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Research Article

Validity of Waist-to-Height Ratio for Hypertension Screening among Pre-Elderly Men and Women in Indonesia

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ABSTRACT

The research was conducted to validate the Waist-to-Height Ratio (WHtR) as a predictor of hypertension among pre-elderly individuals in Indonesia. The study utilized a cross-sectional analysis based on secondary data from the 2023 Indonesian Longitudinal Aging Survey (ILAS). A total of 2,170 pre-elderly adults aged 45–59 years (993 men and 1,177 women), were included, with 46.4% classified as hypertensive. Predictive performance of WHtR was assessed using Receiver Operating Characteristic (ROC) analysis. Optimal cutoff points were then determined using Youden index and accuracy. Diagnostic performance was evaluated based on sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Values (NPV). The Area Under the Curve (AUC) of WHtR for the predicting hypertension was 0.648 (95% CI: 0.614–0.683, p<0.001) in men and 0.633 (95% CI: 0.601–0.664, p<0.001) in women. The selected cutoff for WHtR was 0.513 in men (sensitivity: 67.6%, specificity: 55.5%), and 0.597 in women (sensitivity: 56.3%, specificity: 65.3%), with an overall accuracy of 61.0%. These results support that WHtR may serve as a practical screening tool for hypertension in pre-elderly individuals in Indonesia, with sex-specific cutoff values that could support early identification and prevention strategies.

INTRODUCTION

Hypertension remains a critical global public health concern, affecting over 1.3 billion individuals worldwide and substantially increasing the risk of cardiovascular disease, stroke, renal failure, and early death (WHO 2023). The desease is often designated “the silent killer”, due to its asymptomatic nature and late clinical manifestation, which often coincide with severe complications (Zethira *et al.* 2024). In Indonesia, the 2018 Basic Health Research (*Riskesdas*) reported a prevalence of 34.1%, with considerable variation across provinces, underscoring the need for targeted prevention strategies (Noor *et al.* 2024). The ILAS 2023 report demonstrated an alarmingly high prevalence of hypertension among individuals aged 45–59 years, suggesting that pre-elderly populations are particularly vulnerable to cardiometabolic disorders (Asian Development Bank *et al.* 2025).

Although commonly used for hypertension screening, traditional anthropometric indicators, such as Body Mass Index (BMI), fail to adequately account for fat distribution, a key factor in blood pressure regulation. (Dereje *et al.* 2021). In contrast, central obesity markers including Waist Circumference (WC), Waist-to-Hip Ratio (WHR), and WHtR show stronger correlations with hypertension (Dereje *et al.* 2021). Several studies have reported that central obesity indices provide positive predictive value for hypertension in adults and the elderly (Sudaryanto *et al.* 2023; Zhang *et al.* 2024; Musa *et al.* 2025). Among these, WHtR has consistently demonstrated superior performance as a predictive measure (Deng *et al.* 2018; Kawamoto *et al.* 2020; Dereje *et al.* 2021; Wu *et al.* 2023; Akbari-khezrabadi *et al.* 2022). However, research examining anthropometric indicators, particularly WHtR, in relation to hypertension remains limited in Indonesia.

The WHtR is an inexpensive and practical tool for screening cardiometabolic risk, offering a more accurate reflection of visceral adiposity than waist circumference alone (Ashwell & Gibson 2014). Its simplicity makes it particularly valuable in resource-limited settings, such as Indonesia, where community-based screening requires affordable and practical instruments (Agustine *et al.* 2025). Evidence from Indonesian populations further confirms the link between central adiposity and hypertension, underscoring the potential of WHtR in preventive health initiatives (Noor *et al.* 2024).

Pre-elderly individuals (45–59 years) remain in the productive age group but face increased risks of hypertension and chronic diseases due to lifestyle changes, reduced physical activity, and metabolic aging (Asian Development Bank *et al.* 2025). According to the ILAS 2023 study, this group is significantly more likely to be centrally obese (over 50% with a WC >90 cm), participate in fewer routine health examinations, and have a higher burden of undetected hypertension. These results highlight the need for population-specific customized screening strategies. Thus, this study aimed to validate the efficacy of WHtR as a hypertension early warning tool in Indonesian pre-elderly men and women using secondary data from the ILAS 2023. Making WHtR a trustworthy predictor could improve early detection and guide community-based health interventions.

METHODS

Design, location, and time

Data was subjected to a cross-sectional analysis, which used secondary data from the ILAS 2023. The survey aimed to monitor trends related to the elderly population in Indonesia. The data were the results of the first wave of the ILAS, conducted from May to June 2023. ILAS interviewed 4,084 respondents aged 45 years and above residing in nine regions (West Sumatra, Lampung, West Java, the Special Region of Yogyakarta, East Java, Bali, South Kalimantan, South Sulawesi, and Maluku), where the proportion of elderly individuals in those areas reached or approached 10%. ILAS 2023 officially obtained ethical approval from the BRIN Social Humanities Ethics Committee, with reference number 558/KE.01/SK/12/2022.

Sampling

The Indonesian Longitudinal Aging Survey (ILAS) sample was drawn from nine Indonesian provinces with high proportions of elderly populations (>10%). A multistage random sampling approach was used, considering socioeconomic status, rural-urban area differences, the share of the population aged 45–69 years, and the share of the population aged ≥70 years. From 17 households per selected village those met the requirement of one or more members aged ≥45 years, yielding 2,448 households and 4,177 individuals. Of these, 4,084 successfully completed interviews, comprising 60.8% pre-elderly (45–59 years) and 39.2% elderly (≥60 years). For this analysis, 2,170 pre-elderly participants with complete data regarding blood pressure, weight, height, Waist Circumference (WC), and Hip Circumference (HC) were included.

Data collection

The anthropometric variables analyzed in this study were derived from the ILAS. All measurements were conducted by ILAS personnel using calibrated instruments and standardized procedures as specified in the ILAS Guidebook, ensuring methodological consistency across survey sites. Participants' body weight was measured on digital scales while they were barefoot and advised to wear the lightest clothing possible. Weight recorded to the nearest 0.1 kg. Measurements were taken twice, or three times if discrepancies occurred, with the lowest value recorded. Height was obtained using a microtoise. During measurement, respondents were carefully positioned against the stick, ensuring their feet, heels, buttocks, and shoulder blades were touching it, with the head aligned in the Frankfurt horizontal plane. Both waist and hip circumferences were taken in duplicate while the respondents were standing straight and relaxed. The measure tape was circled horizontally at the middle point between the lowest rib and the highest pelvic bone to record the waist circumference, or at the navel point on the bulging stomach. Hip circumference was measured at the widest part of the respondent's thigh (WHO 2011). The measurements were obtained in Centimeters (cm), with a precision of 0.1 cm.

Blood pressure was obtained from a digital blood pressure monitor through three sequential readings (left arm, right arm, left arm), and the mean of the two left-arm measurements was analyzed. Sociodemographic and lifestyle data regarding age, ethnicity, education, medical diagnosis history, smoking, and alcohol consumption habits were collected using questionnaires

Data analysis

All statistical computations were executed using version 25 of IBM SPSS Statistics and Microsoft Excel (Microsoft Excel 365 Enterprise, Microsoft Corporation). Data distribution was assessed using normality testing to determine the appropriate descriptive approach. The data analysis began with stratification by sex (male and female) and hypertension status. Hypertension was categorized as: Yes (Systolic Blood Pressure (SBP) ≥140 mmHg and/or Diastolic Blood Pressure (DBP) ≥90 mmHg) and No (SBP <140 mmHg and/or DBP <90 mmHg) strictly according to the measured blood pressure values, irrespective of any formal, existing diagnosis of hypertension. For descriptive statistics, non-normally distributed variables were summarized using the median and Interquartile Range (IQR), whereas the mean and Standard Deviation (SD) were applied to normally distributed variables. Categorical data were presented as frequencies and percentage. Group comparisons were performed using the chi-square test for nominal and ordinal variables, and the Mann–Whitney U test for non-normally distributed numerical data.

Receiver Operating Characteristic (ROC) analysis was employed to assess the efficacy of WHtR as a hypertension screening tool. The AUC was used to evaluate diagnostic performance, where 1.0 indicates perfect accuracy and 0.5 reflects no discriminative ability (Çorbacıoğlu & Aksel 2023). Interpretation of AUC was categorized as excellent (AUC ≥0.9), good (0.8–0.9), fair (0.7–0.8), weak (0.6–0.7), and failure (0.5–0.6) (Nahm 2022). An AUC value greater than 0.6 is generally considered to indicate a moderately meaningful discriminatory ability (De Hond *et al.* 2022).

The optimal discriminative value points were chosen based on the maximum values of the Youden index (sensitivity + specificity – 1) (Youden 1950). When there were more than one values, the higher accuracy score was used to choose the best cutoff value (Nahm 2022). The selected cutoff point was presented with sensitivity, specificity, PPV, and NPV calculated based on the traditional metric (Trevethan 2017).

RESULTS AND DISCUSSION

The dataset included 2,170 participants stratified by sex (men and women) and further categorized by hypertension status (hypertension vs. normotension). This stratification allows comparison between subgroups, making it possible to evaluate demographic, behavioral, and clinical variable differences between groups. The baseline characteristics of participants grouped based on gender were shown in Table 1 and Table 2 respectively.

As shown in Table 1, the hypertension groups were generally older than the normotension groups. The discrepancy between the groups reached statistical significance, suggesting a potential relationship between age and hypertension. A study assessing the prevalence and risk factors of hypertension in Banyuwangi, East Java, Indonesia found that increasing age was associated with systolic and diastolic hypertension (ORsystolic=1.11; 95% CI: 1.03–1.19, p=0.01 and ORdiastolic=1.07; 95% CI: 1.01–1.15, p=0.03) (Astutik *et al.* 2020).

The set of anthropometric indices, comprising weight, BMI, waist circumference, hip circumference, and WHtR, were all significantly higher in hypertensive men (all p<0.001). In contrast, smoking (80.7% vs. 74.0%, p=0.012) and alcohol consumption (16.1% vs. 11.7%, p=0.044) were more frequent in normotensive men.

Education level did non-differ significantly between hypertensive and normotensive men. Conversely, a significant association was found between education and hypertension status among women. Women with hypertension were more likely to have a lower educational background (4.5%) than women with normotension (2.4%) as shown in Table 2. Thus, it may reflect differences in health awareness, lifestyle behaviors, and access to healthcare services. Women with higher educational attainment raised ability to adopt healthier lifestyles—such as managing a balanced diet, maintaining habitual physical activity, and utilizing preventive health services, which may contribute to lower hypertension risk (Alves & Faerstein 2016; Wang *et al.* 2023). However, comprehensive evidence explaining these mechanisms, particularly within the Indonesian context, remains limited.

Female showed a similar pattern with male participants in term of age regarding hypertension. Stroke prevalence was markedly higher in hypertensive women (3.2% vs. 0.5%, p<0.001), whereas no significant distinctions were observed for diabetes, heart disease, or hypercholesterolemia (all p>0.05), highlighting

Table 1. Baseline characteristics of men subjects according to hypertension status

Baseline characteristic	Men (n=993)		p^*
	Hypertension (n=454)	Normotension (n=539)	
Age (years)	53 (49–56)[a]	51 (48–54)[a]	<0.001[c]
Education (n (%))			
No formal education	9 (2.0)	6 (1.1)	0.210[d]
Primary school	162 (35.7)	206 (38.2)	
Junior high school	93 (20.5)	92 (17.1)	
Senior high school	130 (28.6)	177 (32.8)	
University	60 (13.2)	58 (10.8)	
Stroke diagnosed (n (%))			
Yes	16 (3.5)	7 (1.3)	0.020[d]
No	438 (96.5)	532 (98.7)	
Diabetes diagnosed (n (%))			
Yes	26 (5.70)	19 (3.5)	0.097[d]
No	428 (94.30)	520 (96.5)	
Heart disease diagnosed (n (%))			
Yes	9 (2)	13 (2.4)	0.647[d]
No	445 (98.00)	526 (97.6)	
Hypertension diagnosed (n (%))			
Yes	114 (31.7)	37 (6.9)	<0.001[d]
No	310 (68.3)	502 (93.1)	
High cholesterol diagnosed (n (%))			
Yes	59 (13.0)	47 (8.7)	0.030[d]
No	395 (87.0)	492 (91.3)	
Smoking status			
Yes	336 (74.0)	435 (80.7)	0.012[d]
No	118 (26.0)	104 (19.3)	
Alcohol consumption n (%))			
Yes	53 (11.7)	87 (16.1)	0.044[d]
No	401 (88.3)	452 (83.9)	
Weight (kg)	62.93 (54.79–72.01)[a]	57.95 (51.35–65.05)[a]	<0.001[c]
Height (cm)	161.40 (158.00–164.92)[a]	161.5 (157.4–165.5)[a]	0.708[c]
BMI (kg/m^2)	24.38 (21.62–27.02)[a]	22.23 (19.94–24.86)[a]	<0.001[c]
WC (cm)	87.65 (80.00–95.72)[a]	81.70 (74.30–89.40)[a]	<0.001[c]
HC (cm)	94.20 (89.10–99.30)[a]	91.00 (86.5–96.4)[a]	<0.001[c]
WHR (mean±SD)	0.93±0.06[b]	0.90±0.06[b]	<0.001[c]
WHtR	0.54 (0.50–0.59)[a]	0.50 (0.46–0.55)[a]	<0.001[c]
Sistole (mmHg)	149.00 (141.00–161.50)[a]	122.00 (113.50–127.50)[a]	<0.001
Diastole (mmHg)	96.25 (91.00–103.00)[a]	80.00 (75.50–84.50)[a]	<0.001

WC: Waist Circumference; HC: Hip Circumference; WHR: Waist-to-Hip Ratio; WHtR: Waist-to-Height Ratio; BMI: Body Mass Index; SD: Standard Deviation; IQR: Interquartile Range; [a]: Median (IQR); [b]: mean±SD: [c]: Mann-Whitney U; [d]: Chi-square

the link between hypertension and stroke. However, no notable difference in diabetes, heart disease, or hypercholesterolemia prevalence were observed in men or women (p>0.05).

Women also demonstrated similar trends with men, exhibiting greater body weight (59.48 kg vs. 54.65 kg) and BMI (26.30 kg/m^2 vs. 24.4 kg/m^2) in hypertensive group (p<0.001). These conclude that for the anthropometric measurements, the hypertension groups, regardless of sex, had significantly higher body weight, BMI, WC, HC, WHR, and WHtR than the normotension group

In women, lifestyle behaviors such as smoking and alcohol consumption showed minimal variation between hypertensive and normotensive groups. Only a small proportion of women reported smoking or alcohol use, and the differences were not statistically different.

Hypertensive men and women had average systolic pressures of 149 mmHg and 153 mmHg, respectively, and diastolic pressures of 96.3 mmHg and 96.0 mmHg, respectively, all of which were substantially higher than those observed in the normotensive groups. These findings highlight

Table 2. Baseline characteristics of women subjects according to hypertension status

Baseline characteristic	Women (n=1,177)		p*
	Hypertension (n=558)	Normotension (n=619)	
Age (years)	53 (49–56)[a]	51 (48–55)[a]	<0.001[c]
Education (n (%))			
No formal education	25 (4.5)	15 (2.4)	<0.001[d]
Primary school	268 (48.0)	231 (37.3)	
Junior high school	96 (17.2)	122 (19.7)	
Senior high school	121 (21.7)	171 (27.6)	
University	48 (8.6)	80 (12.9)	
Stroke diagnosed (n (%))			
Yes	18 (3.2)	3 (0.5)	<0.001[d]
No	540 (96.8)	616 (99.5)	
Diabetes diagnosed (n (%))			
Yes	41 (7.3)	48 (7.8)	0.792[d]
No	517 (927)	571 (92.2)	
Heart disease diagnosed (n (%))			
Yes	21 (3.8)	14 (2.3)	0.130[d]
No	537 (96.2)	605 (97.7)	
Hypertension diagnosed (n (%))			
Yes	252 (45.2)	83 (13.4)	<0.001[d]
No	306 (54.8)	536 (86.6)	
High cholesterol diagnosed (n (%))			
Yes	124 (22.2)	134 (21.6)	0.812[d]
No	434 (77.8)	485 (78.4)	
Smoking status (n (%))			
Yes	13 (2.3)	21 (3.4)	0.277[d]
No	545 (97.7)	598 (96.6)	
Alcohol consumption (n (%))			
Yes	2 (0.4)	1 (0.2)	0.504[d]
No	556 (99.6)	618 (99.8)	
Weight (kg)	59.48 (52.00–66.80)[a]	54.65 (48.45–63.65)[a]	<0.001[c]
Height (cm)	149.80 (146.10–152.90)[a]	150.2 (146.50–153.50)[a]	0.169[c]
BMI (kg/m^2)	26.30 (23.61–29.52)[a]	24.40 (21.50–27.63)[a]	<0.001[c]
WC (cm)	91.15 (83.88–97.10)[a]	85.50 (78.00–93.40)[a]	<0.001
HC (cm)	97.80 (92.48–104.60 [a]	94.90 (89.30–100.90)[a]	<0.001[c]
WHR (Mean±SD)	0.92±0.06[b]	0.90±0.06[b]	<0.001[c]
WHtR	0.61 (0.56–0.65)[a]	0.57 (0.52–0.62)[a]	<0.001[c]
Sistole (mmHg)	153.00 (142.50–168.50)[a]	121.50 (113.00–129.00)[a]	<0.001[c]
Diastole (mmHg)	96.00 (91.50–103.62)[a]	79.00 (73.50–83.50)[a]	<0.001[c]

WC: Waist Circumference; HC: Hip Circumference; WHR: Waist-to-Hip Ratio; WHtR: Waist-to-Height Ratio; BMI: Body Mass Index; SD: Standard Deviation; IQR: Interquartile Range; [a]: Median (IQR); [b]: mean±SD; [c]: Mann-Whitney U; [d]: Chi-square

clear disparities in baseline characteristics between hypertensive and normotensive individuals, influenced by factors such as age, education, lifestyle, comorbidities, and adiposity. Recognizing these relationships is essential for developing targeted prevention and management strategies. In this context, WHtR offers promise as a simple and practical index for predicting hypertension risk in pre-elderly populations.

The Mann-Whitney test assessed the association between hypertension and WHtR, resulting in a significant association with hypertension in both sexes ($p<0.001$). The analysis utilized 95% confidence intervals, and results were considered stastistically significant when when $p<0.05$.

ROC is a visualized graph that plots sensitivity (True Positive Rate) on the y-axis against 1 - specificity (False Positive Rate) on the x-axis, connecting the coordinate points derived from all possible cutoff values measured in the data. The ROC curves for WHtR related to hypertension in men and women are shown in Figure 1 and Figure 2.

According to the visualizations, the ROC curve is not too far from the diagonal line of chance in both sexes. The WHtR had an Area Under the Curve (AUC) of 0.648 (95% CI: 0.614–0.683) in male and AUC of 0.633 (95% CI: 0.601–0.664) in female. Based on the interpretation of the curve, the model demonstrates acceptable predictive ability.

To analyze the optimal cutoff value based on ROC curve analysis, Youden Index was used. The Youden index identifies the point on the ROC curve that provides the greatest vertical separation from the line of equality (the diagonal), thereby maximizing the sum of sensitivity and specificity minus one. As shown in Table 3, the highest Youden index values for men were at two points; 0.508 with a sensitivity of 70.9% and specificity of 52.1%, and 0.513 with a sensitivity of 67.6% and specificity of 55.5%. Based on the higher accuracy, the better cutoff for men was at WHtR 0.513. The best cutoff value for women was 0.597, with a sensitivity of 56.3% and specificity of 65.3%.

Based on outcome, the instrument's diagnostic utility was sufficient for screening purposes, although it did not reach high precision. A recent publication on research conducted in Indonesia among non-hypertensive adult aged 35–94 populations reported comparable findings, indicating that WHtR demonstrated the highest diagnostic performance for hypertension in both men (AUC=0.650; 95% CI: 0.629–0.671) and women (AUC=0.615; 95% CI: 0.598–0.633) (Sartika *et al.* 2025).

Moreover, this result is still comparable to the analysis based on the Chinese middle-aged and elderly population (AUC=0.593; 95% CI: 0.552–0.613, p<0.001 in men and AUC=0.609; 95% CI: 0.579−0.638, p<0.001 in women), and Sudanese population (AUC=0.67; 95% CI: 0.59–0.75 in men and AUC=0.64; 95% CI: 0.53–0.75 in women) (Li *et al.* 2023; Musa *et al.* 2025). However, this result is still poor compared to the study in the Japanese middle-aged and elderly

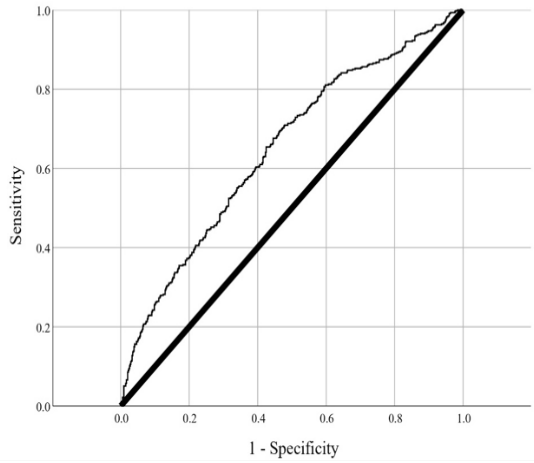

Figure 1. Receiver Operating Characteristic (ROC) curve for men

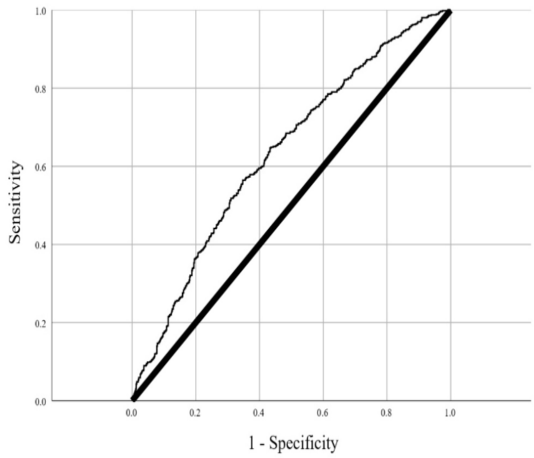

Figure 2. Receiver Operating Characteristic (ROC) curve for women

population (AUC=0.645; 95% CI: 0.605–0.686, p<0.001 in men and AUC=0.690; 95% CI: 0.656–0.725, p<0.001 in women) and in Southwestern Ethiopia (AUC=0.769; 95% CI: 0.711–0.827, p<0.001 in men and AUC=0.766; 95% CI: 0.695–0.837, p<0.001 in women) (Kawamoto *et al.* 2020; Dereje *et al.* 2021).

The disparity in results likely stems from racial variations, which could affect body stature

Table 3. Cut off values of baseline WHtR to predict hypertension in the cross-sectional

Subject	n	Cut off	Youden index	Se	Sp	PPV	NPV	Accuracy
Men	993	0.508	0.231	0.709	0.521	0.555	0.680	0.607
		0.513	0.231	0.676	0.555	0.561	0.670	0.610
Women	1177	0.597	0.217	0.563	0.653	0.594	0.624	0.610

Youden index test significantly at p<0.05; Se: Sensitivity; Sp: Specificity; PPV: Positive Predictive Value; NPV: Negative Predictive Value measurements. Based on an analysis of 837 population-based studies (n=7.5 million), South Asia exhibited the highest mean WHtR for men and women. Mean values were marginally lower in Latin America and the Caribbean, Central Asia, the Middle East, and North Africa. In contrast, the lowest mean WHtR was found in Central and Eastern Europe for both sexes, in high-income Western countries among women, and in Oceania among men (Zhou *et al.* 2024).

Dereje *et al.* (2021) explored the utility of various body measurements—including BMI, WC, WHR, and WHtR—for identifying hypertension risk among employees in southwestern Ethiopia. Their analysis revealed that, among the tested metrics, WHtR was the most predictive variable, achieving an AUC of 0.769 for men and 0.766 for women. However, despite this relative superiority, the study concluded that the tool's overall accuracy was low. The optimal cutoff points were 0.51 and 0.52 for males and females, respectively. The findings of that study were taken into consideration in our evaluation of the effectiveness of WHtR as a predictor of hypertension risk. As illustrated in Figure 1 and 2, our results demonstrated that the AUC values for both men and women showed comparable performance consistent with the previous studies, though still has limited discriminative accuracy.

The WHtR has emerged a valuable anthropometric indicator for estimating hypertension risk across diverse populations in Indonesia. Unlike BMI, which does not account for fat distribution, WHtR more accurately reflects central adiposity—a major contributor to hypertension and cardiovascular disease (Mulyasari & Pontang 2018). Evidence from multiple studies supports its predictive power. A cross-sectional study among medical students in Jakarta identified WHtR as superior to BMI, with an optimal cutoff of 0.49 and an AUC of 0.774 compared to BMI's 0.452 (Winata *et al.* 2022). Similarly, research in Yogyakarta adolescents found WHtR=0.45 to be the best balance of sensitivity (76%) and specificity (74%) for detecting elevated blood pressure, supporting its use as an early screening tool in younger populations (Febriana *et al.* 2015). Further, a study in Cimahi City reported an AUC of 0.66 with a suggested cutoff of 0.56, reinforcing WHtR's utility for community-level screening (Faisal & Syarif 2019).

The advantage of WHtR lies in its consideration of both waist circumference and height. Shorter individuals, for instance, are more prone to central fat accumulation, higher cholesterol, and elevated systolic blood pressure than taller individuals (Nelson *et al.* 2015). This aligns with evidence of an inverse relationship between height and cardiovascular risk factors, including hypertension (Ashtary-Larky *et al.* 2018; Das Gupta *et al.* 2019; Cochran *et al.* 2021). Beyond anthropometry, WHtR is biochemically linked to metabolic and inflammatory pathways: higher WHtR values correlate with lower adiponectin levels and higher concentrations of leptin and IL-6 in women with abdominal obesity (Noer *et al.* 2022). These associations further support its role as both a practical measurement and a proxy for underlying pathophysiological processes.

Despite BMI widespread correlation with key metabolic markers, including fasting blood glucose, blood pressure, waist circumference, visceral fat, body water content, and body fat percentage (Nuryani *et al.* 2025), WHtR provides a clearer picture of visceral fat distribution, which is more closely related to elevated blood pressure. While WHtR cutoff may varies depending on the population, WHtR consistently demonstrated reliability as an early predictor for hypertension risk in adolescents, working adults, women with abdominal obesity, and pre-elderly individuals (Febriana *et al.* 2015; Faisal & Syarif 2019; Noer *et al.* 2022; Winata *et al.* 2022).

As hypertension prevalence remains high in aging population (Asian Development Bank *et al.* 2025), adopting WHtR as a screening criterion would help identify high-risk individuals earlier, allowing for timely lifestyle interventions such as dietary modification, increased physical activity, and smoking or alcohol reduction programs. The observed sex-specific cutoff values (0.513 for men and 0.597 for women) further suggest differences in fat distribution and physiological responses, which should be considered in developing targeted screening strategies especially in pre-elderly individuals in Indonesia. Moreover, the public health message of maintaining a waist circumference less than half of one's height is simple and memorable, making it a powerful tool for raising awareness and motivating behavioral change across different population groups.

Nonetheless, certain methodological limitations must be acknowledged. Its cross-sectional design did not prove causation, and the threshold values identified may not be generalizable across all Indonesian ethnic groups or other age categories. As it utilized secondary data from the ILAS, the analysis was restricted to available variables, confounding from variables not included in the analysis, such as individual dietary patterns, physical activity, and medication use, remains a possibility that could influence the results. No multivariate analysis was performed to control for potential confounders; thus, the observed associations were based on unadjusted comparisons. In addition, blood pressure was measured only once, which may not reflect long-term hypertension status. Lastly, although ILAS included nine provinces representing major regions of Indonesia, the findings may not fully capture all regional or ethnic differences.

Despite these limitations, this study offers important strengths and contributions. The inclusion of participants from multiple provinces across major Indonesian islands enhances the representativeness of the findings. In addition, sex-stratified analyses provided valuable insights into potential gender differences in the performance of anthropometric indicators for hypertension screening. The present findings also strengthen the evidence base for using WHtR as a practical, sensitive, and cost-effective tool to identify individuals at risk of hypertension, particularly in pre-elderly populations. As it said in previous studies, its simplicity, affordability, and sensitivity make it especially valuable in resource-limited settings, where early detection and timely intervention are crucial to preventing cardiometabolic disease (Ashtary-Larky *et al.* 2018; Dereje *et al.* 2021).

CONCLUSION

WHtR may serve as a useful indicator for predicting hypertension among pre-elderly individuals in Indonesia with higher cutoff values observed in women (0.597) than in men (0.513). It is recommended that the WHtR be considered for inclusion in primary care screening protocols as a simple and effective indicator for early detection of hypertension risk among pre-elderly adults. To our knowledge, this study is the first conducted among pre-elderly individuals in Indonesia. Future research is warranted to compare pre-elderly individuals across different ethnic group or to extend the investigation to elderly populations in order to validate the use of WHtR for hypertension detection in Indonesia.

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DECLARATION OF CONFLICT OF INTEREST

The authors have no conflict of interest.

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