

## Blood Pressure and Dynamic Balance Impairment in Older Adults: A Cross-Sectional Study

Kadek Andre Yasa<sup>1\*</sup>, Anak Agung Gede Angga Puspa Negara<sup>2</sup>, Ari Wibawa<sup>3</sup>, I Putu Yudi Pramana Putra<sup>4</sup>

<sup>1</sup>Undergraduate and Professional Physiotherapy Program, Faculty of Medicine, Udayana University

<sup>2,3,4</sup>Department of Physiotherapy, Faculty of Medicine, Udayana University

\*Corresponding author: [kadekandreyasa62@gmail.com](mailto:kadekandreyasa62@gmail.com)

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### Abstract

**Introduction:** Older adults ( $\geq 60$  years) are prone to health decline due to degenerative processes, including blood pressure disorders, which can impact postural balance and increase fall risk. This study analyzes the relationship between blood pressure, dynamic balance, and fall risk in older adults in Singapadu Tengah Village, Sukawati District, Gianyar Regency.

**Methods:** This cross-sectional analytical study was conducted from March to December 2024 using total sampling purposive sampling, including 58 older adults meeting the inclusion criteria. Blood pressure was measured with a manual sphygmomanometer, dynamic balance with the Timed Up and Go Test (TUG), and fall risk with the Modified Indonesian Fall Risk Assessment Tool (M-IFRAT). Data were analyzed using descriptive statistics and the chi-square test.

**Results:** The chi-square test showed significant relationships between blood pressure and dynamic balance ( $\chi^2 = 8.080$ ,  $df = 3$ ,  $p = 0.044$ ) and between blood pressure and fall risk ( $\chi^2 = 9.704$ ,  $df = 3$ ,  $p = 0.021$ ). Among participants with stage 1 hypertension, 32.8% had impaired balance, and 27.6% were at high fall risk. In stage 2 hypertension, 100% experienced both conditions. Prehypertensive individuals showed 31.0% impaired balance and 20.7% high fall risk, while those with normal blood pressure had the lowest proportions (3.4% and 1.7%, respectively).

**Conclusion:** Hypertension is significantly associated with dynamic balance impairment and increased fall risk in older adults, with stage 1 hypertension contributing the most.

**Keywords:** older adults, blood pressure, dynamic balance, fall risk

### Introduction

Older adults ( $\geq 60$  years) represent a growing global population, including in Indonesia. This trend impacts various aspects of public health, particularly due to degenerative processes. According to a review by BAPPENAS, the number of older adults in Indonesia is projected to reach 36 million by 2025.<sup>1</sup> In Bali Province, the older adult population in 2022 was 568,380, with 14.27% residing in Gianyar Regency, making Bali the fourth-largest province in Indonesia in terms of the older adult population.<sup>2</sup>

Aging affects health quality, as older adults are more susceptible to degenerative-related issues such as blood pressure disorders and declining dynamic balance, both of which increase the risk of falls.<sup>1</sup> Blood pressure disorders, including hypertension and hypotension, play a crucial role in reducing dynamic balance and increasing fall risk. Hypertension disrupts the body's hemodynamics, affecting proprioceptive and vestibular function, thereby contributing to impaired dynamic balance and a higher fall risk.<sup>3,4</sup> The prevalence of hypertension among older adults in Indonesia is significant, with 63.2% of individuals aged 65–74 years affected, increasing to 69.5% in those over 75 years. In Bali, the prevalence is 29.1%, with Gianyar Regency reporting a 30.1% hypertension rate in 2020.<sup>5,6</sup> Conversely, hypotension reduces cerebral blood flow due to low vascular pressure, impairing the brain's ability to regulate balance and increasing fall risk.<sup>7</sup> The prevalence of balance disorders among older adults in Indonesia ranges from 63.8% to 68.7%, while in Bali, it is estimated at 30–50%.<sup>3</sup>

Several studies have examined the relationship between blood pressure and fall risk; however, few have integrated both hypertension and hypotension in relation to dynamic balance. Additionally, research on this topic in Gianyar Regency remains limited. A study by Yuliati et al. (2021) confirmed a significant association between hypertension and fall risk among older adults but did not include hypotension as a variable.<sup>8</sup> Moreover, local studies on the relationship between blood pressure disorders and dynamic balance are scarce, particularly in Gianyar Regency, Bali, where the prevalence of hypertension among older adults is notably high.<sup>6</sup>

Based on the literature review, the hypothesis suggests that both hypertension and hypotension are associated with decreased dynamic balance and an increased fall risk among older adults. This study aims to analyze the relationship between blood pressure (hypertension and hypotension), dynamic balance, and fall risk among older adults in Singapadu Tengah Village, Sukawati District, Gianyar Regency. The novelty of this research lies in the inclusion of both hypertension and hypotension as predictors of dynamic balance decline and fall risk among older adults. The findings are expected to provide a foundation for preventive interventions in blood pressure management to reduce fall

risk. Additionally, this study aims to serve as an educational resource for healthcare professionals and the community, emphasizing the importance of blood pressure control in maintaining balance and mobility in older adults.

## Methods

This study is an analytical observational study with a cross-sectional approach, aiming to analyze the relationship between blood pressure, dynamic balance, and fall risk in older adults. The research was conducted in Singapadu Tengah Village, Sukawati District, Gianyar Regency, with data collection carried out from March to December 2024 across Banjar Abasan, Kutri, Griya Kutri, Belaluan, and Negari. The study employed total sampling purposive sampling, with a total of 58 older adult participants.

Inclusion criteria were individuals aged 60–80 years, of both genders, with blood pressure categorized as hypertensive, normal, or hypotensive, having a Body Mass Index (BMI) ranging from underweight to overweight, able to communicate, read, and write, and willing to participate by signing informed consent. Exclusion criteria included older adults with musculoskeletal disorders (fractures, lower extremity injuries, osteoarthritis), neurological disorders, vision or hearing impairments, depression, dependence on mobility aids or assistance while walking, and those classified as obese (BMI categories I and II). These criteria were based on literature indicating their potential impact on dynamic balance and fall risk.

The independent variable was blood pressure, measured using a sphygmomanometer and stethoscope and recorded in mmHg. Blood pressure was categorized according to the Joint National Committee-8 (JNC-8) guidelines<sup>9</sup>: normal (<120/80 mmHg), prehypertension (120–139/80–89 mmHg), stage 1 hypertension (140–159/90–99 mmHg), and stage 2 hypertension ( $\geq$ 160/100 mmHg). The dependent variables were dynamic balance and fall risk. Dynamic balance was assessed using the Timed Up and Go (TUG) Test, which has a reliability value of ICC 0.97. A score of <10 seconds indicated normal dynamic balance, while  $\geq$ 10 seconds indicated impaired balance.<sup>10</sup> Fall risk was measured using the Modified Indonesian Fall Risk Assessment Tool (M-IFRAT), with a specificity of 73.26% and a sensitivity of 71.15%. Participants were scored based on responses, with scores of 0, 1, or 3 points. A total M-IFRAT score of  $\geq$ 11 indicated high fall risk, while <11 indicated low fall risk.<sup>11</sup>

Control variables included age and BMI. Age was controlled because aging is associated with central nervous system degeneration, joint deterioration, muscle and bone weakening, all of which contribute to balance disorders.<sup>12</sup> Participants classified as obese were excluded, as excess BMI may impact muscle strength, posture, and balance.<sup>13</sup> Age was verified using an identification card, while BMI was calculated by dividing body weight (kg) by height squared ( $\text{m}^2$ ) and categorized as underweight (<18.5  $\text{kg}/\text{m}^2$ ), normal (18.5–22.9  $\text{kg}/\text{m}^2$ ), overweight ( $\geq$ 23.0  $\text{kg}/\text{m}^2$ ), obesity I ( $\geq$ 25.0–29.9  $\text{kg}/\text{m}^2$ ), and obesity II ( $\geq$ 30.0  $\text{kg}/\text{m}^2$ ).<sup>14</sup>

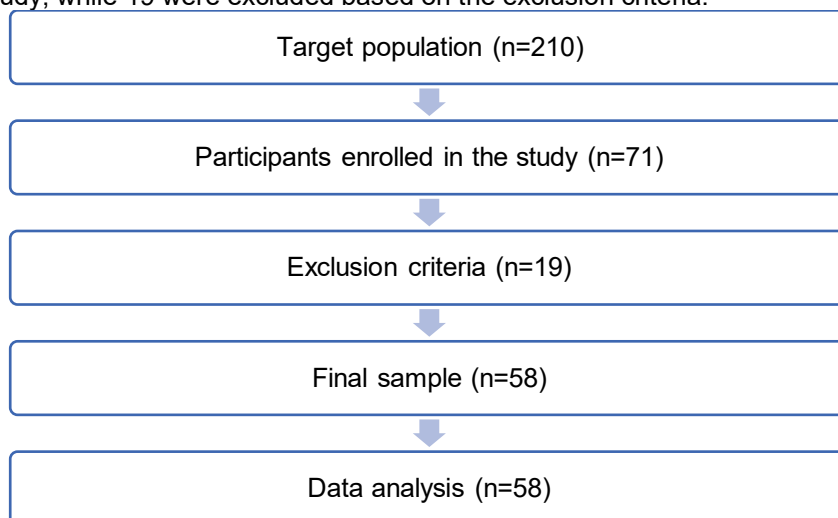
This study obtained ethical approval from the Research Ethics Committee, Faculty of Medicine, Udayana University, under approval number 1141/UN14.2.2.VII.14/LT/2024. Permissions were also obtained from the Singapadu Tengah Village Head and local Banjar leaders. Participants were informed about the study, provided informed consent, and underwent a selection process based on inclusion criteria. Measurements were conducted in sequence: blood pressure assessment, BMI measurement, dynamic balance evaluation, and fall risk assessment.

Data analysis included univariate and bivariate analyses. Univariate analysis described each variable using frequency distribution tables, covering age, gender, blood pressure, BMI, dynamic balance, and fall risk. Bivariate analysis used the Chi-Square test to examine relationships between blood pressure, dynamic balance, and fall risk.<sup>15</sup> Subgroup analysis was conducted based on age and gender to assess specific risk differences. Missing data were handled using mean imputation for  $\leq$ 5% missing data or multiple imputation for >5%, with sensitivity analysis to ensure result consistency. Bias reduction strategies included training the assessment team for measurement consistency, regular calibration of equipment, and standardized measurement procedures for all participants.

## Results

### Sample Characteristics

The subject identification process is illustrated in Figure 1. Out of 210 elderly individuals in the target population, 77 participated in the initial selection process. A total of 58 elderly individuals met the inclusion criteria and were included as respondents in this study, while 19 were excluded based on the exclusion criteria.



**Figure 1.** Subject Identification Process

Among the 210 elderly individuals in the target population, 133 did not participate in the study for various reasons: 85 individuals declined participation, 28 were experiencing acute health conditions, and 20 could not be contacted. Additionally, 19 individuals were excluded based on the exclusion criteria, including 8 individuals over the age of 80, 7 individuals classified as obese based on BMI, and 4 individuals with musculoskeletal disorders.

The sample characteristics include age, gender, BMI, blood pressure, dynamic balance, and fall risk. The univariate analysis provided the frequency distribution of sample characteristics, as shown in the table below:

**Table 1.** Distribution of Respondents' Demographic Characteristics

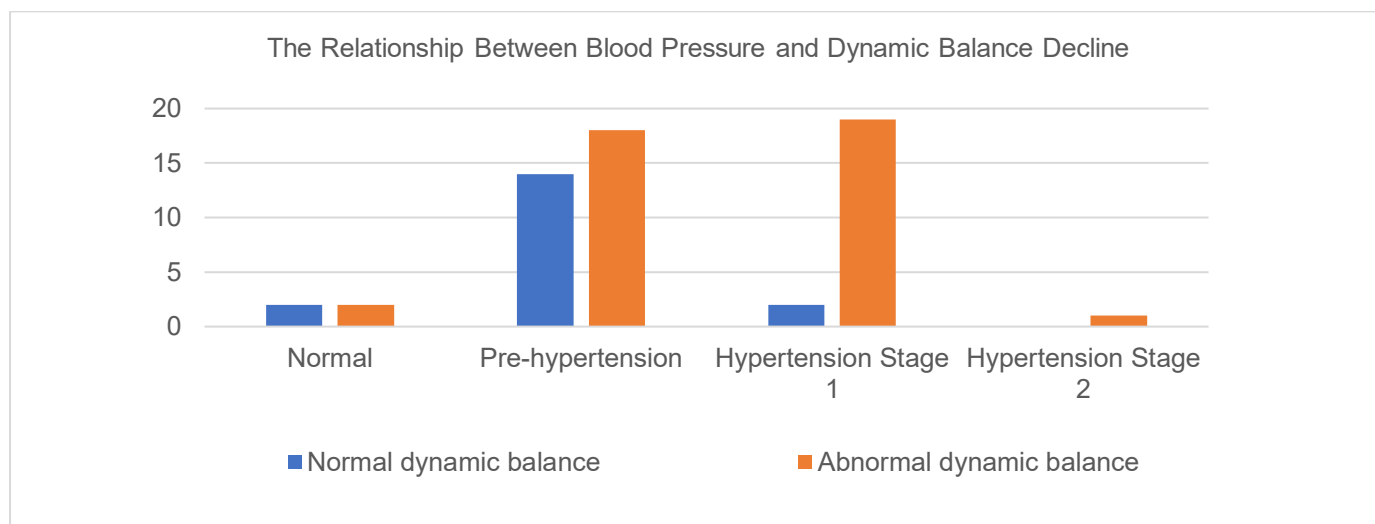
Characteristic	Frequency (n)	Percentage (%)
Age		
60-80 years	58	100.0
Gender		
Male	21	36.2
Female	37	63.8
BMI		
Normal	20	34.5
Overweight	33	56.9
Underweight	5	8.6
Blood Pressure		
Normal	4	6.9
Prehypertension	32	55.2
Hypertension Stage 1	21	36.2
Hypertension Stage 2	1	1.7
Dynamic Balance (TUG Test)		
Normal	18	31.0
Impaired	40	69.0
Fall Risk (M-IFRAT)		
Low risk	28	48.3
High risk	30	51.7

Table 1 shows that all respondents were aged between 60 and 80 years (100%). The majority of respondents were female (63.8%, n=37), while 36.2% (n=21) were male. Regarding BMI, most participants were classified as overweight (56.9%, n=33), followed by normal weight (34.5%, n=20), and underweight (8.6%, n=5).

In terms of blood pressure, the largest proportion of respondents had prehypertension (55.2%, n=32), followed by hypertension stage 1 (36.2%, n=21), normal blood pressure (6.9%, n=4), and hypertension stage 2 (1.7%, n=1). The majority of participants had impaired dynamic balance (69.0%, n=40), while only 31.0% (n=18) had normal dynamic balance. Similarly, 51.7% (n=30) of participants were classified as having a high risk of falling, while 48.3% (n=28) had a low fall risk.

**Table 2.** Relationship Between Blood Pressure and Dynamic Balance (Chi-Square Test)

Blood Pressure	Dynamic Balance Normal (n, %)	$\chi^2$ Impaired (n, %)	df Total (n, %)	p-value
Normal	2 (3.4)	2 (3.4)	4 (6.9)	8.080
Prehypertension	14 (24.1)	18 (31.0)	32 (55.2)	
Hypertension Stage 1	2 (3.4)	19 (32.8)	21 (36.2)	
Hypertension Stage 2	0 (0.0)	1 (1.7)	1 (1.7)	
Total	18 (31.0)	40 (69.0)	58 (100.0)	



**Figure 2.** Distribution of Dynamic Balance by Blood Pressure

Table 2 and Figure 2 present the results of the Chi-square test, which indicate a significant relationship between blood pressure and dynamic balance ( $\chi^2 = 8.080$ ,  $df = 3$ ,  $p = 0.044$ ). This suggests that dynamic balance significantly differs across blood pressure categories. The highest proportion of impaired dynamic balance was observed in individuals with hypertension stage 1 (32.8%) compared to other blood pressure groups.

Table 3. Relationship Between Blood Pressure and Fall Risk					
Blood Pressure	Fall Risk		$\chi^2$	df	p-value
	Low (n, %)	High (n, %)			
Normal	3 (5.2)	1 (1.7)		4 (6.9)	
Prehypertension	20 (34.5)	12 (20.7)		32 (55.2)	
Hypertension Stage 1	5 (8.6)	16 (27.6)		21 (36.2)	9.704
Hypertension Stage 2	0 (0.0)	1 (1.7)		1 (1.7)	
Total	28 (48.3)	30 (51.7)		58 (100.0)	

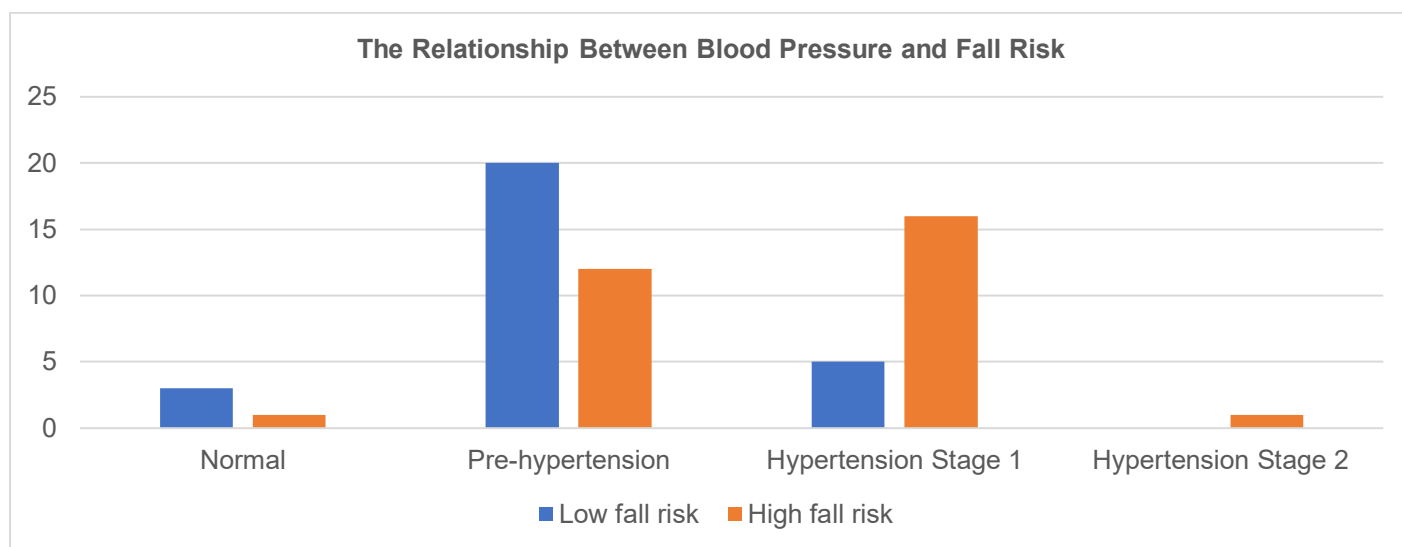


Figure 3. Distribution of Fall Risk by Blood Pressure

Table 3 and Figure 3 show the results of the Chi-square test, which indicate a significant relationship between blood pressure and fall risk ( $\chi^2 = 9.704$ ,  $df = 3$ ,  $p = 0.021$ ). This suggests that higher blood pressure is associated with an increased risk of falling among elderly individuals. The highest proportion of high fall risk was observed in participants with hypertension stage 1 (27.6%) compared to other blood pressure groups.

## DISKUSI

### Karakteristik Sampel Penelitian

The sample measurement was conducted from June 8 to October 19, 2024, using a total sampling purposive sampling method in Singapadu Tengah Village, Sukawati District, Gianyar Regency. Out of 77 elderly individuals screened, 58 met the inclusion and exclusion criteria. The sample consisted of elderly individuals aged 60-80 years, in accordance with the WHO definition and Law No. 13 of 1998, which defines elderly individuals as those aged 60 years and above. This age range was chosen due to its relevance to physical activity and quality of life in older adults, as there is a significant relationship between physical activity and quality of life in individuals aged 60-69 years. In this age group, 55.6% of elderly individuals have a moderate level of physical activity, and 54.2% report a high quality of life.<sup>15</sup>

The majority of the sample were female, with 37 elderly individuals (63.8%), while 21 were male (36.2%). This aligns with 2023 data from the Central Statistics Agency (BPS), which indicates that female life expectancy is higher than that of males.<sup>16</sup> Most of the sample had a BMI in the overweight category (30 individuals, 56.9%), while 20 individuals (34.5%) had a normal BMI, and 5 individuals (8.6%) were underweight. Good dynamic balance was more commonly observed in elderly individuals with a normal or underweight BMI, whereas overweight individuals had a lower risk of falls. Elderly individuals classified as obese were excluded from the study, as obesity could affect the research outcomes. Excessive BMI can lead to decreased muscle strength and mass, postural changes, and balance disorders.<sup>17</sup>

Most of the study sample had pre-hypertension (32 elderly individuals, 55.2%) and stage 1 hypertension (21 individuals, 36.2%). With increasing age, structural changes in large blood vessels occur, such as lumen narrowing and arterial wall stiffness, which can increase the risk of hypertension.<sup>18</sup> The majority of the study sample had abnormal dynamic balance (40 elderly individuals, 69.0%), while 18 individuals (31.0%) had normal balance. Aging leads to degeneration in the central nervous system, joints, muscles, and bones, contributing to balance disorders.<sup>12</sup> Additionally, 51.7% of the sample (30 elderly individuals) had a high fall risk, while 48.3% (28 individuals) had a low fall risk. This aligns with WHO (2021) data, as cited in Fadilah et al. (2024), which states that 28-35% of elderly individuals over 65 experience falls each year, increasing to 32-42% in those over 70 years old.<sup>19</sup>



## The Relationship Between Blood Pressure, Dynamic Balance Decline, and Fall Risk in the Elderly

Falls among the elderly are a major health concern, especially for those with comorbidities such as hypertension. Falls can result in physical injuries and psychological effects, such as depression and fear of falling, which may limit daily activities. Physiologically, hypertension reduces blood vessel elasticity and impairs blood flow to the brain, particularly areas that control balance, such as the cerebellum and basal ganglia, disrupting the brain's ability to integrate sensory and motor information. Elderly individuals with hypertension are more prone to dizziness and instability when walking on uneven surfaces, increasing their risk of falling.<sup>8</sup> Hypertension exacerbates balance disorders by damaging large arteries and reducing microcirculation, leading to sensory information impairment. Elderly individuals with hypertension are more susceptible to orthostatic hypotension, baroreflex dysfunction, and vision problems due to retinopathy, all of which contribute to an increased fall risk.<sup>20</sup>

Balance disorders occur when the body is unable to maintain its position in equilibrium. Optimal body balance is achieved when the center of mass or gravity is directly above the base of support. The nervous system, musculoskeletal system, and contextual effects work together to maintain balance. The nervous system regulates sensory input through the visual, vestibular, and somatosensory systems. The musculoskeletal system supports balance by maintaining postural alignment and flexibility, including joint range of motion (ROM), muscle strength, joint integrity, and sensory perception. Contextual effects act as a mediator between the nervous and musculoskeletal systems, including factors such as surface conditions, lighting, gravitational influence, body inertia, and performed activities. In elderly individuals, sensory system decline (visual, vestibular, and somatosensory) significantly impacts balance maintenance.<sup>21</sup> Elderly individuals with good balance typically have stronger lower extremity muscles, higher physical sensitivity, and quicker responses, reducing fall risk. However, balance declines by approximately 16% per decade due to aging-related decreases in muscle strength and joint flexibility.<sup>22</sup>

The hypothesis test results presented in Tables 2 and 3 indicate a significant relationship between blood pressure and dynamic balance decline, with a p-value of 0.044 ( $p < 0.050$ ), and a significant relationship between blood pressure and fall risk, with a p-value of 0.021 ( $p < 0.050$ ), among elderly individuals in Singapadu Tengah Village, Sukawati District, Gianyar Regency. This study found that elderly individuals with stage 1 hypertension had a higher proportion of abnormal dynamic balance (32.8%) and high fall risk (27.6%) compared to other blood pressure categories. These findings contribute to a broader understanding of the relationship between hypertension and dynamic balance in the elderly. The decline in dynamic balance, leading to an increased fall risk, supports previous literature indicating that hypertension can cause hemodynamic disturbances affecting proprioceptive and vestibular function.

A similar study by Maisura et al. (2024) found a strong correlation between hypertension and fall risk in the elderly, with a p-value of 0.001 ( $p < 0.050$ ).<sup>23</sup> Additionally, research by Yuliati et al. (2021) found that the duration of hypertension was significantly associated with fall risk, with a p-value of 0.000 ( $p < 0.050$ ).<sup>8</sup> This study found a high prevalence of dynamic balance decline and fall risk among elderly individuals in Singapadu Tengah Village, particularly among older age groups and those with hypertension. These findings align with global data from WHO (2021), as cited in Fadilah et al. (2024), stating that fall prevalence among elderly individuals over 65 ranges from 28-35%, depending on region and population studied, with hypertension being a major risk factor for balance decline and fall risk.<sup>19</sup> This has significant public health policy implications, particularly in addressing the high prevalence of hypertension among the elderly. Therefore, comprehensive interventions are necessary to manage blood pressure and prevent falls in elderly individuals. Education on fall risk and prevention strategies, such as balance training and physiotherapy, can serve as effective preventive measures for elderly individuals and their families.

The findings of this study emphasize the importance of screening, managing, and educating elderly individuals about blood pressure disorders to minimize fall risk. Hypertension management in the elderly can be conducted through regular pharmacological and non-pharmacological therapies, including a low-salt, low-fat, high-fiber diet, light physical activity, and educating elderly individuals and their families on the impact of hypertension on balance and fall risk. Additionally, elderly individuals can engage in physical exercises such as yoga, elderly gymnastics, and balance training, which have been proven effective in improving balance and reducing fall risk.<sup>24</sup> Beyond these measures, physiotherapists play a crucial role in prevention and treatment by providing exercises such as deep breathing exercises, which involve diaphragmatic breathing to improve ventilation, strengthen respiratory muscles, and reduce tension in hypertensive elderly individuals.<sup>25</sup> For balance disorders and fall risk, physiotherapists can provide core stability exercises and tandem walking exercises. Core stability exercises focus on controlling body position and movement, including the trunk, pelvis, and legs, to enhance postural control, spinal stabilization, and motor patterns. Tandem walking exercises are proprioceptive training exercises involving controlled movements to help the nervous system analyze body position and regulate muscle contractions, thereby maintaining postural balance.<sup>26</sup>

This study has several limitations. Firstly, it was conducted at a single location, which may limit the generalizability of the findings to the broader elderly population. Additionally, the sampling method used poses a risk of selection bias. Environmental factors, such as social conditions and infrastructure, were not strictly controlled. Moreover, the study design only identifies relationships between variables without establishing causality.

To enhance the validity of future research, objective measurement tools such as force plates or gait analysis should be used to assess balance more accurately. Additionally, employing stronger study designs, such as longitudinal or interventional studies, could provide more robust findings. This would allow for a more precise evaluation of fall prevention strategies in elderly individuals with hypertension.

## Conclusion

This study found a significant relationship between blood pressure and a decline in dynamic balance ( $p = 0.044$ ) as well as between blood pressure and fall risk ( $p = 0.021$ ) among elderly individuals in Singapadu Tengah Village,

Sukawati District, Gianyar Regency. Elderly individuals with stage 1 hypertension exhibited more pronounced balance impairments, likely due to hemodynamic changes affecting proprioceptive and vestibular function.

These findings highlight the importance of early detection and management of hypertension as a preventive measure to maintain balance and reduce fall risk in older adults. Preventive programs incorporating balance-based physical therapy, health education, and regular blood pressure monitoring are highly recommended. Further studies are needed to explore the interaction of other factors, such as lifestyle and physical activity, on balance in elderly individuals with hypertension.

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