Association between obesity, cardiometabolic risk, and body composition in Gorontalo women

Nuryani[1,2], *Ali* Khomsan[1*], *Mira* Dewi[1], *Cesilia* Meti Dwiriani[1], *Widjaja* Lukito[3], *Mutia* Reski Amalia[4], and *Nurzalinda* Zalbahar[5]

[1]Department of Community Nutrition, Faculty of Human Ecology, IPB University, 16680 Bogor, Indonesia
[2]Department of Nutrition, Gorontalo Health Polytechnic Ministry of Health Republic of Indonesia, 96113 Gorontalo, Indonesia
[3]Postgraduate Program for Physician Specialist-1 in Clinical Nutrition/Departement of Nutrition, Faculty of Medicine, Universitas Indonesia, 16424 Jakarta, Indonesia
[4]Department of Nutrition, Gorontalo Health Polytechnic Ministry of Health Republic of Indonesia, 96113 Gorontalo, Indonesia
[5]Department of Nutrition, Universiti Putra Malaysia, 43400 Selangor, Malaysia

Abstract. Cardiovascular diseases are current issues that increase morbidity. Risk factors for cardiometabolic diseases include hyperlipidaemia, obesity, elevated blood glucose and blood pressure. The aim of study to determine associations between cardiometabolic risks and body composition with obesity among adult women in Gorontalo district. A total of 223 women adults were recruited using simple random sampling at two health centres in the Gorontalo district. Data were collected between August and October 2023. Cardiometabolic risk factors were determined through the measurements of cholesterol levels, blood glucose and blood pressure while the body composition parameters included body water, muscle mass, visceral fat, bone mass and waist circumference. Study was conducted using questionnaires and direct measurements. Statistical analyses were performed using Pearson and Spearman correlations method. A total of 84.4% of the women having central obesity. A significant association was found between body mass index with fasting blood glucose, blood pressure, waist circumference, muscle mass, visceral fat, body water, body fat, and bone mass (p=0.000). Obesity aggravates the risk of cardiovascular disease, thus maintaining nutritional status through physically active and dietary management is essential to prevent cardiometabolic risk.

1 Introduction

The incidence of metabolic disease including cardiovascular disease (CVD)has increased globally over the past 20 years . High risk lifestyles trigger epidemiological transitions and

* Corresponding author: khomsanali@apps.ipb.ac.id

sociodemographic conditions contribute to increase number of non-communicable diseases (NCDs) in developing countries . A high percentage of deaths in low and middle-income countries(over 75.0%) are caused by CVD[1]

High blood glucose levels, obesity, high blood pressure, and hyperlipidaemia are cardiometabolic diseases risk factors. Female respondents with overweight, obesity, and high percentage of body fat presented higher anthropometric indicator values and blood pressure [2]Visceral fat is strongly associated with NCD through visceral adiposity, which influences insulin resistance via adipokine induction and disruption of pro-inflammatory cytokines [3] . Obesity can be measured using waist circumference (WC) and body mass index (BMI). BMI is a measurement BMI is a measurement of excessive weight rather than excessive body fat, while WC is an anthropometric measurement of fat accumulation in the abdominal zone to assess central obesity [3]

The prevalence of adult women obesity in a few countries, including Egypt 58,99%, Saudi Arabia 48,34%, South Africa 47,35%, United States 43,82%, Mexico 41,8%, Brazil 32,6%, Germany 18,96%, Italy 17,65%, France 9,82%, India 9,78%, China 7,78%, and Japan 3,63% [4]. Women's reproductive age is an essential period in the life cycle to support the development of human life quality in globally. The women have a high risk of diabetes mellitus,related to a greaterof body fat percentage, causing more experience overweight and obesity [5] [12]. In Southeast Asia, one of the countries with a trend of increasing of obesity prevalence is Indonesia. . In Gorontalo, the obesity prevalence was 24.4%, and central obesity was 36.6%. Both rates were higher than the national prevalence [6]. The study aimed to analyzed the association among obesity, body composition and cardiometabolic risk in adult Gorontalonese women.

2 Materials and methods

2.1 Study design

The study was a quantitative, analytical, and a cross-sectional design with observational study. The study population included adult women in the Limboto and Telaga Biru Health Centre Gorontalo Regency, Sulawesi, Indonesia. The consideration to select two of location study base on data about the highest prevalence on diabetes mellitus and low coverage patient control in health service. Inclusion criteria were included adult women (age 25–55 years), domiciled in Gorontalo regency,signed informed consent and willing to participating in the research. . While, the exclusion criteria were included participants who have comorbid/chronic diseases based on a doctor's diagnosis (heart disease, diabetes, stroke), pregnant and breastfeeding. The study was conducted between August and October 2023.

2.2 Technical sampling

The sample size was calculated using an equation sampling formula (n), with equation;

$$n = \frac{Z^2_{(1-\alpha/2)}Z(1-P)}{d^2}. \quad (1)$$

The assumtion of α=5% (Zα=1.96), power of the test=95% and prevalence of hyperglycemia. The prevalence of hyperglycaemia was used for sample size calculation because hyperglycemia is one of cardiometabolic risk factor that measured in the study. The prevalence of hyperglycemia in Gorontalo disctrict base on previous study was 15,4% [7]. A total of 223 housewives were recruited through random sampling.

2.3 Data collection

Cardiometabolic risk factors were determined blood glucose, cholesterol levels and blood pressure, whereas body composition included body water, muscle mass, visceral fat, waist circumference and bone mass. BMI and WC were used to measure the nutritional status. BMI was measured with equation of body weight divided by height squared (kg/m^2), and nutritional status was categorised as normal (BMI = 18.5–25), overweight (BMI > 25-27), and obesity (BMI ≥ 27) by. Abdominal obesity was measured using waist circumference that was measured using one med waist roller OD 235 with an accuracy of 0.1 cm, categorised as abdominal obesity (waist circumference ≥ 80 cm) The measurement of body fat percentage was using the Tanita Bioelectrical Impedance Analysis (BIA) model BC-5419, categorised as normal (25–34.9%), high (35.0 – 39.9%), and very high (≥40%) [17]. Blood pressure was measured using a OneMed sphygmomanometer and was categorised as normal (<130/80 mmHg) and hypertension (≥ 130/80 mmHg) . Physical activity was measured using physical activity level (PAL) categorised as sedentary (PAL=1.0-1.39), low active (PAL=1.4-1.59), active (PAL=1.6-1.89), and very active (PAL=1.9-4.8) [9].

Blood pressure was measured using a OneMed tensimeter. The measurement of blood glucose was using a portable Accu check active, and cholesterol was using a portable, easy touch.. Fasting blood glucose (FBG) was measured by taking venous blood after the respondent fasted for 8 h and categorised as IFG (FBG 100-125 mg/dl) Body weight and composition measurements were conducted using BIA model BC-5419. .

2.4 Data analysis

Statistical analysis of the test normality data was confirmed using the Kolmogorov-Smirnov test, , because the sample size was ≥ 50. The result analysis indicated that data were normal distributed (p-value > 0.05) [10]. Normally distributed data were analysed using correlation analysis with ANOVA, pearson correlation and independent T-test, while Kruskal-Wallis, Mann Whitney test, and Spearman correlations will be used if the data not normally distributed. Data analysis was using the SPSS version 18.0.

2.5 Ethical clearance

The study ethical code approval number was 094/ KE/07/2023 from the University of Muhammadiyah Semarang.

3 Results and discussion

3.1 Characteristic and nutritional status

The characteristics and nutritional status of respondents based on the measurement of waist circumference is shown in Table 1.

Table 1. Description of characteristic and nutritional status of respondents

Characteristic	n(%)	Normal		Central obesity	
		n(%)	Mean±SD	n(%)	Mean±SD
Age					
26-35 years	71 (31.8)	16 (22.5)	76.1±3.4	55 (77.5)	93.0±9.8
36-45 years	108 (48.4)	9 (8.4)	72.5±4.7	99 (91.6)	94.5±8.5

Table 1. Description of characteristic and nutritional status of respondents (continue)

46-55 years	44 (19.8)	9 (20.5)	70.1±4.5	35 (79.5)	97.7±15.8
ρ^a			0.025		0.188
Educational level					
Low	148 (66.4)	22 (14.9)	73.3±5.0	126 (85.1)	94.9±10.0
High	75 (33.6)	12 (16.0)	74.1±4.4	63 (84.0)	94.1±11.7
ρ^b			0.645		0.612
BMI (kg/m^2)					
Underweight	7 (3.1)	6 (85.7)	67.6±3.5	1 (14.3)	92.0±0.0
Normal	60 (26.9)	25 (41.7)	74.7±4.1	35 (58.3)	83.5±3.2
Overweight	37 (16.6)	1 (2.7)	75.0±0.0	36 (97.3)	89.7±5.4
Obesity	119 (53.4)	2 (1.7)	77.1±2.9	117 (98.3)	99.5±10.1
ρ^a			0.003		0.000
Body fat (%)					
Normal	59 (26.5)	30 (50.9)	73.4±4.9	29 (49.1)	84.8±5.3
High	61 (27.4)	2 (3.3)	75.0±0.0	59 (96.7)	88.9±5.3
Extremely high	103 (46.1)	2 (1.9)	75.2±5.5	101 (98.1)	100.8±10.1
ρ^a			0.803		0.000
Blood pressure (mmHg)					
Normal	132 (59.2)	22 (16.7)	74.1±5.2	110 (83.3)	93.7±9.8
Hypertension	91 (40.8)	12 (13.2)	72.6±3.7	79 (86.8)	95.8±11.6
ρ^b			0.420		0.184
Physical activity					
Sedentary	61 (27.4)	5 (8.2)	76.4±2.7	56 (91.8)	95.6±11.7
Low active	146 (65.4)	25 (17.1)	73.7±4.5	121 (82.9)	94.2±10.3
Active	16 (7.2)	4 (25.0)	69.0±6.0	12 (75.0)	94.7±8.6
ρ^a			0.060		0.717

Note: ^{a} ANOVA, $\rho < 0.05$; ^{b} Independent T-test, $\rho < 0.05$; n = number of respondents; % = percentage; SD = standar deviation.

The percentages of central obesity based on waist circumference measurements were 84.8%, respectively. The number of respondents included 108 (48.4%) adult women aged 36-45 years. The ANOVA analysis showed significantly different waist circumferences based on age in the normal nutritional status group (ρ=0.025). The respondents who had normal nutritional status tended to have decreased waist circumference with increasing age, but this condition was not found in respondents with central obesity. Respondents with central obesity tend to have increased waist circumference along with the increasing of age. The increament of age in chategory 46-55 years have the highest waist circumference (97.7 cm). Age is significantly correlated with risk factors cardiovascular disease, including systolic and diastolic blood pressure, cholesterol levels and HbA1c [11] . This indicated that increasing age is associated with higher cardiometabolic risk. Low educational levels were 66.4% and there was no significant difference waist circumference between high and low educational level based on independent t-test.

BMI analysis indicated that the majority of the respondents were obese (53.4%). ANOVA indicated a significant difference waist circumference based on BMI. The percentage of respondents with extremely high body fat was greater than normal, and the high percentage of body fat was 46.1%. ANOVA analysis indicated no significant difference in waist circumference between the three categories of percent body fat in the normal category (ρ=0.803); however, significant waist circumference was found based on percent body fat in respondents with central obesity (ρ=0.000). The increasing of waist circumference was followed by high in body fat.

The percentage of respondents with physical activity in the low activity category was 65.4%. However, there was no association and significant differencebetween waist circumference, BMI and physical activity level. However, the physical activity level score tended to increase in subjects with low waist circumference. PAL levels tended to increase in subjects with a lower WC. This finding was supported by a previous study that found sedentary habits increase cardiometabolic conditions, while regular physical activity was related to low cardiometabolic conditions [12] Another study found that the intervention of a combination o of physical activity and a healthy diet strongly decreased visceral adipose tissue (VAT) [13]. However, the intervention of brisk walking in obese adults did not significantly influence the decrease in blood pressure [27].

3.2 Correlation of cardiometabolic risk, body composition, and BMI

Correlation analysis showed an association between BMI with cardiometabolic risk and body composition (Table 2). The results of anthropometric measurements showed an average height of 150.5 cm, weight of 63.7 kg, and BMI of 28.0. Cardiometabolic risk refers to the damage to the heart and blood vessels. WHO risk prediction models estimate cardiovascular risk, including sex, age, smoking habits, high blood pressure, diabetes and elevated total cholesterol [1].

Table 2. Correlation and p-value between cardiometabolic risk, body composition, and BMI

Variable	Mean±SD	BMI Correlation
[a]Height (cm)	150.5±5.3	r=0.021; ρ=0.755
[a]Weight (kg)	63.7±14.5	r=0.949; ρ=0.000
[a]BMI (kg/m^2)	28.0±6.0	-
[b]Age (year)	39.2±6.3	r=0.044; ρ=0.516
[b]Physical activity level (PAL)	1.45±0.98	r=-0.091; ρ=0.174
Cardiometabolic risk		
[b]Systolic blood pressure (mmHg)	129±21	r=0.237; ρ=0.000
[a]Diastolic blood pressure (mmHg)	86±13	r=0.221; ρ=0.001
[b]Fasting blood glucose (mg/dL)	99.3±31.3	r=0.270; ρ=0.000
[b]Total cholesterol (mg/dL)	214±45	r=-0.079; ρ=0.241
Body composition		
[a]Waist circumference (cm)	91±12	r=0.791; ρ=0.000
[a]Visceral fat	7.8±3.0	r=0.944; ρ=0.000
[a]Muscle mass	35.8±4.3	r=0.623; ρ=0.000
[a]Body fat (%)	38.9±7.1	r=0.932; ρ=0.000
[a]Body water (%)	44.5±5.3	r=-0.919; ρ=0.000
[a]Bone mass	2.1±0.3	r=0.675; ρ=0.000

Note: [a]Data normally distributed, analysis performed using Pearson correlation coefficient test; [b]Data not normally distributed, analysis performed using Spearman correlation coefficient test; SD = standar deviation; BMI = body mass index; r = regression analysis; ρ = p-value

Blood pressure was correlated with BMI. Elevated blood pressure is the most common factor of metabolic syndrome among middle-aged individuals [15] Similarly, a previous study found that obesity and a high percentage of body fat are present in people with high levels of blood pressure [2]. At the cellular level, multiple molecules secrete excessive proinflammatory and vasoactive adipokines,such as angiotensinogen, aldosterone, angiotensin II and resist the increase in plasma renin activity. . Reactive oxygen species (ROS), which stimulate NADPH oxidase, can increase the number of adipocytes as a free fatty acid. NADPH oxidase is an enzyme involved in vascular injury, radical superoxide generation, and nutrient-based ROS generation. The progression of hypertension through central sympathetic system triggered by NADPH oxidase activation .

WC, visceral fat, and body fat were positively correlated with BMI. This study was supported by a previous study that indicated a significant correlation between WC and BMI, body fat, and visceral fat [3]. Visceral fat correlated with BMI. VAT is an excessive of ectopic fat in surrounding organs the abdominal cavity. Our findings support previous epidemiological studies indicating that visceral fat is a significant independent predictor of cardiometabolic risk [13]. Poor nutritional status is more prevalent in cardiometabolic conditions . Status VAT increases the cardiometabolic risk through high metabolic activity and its proinflammatory effect (cytokine production as an inflammatory effect and blocking of those anti-inflammatory effects). VAT has more extensive fat deposits than the others, leading to dysfunctional adipocytes and inducing low insulin sensitivity and high lipolytic activity. The growth of adipocytes leads to the accumulation of triglycerides, leading to develoving leptin resistant and promoting the synthesis and release of free fatty acids. Decreasing VAT decreases body fat, which plays a protective role in cardiometabolism .

The limitation of the study was the measurement of nutritional status using BMI, waist circumference, and visceral adiposity using bioelectrical impedance analysis (BIA); we did not measure the waist-hip ratio and biomedical imaging. The study had a cross-sectional design, and further longitudinal studies are needed.

4 Conclusion

A significant positive association was observed between the participant's BMI and cardiometabolic risk factors, including blood pressure, fasting blood glucose, and body composition. Nutritional status base on anthropometric measurements is associated with an increased risk of cardiovascular disease; therefore, maintaining normal body mass index (BMI) status is essential to prevent CVD risk factors. The government should provide facilities that can increase physical activity to improve the weight management status. Public health initiatives are needed for the public sector to improve health status and alleviate the impact of society on the high prevalence of cardiometabolic risk.

Acknowledgments

We would like to thank the participants for their voluntary participation in this study. We also thank the Directorate General of Higher Education, Research and Technology, Ministry of Education, Culture, Research and Technology, for funding this research under the Doctoral Dissertation Research scheme (PPS-PDD) with contract No.18831/IT3.D10/PT.01.03/P/B/2023. The author would also like to thank the Indonesian Education Scholarship (BPI) for the PhD scholarship fund of the first author, thus making it possible for the authors to work in this article.

References

1. S. Kaptoge, L. Pennells, D. De Bacquer, M. T. Cooney, M. Kavousi, G. Stevens, L. M. Riley, S. Savin, T. Khan, S. Altay, P. Amuyel, World Health Organization cardiovascular disease risk charts: revised models to estimate risk in 21 global regions. Lancet Glob. Heal. **7**, 1, e1332–e1345 (2019). doi: 10.1016/S2214-109X(19)30318-3.
2. V. P. N. Miranda, P. R. dos Santos Amorim, R. R. Bastos, K. L. R. Canabrava, M. V. M. Junior, F. R. Faria, S. do Carmo Castro Franceschini, M. do Carmo Gouveia Peluzio, E. Priore, Association of lifestyle and body composition on risk factors of cardiometabolic diseases and biomarkers in female adolescents. Mediators Inflamm. **20**, 1–12 (2020). doi:10.1155/2020/9170640.
3. N. Chumpathat, C. Phosat, C. Uttamachai, P. Panprathip, and K. Kwanbunjan, Association between waist circumference at two measurement sites and indicators of metabolic syndrome and cardiovascular disease among Thai adults. Mal J Nutr. **24**, 3, 371–380 (2018).
4. I. Budiastutik, M. I. Kartasurya, H. W. Subagio, and B. Widjanarko, High Prevalence of Prediabetes and Associated Risk Factors in Urban Areas of Pontianak, Indonesia: A Cross-Sectional Study. J. Obes. **2022**, 1-9 (2022). doi: https://doi.org/10.1155/2022/4851044.
5. G. O. Observatory, Rangking obesity by country. Observatory, Global Obesity. (2024). https://data.worldobesity.org/rankings/
6. MOH, National health survey (Riskesdas) 2018. Jakarta: MOH, 2018.
7. B. Bohari, N. Nuryani, R. Abdullah, L. Amaliah, and F. Hafid, Association physical activity and central obesity with hyperglycemia among adult women: Cross-sectional study. AcTion Aceh Nutr. J. **6**, 2, 199–206 (2021). doi: https://doi.org/10.30867/action.v6i2.587.
8. D. Gallagher, S. B. Heymsfield, M. Heo, S. A. Jebb, P. R. Murgatroyd, and Y. Sakamoto, Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index, Am. J. Clin. Nutr. **72**, 3, 694–701 (2000). doi: https://doi.org/10.1093/ajcn/72.3.694.
9. C. E. Matthews, S. Patel, P. Saint-Maurice, E. Loftfield, S.K. Keadle, K.Y. Chen, R. Brychta, S. LaMunion, D. Berrigan, Physical Activity Levels (PAL) in United States Adults–2019. Med. Sci. Sports Exerc. **55**, 5, 1–17 (2023). doi: https://doi.org/10.1249/MSS.0000000000003102.
10. P. Mishra, C. M. Pandey, U. Singh, A. Gupta, C. Sahu, and A. Keshri, Descriptive statistics and normality tests for statistical data. Ann. Card. Anaesth. **22**, 1, 67–72 (2019). doi: https://doi.org/10.4103/aca.ACA_157_18.
11. Y. F. Chee, S. Kaur, and R. W. K. Yap, Association between Dietary Patterns and Cardiometabolic Risks in Malaysian Punjabi Adults. Malaysian J. Med. Heal. Sci. **16**, 6, 106–115 (2020).
12. L. Shi, J. A. Morrison, J. Wiecha, M. Horton, and L. L. Hayman, Healthy lifestyle factors associated with reduced cardiometabolic risk. Br. J. Nutr. **105**, 5, 747–754 (2011). doi: https://doi.org/10.1017/S0007114510004307.
13. I. J. Neeland, R. Ross, J.P. Despres, Y. Matsuzawa, S. Yamashita, I. Shai, J. Seidell, P. Magni, R.D. Santos, B. Asenault, A. Cuevas, Visceral and ectopic fat, atherosclerosis, and cardiometabolic disease: a position statement. lancet Diabetes Endocrinol. **7**, 9, 715–725 (2019). doi: https://doi.org/10.1016/S2213-8587(19)30084-1.

14. I. Harun, H. Riyadi, D. Briawan, and A. Khomsan, Effect of 12-Weeks Brisk Walking Exercise Duration on Blood Pressure and VO2max on Overweight and Obese Female Students in Indonesia. Nutr. Clín y Diet Hosp. **42**, 4, 79–85 (2022). doi: https://doi.org/10.12873/424harun.
15. N. M. Nurdin, F. Anwar, R. Diana, H. Riyadi, and A. Khomsan, High Prevalence of Metabolic Syndrome among Middle-Aged People in the Rural Area of Cianjur, Indonesia. Mal J. Med. Heal. Sci. **19**, 85, (2023).