the WtHR varies from 0.46 to 0.62, and this variation is due to ethnic differences. The optimal cut-off point of WtHR against cardiovascular disease risk in this study was 0.5249 (cents = 0.3549; spe = 0.7626) in male subjects and 0.5796 (cents = 0.4382; spe = 0.7028) in subjects. woman. Waist to height ratio has a high specificity compared to its sensitivity. Similar to research conducted by Mellati et al. (2009), if the optimal cutoff point of the waist circumference/height ratio in male and female subjects in Iran is 0.5 with a sensitivity of 58.8% and 66% and a specificity of 73.4% and 71.4% [13].

The AUC value, sensitivity, and specificity of WtHR had low values, as in the study of Battie et al. (2016) conducted on Filipino ethnicity in America. Research by Battie et al. (2016) showed that the AUC ratio of waist circumference/height in predicting hypertension and diabetes was 0.65 ± 0.2 (cents = 65%; spe = 55%) and 0.65 ± 0.04 (cents = 73%; spe = 63%). The comparison shows that WtHR cannot predict cardiovascular disease risk if used without considering other factors (10,14) [14].

One of the factors that influence the low AUC value is age. Research by Mirmiran et al. (2004) stated that the AUC WtHR had a high value in the young age group and then decreased in the older age group. AUC for men and women in the age group 18-34 years was 0.77 and 0.8, in the 35-54 year age group the AUC value for men was 0.72 and for women was 0.69, then in the age group 55-74 years the AUC value was 0.62 in men and 0.58 in women [15]. Mirmiran et al. conducted the study on subjects aged 40-74 years with an average subject age of 52.17 ± 9.12 years so that this study had a weak diagnostic power of 0.5817 in male subjects and 0.5904 for female subjects.

In female subjects, the NDP was 41.4%, and the NDN was 75.8%. The high NDP means that if the WtHR measurement results are normal, the subject has a low risk of cardiovascular disease [16]. The higher NDP value in men and higher NDN in women may be due to the difference in the risk of cardiovascular disease. Men are more at risk of suffering from cardiovascular disease than women because of the physiological and metabolic differences related to sex.

From a physiological point of view, men tend to have more fat in the abdominal area than women due to the sex hormones that affect the amount and distribution of body fat. In women, estrogen plays a role in increasing fat stores in the body, while testosterone inhibits fat storage. Therefore men tend to have less body fat than women. However, the hormone estrogen in women causes most of the fat in the body to be stored in the subcutaneous part, and only a little fat is stored in the intra-abdominal part. Meanwhile, in men, the fat is stored more in the intra-abdominal than in the subcutaneous region [17].

Men experience hypertension at a younger age than women, thus increasing cardiovascular disease risk in men. The increased risk highly correlated with the locus sry of the Y chromosome found in experimental animals plays a role in tyrosine hydroxylase activity, which is an essential enzyme in norepinephrine synthesis. The high activity of thyroxine hydroxylase in men causes men to develop hypertension more easily than women. In contrast to the Y chromosome, which makes men more at risk of cardiovascular disease than women, the female hormone estrogen causes endothelial nitric oxide synthase modulation, which slows atherosclerosis progression [18].

WtHR is very suitable if used in countries with limited facilities and infrastructure and countries with a low level of public knowledge about preventing the risk of cardiovascular disease. This was due to the easier use of WtHR and simpler calculations [19]. The cutoff value of WtHR based on this study is 0.5249 and 0.5796 so that the health message that can be given to the public to prevent the risk of cardiovascular disease is to keep the waist circumference at a maximum of half the height.

CONCLUSION

The AUC WtHR value in male subjects was 0.5817 (95% CI 0.5610-0.624), while the AUC value in female subjects was 0.5904 (0.5727-0.6084 CI). From the two AUC values, the diagnostic values are both in the very weak category. The optimal cutoff point for male subjects was 0.5249 (sens= 0.3549; spe= 0.7626), while the cut point for female subjects was 0.5796 (sens= 0.4382; spe= 0.7024). The health message that can be given to the public to prevent cardiovascular disease is to keep the waist circumference at a maximum of half the height. We recommend using primary data with a large number of respondents to obtain results that can present the Indonesian population's characteristics.

REFERENCES

1. WHO. Cardiovascular diseases. In: World Health Organization (WHO) [Internet]. 2017 [cited 16 Oct 2020]. Available: http://www.who.int/cardiovascular_diseases/en/
2. Kemenkes RI. Riset Kesehatan Dasar. Jakarta: Badan Penelitian dan Pengembangan Kesehatan, Departemen Kesehatan, Republik Indonesia. 2013.
3. Kemenkes RI. Hasil Utama Riset Kesehatan Dasar 2018. 2018.
4. Kemenkes RI. Infodatin: Situasi Kesehatan Jantung. Pusat Data dan Informasi Kementerian Kesehatan RI. 2014; 1–8.
5. Selvarajah S, Kaur G, Haniff J, Cheong KC, Hiong TG, van der Graaf Y, et al. Comparison of the Framingham Risk Score, SCORE and WHO/ISH cardiovascular risk prediction models in an Asian population. Int J Cardiol. 2014;176: 211–218.
6. Ashwell M, Mayhew L, Richardson J, Rickayzen B. Waist-to-height ratio is more predictive of years of life lost than body mass index. PLoS One. 2014;9: e103483.
7. Bastien M, Poirier P, Lemieux I, Després J-P. Overview of epidemiology and contribution of obesity to cardiovascular disease. Prog Cardiovasc Dis. 2014;56: 369–381.
8. Ashwell M, Gibson S. Waist to height ratio is a simple and effective obesity screening tool for cardiovascular risk factors: Analysis of data from the British National Diet And Nutrition Survey of adults aged 19-64 years. Obes Facts. 2009;2: 97–103.
9. Savva SC, Lamnisos D, Kafatos AG. Predicting cardiometabolic risk: waist-to-height ratio or BMI. A meta-analysis. Diabetes Metab Syndr Obes. 2013;6: 403–419.
10. Dahlan MS. Penelitian diagnostik. Jakarta: Salemba Medika. 2009.
11. Palmisano BT, Zhu L, Eckel RH, Stafford JM. Sex differences in lipid and lipoprotein metabolism. Mol Metab. 2018;15: 45–55.
12. Caminha TCS, Ferreira HS, Costa NS, Nakano RP, Carvalho RES, Xavier AFS Jr, et al. Waist-to-height ratio is the best anthropometric predictor of hypertension: A population-based study with women from a state of northeast of Brazil. Medicine . 2017;96: e5874.
13. Mellati AA, Mousavinasab SN, Sokhanvar S, Kazemi SAN, Esmailli MH, Dinmohamadi H. Correlation of anthropometric indices with common cardiovascular risk factors in an urban adult population of Iran: data from Zanjan Healthy

Heart Study. Asia Pac J Clin Nutr. 2009;18: 217–225.
14. Battie CA, Borja-Hart N, Ancheta IB, Flores R, Rao G, Palaniappan L. Comparison of body mass index, waist circumference, and waist to height ratio in the prediction of hypertension and diabetes mellitus: Filipino-American women cardiovascular study. Preventive Medicine Reports. 2016;4: 608–613.
15. Mirmiran P, Esmaillzadeh A, Azizi F. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. Eur J Clin Nutr. 2004;58: 1110–1118.
16. Akobeng AK. Understanding diagnostic tests 1: sensitivity, specificity and predictive values. Acta Paediatr. 2007;96: 338–341.
17. Song X, Tabák AG, Zethelius B, Yudkin JS, Söderberg S, Laatikainen T, et al. Obesity attenuates gender differences in cardiovascular mortality. Cardiovasc Diabetol. 2014;13: 144.
18. Winham SJ, de Andrade M, Miller VM. Genetics of cardiovascular disease: Importance of sex and ethnicity. Atherosclerosis. 2015;241: 219–228.
19. Meseri R, Ucku R, Unal B. Waist:height ratio: a superior index in estimating cardiovascular risks in Turkish adults. Public Health Nutr. 2014;17: 2246–2252.