Hastuti, A. P. et al. (2022)
Jurnal Keperawatan Soedirman – Vol 17, No 3 page 131-136
http://jos.unsoed.ac.id/index.php/jks/index

ORIGINAL ARTICLE

THE RELATIONSHIP BETWEEN WAIST CIRCUMFERENCE AND WAIST-TO-HIP RATIO WITH RISK OF CARDIOVASCULAR DISEASE IN INDONESIA

Anung Puji Hastuti*, Dwi Ari Murti Widigdo, Bambang Sarwono, Heru Supriyatno

Nursing Department, Health Polytechnic of the Ministry of Health, Semarang, Indonesia

Article Information
Received: 4 July 2022
Revised: 4 October 2022
Accepted: 25 November 2022

***Corresponding Author**
Anung Puji Hastuti
anunghastuti85@gmail.com

DOI
10.20884/1.jks.2022.17.3.6313

ABSTRACT

Cardiovascular disease (CVD) is one of the non-communicable diseases which is the mayor leading cause of death in the world. One of the modifiable factors of cardiovascular disease is central obesity. Assessment of central obesity status was carried out by measuring waist circumference (WC) and waist-to-hip ratio (WHR). This study aimed to determine the relationship between WC and WHR with the risk of cardiovascular disease. This was an observational study with a cross-sectional design. There were 106 respondents selected using a convenience sampling technique. In this study, the risk of cardiovascular disease was calculated using the Jakarta Cardiovascular Score. The Spearman Rho's was used as bivariate analysis for this study. The findings showed that WC and the risk of cardiovascular disease indicates a significant relationship with a moderate correlation ($p < 0.001$ and $r = 0.467$). Meanwhile, there was a significant relationship between WHR and the risk of cardiovascular disease ($p < 0.001$ and $r = 0.385$). Nurse may use this study result as an evidence to develop a preventive central obesity program.

Keywords: Cardiovascular risk; waist circumference; waist-to-hip ratio

ISSN : 1907-6637 **e-ISSN : 2579-9320**

INTRODUCTION

Cardiovascular disease (CVD) is one of the non-communicable diseases that is the most common cause of death in the world. In 2019, 16% of the total deaths worldwide or 8.9 million people were caused by coronary heart disease (World Health Organization, 2021). According to RISKESDAS 2018, the prevalence of heart disease in Indonesia was 1,017,290 case or 1.5% of the total population (Ministry of Health Republik of Indonesia, 2018). One of the risk factors for cardiovascular disease is obesity, especially central obesity (Setiadi & Halim, 2018). Central obesity cases in Indonesia always increase from 2007 to 2018 based on RISKESDAS 2018 (Ministry of Health Republik of Indonesia, 2018). Obesity is associated with complex pathophysiology. Increased availability of palatable foods and beverages, containing rich sugar or fat is supposed to be major determinant of increasing rates of obesity worldwide (Mullee et al., 2019)

Central obesity, also known as abdominal obesity, is different from general obesity because of excessive abdominal fat accumulation around the stomach and abdomen which may occur in both obese and non-obese patients (Wien, 2022). The proportion of habitual consumption of sweet foods, sweet drinks and fatty/cholesterol/fried foods more than 1 time per day in Pekalongan City is quite high compared to other areas in Central Java (Health Departement of Central Java, 2018). This habit can certainly increase the risk of obesity and cardiovascular disease in the future. Especially with the increase in obesity cases in Pekalongan City which is increased significantly in 2020 (Health Departement of Pekalongan City, 2021).

There are several anthropometric measurements of central obesity are waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR). Waist circumference provide an overview of body fat stores, especially in the abdomen. These fats are dangerous because their proximity to the liver increases the production of free fatty acids and decreases the effectiveness of insulin (Par'i, Wiyono, & Harjatmo, 2017). In addition, fat deposits in the abdominal area have an effect on decreasing adiponectin levels (anti-inflammatory adiposity cells) and increasing pro-inflammatory cytokines which continue in metabolic complications such as cardiovascular disease (Widjaja,

Prihaningtyas, Hanindita, & Irawan, 2020). Waist circumference of more than 102 cm in men and more than 88 in women gives an illustration of the amount of fat that accumulates in the abdominal area and has more risk for diseases such as diabetes, heart disease and others (Par'i et al., 2017).

The waist-to-hip ratio (WHR) is the result of dividing the waist circumference measured at the smallest part of the abdomen horizontally with the hip circumference measured around the largest part of the buttocks. WHR values more than 0.9 for men and 0.8 for women are associated with apple shaped obesity. This body shape indicates more abdominal fat accumulation and has a higher risk of cardiovascular disease (Sudargo, Freitag, Rosiyani, & Kusmayanti, 2016).

There are inconsistencies between some previous studies regarding the correlation between waist circumference and waist-to-hip ratio with the risk of cardiovascular disease. A previous study found that waist circumference and waist-to-hip ratio have a relationship with the risk of cardiovascular disease as well as the opposite side (Bi et al., 2016; Hassan et al., 2021; Markova, Boyanov, Bakalov, & Tsakova, 2020; Rompas, Panda, & Rampengan, 2013). However, several studies revealed that the waist-to-hip ratio is stronger in determining the risk of cardiovascular disease than waist circumference and other antropometric measure (Hassan et al., 2021; Peters, Bots, & Woodward, 2018).

This study is important because central obesity is a one of modifiable risk factor for cardiovascular disease and the increasing number of obese people in Indonesia. It is necessary to conduct a study aimed to measure obesity related to cardiovascular disease risk as a preventive measure by screening the risk of cardiovascular disease. Based on previous data on differences in some studies regarding the relationship between anthropometric indicators of central obesity and the risk of cardiovascular disease and the importance of prevention by screening risk factors.

METHOD

Study Design

This is an analytic observational study with a cross sectional design conducted in the working area of the Klego Public Health Center, Pekalongan City.

Sample

A total of 106 samples were selected using a convenience sampling technique. The criteria for inclusion in this study were 25-64 years old and willing to participate in this study.

The exclusion criteria applied were individuals with a history of angina, stroke, and other heart disease, had ascites, were pregnant, could not stand properly or had to be assisted by other people or equipment and refused to participate in this study.

Instrument

The risk of cardiovascular disease in this study was measured using the Jakarta Cardiovascular Score designed by Kusmana (2002). The Jakarta Cardiovascular Score has a sensitivity of 77.9%, a specificity of 90%, a positive predictive value of 92.2% and a negative predictive value of 72.8% (Kusmana, 2002). The Jakarta Cardiovascular Score has 7 indicators that are used to assess the risk of cardiovascular disease with their scores. These 7 indicators include age, gender, blood pressure, body mass index (BMI), smoking history, history of diabetes, and level of physical activity. After the data is collected on each indicator, the Jakarta Cardiovascular Score is summed with the categories of total scores, namely low risk (score (-7) – 1), moderate risk (score 2-4) and high risk (score ≥5).

Waist circumference (WC) was measured using a metline at the smallest or midway between the lower costal margin and the iliac crest without pressing the skin (Rinaldo & Gualdi-russo, 2015). Waist circumference was categorize into normal (WC≤92 cm for men and ≤80 cm for women), increased risk (WC>92 cm for men and WC>80 cm for women), and high risk (WC > 102 cm for men and >88 for women) (Par'i et al., 2017).

The waist-to-hip ratio (WHR) measurement used the formula for dividing waist circumference by hip circumference. Hip circumference is measured using a metline around the maximum buttocks and make sure it doesn't press the skin (Rinaldo & Gualdi-russo, 2015). WHR was categorized into normal (WHR≤0.9 for men and ≤0.8 for women) and elevated (WHR >0.9 for men and >0.8 for women) (Par'i et al., 2017).

Data Collection

Data collection was carried out on April 4-16, 2022 in 2 villages which were included in the area of the Klego Public Health Center in Pekalongan City. They were Klego Village and Kauman Village. Data collection was carried out once by researchers and enumerators. Before taking measurements, the researcher explained the purpose and procedure of the study and asked for informed consent from the respondents orally and signed the written informed consent after respondent agreed to participate in this study.

Data Analysis

SPSS version 26 was used for statistical analysis, both univariate and bivariate analysis. Univariate analysis was presented by frequency and percentage of respondents' characteristics. Spearman Rho's test was conducted to determine the relationship between two variables in this study.

Ethical Consideration

This research has obtained ethical agreement from the ethics committee of the Health Polytechnic of the Ministry of Health, Semarang No. 0653 /EA /KEPK /2022.

RESULTS

A total of 106 individuals were included in analyses. Table 1 shows about education level and occupation characteristic. The majority of respondents had high school education level. In this study, the highest percentage of respondents who work as housewives. This was because the proportion of women were higher than men.

Tabel 1. Characteristics of respondents by education and occupation

Characteristics	n	%
Education		
No education	4	3,8
Elementary School	22	20,8
Junior High School	25	23,6
High School	36	34,0
Vocational High School	3	2,8
Bachelor degree	15	14,1
Master degree	1	0,9
Occupation		
Unemployed	17	16,0
Housewife	30	28,3
Worker	20	18,9
Employed	13	12,3
Teacher	4	3,8
Self employed	22	20,7

Based on table 2, this study was dominated by women, which made up 70% of the total respondents. They were also more likely to have a high risk of cardiovascular disease. The 25-34, 45-49, and 55-59 age groups had the same frequency but the number of respondents who have a high risk of cardiovascular disease in these group age increased with age. Therefore, it can be concluded that increasing age could increase the risk of cardiovascular disease. Based on blood pressure, respondents with level 1 hypertension category began to increase in the number of respondents with a high risk of cardiovascular disease. Even more than half of the respondents in this category had a high level of risk. Likewise, in the category of level 2 and level 3 hypertension, both of them also had half the number of respondents who have a high level of risk. The smoking history, more than 90% of respondents stated that they had never smoked or had stopped smoking for more than 10 years. Based on table 2, the majority of respondents do not have a history of diabetes mellitus. Respondents in this category are more likely to have a low level of risk. The majority of respondents had a low level of weekly physical activity.

Tabel 2. Characteristics of respondent by CVD risk category

Risk Factor	CVD Risk			Total
	Low n (%)	Moderate n (%)	High n (%)	
Gender				
Female	22 (20.8)	19 (17.9)	34 (32,0)	75
Male	16 (15,1)	6 (5.7)	9 (8.5)	31
Age (year)				
25-34	16 (15.1)	1 (0,9)	0 (0,0)	17
35-39	11 (10,4)	1 (0,9)	0 (0,0)	12
40-44	7 (6,6)	2 (1,9)	1 (0,9)	10
45-49	4 (3,8)	8 (7,6)	5 (4,7)	17
50-54	0 (0,0)	8 (7,6)	7 (6,6)	15
55-59	0 (0,0)	4 (3,8)	13 (12.3)	17
60-64	0 (0,0)	1 (0,9)	17 (16.0)	18
Blodd Pressure (mmHg)*				
Normal	17 (16,0)	10 (9,4)	7 (6,6)	34
High Normal	12 (11,3)	4 (3,8)	4 (3,8)	20
Grade 1 Hypertension	5 (4,7)	8 (7,6)	16 (15,1)	29
Grade 2 Hypertension	2 (1,9)	2 (1,9)	12 (11,3)	16
Grade 3 Hypertension	2 (1,9)	1 (0,9)	4 (3,8)	7
Body Mass Index (BMI)				
13,79 – 25,99	27 (25.4)	17 (16.0)	20 (18.9)	64
26,00 – 29,99	9 (8.5)	6 (5.7)	15 (14.1)	30
30,00 – 35,58	2 (1,9)	2 (1,9)	8 (7.6)	12
Smoking				
Never	38 (35.9)	24 (22.6)	40 (37.8)	102
Ex-Smoker	0 (0,0)	0 (0,0)	0 (0,0)	0
Smoker	0 (0,0)	1 (0.9)	3 (2.8)	4
History of diabetes				
No	38 (35.9%)	24 (22.6%)	37 (34.9%)	99
Yes	0 (0,0%)	1 (0.9%)	6 (5,7%)	7
Physical activity levels				
Low	24 (22,6%)	17 (16,0%)	34 (32,1%)	75
Moderate	10 (9,5%)	7 (6,6%)	9 (8,5%)	26
High	4 (3,8%)	1 (0,9%)	0 (0,0%)	5

**Normal (<135/<85), High Normal (130-139/85-89), Grade 1 Hypertension (140-159/90-99), Grade 2 Hypertension (160-179/100-109), Grade 3 Hypertension (≥180/≥110)*

According to table 3, in this study the majority of female respondents had waist circumference in the high risk category and had elevated WHR.

Tabel 3. Characteristic WC and WHR of women and men

	Women (n=75)	Men (n=31)
Waist circumference		
Low risk	10 (9,4)	21 (19,8)
Increased risk	19 (17,9)	8 (7,6)
High risk	46 (43,4)	2 (1,9)
Waist-to-hip ratio		
Normal	6 (5,7)	20 (18,9)
elevated	69 (65,0)	11 (10,4)

Based on table 4, the majority of respondents had waist circumference in the high risk category also had a high level of cardiovascular disease risk. The bivariate analysis using the Spearman Rho test showed $p < 0.001$ and $r = 0.467$. Almost half of the respondents who had excess WHR category (women ≥ 0.8 and men ≥0.9) also had a high level of cardiovascular disease risk. The Spearman Rho's test showed $p<0.001$ and $r=0.385$.

Tabel 4. Correlation WC and WHR with CVD risk

	CVD Risk			Total	Sign.	r
	Low (n=38)	Moderate (n=25)	High (n=43)			
Waist circumference						
Low risk	18 (16,9%)	6 (5,7%)	7 (6,6%)	31		
Increased risk	13 (12,3%)	8 (7,5%)	6 (5,7%)	27		
High risk	7 (6,6%)	11 (10,4%)	30 (28,3%)	48		
Total				106	<0.001	0.457
Waist-to-hip ratio						
Normal	15 (14,2%)	6 (5,7%)	5 (4.7%)	26		
Elevated	23 (21,7%)	19 (17,9%)	38 (35,8%)	80		
Total				106	<0.001	0.385

DISCUSSION

Our study found 45.3% of respondents had a waist circumference in the high risk category (women > 88 cm and men > 102 cm) and 43.5% of them were women. This shows that the incidence of central obesity in women in this study is higher than men. The high incidence of obesity could be caused by the number of women respondents being more than male and the majority of women respondents working as housewives, where there were more low activities at home. This low physical activity also encourages an imbalance calorie intake and energy expenditure so that a lot of energy is accumulated as fat, resulting in obesity (Sudargo et al., 2016).

In this study, 28.3% of respondents that had a high risk category of waist circumference also had a high risk of cardiovascular disease. The bivariate analysis using the Spearman Rho test showed that there was a significant moderate correlation between waist circumference and the risk of cardiovascular disease. This was supported by Klisić et al. (2018) which reported that WC has a significant relationship $p<0.001$ with strength correlation ($r=0.470$) on the risk of cardiovascular disease calculated using the Reynolds Risk Score (RRS). Bi et al. (2016) also stated that waist circumference has a greater correlation than other anthropometric indicators (BMI, WHR, hip circumference, body adiposity index) to cardiovascular disease risk indicators. Another study conducted by Li, Zhu, & Wang (2022) regarding the risk of death from cardiovascular disease related to waist circumference and diabetes reported that an increase in waist circumference (≥94 cm) was associated with an increase in mortality from cardiovascular disease ($p<0.05$) and has a hazard ratio (HR) value of 2.65.

According to Sudargo et al. (2016), an increase in waist circumference is an indicator of central obesity. A large waist circumference indicates an accumulation of excess fat in the abdominal area, especially visceral fat. Visceral fat in the abdominal area is more dangerous because its proximity to the liver increases the production of free fatty acids and fat metabolism. In addition, fat deposits in the abdominal area have an effect on decreasing adiponectin levels (anti-inflammatory adiposity cells) and increasing pro-inflammatory cytokines which continue in metabolic complications such as cardiovascular disease (Widjaja et al., 2020).

Our study found that 35.8% of respondents with elevated WHR were in the category of a high level of cardiovascular disease risk. Supported by the results of bivariate statistical data processing, there was a weak correlation between WHR and the risk of cardiovascular disease that calculated using the Jakarta Cardiovascular Score. The results of our study are in line with research conducted by (Alifiya, Indrayana, & Josafat, 2017) which reported that WHR has a significant relationship with the risk of cardiovascular disease calculated using the Framingham Risk Score on the Lombok island population with a p-value of 0.001 and a coefficient correlation of 0.390. Rahayu & Maulina (2017) also showed the results of $p = 0.04$ ($P <0.05$) which means that there was a relationship between WHR and coronary heart disease (CHD) in CHD patients at Cut Meutia Hospital.

A high WHR indicates the presence of obesity with the android type. Where in android type obesity, there is more fat accumulation in the abdomen and less fat in the hip and thighs. This type has a higher risk of diseases related to sugar and fat metabolism such as diabetes mellitus, hypertension, and cardiovascular disease (Hermawan et al., 2020; Sudargo et al., 2016).

The measurement of hip circumference itself is an anthropometric measurement that is more specific to subcutaneous fat only. Waist circumference measures the presence of visceral fat and subcutaneous fat. Thus, combining waist circumference and hip circumference measurements in a ratio allows a more specific estimate of visceral fat. In addition, the impact of gluteofemoral subcutaneous fat which can be measured by the hip

circumference is believed to provide protection against the risk of cardiovascular disease by retaining free fatty acids and preventing an increase in lipid levels (Cameron, Magliano, & Söderberg, 2013). This was also explained by Frank, De Souza Santos, Palmer, & Clegg (2019) that reported there was a protective effect of gluteofemoral subcutaneous fat on the risk of cardiovascular disease and type 2 diabetes.

In our study, the strength of correlation of WHR was lower (r=0.385) than the strength of correlation of WC(r=0.467) with risk of cardiovascular disease. This is different from several other studies which state that the WHR is superior to other anthropometric measurements as in the study by Hassan et al. (2021) regarding the relationship between anthropometric measurements of obesity (BMI, WC, WHR and waist-to-height ratio) to cardiovascular risk stated that the measurement of WHR had a stronger relationship with the risk of cardiovascular disease than measurements of BMI and WHtR with an OR value of 2.39 (95% CI: 1.92-2.98). However Hassan et al. (2021) showed no significant relationship between WC and cardiovascular disease (p value=0.109). Peters et al., (2018) also stated that WHR correlated more strongly with the incidence of myocardial infarction than BMI and WC with an HR (hazard ratio) value of 1.49 in women and 1.36 in men. This correlation was 18% stronger as a predictor of myocardial infarction in women. compared to men, which is only 6%.

This study had several limitations, including the small number of research samples, not analyzed by gender and dominated by women, while in calculating the risk of cardiovascular disease using the Jakarta Cardiovascular Score, men had a higher score. So that in future research it is recommended to balance the proportion of men and women. In addition, this study only used 2 indicators of central obesity and only used indicators of obesity as a risk factor for cardiovascular disease.

CONCLUSION AND RECOMMENDATION

Our study showed that there was a significant relationship between waist circumference and waist-to-hip ratio with the risk of cardiovascular disease. The value of the coefficient correlation of waist circumference to the risk of cardiovascular disease is higher than the coefficient correlation of the ratio of waist to hip ratio. It is recommended to Indonesia Ministry of Health to add waist-to-hip ratio measurement as an indicator for health screening in order to make cardiovascular disease risk early detection.

ACKNOWLEDGEMENT

The authors would like to thank the respondents, enumerators, and Public Health Center Klego for their contributions in this study.

REFERENCES

Alifiya, S., Indrayana, Y., & Josafat, A. (2017). The Relationship between Waist-Hip Ratio and Cardiovascular Disease Risk using Framingham Risk Score Percentage on Population in Lombok Island. *Jurnal Kedokteran Universitas Mataran*, *6*(3.1). Retrieved from http://jku.unram.ac.id/article/view/270

Bi, X., Tey, S. L., Leong, C., Quek, R., Loo, Y. T., & Henry, C. J. (2016). Correlation of adiposity indices with cardiovascular disease risk factors in healthy adults of Singapore: A crosssectional study. *BMC Obesity*, *3*(1), 1–7. https://doi.org/10.1186/S40608-016-0114-4

Cameron, A. J., Magliano, D. J., & Söderberg, S. (2013). A systematic review of the impact of including both waist and hip circumference in risk models for cardiovascular diseases, diabetes and mortality. *Obesity Reviews*, *14*(1), 86–94. https://doi.org/10.1111/j.1467-789X.2012.01051.x

Frank, A. P., De Souza Santos, R., Palmer, B. F., & Clegg, D. J. (2019). Determinants of body fat distribution in humans may provide insight about obesity-related health risks. *Journal of Lipid Research*, *60*(10), 1710–1719. https://doi.org/10.1194/jlr.R086975

Hassan, S., Oladele, C., Galusha, D., Adams, O. P., Maharaj, R. G., Nazario, C. M., … Nunez-Smith, M. (2021). Anthropometric measures of obesity and associated cardiovascular disease risk in the Eastern Caribbean Health Outcomes Research Network (ECHORN) Cohort Study. *BMC Public Health*, *21*(1), 1–12. https://doi.org/10.1186/s12889-021-10399-3

Health Departement of Central Java. (2018). *Central Java Basic Health Research (Riskesdas) Report*. Semarang.

Health Departement of Pekalongan City. (2021). *Non-Communicable Disease Report in Pekalongan*. Pekalongan.

Hermawan, D., Muhani, N., Sari, N., Arisandi, S., Widodo, S., Lubis, M. Y., … Firdaus, A. A. (2020). *Knowing Obesity* (1st ed.). Yogyakarta: ANDI.

Klisić, A., Kavarić, N., Bjelaković, B., Jovanović, M., Zvrko, E., Stanišic, V., … Ščepanović, A. (2018). Cardiovascular risk assessed by reynolds risk score in relation to waist circumference in apparently healthy middle-aged population in Montenegro. *Acta Clinica Croatica*, *57*(1), 22–30. https://doi.org/10.20471/acc.2018.57.01.03

Kusmana, D. (2002). The influence of smoking cessation, regular physical exercise and/or physical activity on survival: A 13 years cohort study of the Indonesian population in Jakarta. *Medical Journal of Indonesia*, *11*(4), 230–242. https://doi.org/10.13181/mji.v11i4.78

Li, M., Zhu, P., & Wang, S. (2022). Risk for Cardiovascular Death Associated With Waist Circumference and Diabetes : A 9-Year Prospective Study in the Wan Shou Lu Cohort. *Frontiers in Cardiovascular Medicine*, *9*(April), 1–11. https://doi.org/10.3389/fcvm.2022.856517

Markova, A., Boyanov, M., Bakalov, D., & Tsakova, A. (2020). Body composition indices and cardiovascular risk in type 2 diabetes. CV biomarkers are not related to body composition. *Open Medicine (Poland)*, *15*(1), 309–316. https://doi.org/10.1515/med-2020-0043

Ministry of Health Republik of Indonesia. (2018). *National Basic Health Research (Riskesdas) Report 2018*. Jakarta.

Par'i, H. M., Wiyono, S., & Harjatmo, T. P. (2017). *Nutritional Status Assessment*. Jakarta: Human Resources Education Center of Ministry of Health.

Peters, S. A. E., Bots, S. H., & Woodward, M. (2018). Sex differences in the association between measures of general and central adiposity and the risk of myocardial infarction: Results from the UK Biobank. *Journal of the American Heart Association*, *7*(5), 6–10. https://doi.org/10.1161/JAHA.117.008507

Rahayu, M. S., & Maulina, M. (2017). The Relationship between Waist-tohip Ratio and Coronary Heart Disease. *Jurnal Aceh Medika*, *1*(1), 1–10.

Rinaldo, N., & Gualdi-russo, E. (2015). Anthropometric technique. *Annali Online Dell'Università Di Ferrara*, *10*(9), 275–289. https://doi.org/10.1086/200577

Rompas, T. C. C. W., Panda, A. L., & Rampengan, S. H. (2013). The Relationship between General Obesity and Central Obesity With Coronary Heart Disease Patients In Prof. Dr. R.D. Kandou Hospital Manado. *E-CliniC*, *1*(2), 1–6. https://doi.org/10.35790/ecl.1.2.2013.3284

Setiadi, A. P., & Halim, S. V. (2018). *Cardiovascular Disease : Rational Medicine Series*. Yogyakarta: Graha Ilmu.

Sudargo, T., Freitag, H., Rosiyani, F., & Kusmayanti, N. A. (2016). *Dietary Habits and Obesity*. Yogyakarta: Gadjah Mada University Press.

Mullee A, Romaguera D, Pearson-Stuttard J, et al. Association between soft drink consumption and mortality in 10 european countries. JAMA Intern Med 2019: e192478. https://doi.org/10.1001/jamainternmed.2019.2478.

Widjaja, N. A., Prihaningtyas, R. A., Hanindita, M. H., & Irawan, R. (2020). Waist Circumference And Adiponectin in Obese Adolescent. *Media Gizi Indonesia*, *15*(2), 88–93. https://doi.org/https://doi.org/10.204736/mgi.v15i2.88–93

Win, Ye (2022). Central Obesity. Myanmar Journal of Current Medical Practice

World Health Organization. (2021). Cardiovascular diseases (CVDs). Retrieved November 12, 2021, from WHO Newsroom website: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)