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The Role of Gait Parameters in Cardiovascular Health Among Older Adults: A Cross-Sectional Study

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Abstract

Introduction: Gait patterns in older adults change due to aging, particularly in stride length and walking speed. These changes may affect cardiorespiratory parameters such as blood pressure, heart rate, and oxygen saturation. Previous studies indicate that the most noticeable gait parameter changes in older adults are stride length and walking speed. Cardiorespiratory parameters often indicate overall health, including in older adults. The primary cardiorespiratory components relevant to assessing physiological function in older adults include blood pressure, heart rate, and oxygen saturation.
Methods: This cross-sectional study involved 45 older adults selected through purposive sampling in November 2024. The independent variables were stride length and walking speed, while the dependent variables included blood pressure, heart rate, and oxygen saturation. Data were analyzed using Spearman's rho test due to non-normal distribution.
Results: Spearman's rho analysis showed a strong and significant correlation between walking speed and systolic blood pressure ($r = 0.865$, $p < 0.001$) as well as heart rate ($r = 0.659$, $p < 0.001$). However, no significant correlation was found between walking speed and diastolic blood pressure ($r = 0.068$, $p = 0.659$) or oxygen saturation ($r = -0.266$, $p = 0.078$). Stride length did not significantly correlate with blood pressure, heart rate, or oxygen saturation.
Conclusion: Walking speed is strongly associated with systolic blood pressure and heart rate in older adults, whereas stride length does not correlate significantly with the measured cardiorespiratory parameters.

Keywords: Older adults, Stride Length, Walking Speed, Blood Pressure, Heart Rate, SpO_2, Gait Pattern

Introduction

Every living organism undergoes an aging process as part of its growth and development cycle. Aging is characterized by a decline in bodily functions, including motor and sensory abilities, cognitive function, and cardiorespiratory efficiency[1]. These changes impact the quality of life and the efficiency of daily activities in older adults.

Older adults, or the elderly, are defined as individuals aged 60 years or older.[2] According to the *World Population Ageing* Report, the global elderly population reached 703 million in 2019. Meanwhile, Indonesia's Ministry of Health reported that in 2021, the national elderly population was 29.3 million, accounting for 10.82% of the total population. This 10% threshold indicates that Indonesia is entering an aging population structure. The degenerative phase in older adults is marked by reduced physiological, organ, and cognitive functions, making them more vulnerable than younger individuals. One of the most affected functional movements due to aging is gait.[3]

Gait is a cyclic activity that can be divided into several segments or phases. According to Alice Banofey (2015), gait integrates multiple bodily components, including the musculoskeletal system, the nervous system (peripheral and central), organ systems, cognitive function, and external factors such as footwear and walking surface. Additionally, several body segments contribute to this functional movement, including the ankle joint, foot segments, knee joint, hip joint, pelvic segment, spine, and arm swing. In older adults, these declines need to be assessed and analyzed further. Several parameters must be considered when analyzing gait, including walking speed, stride length and width, and step variability.[4] A review of previous literature indicates that the most prominent gait parameter changes in older adults are stride length and walking speed.[4,5]

Movement functions such as walking significantly influence an individual's ability to perform activities of daily living efficiently. However, the quality of cardiorespiratory function also affects efficiency in daily activities. The cardiorespiratory function is defined as the ability of the heart, lungs, and blood vessels to function optimally at rest and during physical exertion by absorbing oxygen and delivering it to active tissues for metabolism. Several parameters can be used to monitor or provide insight into cardiorespiratory function, such as blood pressure, heart rate, and oxygen saturation (SpO_2).[6] Handayani (2022) emphasized that blood pressure, heart rate, and SpO_2 are essential for early and straightforward health evaluations. These three factors can also indicate the intensity of physical activity that the body, including older adults, can tolerate.

No studies in Indonesia, particularly in Bali, have specifically examined the relationship between stride length and walking speed with resting blood pressure, heart rate, and oxygen saturation in older adults. Previous research has primarily focused on the relationship between stride length and balance or cardiorespiratory fitness and movement coordination. This gap warrants further investigation, especially given the high prevalence of these aspects alongside the rising elderly population each year. Although theoretical frameworks suggest that cardiorespiratory health parameters are influenced when older adults engage in physical activities, the specific walking speeds and stride lengths that produce measurable effects remain unclear. Additionally, the magnitude of these effects has not been well established.

Therefore, this study is necessary to determine optimal and safe walking speed and stride length for older adults to compensate for the declining adaptability of the cardiorespiratory system due to aging. Identifying appropriate stride length and walking speed is expected to minimize potential adverse effects and help maintain good health conditions in older adults. These considerations have led researchers to explore the general relationship between stride length and walking speed with resting blood pressure, heart rate, and SpO_2 in older adults.

Thus, this study addresses this research gap by analyzing the relationship between stride length and walking speed with blood pressure, heart rate, and oxygen saturation in older adults.

Methods

This study employed an observational analytic research design with a cross-sectional approach. The cross-sectional design was chosen as this study aimed to examine the relationship between step length and walking speed with blood pressure, pulse rate, and oxygen saturation (SpO_2) at a specific point in time, eliminating the need for long-term observation. Other study designs were deemed less effective compared to the cross-sectional approach. Longitudinal studies require extended durations and pose a high dropout risk among older people, experimental studies necessitate interventions irrelevant to this research, and case-control studies are unsuitable as they do not compare case and control groups. Additionally, cohort studies are inefficient for this research, focusing on future risk rather than the direct relationship between variables. Therefore, the cross-sectional design was deemed more efficient, cost-effective, and practical for older people.

The study was conducted in Banjar Padang Sumbu Kaja, Padangsambian Klod Village, West Denpasar District, Denpasar City, on Tuesday, November 12, 2024, coinciding with the routine activities of the elderly health post (Posyandu Lansia). The minimum required sample size was calculated using Bonett's formula, with an additional 25% to account for potential dropout, resulting in a target sample of 43 individuals. Ultimately, 45 participants meeting the criteria were included in the study.

A total of 45 subjects were selected from the available population on the examination day using purposive sampling. Purposive sampling is a non-random sampling technique that selects subjects based on specific criteria to ensure the collected data is relevant to the research objectives. This method allows researchers to select respondents who meet predetermined criteria, such as age and the absence of health conditions that could influence the results (e.g., cardiovascular or pulmonary diseases). However, using purposive sampling presents certain limitations, including the lack of generalizability to the broader population, as the sample is selected based on specific criteria without randomization, potentially introducing selection bias.

The inclusion criteria for this study were as follows: (1) elderly individuals aged ≥ 60 years, (2) able to walk independently with or without assistive devices, and (3) willing to participate in the study by signing informed consent (7). The exclusion criteria included: (1) individuals with a history of heart disease (e.g., coronary heart disease, heart failure, arrhythmias, or congenital heart disease) identified through auto/anamnesis, (2) individuals classified as obese based on BMI, (3) individuals who smoked more than one pack per day, and (4) individuals unable to perform the required tests due to disability.[4,7,8]. Before the measurements, all subjects were interviewed by the research team regarding their medical history and health conditions on the examination day.

The independent variables in this study were step length and walking speed. Step length refers to the longitudinal distance between two successive placements of the same foot while walking or running.[7,9] It was measured using the 10-Meter Walking Test (10MWT) by calculating the average distance covered divided by the number of steps taken, yielding a final measurement in meters (m).[9] Walking speed is an individual's ability to traverse a specific distance using the lower extremities. It is classified based on age-related average scores regardless of gender.[10]. Walking speed was measured using the 10MWT, with calculations based on the formula: distance divided by time, resulting in a measurement unit of meters per second (m/s).[9] Each participant completed the 10MWT three times, and the average value was recorded to ensure accuracy and reliability.

The dependent variables in this study were cardiorespiratory components, including blood pressure, pulse rate, and oxygen saturation (SpO_2) at rest. Blood pressure was assessed by measuring systolic and diastolic pressure, typically in the brachial area, using either a digital or manual sphygmomanometer. The changes in blood pressure were analyzed by comparing pre-test and post-test values.[11] Pulse rate was measured at baseline and during the resting period after completing the walking test to assess step length and walking speed in elderly participants. Pulse rate was recorded simultaneously with SpO_2 using a fingertip pulse oximeter.[12.] Oxygen saturation was assessed through SpO_2 measurement, which evaluates the body's oxygen levels.[13] All cardiorespiratory measurements were conducted twice, before and after the 10MWT, to determine the changes induced by the test. Participants were instructed to rest before the pre-test measurements to minimize potential bias due to prior physical activity. Blood pressure measurements were taken while participants were seated with their arms supported on a table.

Certain variables, such as hypertension status, smoking habits, and BMI, were controlled in this study. However, potential confounding factors might still introduce bias, including nutritional intake before testing, physical activity before the test, and the consumption of medications (e.g., for vertigo, cholesterol, or insulin). All data collection was conducted by the research team, with assistance from healthcare center (Puskesmas) staff and elderly health post (Posyandu) volunteers, ensuring the safety and well-being of elderly participants. The study was conducted after obtaining ethical approval from the Ethics Committee of the Faculty of Medicine, Udayana University, with approval number 2353/UN14.2.2.VII.14/LT/2024. Additionally, approval was granted by the local community leaders and elderly health post coordinators.

The research process began with obtaining informed consent, guided by the research team. Subsequently, body mass index (BMI) and body weight measurements were taken, followed by anamnesis regarding medical history and health conditions on the examination day. Eligible participants then underwent initial blood pressure, pulse rate, and SpO_2 measurements. Following these assessments, participants completed the 10MWT under the supervision of the research team, with continuous monitoring for any complaints or changes in condition. After completing the 10MWT, post-test measurements of blood pressure, pulse rate, and SpO_2 were taken after a resting period of 1-3 minutes.

The 10MWT is widely used to evaluate gait parameters due to its simplicity and applicability across various age groups. According to Peters, D., in the study titled *Assessing the Reliability and Validity of a Shorter Walk Test Compared with the 10-Meter Walk Test for Measurements of Gait Speed in Healthy, Older Adults* (*Journal of Geriatric Physical Therapy*, 2013), the 10MWT has an intraclass correlation coefficient (ICC) reliability ranging from 0.96 to 0.98. Therefore, the 10MWT was deemed an appropriate tool for assessing gait parameters in this study.

Data analysis was performed using the latest version of SPSS. Univariate analysis was conducted to examine subject characteristics through frequency distribution. Bivariate analysis was also performed to evaluate the relationship between the independent variables (step length and walking speed) and the dependent variables (blood pressure, pulse rate, and oxygen saturation). The Spearman's Rho test was selected for bivariate analysis due to its suitability for ordinal or non-parametric data. Unlike Pearson's correlation test, Spearman's Rho does not require normality assumptions and is more robust against outliers, which is common in physiological data from elderly populations. Given these advantages, Spearman's Rho was this study's most appropriate correlation test. Normality tests were conducted using the Shapiro-Wilk test, which provides greater accuracy for small sample sizes (n≤50).

Results

From the total members of the Posyandu Br. Padang Sumbu Kaja, 88 individuals attended the examination day. However, 43 individuals did not meet the inclusion criteria, which included a history of severe heart disease, inability to walk, obesity, and smoking more than one cigarette per day. Consequently, the final sample consisted of 45 individuals.

The collected data were analyzed using univariate and bivariate analyses. Univariate analysis was performed to examine characteristics such as age, gender, BMI, step length distribution, walking speed, changes in blood pressure, heart rate, and SpO_2 levels.

Table 1. Frequency Distribution of Sample Characteristics

Characteristic	Category	Frequency (n)	Percentage (%)
Age	60-69 years	27	60.0
	70-79 years	12	26.7
	80-99 years	6	13.3
Gender	Male	26	57.8
	Female	19	42.2
Body Mass Index	Underweight	3	6.7
	Normal weight	23	51.1
	Overweight	19	42.2
Walking Speed	Fast	20	44.4
	Normal	4	8.9
	Slow	21	46.7
Step Length	Long	3	6.7
	Normal	5	11.1
	Short	37	82.2
Systolic Blood Pressure Change	< 20 mmHg	19	42.2
	≥ 20 mmHg	26	57.8
Diastolic Blood Pressure Change	< 10 mmHg	29	64.4
	≥ 10 mmHg	16	35.6
Heart Rate Change	> 75% HR Max	5	11.1
	≤ 75% HR Max	40	88.9
SpO_2 Change	< 95%	4	8.9
	≥ 95%	41	91.1

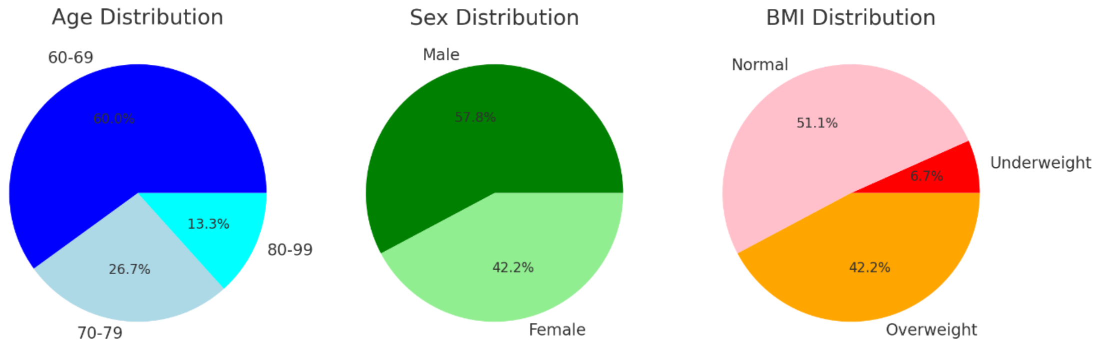

Figure 1. Frequency Distribution of Age, Sex, and Body Mass Index (BMI)

No missing data were identified from the analyzed data, and all participants completed the tests and measurements according to the research protocol. Several cut-off points were applied to continuous variables such as blood pressure, heart rate, and oxygen saturation.

For systolic blood pressure, a cut-off point of 20 mmHg was chosen based on previous studies and clinical standards that consider normal physiological cardiovascular responses. According to the American Heart Association (2018), an increase of more than 20 mmHg is regarded as an indicator of latent hypertension, vascular disorders, or autonomic nervous system dysfunction. For diastolic blood pressure, the classification was divided into two groups: ≥ 10 mmHg and < 10 mmHg, with a cut-off point of 10 mmHg based on cardiovascular and clinical research standards. Pescatello et al. (2004) suggested an increase of ≥ 10 mmHg indicates a significant vascular response to physical activity or other interventions.

Regarding heart rate changes, the American College of Sports Medicine (ACSM, 2021) defines a safe heart rate increase after light activity for older adults as 60-75% of HR Max. An increase exceeding 75% HR Max may indicate cardiovascular deconditioning, meaning the body is unaccustomed to physical activity, requiring the heart to work harder to pump blood. For oxygen saturation, normal levels are considered to be in the range of 95%-100%.

Based on Table 1, most participants (60.0%) were aged 60–69 years, followed by 26.7% aged 70–79 years and 13.3% aged 80–99 years. The sample comprised 26 men (57.8%) and 19 women (42.2%). Regarding BMI, most participants (51.1%) had a normal weight, while 42.2% were overweight and 6.7% were underweight. Regarding walking speed, 46.7% had a slow pace, 44.4% had a fast pace, and 8.9% had a normal pace. Step length was predominantly short (82.2%), with 11.1% having a regular step length and 6.7% having a long step length. Systolic blood pressure increased by ≥ 20 mmHg in 57.8% of participants and by < 20 mmHg in 42.2%, while diastolic blood pressure changes of < 10 mmHg were observed in 64.4%, with 35.6% experiencing changes of ≥ 10 mmHg. Additionally, 88.9% of participants had a heart rate change of ≤ 75% HR Max, while 11.1% had an increase of > 75% HR Max. Most participants (91.1%) had an oxygen saturation level of ≥ 95%, whereas 8.9% had levels < 95%.

Relationship Between Step Length and Blood Pressure in Older Adults

Table 2. Correlation Between Step Length and Blood Pressure

Description	Correlation Coefficient	Sig. (2-tailed)	N
Step Length - Systolic BP	-0.225	0.137	45
Step Length - Diastolic BP	-0.043	0.778	45

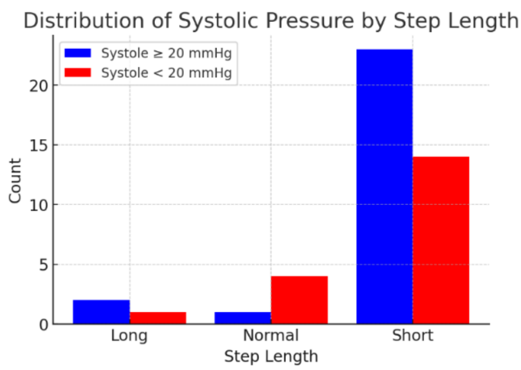

Figure 2. Relationship Between Step Length and Systolic Blood Pressure

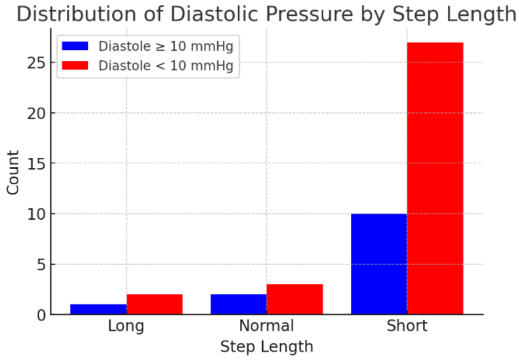

Figure 3. Relationship Between Step Length and Diastolic Blood Pressure

The analysis of 45 samples yielded a correlation coefficient -0.225, indicating a weak negative correlation. This suggests that systolic blood pressure changes tend to decrease as step length increases. However, the significance value of 0.137 (greater than 0.05) indicates that the relationship is not statistically significant. For diastolic blood pressure, the correlation was very weak and negative ($r = -0.043$, $p = 0.778$), suggesting no significant statistical relationship between step length and diastolic blood pressure.

Relationship Between Walking Speed and Blood Pressure in Older Adults

Table 3. Correlation Between Walking Speed and Blood Pressure

Description	Correlation Coefficient	Sig. (2-tailed)	N
Walking Speed - Systolic BP	0.865	<.001	45
Walking Speed - Diastolic BP	-0.068	0.659	45

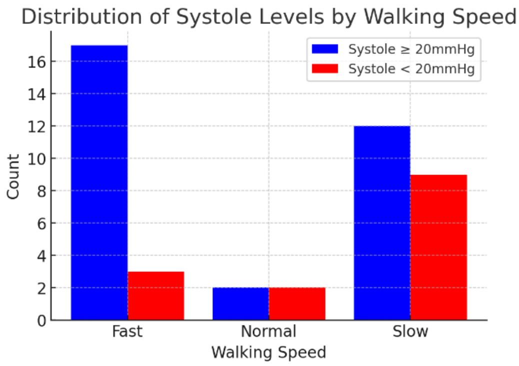

Figure 4. Relationship Between Walking Speed and Systolic Blood Pressure

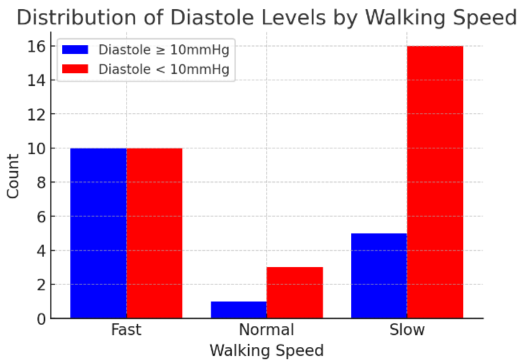

Figure 5. Relationship Between Walking Speed and Diastolic Blood Pressure

A strong positive correlation ($r = 0.865$) was found between walking speed and systolic blood pressure changes, indicating that increased walking speed is associated with more incredible systolic blood pressure changes. The p-value (< 0.001) confirms statistical significance. For diastolic blood pressure, a weak negative correlation was observed ($r = -0.068$, $p = 0.659$), indicating no significant relationship.

Table 4. Relationship Between Step Length and Heart Rate in Older Adults

Description	Correlation Coefficient	Sig. (2-tailed)	N
Step Length – Heart Rate	-0.288	0.055	45

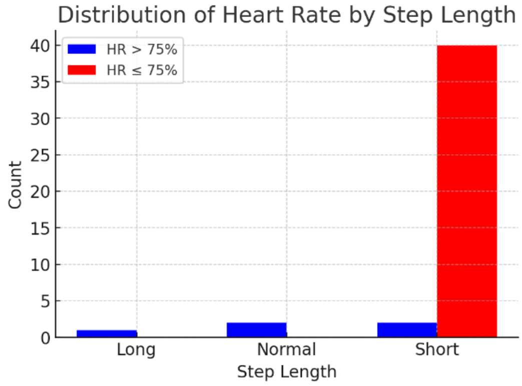

Figure 6. Relationship Between Step Length and Heart Rate

The table shows a correlation coefficient of -0.288, indicating a weak negative correlation between the two variables. This negative relationship suggests that heart rate changes tend to be smaller as step length increases. The significance value of 0.055 (greater than 0.05) indicates that this correlation is not statistically significant.

Table 5. Relationship Between Walking Speed and Heart Rate in Older Adults

Description	Correlation Coefficient	Sig. (2-tailed)	N
Walking Speed – Heart Rate	0.659	<.001	45

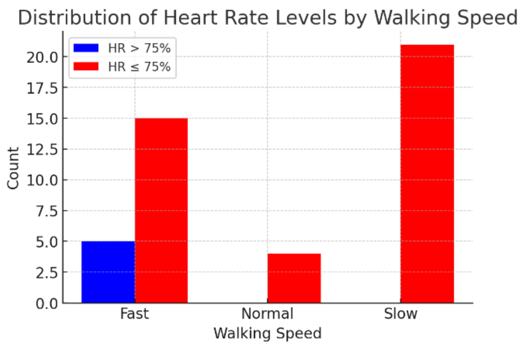

Figure 7. Relationship Between Walking Speed and Heart Rate

Table 5 presents a correlation coefficient 0.659, indicating a strong positive relationship between walking speed and heart rate. This means that as walking speed increases, heart rate also increases significantly. The p-value of <0.001 confirms that this relationship is statistically significant.

Table 6. Relationship Between Step Length and Oxygen Saturation in Older Adults

Description	Correlation Coefficient	Sig. (2-tailed)	N
Step Length – SpO_2	0.038	0.803	45

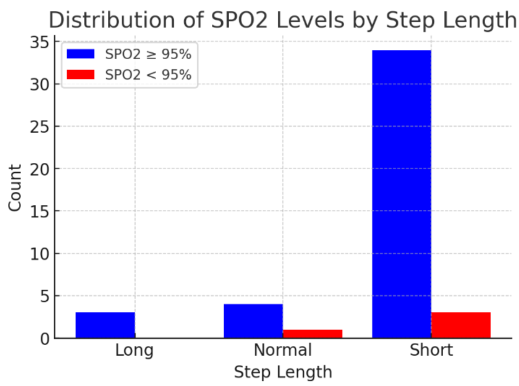

Figure 8. Relationship Between Step Length and Oxygen Saturation

The analysis in Table 6 shows a very weak and statistically insignificant correlation ($r = 0.038$, $p = 0.803$) between step length and oxygen saturation (SpO_2). This suggests that changes in step length have little to no effect on SpO_2 levels.

Table 7. Relationship Between Walking Speed and Oxygen Saturation in Older Adults

Description	Correlation Coefficient	Sig. (2-tailed)	N
Walking Speed – SpO_2	-0.266	0.078	45

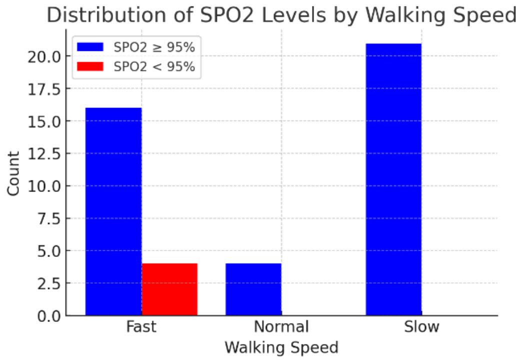

Figure 9. Relationship Between Walking Speed and Oxygen Saturation

As shown in Table 7, the correlation analysis conducted on 45 participants indicates a weak negative relationship between walking speed and oxygen saturation (r = -0.266). This suggests that as walking speed increases, SpO_2 levels tend to decrease. However, the p-value of 0.078 (greater than 0.05) indicates this relationship is not statistically significant.

Discussion

This study examined the relationship between older people's gait patterns and cardiorespiratory components. The analysis results indicate that several independent variables have a strong relationship with their dependent counterparts. The majority of the sample consisted of individuals aged 60–69 years (n = 27; 60.0%), followed by those aged 70–79 years (n = 12; 26.7%) and 80–99 years (n = 6; 13.3%). Demographically, this distribution reflects that the elderly population in Indonesia is predominantly in the 60–69 age group, as mortality rates increase with age, resulting in fewer individuals reaching 70 years and older.[14]

Regarding gender distribution, the sample was dominated by female elderly individuals (n = 26; 42.2%), compared to males (n = 19; 57.8%). This discrepancy is attributed to the longer life expectancy of women and the generally higher risk of diseases among men.[1015]

Based on body mass index (BMI), most participants had a normal weight (n = 23; 51.1%), while 19 individuals (42.2%) were overweight, and three individuals (6.7%) were underweight. This may be due to decreased muscle mass, physical activity, and reduced nutritional intake.[16]

Following the analysis of walking speed, the sample was predominantly categorized as slow, with 21 individuals (46.7%), followed by 20 individuals (44.4%) in the fast category and four individuals (8.9%) in the normal category. According to Spekalski et al. (2024) and Bintang et al. (2020), physiological changes affecting the musculoskeletal system contribute to a decline in walking speed.[17].

The assessment of step length in the sample showed that the majority of older adults had a short step length (37 individuals, 82.2%), while five individuals (11.1%) had a regular step length, and three individuals (6.7%) had a long step length. According to Widiyantari et al. (2023), walking ability depends on muscle strength, which gradually changes with age. Older adults experience alterations in step length while walking as they continue to age.[17,18]

In this study, systolic blood pressure measurements were categorized into two groups: an increase of ≥ 20 mmHg was observed in 26 individuals (57.8%), while a rise in < 20 mmHg was noted in 19 individuals (42.2%). According to the American Heart Association (2018), a systolic blood pressure increase of ≥ 20 mmHg is influenced by several factors, particularly degenerative processes and physiological aging, cardiovascular conditions, and the body's compensatory mechanisms in response to physical activity. A reduction in arterial elasticity is commonly associated with the aging process.[19,20]

A diastolic blood pressure change of ≥ 10 mmHg indicates a significant vascular response to physical activity or other interventions. The lower diastolic cutoff point compared to systolic pressure is based on the diastolic pressure mechanism, which is more stable due to its dependence on peripheral vascular resistance and the blood vessels' ability to relax. Minor variations (< 10 mmHg) are generally regarded as normal fluctuations rather than indications of significant cardiovascular changes.[,21,22]

Heart rate measurements revealed that 40 individuals (88.9%) experienced a heart rate change of ≤ 75% HR Max, whereas five individuals (11.1%) experienced an increase of > 75% HR Max. A heart rate increase exceeding 75% HR Max is primarily due to cardiovascular deconditioning, requiring the heart to work harder to pump blood. An excessive sympathetic response may also lead to an abnormally high heart rate. Autonomic dysfunction, such as dysautonomia, can also impair heart rate regulation.[23,24] The distribution of oxygen saturation characteristics was divided into two groups. The majority of participants (41 individuals, 91.1%) had normal oxygen saturation levels (≥ 95%), while four individuals (8.9%) had levels below 95%. This phenomenon may be attributed to walking being a mild-to-moderate physical activity, which is generally insufficient to cause oxygen desaturation. Other contributing factors may include pulmonary aging-related reductions in lung elasticity; however, physically active older adults tend to maintain good pulmonary function and cardiovascular health, allowing them to sustain adequate blood oxygen levels.[24–26]

Step Length and Blood Pressure

According to Table 2, the correlation coefficient between step length and systolic blood pressure change was -0.225 ($p = 0.137$). This indicates a weak negative correlation, meaning that a longer step length while walking tends to be associated with a decrease in systolic blood pressure. However, this relationship is not statistically significant.

Anderson et al. (2020) explained that a greater step length is associated with improved biomechanical efficiency during walking, allowing for better energy distribution and reducing the cardiovascular system's workload. A longer step length can enhance walking stability, decrease the number of steps per minute, improve muscle movement efficiency, and ultimately reduce stress on the cardiovascular system, preventing spikes in blood pressure. Williams et al. (2022) noted that increased muscle mobility due to a longer step length may stimulate the release of nitric oxide, which plays a role in vasodilation and helps lower blood pressure.[27]

Diastolic blood pressure is more influenced by arterial elasticity than by physical activity. In older adults, arterial elasticity tends to decline, limiting the body's ability to regulate blood pressure in response to physical activity. Diastolic pressure remains more stable during physical activity than systolic pressure due to vascular autoregulation mechanisms. Therefore, in older adults, step length changes are unlikely to affect diastolic blood pressure significantly.[28]

The non-significant effect of step length on blood pressure suggests that other factors, such as age, fitness level, walking technique, and underlying health conditions, may play a more dominant role in blood pressure changes following walking.

Walking Speed and Blood Pressure

A strong correlation was found between walking speed and changes in systolic blood pressure ($r = 0.865$, $p < 0.001$), indicating that the faster a person walks, the more significant the change in their systolic blood pressure. This finding supports previous studies suggesting that the intensity of physical activity influences systolic blood pressure changes following brisk walking.[28] An increase in systolic blood pressure of ≥20 mmHg may occur in individuals with lower fitness levels or those with risk factors for hypertension.

The significant p-value ($p < 0.001$) suggests that walking speed is a statistically significant factor contributing to systolic blood pressure changes in older adults. This relationship can be explained by physiological principles: higher physical activity levels stimulate more active blood circulation due to the body's increased demand for oxygen and nutrient-rich blood. This tendency may also be attributed to increased cardiac output. When walking speed increases, muscles work harder and require more oxygen, prompting the heart to respond by increasing heart rate (HR) and stroke volume (SV), or the amount of blood pumped per beat. Increased cardiac output results in a greater volume of blood being pumped into the arteries within a short period, leading to a rise in systolic blood pressure.[29]

In contrast to systolic pressure, walking speed showed a weak negative correlation with diastolic pressure ($r = -0.068$, $p = 0.659$), indicating no statistically significant relationship between the two variables. The vasodilation mechanism may explain this lack of association during physical activity. Diastolic pressure tends to remain relatively stable during moderate to intense aerobic activity due to compensatory responses from the parasympathetic nervous system, which regulates blood vessel relaxation following the heart's contraction phase.[12]

For individuals with healthy and elastic blood vessels, diastolic pressure remains more stable during physical activity. However, those with greater arterial stiffness may experience more significant fluctuations in diastolic pressure.[28] In this study, diastolic pressure remained stable despite increased walking speed. According to Seals & Chase, the aging cardiovascular system undergoes adaptive changes, including reduced responsiveness to the sympathetic nervous system and enhanced vascular relaxation due to increased nitric oxide (NO) release. This suggests that while physical activity raises systolic pressure, diastolic pressure remains more stable in older individuals due to more active compensatory mechanisms. Other studies have also found that blood pressure responses to physical activity are more pronounced in systolic rather than diastolic pressure in older adults. Additionally, diastolic pressure stability can serve as an indicator of vascular health. Individuals whose diastolic pressure remains stable during physical activity likely have good blood vessel elasticity, an essential factor in preventing cardiovascular disease.

Step Length and Heart Rate

The findings of this study align with those of Bächer et al. (2020), who reported that physical changes such as step length can influence heart rate, particularly in older adults. It was found that elderly individuals with shorter step lengths tend to have higher heart rates, as their bodies must exert more effort to compensate for age-related declines in physical capacity. When taking shorter steps, older adults consume more energy during activities, causing their bodies to work harder and increase their heart rate. In other words, a shorter step length may indicate reduced muscle strength, balance issues, or lower endurance, which can impact cardiac performance during physical activity.[30].

This study's analysis revealed a significance value of 0.055, slightly above the 0.05 threshold, indicating that the relationship between step length and heart rate is not statistically significant. This result may be influenced by variations in sample size ($N = 45$), which may not fully represent the broader elderly population. Other factors could also contribute to this finding, as suggested by Tzeng et al. (2018), who examined the relationship between walking posture and heart rate in older adults. Their study found that good walking posture was associated with lower heart rates during physical activity, suggesting that posture may influence step length, which affects heart rate. This highlights the complexity of the interactions among various physical factors.

Additionally, the intensity of daily activity may play a role in these findings. Bougherara et al. (2022) noted that lower-intensity activities, which allow for longer step lengths, tend not to increase heart rate significantly. Underlying health conditions may also influence the relationship between heart rate and step length during walking. Almeida et al.

(2020) conducted a study measuring heart rate and step length in elderly individuals with diabetes, emphasizing the need for tailored exercise programs for older adults with specific health conditions.[3131,32]

Walking Speed and Heart Rate

Research findings indicate a significant and strong negative correlation between walking speed and heart rate (r=-0.667, p<0.001), meaning that the less time an individual takes to cover a distance, the higher their heart rate increases.

Regarding speed, oxygen demand rises when a person increases their walking pace because active muscles require more oxygen.[33] The heart pumps blood faster to meet this demand, increasing heart rate. Simultaneously, sympathetic activity increases as the sympathetic nervous system is stimulated during intense activity, contributing to an elevated heart rate.[34] Previous research by Bächer et al. (2020) also supports these findings, stating that increased physical activity intensity, such as brisk walking, contributes to an increased heart rate in older adults.[3035]

Thus, the relationship between walking speed and heart rate in older people is significant. These findings provide a strong foundation for developing exercise programs and health monitoring strategies for older adults. Awareness of the impact of walking speed on cardiovascular health is crucial in designing effective interventions to improve the quality of life in older people.

Step Length and Oxygen Saturation

The analysis of the relationship between step length and oxygen saturation revealed a very weak and non-significant correlation (r=0.038, p=0.803). This result indicates that step length does not have a meaningful impact on oxygen saturation in older adults.

Oxygen saturation measures the amount of oxygen bound to hemoglobin in the blood. In this study, the weak relationship between step length and oxygen saturation suggests there is no substantial evidence to indicate that changes in step length among older people affect their oxygen intake during physical activity.

These findings align with research conducted by Widyastuti et al. (2022) on the relationship between physical activity, blood pressure, and oxygen saturation in older adults in Batubulan Kangin Village. Their study found a significant relationship between physical activity and blood pressure but no significant relationship between physical activity and oxygen saturation. This suggests that the level of physical activity, including variations in step length, does not directly influence oxygen saturation in older people.[36]

Several other factors may affect an individual's oxygen saturation. For instance, lung function tends to decline with age due to reduced elasticity and capacity, affecting gas exchange efficiency. However, light to moderate physical activity may not be sufficient to impact oxygen saturation significantly. Another factor is hemoglobin levels; low hemoglobin can reduce the blood's capacity to transport oxygen, but this is more influenced by nutritional status and overall health than step length. A study by Smith et al. (2018) found that although physical activity impacts oxygen saturation, there is no significant relationship between step length and oxygenation in elderly populations. They suggested that variations in breathing techniques and individual health conditions play a more critical role. In studies observing average oxygen saturation in older adults engaging in various physical activities, findings indicate that higher-intensity activities affecting both speed and step length do not always result in increased oxygen saturation, particularly in individuals with pulmonary diseases.[30]

Walking Speed and Oxygen Saturation

A weak negative correlation was found between walking speed and oxygen saturation (r=-0.266, p=0.078). Although there is a tendency for oxygen saturation to decrease as walking speed increases, this relationship is not statistically significant. The negative correlation suggests that the higher an elderly individual's walking speed, the lower their oxygen saturation.

Oxygen saturation decline may be attributed to several conditions, such as increased oxygen demand. The body requires more oxygen when walking at a high speed (41). However, in individuals with limited lung capacity, increased activity may decrease gas exchange efficiency, reducing oxygen saturation. Physiological responses during intense physical activity cause muscles to work harder to maintain performance, which may lead to a lower proportion of blood flow to other organs, including the lungs. This can affect detectable oxygen saturation levels. The natural aging process leads to decreased lung elasticity and respiratory muscle strength, impacting gas exchange efficiency and ultimately reducing oxygen saturation (Wulandari et al., 2015). Body Mass Index (BMI) is another factor; research by Sari et al. (2020) found that increased body fat, particularly around the chest and abdomen, can limit optimal lung expansion, thereby decreasing oxygen saturation.[36]

Several other studies on oxygen saturation during physical activity have reported similar findings. Budiman et al. (2021) stated that while physical activity positively affects cardiovascular health, not all individuals show increased oxygen saturation during exercise. This is mainly dependent on lung capacity and physiological adaptation to training.[37] Additionally, studies assessing the relationship between physical activity levels and oxygen saturation in older adults found that oxygen saturation does not always increase with exercise, particularly in individuals with a history of respiratory diseases.[38]

Conclusion

This study found that step length and walking speed significantly influence blood pressure and heart rate in older adults but do not substantially af oxygen saturation (SpO2). Step length showed a weak, negative, and non-significant correlation with systolic and diastolic blood pressure and resting heart rate, suggesting a minimal effect. In contrast, walking speed had a strong, positive, and significant correlation with systolic blood pressure and heart rate, indicating increased cardiac workload at higher speeds. The relationship between walking speed and diastolic blood pressure was weak and non-significant. SpO2 showed a weak, non-significant negative correlation with walking speed, suggesting a slight tendency for oxygen levels to decrease with faster walking.

These findings highlight the need for tailored exercise programs for older adults. Gradually increasing step length may support cardiovascular stability, while higher walking speeds require careful monitoring, especially for those with hypertension or cardiovascular risks. Light aerobic exercises like walking are beneficial for heart and lung health. According to ACSM, older adults should walk at least 30 minutes daily, five times a week, to improve cardiovascular and respiratory function.

Future research should expand sample sizes and measurement methods while exploring additional factors influencing SpO2, such as lung capacity and breathing patterns. Pulmonary-focused interventions, including breathing exercises, may further support oxygen saturation in older adults.

Author Contribution

Putu Ayu Diah Puspita: Conceptualization, methodology, data collection, data analysis, and manuscript drafting.
Putu Ayu Sita Saraswati: Supervision, guidance on research design, and critical review of the manuscript.
Anak Agung Gede Angga Puspa Negara: Supervision, validation, and manuscript editing.

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Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this study.

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Ethics Statement

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Universitas Udayana (Approval No. 0705/UN14.2.2.VII.14/LT/2024). All participants provided informed consent prior to data collection.

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