Relationship between lower extremity muscle strength and postural instability in elderly

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Abstract.
The elderly population represented 11.75% of indonesia's total population in 2023 and will be multiplied in next few years. As the consequences of aging process, functions of organs and physiological body system declining continuously along with advancing age. Decreased lower extremity muscle strength caused by aging have negative impact in the occurrence of postural instability. This study aim to analyze the relationship between lower extremity muscle strength and postural instability in elderly. This research is descriptive quantitative with cross sectional study approach. Samples were selected using purposive sampling technique. The sample consisted of 41 elderly aged 60-70 years. The measuring instrument used to measure lower extremity muscle strength is five times tit to stand test (FTSST) and to measure postural instability using berg balance scale (BBS). Based on this study, the result showed that majority of the elderly (97.5%) had decreased lower extremity muscle strength and (46%) had moderate risk of postural instability and fall. Analysis of the relationship using the pearson correlation and simple linear regression revealed a statistically significant result ($p < 0.001$), indicating a meaningful association between lower extremity muscle strength and postural instability in the elderly. The correlation coefficient ($r = -0.831$) reflects a strong negative inverse correlation, meaning that stronger lower extremity muscle strength is associated with lower postural instability score. The coefficient of determination ($R^2 = 0.690$) analysis showed that lower extremity muscle strength contributes 69% to the occurrence of postural instability in elderly.

Keywords: Lower Extremity Muscle Strength, Postural Instability, FTSST, BBS, Older Adults

1. Introduction

Elderly age represents the final stage of the human life cycle, during this stage elderly undergo aging and various degenerative processes physiologically and morphologically. According to the World Health Organization (WHO), elderly are defined as individuals aged 60 years and above. The aging process is characterized by physiological changes, particularly deterioration within body tissues and multiple organ systems, and contribute to a gradual decline in functional capacity. Advancing age, insufficient physical activity, pain, malnutrition, smoking, declining sleep quality, and chronic diseases are contributing factors to age-related morphological changes in skeletal muscle (Yuan & Larsson, 2023). These changes not only increase vulnerability to diseases but also pose financial challenges due to the growing need for healthcare services (Li et al., 2024).

Along with their aging process, elderly also accompanied by clinical symptoms or geriatric syndromes, instability, characterized by massive sway, and immobility, become less mobile, result increase the risk of falling caused by muscle weakness and less stable gait (Rubenstein, 2006). Stated by World Health Organization (WHO), falls are a serious health problem with a high prevalence of around 28-35% of elderly people aged 65 years experience falls every year and the prevalence rate of fall risk continues to increase with aging. This can lead to injury like fracture, hospitalization, and increasing mortality (Florence et al., 2018).

Degeneration affect changes in the neuromusculoskeletal system, causing loss of muscle mass and reduction of lower extremity muscle strength and increase adipose non-contractile tissue, this phenomenon is referred to as sarcopenia (de Maio Nascimento et al., 2022). Reductions motor unit related to sarcopenia induced denervation of type II fast twitch muscle fiber that are capable of generating greater force, reinnervated with slower type I fibers. This muscle composition changes delay the dynamic production of lower extremity muscle strength during movement (Reid et al., 2014). Greater decline happens in lower-extremity muscle mass than upper extremity in elderly may result from reduced participation in activities of daily living (ADL) and diminished physical activity related to retirement (Chigira, 2025). Transitioning into retirement often leads to the loss of structured daily routines, occupational demands, and adopt more sedentary lifestyles, spending extended periods sitting

or engaging in less physically demanding task. This accelerates age related muscle atrophy and contributes to sarcopenia, which in return increases the risk of balance impairments, fall and functional decline.

Muscles mainly in lower extremity play a important role as base of support and active joint stabilizers by maintaining proper alignment throughout movement. When muscle strength is inadequate, leading to joint instability and consequently elevating the risk of falls (Wang et al., 2025). In the lower extremity, the most affected muscle groups are the plantarflexors and dorsiflexors at the ankle, flexors and extensors at the hip, if changes in muscle strength occur in these group muscles, it will hinder the elderly in carrying out simple daily activities such as getting up from sitting to standing, walking, climbing stairs, and leaning over (Borges et al., 2017). The decline in lower extremity muscle strength among elderly contributes to an increased risk of falls and impairs the ability to maintain balance in both static and dynamic conditions. Weakening of the lower extremity muscles results in shorter and slower steps, with less stable foot placement, thereby increasing susceptibility to balance loss (LaRoche et al., 2011). As a result, when disturbances such as slipping or tripping occur, the response of older elderly to anticipate and restore balance becomes slower and less effective, leading to a greater risk of falls.

Postural control involves the integration of sensory inputs (proprioceptive, vestibular, and visual) with musculoskeletal components (muscles, joints, and other soft tissues), which are centrally processed in the brain (Arifiati, 2024, Muir, 2010). Degeneration of the neural systems due to aging, causing brain atrophy, decreased nerve conduction velocity and decline in somatosensory systems reduces orientation and body position awareness, thereby impairing movement coordination and slowing motor reaction time in the lower extremity muscles. Proprioceptive function declines due to a reduced responsiveness of the muscle spindle, decreases in sensitivity weakens the accuracy of information integration, and disrupts postural control (Henry & Baudry, 2019). These deficits contribute to impaired postural stability, often manifested as increased postural sway or postural instability (Sarabon, 2013, Baltich, 2015). The use of various medications may also further disrupt balance (Phillips et al., 2019). Another external factors such as slippery floor surfaces or inadequate lighting can also heighten the risk of postural instability. Based on these factors, elderly become more susceptible to losing balance and experiencing falls (Ishigaki et al., 2014).

Postural instability is defined as the inability to maintain the body's center of mass or center of gravity over the base of support in both static and dynamic conditions. A decline in lower extremity muscle strength leads to reduced capacity for maintaining postural stability (Prasetyo & Indardi, 2014). Lower extremity muscle strength is a key determinant in sustaining an upright posture and executing immediate compensatory postural actions in response to external disturbances, thereby minimizing body imbalance that may result in falls among elderly. A decrease in lower extremity muscle strength slows postural reactions and contributes to greater body sway in the elderly (Paillard, 2017). The greater postural sway observed in elderly compared to younger individuals is indicative of postural instability in elderly (Magalhães et al., 2022).

Therefore, physiotherapy plays a crucial role in promoting the health of elderly, not only by restoring functional body movements but also by contributing to the prevention and reduction of fall risk. Consequently, it is essential to understand the relationship between lower-extremity muscle strength and postural instability in the elderly population. This study aims to examine the association between these two variables and to explain how reduced lower-extremity muscle strength may increase postural instability, thereby elevating the potential risk of falls among elderly. The findings of this research are expected to enhance knowledge and serve as a foundation for preventive strategies in fall prevention among the elderly.

2. Method

This research is descriptive quantitative with cross sectional study approach. The sample consisted of 41 elderly in Nusaloka Residency, Tangerang Selatan conducted from 8-28 June 2025. Samples were selected using purposive sampling technique with inclusion criteria of this study consisted of: 1) elderly who were willing to participate as respondents in the study; 2) aged between 60 and 79 years; 3) able to walk independently without assistive devices or with minimal assistance, such as a cane; and 4) having a height of ≥150 cm. And exclusion criteria the exclusion criteria included are 1) elderly with a

history of injuries affecting gait ability, 2) those with cardiovascular or neurological diseases, 3) elderly with physical limitations or cognitive impairments, 4) and those who had taken sedative medications within the last 24 hours that could cause drowsiness or imbalance.

Independent variable in this study was lower extremity muscle strength measured using Five Times Sit to Stand Test (FTSST). FTSST is a functional mobility assesment measured in seconds, required for an individual to repeatedly transition from a seated position to a full standing posture and return to sitting a total of five times with standarized chair. A performance time greater than 11.6 seconds in elderly aged 60-69 years and 12.9 seconds in those aged 70-79 years is indicating reduced lower extremity muscle strength.

And the dependent variable were postural instability measured using Berg Balance Scale (BBS). The Berg Balance Scale (BBS) is performance based assessment tool designed to evaluate postural control and the risk of instability in elderly and patients with balance impairments. It consists of 14 functional tasks, such as sitting to standing, standing unsupported, reaching, turning, and single-leg standing, each scored on a 5-point ordinal scale ranging from 0 (unable to perform) to 4 (independent). The total score ranges from 0 to 56, with lower scores indicating greater postural instability and a higher risk of falls, while higher scores reflect better balance performance and functional independence.

The data in this study were analized using the SPSS computer program. Normality test using the Saphiro-Wilk test indicated that the data were normally distributed. Analysis of the relationship between lower extremity muscle strength and postural instability using the pearson correlation test because the data were normal and further analysis with simple linear regression. This study has passed the ethical test from the Research Ethics Committee. Universitas Esa Unggul with number: 0925-07.067/DPKE-KEP/FINAL-EA/UEU/VII/2025.

3. Result and Discussion

Table 1. Distribution of respondent characteristics.

Characteristics	f	%
Age		
60 – 69 years	26	65
70 – 79 years	14	35
Gender		
Male	20	49
Female	21	51
BMI		
Underweight	5	12
Normal	11	31
Overweight	5	12
Obesity I	17	42
Obesity II	3	7
Blood Pressure		
Normal	6	15
Prehypertension	30	75
Stage 1 Hypertension	3	7
Stage 2 Hypertension	1	3
Fall more than once		
Yes	11	27
No	30	73
Occupation		
Housewife	15	37
Entrepreneur	5	12
Employee	7	17
Priest	1	3
Retirement	13	31
Comorbid		
High Cholesterol	5	12
Hypertension	17	42
Diabetes	6	15

Characteristics	f	%
Asthma	1	2
GERD	2	5
No Comorbid	10	24
Prescription Medicine Consumption		
Yes	25	61
No	16	39

Table 1 explains distributions of respondent characteristics. Based on age distribution, the majority of respondents were in the 60 – 69 year group (65%) 26 respondents. The results showed that participants aged 60–69 years had greater lower extremity muscle strength and postural stability compared to those aged 70–79 years. This was reflected in the decline of the mean Berg Balance Scale (BBS) score comparisons from 42.04 (low fall risk) in the elderly group to 35.64 (moderate fall risk) in the older adults group. These findings align with study reported that after the age of 70 years, BBS scores decrease by approximately 0.7 points every year due to age-related neuromusculoskeletal decline, particularly reduced muscle strength and impaired postural control, later contribute to postural instability in the elderly (Downs et al., 2014).

The highest percentage of gender in this study were female with prevalence (51%) 21 respondents. Men have a lower proportion of intramuscular fat compared to women. This difference is partly explained by the decline in estrogen hormon levels during menopause, which plays a key role in muscle protein synthesis. Consequently, women experience a more rapid loss of muscle mass than men, leading to reduced muscle strength and a higher risk of sarcopenia (Kodete et al., 2024). Most respondents had BMI classified in obesity 1 with highest percentage (42%) 17 respondents. Excess body mass index (BMI) and muscle weakness may alter spinal alignment, increase joint loading, and shift the body's center of gravity (COG), thereby affecting mobility and contributing to a decline in quality of life among elderly (Yuliadarwati et al., 2021).

Most of the respondents have the characteristic of comorbid hypertension with prevalence (75%) 17 respondents. A study discovered that chronic diseases and comorbidities in elderly contribute to balance impairments and reduced muscle strength, which in turn adversely affect quality of life by increasing the risk of falls and disability (Yang et al., 2023). In this study there were 25 elderly (61%) who consumed prescription medication and 30 elderly (75%) have elevated blood preassure categorized prehypertension. Elderly with hypertension and consumed prescription medication often experience autonomic dysfunction affecting blood pressure and heart rate regulation, leading to orthostatic hypotension. Study reported a significant negative correlation between orthostatic blood pressure changes and postural sway in 63 elderly women, most of them had hypertension condition, indicating that postural transitions can exacerbate systolic blood pressure decline, thereby increasing postural instability and fall risk (Murata et al., 2012).

Based on history of multiple fall characteristics in this study, 11 elderly (27%) had experienced more than one fall a year, while 30 (73%) had no history of falling. The age-related decline in physical capacity increases fall risk, as elderly often fail to detect body movements and maintain the center of gravity in a timely manner to preserve stability (Munawarah & Nurhalimah, 2020). The distribution of data based on occupational history showed that the largest proportion of elderly were housewives (37%) 15 respondents, followed by retirement (31%) 13 respondents. Occupational background is closely related to daily activities in later life and may influence muscle strength, balance, motor function, and tissue endurance (Chigira, 2025).

Table 2. Distribution of respondent based on lower extremity muscle strength and postural instability

Variables	Age	f	%	Mean ± SD
Lower Extremity Muscle Strength				
Decreased LEMS	60 – 69 years	14	62,5	**18,9 ± 4,06**
	70 – 79 years	26	35	
No decreased LEMS	60 – 69 years	1	2,5	
Postural Instability				
Low Fall Risk		22	54	**39,8 ± 4,79**
Moderate Fall Risk		19	46	

Based on variable distributions measurements showed that lower extremity muscle strength, assessed using the Five Times Sit-to-Stand Test (FTSST), had a mean value and standard deviation (SD) of 18.9 ± 4.06 seconds. The average time exceeded the cut-off values, indicating a decline in lower extremity strength among the participants (Bohannon et al., 2010). In detail, one participant aged 60–69 years (2.5%) completed the test in <11.4 seconds, whereas 25 participants in the same age group (62.5%) required >11.4 seconds, and 14 participants aged 70–79 years (35%) required >12.6 seconds. Postural stability measured by the Berg Balance Scale (BBS) showed a mean value and standard deviation of 39.8 ± 4.79, with an average score of 39.8. Score within the range of 21–40 indicate postural instability, balance impairment and a moderate risk of falling (Alghwiri et al., 2016).

Table 3. Relationship between lower extremity muscle strength and postural instability

Variables	Postural instability				
	n	r	R^2	*b*	p-value
Lower Extremity Muscle Strength	41	-0,831	0,690	-0,981	p< 0,001

Based on table 3 above, it can be seen that based on the Pearson correlation test between lower extremity muscle strength and postural instability, demonstrated a significance value of p = 0.001, where $p < \alpha$ (0.005), indicating that H_0 was rejected and H1 is accepted. Thus, it can be concluded that there is a significant relationship between lower extremity muscle strength and postural instability among elderly. The correlation coefficient obtained was r = -0.831, which reflects a strong negative correlation means when lower extremities muscle strength increases, the risk the occurence of postural instability decreases. Conversely, when lower extremity decreases, postural instability tends to increase.

Based on further analysis using simple linear regression revealed a coefficient value of (b) = –0.981, meaning if there is one-point increase in muscle strength, will decreases the occurance of postural instability by 0.981 units. Allign with one study conducted in Iran involving 94 elderly, founded a significant correlation between lower extremity muscle strength and fall incidence, showing that elderly with a history of falls exhibited poorer sit-to-stand performance and slower gait speed. Moreover, multivariate regression analysis revealed that an increase of 1 Nm/kg in lower extremity muscle strength, particularly in the hip abductors to maintain medio-lateral balance, reduced postural instability and the risk of falling by 86.3%. These results highlight the importance of maintaining lower extremity muscle strength and endurance as an essential strategy in fall prevention among the elderly.

The results of the coefficient of determination test (R^2) showed that lower extremity muscle strength contributed 0.690, or 69%, to the occurrence of postural instability. The remaining 31% was influenced by other variables not included in this study. Therefore, although lower extremity muscle strength makes a substantial contribution, other factors may also affect postural instability in elderly, including degeneration of the sensory and central nervous systems, cognitive function, body mass index, and comorbid or neurological diseases (Wang, 2025, Sari, 2022).

A study conducted in Kartasura, Indonesia examined the relationship between lower extremity muscle strength, cognitive function, and balance in 94 elderly aged 60 years and above. The findings indicated no correlation between lower extremity muscle strength or cognitive function and static balance. However, a moderate correlation (r = 0.404) was observed between lower extremity muscle strength and dynamic balance. This may be explained by the fact that static balance relies primarily on proprioceptive receptors, which transmit information about joint position, pressure, and muscle tension to the brain, and is therefore less dependent on muscle strength. In contrast, dynamic balance, which involves a wider range of movement, requires greater active muscle contraction, strength and the engagement of major joints such as the ankles, knees, and hips to maintain stability during motion (Masitha, 2022).

Optimal lower-extremity muscle strength plays a crucial role in maintaining postural control, both dynamically and statically. In addition to serving as the primary support base, the lower-extremity muscles generate force and act as active stabilizers that work in coordination with the neuromuscular system to produce synergistic movements and efficient postural reactions during disturbances (Wang et al., 2025). Age-related muscle weakness reduces joint stabilization capacity and alters gait patterns, thereby increasing the risk of postural instability, which is a major factor contributing to falls in elderly. This condition is influenced by diminished sensory input and decreased lower-extremity muscle strength. Therefore, physical exercise is strongly recommended to enhance muscle strength and

stimulate more stable postural reactions, with interventions such as multitasking exercise, square stepping, salsa dancing, and dual-task training shown to strengthen the muscles that support balance (de Maio Nascimento et al., 2022).

Furthermore, a quasi-experimental study conducted in the Czech Republic demonstrated that resistance training, proprioceptive training, and endurance training can enhance postural stability through improvements in lower extremity muscle strength. By strengthen lower extremity muscle, mainly in the knee extensor group, that play a crucial role in generating force, maintaining joint alignment, and promoting joint stability, thereby resulting in a reduction of postural sway and the risk of instability. These effects occur as a result of increased motor unit recruitment and more optimal firing patterns of the muscles involved in balance control. Consequently, postural stability improves through more responsive motor control. The study emphasizes the significant relationship between lower extremity muscle strength and postural stability. Appropriate resistance training facilitates neuromuscular adaptations and enhances postural control, ultimately reducing the risk of injury and falls. In addition, proprioceptive training improves the body's ability in sensitivity to detect positional changes. With optimal proprioceptive function and responsive motor control mediated by the musculoskeletal system, elderly are able to generate more effective postural reactions. Thus, lower extremity muscle strength is established as a key component in reducing postural instability (Svobodová et al., 2025).

This study has several limitations to note. The assessment did not use a gold standard measurement tool. The small sample size reduces statistical power and limits generalizability to wider populations. Other factors that may influence lower extremity muscle strength and postural instability such as pain, physical activity, cognitive function, coordination, proprioception, and vision were not fully considered.

4. Conclusion

Based on the research results and statistical analysis, it can be concluded that there is a significant relationship between lower extremity muscle strength and postural instability in elderly. The stronger lower extremity muscle strength, the lower the risk of postural instability in elderly. And the lower extremity muscle strength contributes 69% to the occurrence of postural instability in elderly. Future research are expected to be able to conduct research with larger samples, standardized tools, and broader factor analysis are needed to provide stronger evidence. Residents in Nusaloka Residency, Tangerang Selatan Based are expected to maintain or even increase lower extremity muscle strength through regular exercise and active participation in daily physical activities, to improve balance and reduce postural instability. The public health services are expected to provide education and information aimed at increasing awareness of the importance of mantaining lower extremity muscle strength as a preventive strategy to minimize the risk of falls in the elderly population.

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