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ORIGINAL ARTICLE

# Relationship between Body Mass Index and Waist Circumference with Isolated Systolic Hypertension in the Elderly

## Hubungan antara Indeks Massa Tubuh dan Lingkar Pinggang dengan Kejadian Hipertensi Sistolik Terisolasi pada Lansia

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## ABSTRACT

### Background

Globally, it is estimated that 15% of the elderly had isolated systolic hypertension (ISH). ISH in the elderly may occur because of the aging process or other risk factors, such as obesity. Obesity is divided into total obesity which is measured by body mass index (BMI), and abdominal obesity which is measured by waist circumference (WC). The difference in these measurement parameters made this study aim to determine the relationship between BMI and WC with the incidence of ISH in the elderly.

### Methods

The study was an analytical observational cross-sectional method and used a consecutive sampling technique with the samples aged ≥ 60 years old that had ISH. The research measured blood pressure, weight, height, and waist circumference. The data was analyzed by Rank Spearman test for the relationship between BMI with the incidence of ISH and Chi-Square test for the relationship between waist circumference with the incidence of ISH, with α values for both tests being 0,05.

### Results

The samples in this study were 110 elderlies with the most criteria being young elderlies (60%), female gender (67,3%), work as farm worker/farmer (41,8%), ISH grade I (66,4%), obesity (36,4%), and abdominal obesity (54,5%). There was no relationship between BMI with the incidence of ISH in the elderly (p= 0,827) but had a relationship between waist circumference with the incidence of ISH in the elderly (p= 0,001).

### Conclusions

BMI as an indicator of total obesity is not associated with the incidence of ISH in the elderly, but waist circumference as an indicator of abdominal obesity shows a relationship with the incidence of ISH in the elderly.

**Keywords**: body mass index (BMI); waist circumference; isolated systolic hypertension (ISH); elderly

## ABSTRAK

**Latar Belakang**

Secara global diperkirakan 15% lansia menderita hipertensi sistolik terisolasi (ISH). ISH pada lansia dapat terjadi karena proses menua atau faktor lainnya, seperti obesitas. Obesitas dibagi menjadi obesitas total yang diketahui dari nilai indeks massa tubuh (IMT) dan obesitas abdominal yang diketahui dari nilai lingkar pinggang (WC). Perbedaan parameter pengukuran tersebut menjadikan penelitian ini bertujuan untuk mengetahui hubungan antara IMT dan WC dengan kejadian ISH pada lansia.

**Metode**

Rancangan penelitian adalah observasional analitik metode potong lintang dan teknik sampling *consecutive sampling* dengan sampel penelitian merupakan lansia umur ≥ 60 tahun yang menderita ISH. Penelitian berupa pengukuran tekanan darah, berat badan, tinggi badan, dan lingkar pinggang. Analisis data menggunakan uji korelasi *Rank Spearman* untuk hubungan IMT dengan kejadian ISH dan uji *Chi-Square* untuk hubungan lingkar pinggang dengan kejadian ISH dengan nilai α kedua uji adalah 0,05.

**Hasil**

Jumlah responden penelitian adalah 110 sampel lansia dengan kriteria sampel terbanyak adalah lansia muda (60%), jenis kelamin wanita (67,3%), bekerja sebagai buruh tani/petani (41,8%), menderita ISH derajat I (66,4%), mengalami obesitas (36,4%), dan mengalami obesitas abdominal (54,5%). Hasil penelitian menunjukkan tidak adanya hubungan antara IMT dengan kejadian ISH pada lansia (p= 0,827) dan adanya hubungan antara lingkar pinggang dengan kejadian ISH pada lansia (p= 0,001).

**Kesimpulan**

IMT sebagai indikator obesitas total tidak berhubungan dengan kejadian ISH pada lansia namun lingkar pinggang sebagai indikator obesitas abdominal menunjukkan adanya hubungan dengan kejadian ISH pada lansia.


**Kata Kunci**: indeks massa tubuh (IMT), lingkar pinggang, hipertensi sistolik terisolasi (ISH), lansia

## INTRODUCTION

Data from basic health research (Riskesdas) in 2018 stated that the prevalence of hypertension (HT) in Indonesia reached 34.11%, with the highest population suffering from it being the elderly (elderly).[1] One type of HT predominant in the elderly is Isolated Systolic Hypertension (ISH).[2] Globally, it is estimated that 15% of the elderly suffer from ISH.[3]

The definition of ISH is an increase in systolic blood pressure only (SBP> 140 mmHg) with diastolic blood pressure (DBP), which is ≤ 90 mmHg. (3) Meanwhile, the definition of elderly, according to Law Number 13 of 1998, is defined as someone who has entered the age of 60 years.[4]

ISH in the elderly can occur along with the ageing process or be caused by other ISH risk factors.[2] The ageing process experienced by the elderly impacts arterial stiffness, which affects the development of ISH. Stiff arteries cause a decrease in elasticity and recoil of blood vessels.[2,5] Therefore, as a result, blood flowing from the heart experiences flow constraints so that it must increase SBP to circulate blood, but due to the reduced recoil ability of blood vessels causes DBP tends to decrease.[5]

Another risk factor for ISH is obesity. In general, obesity is divided into two types, namely total obesity and central (abdominal/abdominal) obesity.[6] The evaluation of total obesity was performed using the body mass index (BMI), while the evaluation of abdominal obesity was carried out using waist circumference (WC).[6] Research conducted by Ukawa et al. (2015) stated that someone with a body mass index (BMI) > 25 could not significantly increase the incidence of ISH.[7] Another study by Lin et al. (2019) stated that obesity indicators (BMI, WC, and body fat percentage) did affect blood pressure (BP) in the elderly > 65 years, but in this study, the effect of WC (abdominal obesity indicator) on increasing blood pressure was higher than BMI (an indicator of total obesity).[8]

Both types of obesity can influence the occurrence of ISH from different pathophysiologies. BMI values in the obese category tend to require more oxygen to meet the body's metabolic needs and excess fat.[9] This can increase the formation of reactive oxygen species (ROS), which impacts the risk of atherosclerosis and vascular stiffness, thereby increasing the risk of ISH.[2,10] The WC value indicating abdominal obesity can also affect the incidence of ISH. This is because the increased production of free fat can affect organs around the abdomen and increase the risk of atherosclerosis. This causes the risk of vascular stiffness to increase and leads to the occurrence of ISH.[2,6]

Saeed et al. (2013) in his study stated that WC was better at predicting ISH than BMI.[11] Likewise, the study of Mehmood et al. (2017) obtained research results that indicator of abdominal obesity (WC) correlated better with the index of arterial stiffness and blood pressure than BMI .[12]

Based on this background, it is known that the possibility of increasing age and obesity (total and abdominal) can increase the risk of atherosclerosis and stiffness of blood vessels which affect the incidence of ISH and the degree of ISH itself. Furthermore, the parameter measurement value between total obesity and abdominal obesity is known to use different indicators, total obesity with BMI while abdominal obesity with WC. Because of the differences in these measurement parameters, the researchers intend to research the relationship between BMI and WC with the incidence of ISH in the elderly, especially in the working area of the Margorejo Health Center.

## METHODS

### Research Design

The design of this study was an analytic observational cross-sectional method with a consecutive sampling technique. The sample size calculation is done using the Slovin formula, so the required sample size is 110. The research took place in September – December 2021 after ethical clearance (EC) was issued from KEPK FK Unimus No.120 /EC/FK/2021.

### Research subject

The research sample was elderly aged ≥ 60 who suffered from ISH in several elderly posyandu in the working area of the Margorejo health center. In this study, 3 locations of the elderly posyandu were used. Exclusion criteria include respondents suffering from kidney disease/abnormalities/DM/edema/ascites, consuming alcohol, smoking, former athletes, and uncooperative respondents.

**Research variable**

This study used BMI and WC as independent variables and the incidence of ISH in the elderly as the dependent variable. BMI is assessed by measuring body weight (BW) and height (BH) and then calculated using the formula BW/BH (kg/m2). BW was measured using a digital scale with an accuracy of 0.1 kg, while BH was measured with a microtoise with an accuracy of 0.1 cm. Furthermore, BMI is classified into four measurement results (kg/m2) according to the Asia Pacific BMI classification, namely obesity (≥ 25), overweight (23–24.9), normal (18.5–22.9), and underweight (<18,5).[13]

WC was assessed using a measuring tape that was looped around the skin of the abdomen through the most distended part of the abdomen in the respondent's position, standing straight and breathing normally.[14] The results of WC measurements in the form of numbers (cm) were then classified as abdominal obesity (Men > 90, Women > 80) or not abdominal obesity (Men ≤ 90), Women ≤ 80).[13]

The ISH assessment measures blood pressure using a digital tensimeter while sitting upright and calm enough before measurement. It is said ISH if SBP > 140 mmHg and DBP ≤ 90 mmHg. (3) Classification of ISH (mmHg) is divided into 3 degrees, namely ISH III (≥ 180/<90), ISH II (160-179/<90), and ISH I (140-159/ <90).[15]

Respondents in this study were elderly aged ≥ 60 years who were then classified into three groups of elderly (years) based on the Indonesian Central Bureau of Statistics, namely old elderly (≥ 80), middle elderly (70–79), and young elderly (60–69).[4]

Research data collection was carried out by local researchers and health workers (village midwives and posyandu cadres).

**Research Analysis**

Data analysis used the Rank Spearman correlation test for the relationship between BMI and the incidence of ISH and the Chi-Square test for the relationship between waist circumference and the incidence of ISH, with the α value of both tests being 0.05.

**Ethical Clearance**

Ethical Clearance issued from KEPK FK Unimus No.120 /EC/ FK/ 2021.

## RESULTS

**Characteristics of the Research Sample**

From the results of the study, it was found that the characteristics of most of the respondents were young elderly (60-69 years) as much as 60%, suffered from ISH degree I (66.4%), had a BMI value in the obesity category (36.4%) and had a WC in the abdominal obesity category. (54.5%). The characteristics of the respondents can be seen further in table 1.

Table 1. Characteristics of Respondents

| Variable | Frequency (n) | Percentage (%) |
|---|---|---|
| **Age Category (Years)** [4] | | |
| Old Elderly (≥80) | 9 | 8,2 |
| Middle Elderly (70-79) | 35 | 31,8 |
| Young Elderly (60-69) | 66 | 60 |
| **Gender** | | |
| Male | 36 | 32,7 |
| Female | 74 | 67,3 |
| **Occupation** | | |
| Farmer/Farmer | 46 | 41,8 |
| Entrepreneur / Trader | 22 | 20,0 |
| Light Worker | 4 | 3,6 |
| Retired/Not Working | 38 | 34,6 |
| **ISH category** | | |
| ISH III | 12 | 10,9 |
| ISH II | 25 | 22,7 |
| ISH I | 73 | 66,4 |
| **BMI Category** | | |
| Obesity | 40 | 36,4 |
| Overweight "at risk" | 26 | 23,6 |
| Normal | 36 | 32,7 |
| Underweight | 8 | 7,3 |
| **WC category** | | |
| Abdominal Obesity | 60 | 54,5 |
| Not Abdominal Obesity | 50 | 45,5 |
| **Longtime Suffering ISH** | | |
| >5 years | 21 | 19,1 |
| >3 years | 27 | 24,5 |
| >1 years | 29 | 26,4 |
| <1 years | 33 | 30,0 |
| **ISH Treatment History** | | |
| Amlodipine | 37 | 33,6 |
| Captopril | 30 | 27,3 |
| unknown | 43 | 39,1 |

ISH: Isolated Systolic Hypertension, BMI: Body Mass Index, WC: Waist Circumference.

**The Relationship between BMI and WC with ISH Incidence in the Elderly**

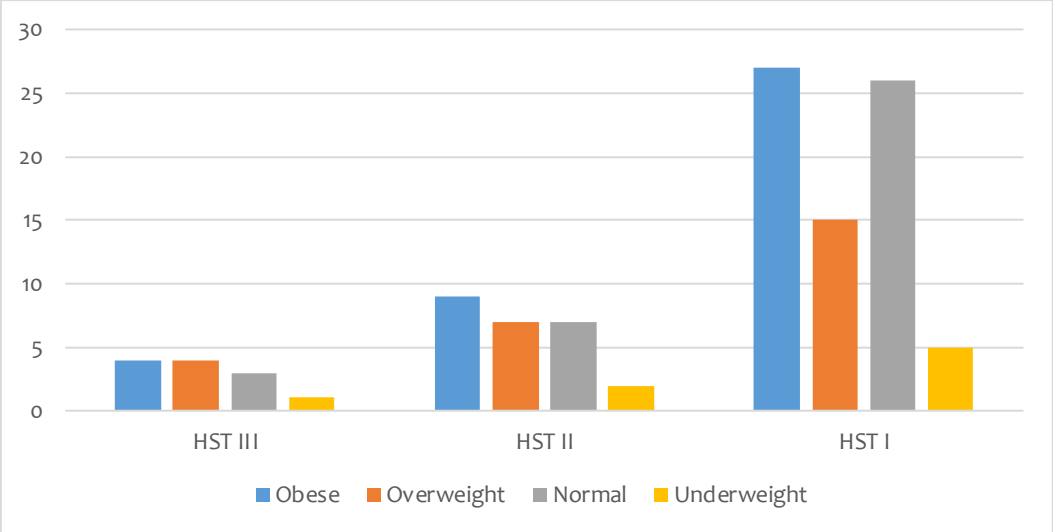
The relationship between BMI and WC and the incidence of ISH in the elderly results can be seen in table 2. The p-value in the test of the relationship between BMI and ISH in the elderly using Spearman's Rank test is 0.827, which means there is no relationship between the two variables. In this test, it was also known that the highest frequency distribution was for respondents with obese BMI and suffering from ISH degree I (24.5%).

Relationship between WC and the incidence of ISH in the elderly using the Chi-Square test, it is known that the value of p=0.001 means that there is a relationship between WC and the incidence of ISH in the elderly. The frequency distribution by connecting the two variables shows that the highest frequency is the respondent with abdominal obesity, especially those who suffer from ISH I (28.2%).

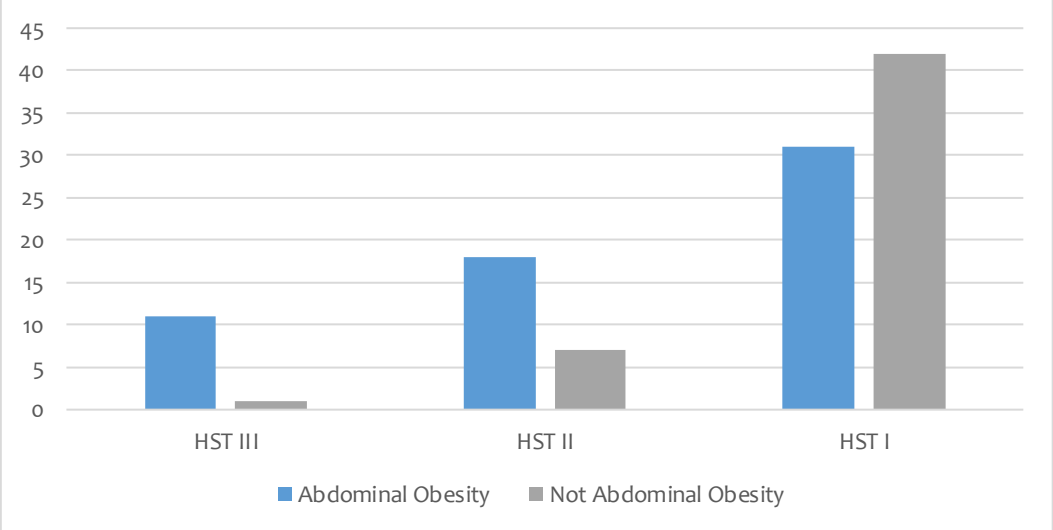
Table 2. Relationship between BMI and WC with ISH Incidence in the Elderly

| Variable | The incidence of ISH in the elderly | | | | | | | | p-value |
|---|---|---|---|---|---|---|---|---|---|
| | ISH III | | ISH II | | ISH I | | Total | | |
| | N | % | N | % | N | % | N | % | |
| **Body Mass Index (BMI)** | | | | | | | | | |
| Obesity | 4 | 3,6 | 9 | 8,2 | 27 | 24,5 | 40 | 36,4 | |
| Overweight "*AtRisk*" | 4 | 3,6 | 7 | 6,4 | 15 | 13,6 | 26 | 23,6 | 0,827 * |
| Normal | 3 | 2,7 | 7 | 6,4 | 26 | 23,6 | 36 | 32,7 | |
| Underweight | 1 | 0,9 | 2 | 1,8 | 5 | 4,5 | 8 | 7,3 | |
| **Waist Circumference** | | | | | | | | | 0,001 ** |
| Abdominal Obesity | 11 | 10,0 | 18 | 16,4 | 31 | 28,2 | 60 | 54,5 | |
| Not Abdominal Obesity | 1 | 0,9 | 7 | 6,4 | 42 | 38,2 | 50 | 45,5 | |

*Spearman's Rank test
**Chi- Square test




Graph 1. Relationship between BMI and ISH Incidence in the Elderly




Graph 2. Relationship between WC and ISH Incidence in the Elderly

## DISCUSSION

### Characteristics of Respondents

The results showed that most respondents were young and elderly, and most suffered from ISH degree I. This was in line with the research by Bavishi et al. (2016), which stated that arterial stiffness could increase the incidence of ISH and its degree with age.[2] Selection of respondents with female gender can also affect the incidence of ISH in the elderly. This is because women who experience menopause experience a decrease in the hormone estrogen, which can affect the protective effect of the vascular endothelium, making it easier for blood pressure to increase.[16,17]

The respondent's work/routine also affects blood pressure. Research by Hu et al. (2004) stated that 30 minutes of moderate-intensity activity, such as gardening, done by most respondents, swimming, cycling, or brisk walking, can maintain body weight and blood pressure.[18] The level of physical activity is known to have a negative relationship with blood pressure, where the high level of physical activity affects the decrease in blood pressure.[19] The results of this study indicate that most respondents are still actively working, and most of them work as farmers/farm laborer, with the highest frequency of respondents suffering from ISH degree I. Therefore, it is likely that the respondents in the study experienced ISH with a low degree due to compensation for the profession that the respondent still carried out.

In this study, the highest percentage of respondents was obese. The mechanism for ISH in obese individuals can be caused by increased cardiac output to meet the demand for oxygen and nutrients throughout the body's tissues, which can also increase SBP.[9] In addition, increased oxygen demand can induce ROS formation, which increases the risk of atherosclerosis so that it occurs more quickly. ISH.[20] Even so, few respondents have a normal BMI/are not obese but suffer from ISH. This may be due to the state of abdominal obesity experienced by many respondents/influenced by the sympathetic nervous system and RAAS.[21] A large number of respondents with abdominal obesity in this study may be due to the tendency for intra-abdominal fat to persist in the elderly even though they are still active at work.[22] The effect of Abdominal obesity on the incidence of ISH can occur through the mechanism of ROS formation or the presence of excess fat metabolism in the abdomen, thereby increasing the risk of atherosclerosis.[6,10]

The duration of suffering from ISH can affect the degree of ISH because age and the development of atherosclerosis can increase calcium and collagen deposits in the blood vessels resulting in a decrease in arterial elasticity and an increase in arterial stiffness in the elderly, which can increase the degree of ISH.[2]

The effect of medical history on the degree of ISH was explained in the study of Bavishi et al. (2016), which stated that diuretic and CCB antihypertensive drugs (such as amlodipine) were the first line used to treat ISH because these classes substantially reduced the risk of stroke and other morbid events. ACEi (such as captopril) and ARBs are second-line treatments for ISH but have less efficacy.[2]

### Relationship between BMI and ISH Incidence in the Elderly

This study's results indicate no relationship between BMI and the incidence of ISH in the elderly. This may be due to the fact that in this study, only 36.4% of respondents were obese and suffered from ISH, while the rest were included in the non-obese category. This is in line with

research by Ukawa et al. (2015), which stated that the incidence of ISH could increase in individuals with BMI values > 25 or obesity.[7]

In obese individuals, there may be an increase in intravascular volume and cardiac output (CO) because the heart works harder to meet the demand for oxygen and nutrients throughout the body's tissues, resulting in a significant increase in SBP. The greater the need for oxygen occurs because, in addition to meeting the needs of tissue metabolism, oxygen is also needed for burning large calories.[9] The increased need for oxygen will also increase oxidation reactions in the body and induce ROS formation. Increased ROS in blood vessels is known to increase vasoconstriction of blood vessels.[20] Increased ROS also triggers LDL oxidation and activates macrophages which cause inflammation and hyperactivation of platelets so that atherosclerotic lesions easily form.[10] The effects of increased ROS on Obese individuals can trigger ISH.[10,20]

The cause of the unrelated BMI with the incidence of ISH in this study could be a large number of respondents with normal/non-obese BMI who also experienced ISH. The distribution of respondents with normal BMI in this study found that some had waist circumferences above normal (abdominal obesity), so ISH could occur through increased ROS by fatty acid metabolism in the stomach. In addition, in this study, there was also a distribution of respondents with normal BMI and not abdominal obesity but suffering from ISH. This can be attributed to the influence of the sympathetic nervous system and RAAS, which can also affect blood pressure.[21]

**Relationship between WC and ISH Incidence in the Elderly**

The relationship test results between waist circumference (WC) and the incidence of ISH show that the two variables are related. This is in line with a study conducted by Saeed (2013) which stated that an obesity indicator of waist circumference could well indicate the incidence of ISH.[11]

The effect of abdominal obesity on the incidence of ISH is known through the mechanism of abdominal fat, which tends to stick to the organs in the abdominal area. Fat metabolism produces free fatty acids, which can affect the performance of surrounding organs, such as the liver, which can increase cholesterol synthesis and increase the risk of atherosclerosis.[6] The presence of fat metabolism in the abdominal area will also increase oxidation reactions in the body and induce ROS formation.[10]

In addition, the influence of abdominal fat can also cause adipokine disturbances and compression of the kidneys. This results in increased activity of the sympathetic nervous system, increased renal sodium reabsorption, increased stimulation of the renin-angiotensin-aldosterone system, and increased risk of atherosclerosis, making it easier for SBP to increase and ISH to occur.[12,23]

**Research Limitations**

This study has limitations, namely the measurement of waist circumference, which is still measured by wearing clothes. Still, even so, efforts have been made according to the guidelines by wearing as little clothing as possible.[14] In addition, the researchers also did not measure the degree of atherosclerosis of the respondents, where it is known that the degree of atherosclerosis affects the degree of ISH.[2]

**Clinical Implications**

The existence of this research is expected to be a reference to increase awareness of the importance of measuring waist circumference as an evaluation of obesity so that the incidence of ISH in the elderly can be well controlled. Evaluation of blood pressure in the elderly should also be monitored routinely because the incidence of ISH has an impact related to cardiovascular disorders (34%), cerebrovascular disorders (33%), and heart failure (24%). A reduction of every ten mmHg SBP in ISH patients can reduce the risk of cardiovascular disorders by 20%, stroke by 17%, heart failure by 18%, and death by 13%.[2]

However, the main risk factor for ISH is increased atherosclerosis, which increases the risk of arterial stiffness. Therefore, it is hoped that future research can directly explain the relationship between the degree of atherosclerosis and the incidence of ISH in the elderly. The degree of atherosclerosis can be measured by determining the ankle-brachial index (ABI) value.[24]

## CONCLUSION

BMI as an indicator of total obesity is not related to the incidence of ISH in the elderly, but waist circumference as an indicator of abdominal obesity shows a relationship with the incidence of ISH in the elderly.

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## AUTHORS CONTRIBUTION

YS: Study concept and design, data collection, analysis and interpretation of results, preparation of manuscripts; S and YT: Concept and study design, analysis and interpretation of results, preparation of manuscripts, and corresponding author.

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## CONFLICT OF INTEREST

There is no conflict of interest between the authors.

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