Jurnal Gizi Indonesia
(The Indonesian Journal of Nutrition)

Jurnal Gizi Indonesia (The Indonesian Journal of Nutrition)
Vol. 13, No. 1, December 2024 (9-15)
Received: 19 March 2024, Revised: 12 August 2024,
Accepted: 19 September 2024, Published: 30 December 2024
https://ejournal.undip.ac.id/index.php/jgi , DOI:10.14710/jgi.13.3.9-15

Differences in non-high density lipoprotein levels, blood pressure and waist circumference between normal-weight obesity, lean, and obese women

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ABSTRACT

Background: *Normal Weight Obesity (NWO) is a condition characterized by an average Body Mass Index (BMI) with high body fat percentage (BFP≥30%), distinct from individuals with normal BMI and normal body fat (BFP <30%), known as Normal Weight Lean (NWL). NWO is associated with an increased risk of cardiovascular diseases, dyslipidemia, and central obesity.*

Objectives: *Investigate differences in non-high-density lipoprotein (non-HDL) levels, blood pressure, and waist circumference among respondents with NWO, NWL, and obesity.*

Materials and Methods: *The research adopts an observational design with a cross-sectional approach. The respondents, 96 adult women aged 30-45 from Padang City, were selected based on inclusion and exclusion criteria. Measurements included BMI, body fat using Bioelectrical Impedance Analysis (BIA), waist circumference, and blood pressure. Nutritional status determination was employed to differentiate between NWL, NWO, and obesity. Subsequently, blood samples were taken for non-HDL analysis. Analysis of customarily distributed data used one-way ANOVA and post-hoc Bonferroni, while non-normally distributed data were analyzed using Kruskal-Wallis and post-hoc Mann-Whitney.*

Results: *The study revealed that 20 women (20.8%) were classified as having NWO. The study results indicate a significant difference in non-HDL levels among NWL, NWO, and obesity (p-value = 0.015). There were differences in non-HDL levels between NWO and NWL women, as well as between NWL women and those with obesity. Blood pressure analysis showed no significant difference in blood pressure among NWO, NWL, and obesity. There was a difference in waist circumference, with a significant difference between NWL and obesity (p-value <0.05) and NWO and obesity (p-value <0.05). However, there was no significant difference between NWO and NWL (p-value = 1.00).*

Conclusion: *There were differences in non-HDL levels and waist circumference among NWO, NWL, and obese women, but no significant difference in blood pressure was observed among the three groups.*

Keywords: *Normal weight obesity; non-HDL; blood pressure; Waist circumference*

BACKGROUND

The World Health Organization (WHO) defines obesity as the accumulation of body fat or excess body fat percentage (BFP) associated with clear health risks. However, BMI cannot depict body composition as it does not differentiate between lean mass and adipose tissue. Therefore, an individual with a normal BMI (18.5–24.9 kg/m2) may have an appropriate or excessive body fat percentage obscured by a normal BMI.[1] As a result, De Lorenzo defines a condition where individuals with a normal BMI have high body fat (BFP ≥30%) as Normal Weight Obesity (NWO). This is distinct from individuals with a normal BMI and normal body fat (BFP <30%), also referred to as Normal Weight Lean (NWL).[2–4]

De Lorenzo et al. describe the global prevalence of NWO at around 10%, with a higher prevalence among women than men. Interactions between genetic and environmental factors such as diet and lifestyle, particularly over-nutrition and sedentary behavior, promote the progression of NWO in women.[2] Wijayatunga et al. report that among adults with average weight, the prevalence of NWO ranges from 29% to 46% in various countries. Research conducted in Asian countries reveals diverse NWO prevalences. Kapoor et al. report a 31.7% prevalence of NWO in Indian adults, Moy et al. in Malaysia report a 19.8% prevalence of NWO in adult women, Ji et al. report a 10.7% prevalence of NWO in adults in China, and research in Korea indicates a majority of 32%, with a breakdown of 27% in adult men and 31% in adult women.[2,3,5,6] Based on the 2018 Basic Health Research (Riskesdas) data, the nutritional status according to BMI in Indonesia shows that 13.6%

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of adults over 18 years old are overweight and 21.8% are obese, with an overweight ratio of 12%:15% and an obesity ratio of 14.5%:29.3% between men and women. The prevalence of central obesity among people aged ≥15 years in Indonesia is 31%.West Sumatra is one of the provinces with a central obesity prevalence above the national average, at 32.8%. The prevalence of central obesity in Padang City is 34.18%, with a much higher prevalence among women (50.49%) compared to men (15.3%). These figures are above the provincial average and have increased since 2013, when the prevalence of obesity in Padang City was 33.7%. However, there has never been a study reporting Normal Weight Obesity (NWO) in Padang City.[7,8]

The meta-analysis conducted by Khonsari et al. revealed a 50% and 42% increased risk of hyperglycemia and diabetes, respectively, in individuals with NWO compared to NWL. Individuals with NWO exhibited a 40%, 83%, and 32% increased risk of hypertension, dyslipidemia, and decreased levels of High-Density Lipoprotein (HDL), respectively. Moreover, individuals with NWO also showed a 90% increased risk of hypertriglyceridemia.[3] Research conducted by Rodriguez et al. demonstrated that NWO is associated with an elevated risk of cardiovascular diseases, high blood pressure, low HDL, central obesity, and weak muscle strength in young adults.[2,9] Research in Brazil at 2020 found that non-HDL reflects cardiovascular risk more accurately than LDL, particularly in relation to visceral fat accumulation and waist circumference. Non-HDL is also a better indicator of cardiovascular risk in obese and diabetic patients.[10–12] Waist circumference correlates strongly with cardiometabolic events and is considered an independent risk factor for cardiometabolic diseases and related mortality. Therefore, assessing waist circumference, blood pressure, and non-HDL is essential for identifying and managing health risks in individuals with NWO and related conditions.[4,13,14]

Nutritional status screening in healthcare facilities still uses BMI as the standard, without monitoring body fat percentage, so individuals with Normal Weight Obesity (NWO) are often overlooked and unaware of the health risks they are experiencing. Many studies have examined the differences in cardiovascular and metabolic risk between Normal Weight Lean (NWL) and NWO, but there were few that compare NWL, NWO, and obesity. Therefore, further research is needed to understand the differences in cardiometabolic risk among individuals with NWL, NWO, and obesity.Therefore, the researchers aim to conduct a study to investigate the differences in Non-High Density Lipoprotein levels, blood pressure, and waist circumference among women with NWO, NWL, and obesity.

MATERIAL AND METHODS

This study was an observational research with a cross-sectional design using a purposive sampling technique. Respondents were selected from four districts: Padang Timur, Padang Barat, Padang Selatan, and Pauh, based on high cardiometabolic disease data from the Padang City Health Office. The researchers contacted the community health centers to request permission to conduct the study and coordinated with the Regional Work Supervisor or village midwives appointed by the Head of the Health Center. Researchers along with volunteers, conducted socialization of the research activities to the community, and respondent examinations along with blood sample collection were carried out on the designated days in each area. The respondents were adult women aged 30-45 years from Padang. Sample size was calculated using the Lemeshow formula, totaling 96 individuals. Height measurements were conducted using a microtoice. Weight and body fat examinations were performed using Bioelectrical Impedance Analysis (BIA) with the OMRON brand. Nutritional status determination was carried out after obtaining BMI and BFP data to differentiate between NWL, NWO, and obesity. NWL is defined as having a BMI of 18.5-24.9 kg/m² and BFP of less than 30%. NWO is defined as having a BMI of 18.5-24.9 kg/m² and a BFP of 30% or higher. Obesity is defined as having a BMI greater than 25 kg/m².

Respondents were asked to refrain from physical activities (exercise, eating), drinking coffee or alcoholic beverages, and smoking for at least 30 minutes before the examination. They were also asked to calm their minds, for example, by sitting and relaxing for approximately 5-15 minutes. Blood pressure measurement was performed three times with the OMRON brand sphygmomanometer. Waist circumference measurements were taken on respondents in an upright standing position, measured at the midpoint between the iliac crest and the costal arch during expiration. Subsequently, respondents underwent a blood sample collection of 3 ml by laboratory personnel for blood cholesterol analysis using the CHOD-PAP method. Non-HDL cholesterol level is obtained by calculating the serum total cholesterol level minus the HDL level.

The collected data were processed and analyzed using IBM SPSS version 27.00 for Windows. Normally distributed data were analyzed using One-Way ANOVA and Post-Hoc Bonferroni. Data analysis

e-ISSN : 2338-3119, p-ISSN: 1858-4942

was conducted with a confidence interval (CI) of 95% and α = 0.05. The test results conclude that if the p-value is < 0.05, then there is a significant difference among the three groups. This research has been approved by the Ethics Research Committee of the Faculty of Medicine, Universitas Andalas, Padang, Indonesia, with no: 547/UN.16.2/KEP-FK/2023.

RESULTS

A total of 96 respondents were gathered, with 20 individuals categorized as NWO (20.8%), eight as NWL (8.3%), and 68 as obese (70.8%). The total of 37 respondents within the age range of 41-45 years (38.5%, followed by the age group of 30-35 years (34.4%), with the highest marital status being married (94.8%). The most common educational background was high school graduates or equivalent, comprising 68 individuals (70.8%), and 70 respondents (72.9%) were unemployed. Physical examinations resulted in an average weight of 65.17±11.79 kg and an average height of 152.70±6.13 cm. BIA examination revealed an average BMI of 27.99±4.65 and an average Body Fat Percentage (BFP) of 35.53±4.62. Respondent characteristics are listed in Table 1.

Table 1. **Characteristics of Research Participants**

Characteristics	*f* (n=96)	%	Mean±SD
Age (years)			
30-35	33	34.4	
36-40	26	27.1	
41-45	37	38.5	
Category			
NWO	20	20.8	
NWL	8	8.3	
Obesitas	68	70.8	
Marital Status			
Single	2	2.1	
Married	91	94.8	
Widowed	3	3.1	
Education Attainment			
Elementary School (SD)	2	2.1	
Junior High School (SMP)	5	5.2	
High School (SMA/equivalent)	68	70.8	
Diploma 3 (D3)	5	5.2	
Bachelor's Degree (S1/DIV)	15	15.6	
Master's Degree (S2)	1	1	
Employment Status			
Unemployed	70	72.9	
Employed	26	27.1	
Weight (kg)	96		65.17±11.79
Height (cm)	96		152.70±6.13
BMI	96		27.99±4.65
BFP	96		35.53±4.62
Waist Circumference (cm)			
Normal (<80 mmHg)	45	46.9	
High Risk (≥80 mmHg)	51	53.1	
Systolic Blood Pressure			
Normal (<140 mmHg)	80	83.3	
High Risk (≥140 mmHg)	16	16.7	
Diastolic Blood Pressure			
Normal (<90 mmHg)	80	83.3	
High Risk (≥90 mmHg)	16	16.7	

The study results indicate a significant difference in Non-High-Density Lipoprotein (Non-HDL) levels among NWL, NWO, and obesity (p-value <0.001). Blood pressure analysis showed no significant difference in systolic blood pressure among NWL, NWO, and obesity (p-value = 0.414) and diastolic blood pressure (p-value = 0.502). Statistical test was conducted to determine the significance of each group, resulting in a

e-ISSN : 2338-3119, p-ISSN: 1858-4942

significant difference between NWL and obesity (p-value <0.05) and NWO and obesity (p-value <0.05). However, there was no significant difference between NWO and NWL (p-value = 1.00). Statistical test results for the mean Non-HDL levels, blood pressure and waist circumference among NWL, NWO, and obesity are presented in Table 2.

Table 2. The Mean Waist Circumference in NWO, NWL, and Obesity

Variable	NWL Mean ±SD	NWO Mean ±SD	Obesity Mean ±SD	*p-value*
Non-HDL	87.18 ±14.79[a]	120.32 ±25.52[b]	122.92 ±22.73[b]	<0.001*
Blood Pressure				
Systolic	116.25 ±17.86	119.20±21.80	124.82±20.29	.435
Diastolic	77.38 ±10.89	77.45 ±9.11	80.59 ±11.31	.232
Waist Circumference	73.81 ±8.10[a]	80.40 ±6.27[a]	95.02 ±9.93[b]	<0.001*

*Statistically significant if p-value less than 0.05

DISCUSSION

The research conducted in four districts in Padang on adult women aged 30-45 years revealed of 20.8% for NWO, 8.3% for NWL, and 70.8% for obesity. This aligns closely with a study conducted by Moy et al. in Malaysia, reporting a prevalence of NWO at 19.8%.[15] Meanwhile, a study in South Korea reported a prevalence of 16.67% for NWO among adults aged 20-79.[16]

This study reveals a significant difference in Non-HDL levels between NWL and both NWO and obesity (p-value <0.001). The variations stem from differences in body composition, particularly in fat distribution and lipid metabolism. Individuals with NWO and obesity often carry a higher percentage of body fat, even if their BMI indicates a normal weight. This fat tends to accumulate around the abdomen (visceral fat), which poses a higher metabolic risk. This distribution can result in elevated non-HDL cholesterol levels. Those with NWO and obesity may experience metabolic dysfunction, making them more susceptible to lipid metabolism disorders, including increased triglycerides and decreased HDL. Consequently, this can lead to heightened non-HDL levels, indicating elevated atherogenic cholesterol. Insulin resistance, commonly associated with NWO and obesity, can also impact lipid metabolism, potentially leading to elevated production of triglyceride-rich lipoproteins and increased non-HDL levels. Additionally, NWO and obesity are frequently linked to heightened inflammation and increased cardiovascular risk, further contributing to elevated non-HDL levels.

The researchers have not found other studies examining non-HDL levels in NWO patients. A survey by Damoon et al. reported differences in HDL levels among NWL, NWO, and obesity but no significant differences in other lipid profiles. In contrast, a study by Kim et al. (2023) in Korea, examining women and men aged >20 years, showed an association between NWO and metabolic syndrome, including lipid profiles and blood pressure. [17,18] Similarly, a meta-analysis by Kohansari et al. (2022) involving 177,792 respondents aged 13–75 years demonstrated an association between NWO and the incidence of dyslipidemia and hypertension.[4]

Statistical tests from the research results indicate no significant difference in non-HDL levels between NWO and obesity. This is due to the excess percentage of body fat in NWO and obesity which may cause inflammation and insulin resistance which both affect fat metabolism, so that non-HDL levels are both higher than NWL. Therefore, there is a possibility that individuals with NWO and obesity have similar risks for cardiovascular diseases. Obesity is commonly accompanied by low HDL-C levels and an increase in triglyceride-rich lipoprotein, which is often termed as atherogenic dyslipidemia. Characteristic for this dyslipidemia is a decreased clearance of triglyceride-rich lipoproteins, which is caused by a relative lack of insulin-sensitive lipoprotein lipase. Lipoprotein lipase hydrolyzes triglycerides of chylomicrons and VLDL, leading to shrinkage of the particles and transfer of surface phospholipids and apolipoproteins to HDL, thus increasing HDL size.[19] During NWO, the response of lipoprotein lipase activity to glucose stimulation has been shown to be reduced, representing one potential factor contributing to the decrease of HDL-C in obesity. A study conducted by Oliosa et al. reported that the proportion of girls with obesity and high non-HDL levels identified by Body Fat Percentage (BFP) is twice as high compared to Body Mass Index (BMI) and four times

e-ISSN : 2338-3119, p-ISSN: 1858-4942

higher compared to Weight-to-Height Ratio (WHtR).[20] Other studies also indicate a strong association between non-HDL levels and visceral obesity, demonstrating that non-HDL is correlated with waist circumference.[21,22]

This study indicates no significant differences in systolic or diastolic blood pressure between NWL, NWO, and obesity. These findings align with the results of studies by Damoon et al. (2023) and Ramsaran et al. (2017), which reported no differences in blood pressure between NWO and NWL individuals.[18,23] This study result contrasts with a study by Shimrah et al. (2023), which showed significantly higher mean systolic and diastolic blood pressure in NWO than in NWL.[24] Similarly, a meta-analysis conducted by Khonsari et al. demonstrated a strong correlation with elevated blood pressure and other cardiometabolic diseases.[4] Physical activity has been proposed as an effort to help reduce the risk of hypertension. Therefore, in addition to traditional pharmacological treatment modalities, physical exercise holds significant potential in preventing or treating hypertension and related conditions. Furthermore, individuals with a family history of hypertension have a higher risk of developing hypertension. While family history cannot be controlled, the risk of overweight or obesity can be reduced through physical activity and a healthy diet within the normal weight range. It is important to note that this study did not analyze family medical history, dietary patterns, and physical activity among respondents. Additionally, the cross-sectional nature of the research methodology limits the ability to analyze causation relationships between these factors.[24–26]

The results of this study indicate a significant difference in waist circumference between NWO, NWL, and obesity. Women with NWO have an average waist circumference of 80.4 cm, showing a significant difference compared to obesity. However, there is no significant difference compared to women with NWL. This differs from a study conducted by Damon et al., which showed a significant difference in waist circumference between NWO and NWL.[18] A balanced diet and moderate exercise with minimal weight loss can reduce visceral fat and decrease waist circumference. On the other hand, more significant weight loss tends to result in the loss of subcutaneous fat.[27,28] Identification of changes in dietary patterns, physical activity, and the exercise regimen followed by the respondents is necessary to analyze the relationship between waist circumference and the occurrence of NWO. The accumulation of adipose tissue in the upper body region is associated with the development of comorbidities and mortality related to cardiometabolic conditions. Intra-abdominal adipose tissue (IAAT), or visceral adipose tissue (VAT), plays a crucial role in insulin resistance and cardiovascular disease risk, in contrast to gluteo-femoral adipose tissue, which is associated with a protective lipid and glucose profile. IAAT is primarily located in the mesentery and omentum, flowing directly through the portal circulation to the liver. One reason for the difference in cardiometabolic disease risk between upper body obesity and lower body obesity is that abdominal fat is characterized by rapid energy absorption and storage from food, as well as increased lipid turnover (lipolysis), whereas lower body obesity has a lower rate of lipid turnover and reduces the diversion of lipids to non-adipose tissues. [13]Changes in fat distribution that occur in NWO may be associated with metabolic disturbances. In addition to increased visceral fat, ectopic fat distribution in the liver and muscles, leading to lipotoxicity and insulin resistance, has been observed in NWO compared to NWL.[29]

CONCLUSION

There were differences in non-HDL levels and waist circumference between NWL and both NWO and obesity. Still, no significant difference was observed in blood pressure between NWO, NWL, and obese women.

Future research is recommended to include both male and female samples, covering a broader age range that can better represent the prevalence in Indonesia. The analysis should encompass risk factors for NWO, such as dietary patterns, physical activity, living environment, and ethnicity, allowing for a comprehensive evaluation of differences between NWO, NWL, and obesity.

ACKNOWLEDGMENTS

The author expresses gratitude to the Faculty of Medicine, Universitas Andalas, Padang, Indonesia, and all those who have contributed to the realization of this research.

ETHICAL CONSIDERATION

This research has been approved by the Ethics Research Committee of the Faculty of Medicine, Universitas Andalas, Padang, Indonesia, with no: 547/UN.16.2/KEP-FK/2023.

e-ISSN : 2338-3119, p-ISSN: 1858-4942

DISCLOSURE

The author reports no conflicts of interest in this work.

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e-ISSN : 2338-3119, p-ISSN: 1858-4942