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Effect of Age, Sex, and Postural Alignment on Dynamic Balance in Older Adults

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ABSTRACT

Dynamic balance has been widely associated with fall risk among older adults and is commonly positioned as a predictor of fall events. However, its role as an indicator of functional mobility quality has received comparatively less attention. In addition, chronological age and sex are frequently considered in the evaluation of mobility performance, even though it does not always accurately represent an individual's actual functional condition. This study aimed to examine the associations of age, sex, and postural alignment with dynamic balance among community-dwelling older adults. An analytical observational study with a cross-sectional design was conducted involving 28 older adults attending a community elderly health post in Bangunrejo, Kricak, Tegalrejo, Yogyakarta. From all individuals who met the initial inclusion criteria, only participants with complete data were included in the final analysis. Age and sex were recorded as demographic characteristics, postural alignment was assessed using the Reedco Posture Score, and dynamic balance was evaluated using the Timed Up and Go (TUG) test. Data analysis was performed using Spearman's correlation. The results showed that age (ρ = 0.207; p = 0.291) and sex (ρ = −0.111; p = 0.575) were not significantly associated with TUG performance. In contrast, postural alignment demonstrated a significant negative association with TUG time (ρ = −0.411; p = 0.030), indicating that better postural quality was related to superior functional mobility. This study concludes that, among community-dwelling older adults, dynamic balance more strongly reflects functional condition influenced by postural alignment rather than demographic factors, highlighting the importance of simple functional assessments in the evaluation of mobility in older populations.

Keywords: *Dynamic Balance, Older Adults, Fall Risk*

INTRODUCTION

Indonesia is experiencing a demographic shift, with a growing proportion of people aged 60 and above. In 2023, national data show that over 11% of the population were older adults, a figure expected to increase significantly in the

coming decades (kementrian PPN/ BAPPENAS, 2022). This shift poses important public health challenges, especially regarding fall-related incidents among seniors. While detailed national data on falls among older Indonesians are limited, the 2018 National Basic Health Research identified falls as a leading cause of injury across all age groups. Globally, about one in three people aged 65 or older experiences at least one fall each year (Kemenkes.RI, 2019; World Health Organization, 2007). Falls among older adults can lead to severe injuries, loss of independence, and higher mortality risk (Vaishya & Vaish, 2020). Consequently, maintaining balance is essential for fall prevention in aging populations. Therefore, maintaining balance function is a critical component of fall prevention in aging populations.

Dynamic balance means the ability to maintain posture while moving or adjusting to changes in bodily position. This ability is essential for older persons since it helps them stay independent and reduces their risk of falling. As people age, their dynamic balance gradually declines, owing to physiological changes such as diminished muscle strength, vestibular difficulties, and slower cerebral processing (Lin et al., 2024). These conditions can result in delayed motor responses and decreased movement coordination, reducing dynamic balance performance. Tor reactions and reduced movement coordination compromise dynamic balancing performance (Gale et al., 2016; Johansson et al., 2016; Ko & Park, 2021; Shieh et al., 2023)

However, the evidence for sex-related differences in balance among older persons is inconsistent. While some studies suggest that women are more vulnerable, others show that men and women have comparable balance performance and fall risk, implying that sex alone is not a reliable predictor of balance deterioration (Gade et al., 2021). These disparate findings suggest that sex-related effects on dynamic balance may be influenced by interactions with other individual factors, particularly neuromuscular and sensory alterations associated with aging.

Postural alignment has also been identified as a factor impacting balance performance in older persons. Structural postural abnormalities, such as thoracic hyperkyphosis, are typical as people age due to spinal degeneration and intervertebral disc modifications (Koelé et al., 2020). Although some studies have found links between altered postural alignment and poor balance control, others have not, particularly when dynamic balance is measured using functional clinical tests rather than instrumented posturographic methods (Lin et al., 2024). These contradictory findings indicate that the role of postural alignment in dynamic balance regulation in older persons is uncertain.

Notably, past research has mostly looked at age, gender, and postural alignment as distinct criteria, without considering their combined impact on dynamic balance performance. Furthermore, empirical information from community-dwelling older populations in low and middle-income countries, including Indonesia, is limited. This gap emphasizes the importance of an integrative analytical approach that takes into account various individual factors within a single framework. As a result, the current study seeks to evaluate the

concomitant effects of chronological age, gender, and postural alignment on dynamic balance among community-dwelling older persons. By combining these elements, this study hopes to offer new empirical information to inform targeted fall prevention measures such as balance training and postural correction programs.

METHODS

An analytical observational study with a cross-sectional design was carried out among community-dwelling older individuals enrolled at the Elderly Posyandu in Bangunrejo, Kricak, Yogyakarta. The study population consisted of 28 elderly people who were chosen based on predetermined inclusion criteria. Data were collected as primary data through direct on-site assessments, with the researcher personally involved in the measurements.

Demographic information, such as chronological age and gender, was collected at the time of assessment. Postural alignment data were gathered using the Reedco Posture Score, which assesses standing posture across different anatomical segments. All posture measurements were conducted directly by the researcher using standardized observation protocols. The Time Up and Go (TUG) test was used to examine dynamic balance. Participants were told to stand up from a seated position, walk three meters, turn around, return to their chair, and sit down at a comfortable and safe speed. The researcher measured the entire time it took to complete the task in seconds.

Data analysis was carried out utilizing statistical tools. Descriptive statistics were employed to summarize participant characteristics. A Spearman rank correlation analysis was used to investigate the associations between chronological age and TUG performance, as well as postural alignment scores and TUG performance. Independent statistical tests were used to compare the dynamic balancing performances of male and female individuals. In addition, a simple linear regression analysis was used to determine the impact of age on dynamic balance outcomes. Statistical significance was defined as a p-value less than 0.05.

RESULT AND DISCUSSION

1. *Participant characteristics*

This study had 28 participants, and all collected data were analyzed (valid N listwise = 28). The participants had a mean age of 69.32 ± 6.79 years, ranging from 60 to 86 years. The gender distribution was evenly balanced, with 14 men (50.0%) and 14 women (50.0%).

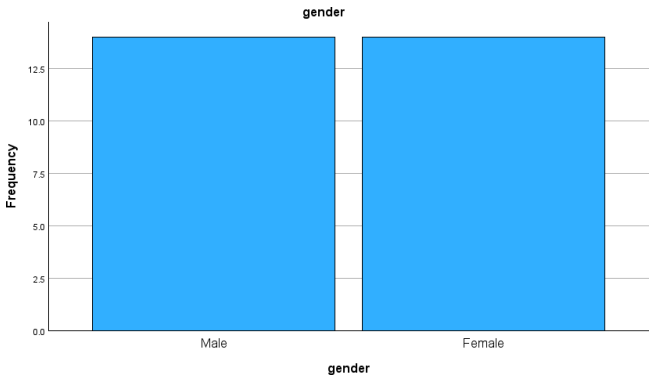
Participants had a mean BMI of 24.18 ± 4.45 kg/m^2, ranging from 15 to 35 kg/m^2, showing a wide range of nutritional status from underweight to obesity. The average BMI score was 2.82 ± 0.67, indicating that the majority of participants were overweight or somewhat obese. None of the individuals used assistive mobility aids, as evidenced by equal minimum and maximum values (1.00 ± 0.00). This finding shows that the usage of assistive devices was consistent throughout the sample and did not add to participant variability.

Partisipant Characteristics

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
usia	28	60	86	69.32	1.284	6.794
gender	28	1	2	1.54	.096	.508
IMT	28	15	35	24.18	.841	4.451
Kategori IMT	28	1	4	2.82	.127	.670
ABG	28	1	1	1.00	.000	.000
Valid N (listwise)	28					

gender

	N	%
Laki laki	14	50.0%
Perempuan	14	50.0%



2. *Correlation between age and TUG*

The Spearman's Rho technique was used to perform the correlation study. The study found a weak positive correlation between age and Timed Up and Go Test (TUG) performance ($\rho = 0.207$; $p = 0.291$). These findings show that age was not substantially connected with TUG performance among the participants in this study.

The findings of this study show that chronological age is not the only factor influencing functional quality in older persons. Clinically, the Timed Up and Go (TUG) test indicates the integration of several physiological function components, such as muscle strength, postural control, cognitive reaction, and motor task coordination. Individuals of similar chronological ages may display varying levels of independence and movement speed. These findings support the view that reductions in mobility in older adults are best characterized through a multifaceted approach rather than using chronological age as a single indicator.

These findings are consistent with previous scientific research that demonstrates the importance of physical activity in maintaining neuromuscular quality in older persons.(Kao et al., 2024). Physically active older persons have been shown to have a slower rate of motor unit loss, less degeneration of type II muscle fibers, and better overall neuromuscular condition than sedentary older adults. Such adaptation mechanisms provide

important functional advantages, particularly for physical tasks that require body transitions, movement speed and accuracy, and postural stability. (O'Bryan & Hiam, 2022).

Furthermore, physical exercise has been linked to reduced muscle fiber denervation and improved muscle function. Consistent physical exercise, including daily activities, stimulates the neuromuscular system repeatedly, hence preserving neural-muscular connection. These adaptive systems help older persons maintain more efficient muscle contraction and motor control, slowing the pace of deterioration in walking ability and other aspects of dynamic balance. (O'Bryan & Hiam, 2022; Wang et al., 2022).

Based on these findings, mobility decline in older adults is more appropriately interpreted using a multifactorial framework rather than attributing it solely to chronological age. Therefore, physical activity may be regarded as a primary protective factor in preserving motor function, independence, and overall quality of life in the older population.

Correlations

			usia	TUG
Spearman's rho	usia	Correlation Coefficient	1.000	.207
		Sig. (2-tailed)	.	.291
		N	28	28
	TUG	Correlation Coefficient	.207	1.000
		Sig. (2-tailed)	.291	.
		N	28	28

3. *Correlation between postural alignment and TUG*

Analysis using Spearman's correlation demonstrated a moderate, statistically significant negative association between Timed Up and Go (TUG) scores and postural control as assessed by the Reedco category ($\rho = -0.411$; $p = 0.030$). These results indicate that higher Reedco postural assessment scores are associated with shorter TUG completion times, reflecting better functional mobility performance among older adults. Conversely, lower Reedco scores are related to longer TUG times, indicating reduced mobility capacity due to poorer postural control.

Clinically, these findings suggest that functional capacity as reflected by the Reedco Postural Test contributes meaningfully to mobility performance, independent of chronological age. This supports the view that walking ability and other aspects of dynamic balance in older adults are more strongly influenced by neuromuscular condition and the level of daily physical activity than by age alone (Sedaghati et al., 2022; Shen et al., 2023; Streckmann et al., 2022). Furthermore, the Reedco Postural Test may be considered a relevant functional indicator for predicting the risk of mobility limitations in the older population.

Correlations

			TUG	Kategori Reedco
Spearman's rho	TUG	Correlation Coefficient	1.000	-.411*
		Sig. (2-tailed)	.	.030
		N	28	28
	Kategori Reedco	Correlation Coefficient	-.411*	1.000
		Sig. (2-tailed)	.030	.
		N	28	28

*. Correlation is significant at the 0.05 level (2-tailed).

4. ***Sex differences in TUG performance***

The analysis was conducted using Spearman's correlation and demonstrated a weak, negative, and statistically non-significant association between Timed Up and Go (TUG) scores and gender ($\rho = -0.111$; $p = 0.575$). These findings indicate that the relationship between gender and functional mobility performance is minimal in the studied population.

From a clinical perspective, this result suggests that functional mobility ability in older adults, as measured by the TUG test, is relatively comparable between men and women. Gender does not appear to be a primary determinant in the assessment of mobility performance. Evidence from existing research suggests that biological sex does not play a substantial role in determining Timed Up and Go (TUG) performance when functional characteristics are taken into account (Almajid & Keshner, 2019; Benavent-Caballer et al., 2016; Ibrahim et al., 2017; Nightingale et al., 2019). Differences in TUG completion time between older men and women are generally small. indicating that functional mobility outcomes assessed by TUG tend to be comparable across sexes in later life. This finding highlights that variability in mobility performance is more closely related to functional determinants rather than sex-related factors. In particular, postural control, neuromuscular function, balance capacity, muscle performance, and habitual physical activity appear to exert a greater influence on dynamic mobility tasks than gender alone. Consistent with this perspective, the present study identified only a weak and non-significant association between gender and TUG performance, reinforcing the view that gender should not be considered a primary determinant in the assessment of functional mobility among older adults, while greater emphasis should be placed on modifiable functional factors that more directly reflect the mechanisms underlying mobility and functional independence.

Correlations

			TUG	gender
Spearman's rho	TUG	Correlation Coefficient	1.000	-.111
		Sig. (2-tailed)	.	.575
		N	28	28
	gender	Correlation Coefficient	-.111	1.000
		Sig. (2-tailed)	.575	.
		N	28	28

CONCLUSION

The present study demonstrates that postural control, as assessed by the Reedco Postural Test, is meaningfully associated with functional mobility performance in older adults, as reflected by Timed Up and Go (TUG) completion time. Higher postural control scores were consistently related to better mobility outcomes, whereas chronological age and gender showed limited influence on TUG performance. These findings reinforce the perspective that functional mobility in later life is primarily determined by neuromuscular condition, dynamic balance, and habitual physical activity rather than demographic characteristics alone. Accordingly, the Reedco Postural Test may serve as a clinically relevant functional indicator for identifying mobility limitations and potential fall risk among older adults, supporting its use as a complementary assessment tool in geriatric functional evaluation.

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