Majalah Ilmiah Fisioterapi Indonesia
Indonesian Scientific Journal of Physiotherapy

**Original Research Articles**
**ISSN (Print): 2303-1921**
**ISSN (Online): 2722-0443**
**Volume 13, Number 01, Pages 043–047 (2025)**
**DOI: https://doi.org/10.24843/mifi.000609**

# Tandem Walking Exercise Improves Dynamic Balance in Reducing Fall Risk Among the Elderly: A Quasi-Experimental Study

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Received 01 December 2024; Revised in revised form 12 December 2024; Accepted 14 December 2024; Published 01 January 2025


## Abstract

**Introduction**: Elderly individuals are prone to balance disorders due to decreased muscle strength, postural changes, and reduced proprioceptive and visual function, all of which increase the risk of falls. This study aims to examine the effect of Tandem Walking Exercises on dynamic balance to reduce fall risk in older people.

**Methods**: This study employed a quasi-experimental design with a pre-test and post-test control group. The study population consisted of elderly individuals in Karangasem Village, Central Java, with 70 participants. The sample was selected using purposive sampling, meeting the inclusion and exclusion criteria, resulting in 50 respondents. Balance was assessed using the Timed Up and Go Test (TUGT). Normality testing was conducted using the Kolmogorov-Smirnov test, as the sample size was ≥50. Data were analyzed using a paired t-test to evaluate balance changes before and after the intervention in the intervention group.

**Results**: The intervention group showed a significant improvement in the average TUGT time (pre-test: 20.65 seconds; post-test: 17.96 seconds; p = 0.012). Conversely, the control group did not exhibit significant changes (pre-test: 19.70 seconds; post-test: 20.33 seconds; p = 0.180).

**Conclusion**: Tandem Walking Exercise is proven effective in improving dynamic balance and reducing fall risk in older people. This intervention can be implemented as part of fall prevention programs in elderly communities.

**Keywords:** Tandem Walking Exercise, Dynamic Balance, Fall Risk, Elderly

## Introduction

Aging is the final stage of the human life cycle, beginning at the age of >60, and is characterized by various mental, physical, and social changes.[1] According to the WHO, individuals aged 45–60 years are classified as middle-aged, 60–75 years as elderly, and 75–90 years as old.[2] The Indonesian Ministry of Health (2005) categorizes the elderly into three groups: presenilins (45–59 years), elderly (>60 years), and high-risk elderly (>70 years or >60 years with health issues).[3] As age increases, there is a decline in muscle strength, joint mobility, and visual and vestibular function, all of which contribute to impaired balance—one of the leading causes of the high incidence of falls among older people.

According to the 2020 projections by the Central Bureau of Statistics, the proportion of the elderly population in Indonesia increased to 9.78% from 7.59% in 2010. This indicates that Indonesia is entering an aging population phase.[4] The decline in nervous, musculoskeletal, and sensory system function in the elderly leads to balance disorders. Proper balance requires a complex interaction between the vestibular, visual, somatosensory, and musculoskeletal systems, which the brain regulates through motor control, sensory processing, the basal ganglia, the cerebellum, and associative areas.[5]

Balance is a crucial ability that enables individuals to walk and move smoothly. It is divided into two types: static and dynamic balance. Static balance refers to maintaining body stability while standing in one position, whereas dynamic balance is the ability to sustain stability in motion.[6] Balance problems in older people increase the risk of falls. A fall is an inability to maintain the body's center of gravity over its support base, such as the feet, while standing or moving, preventing the body from responding quickly to positional changes.[7]

In Indonesia, the prevalence of falls among the elderly aged ≥65 years reaches 67.1%. Approximately 30% of older adults living at home experience falls, with the incidence rising to 50% in those who have fallen more than once.[8] Falls can diminish the quality of life for the elderly, reducing activity and mobility and leading to anxiety, depression, fractures, head injuries, and even death. The risk factors for falls consist of internal factors, such as muscle weakness, joint stiffness, and balance disorders, as well as external factors, such as poor lighting, slippery floors, and obstacles in the surrounding environment.[9]

Aging also affects proprioceptive function, the vestibular system, postural reflexes, and muscle strength, which are crucial for maintaining body balance.[10] Therefore, physiotherapy is vital in providing exercises to improve balance in older people. One intervention that can be implemented in tandem walking exercises.[11]

Tandem Walking Exercise is an exercise that involves walking with the heel of one foot touching the toes of the other in a straight line over a distance of 3-6 meters. This exercise enhances posture, dynamic balance, and muscle structure. Tandem Walking Exercise also strengthens the quadriceps muscles, which are essential for extending the knee and flexing the hip, thereby helping to reduce the risk of falls among older people.[1213]

Although various exercises have been employed to improve balance in older people, research on the effectiveness of Tandem Walking Exercises in enhancing dynamic balance and reducing fall risk is still limited. Therefore, this study aims to evaluate the effect of Tandem Walking Exercises on dynamic balance in older people. This research intends to assess the impact of Tandem Walking Exercises in improving dynamic balance and reducing fall risk among older people. The results indicate that the Tandem Walking Exercise significantly enhances dynamic balance and reduces fall risk in older people compared to the control group.

## Methods

This study is a quasi-experimental research design utilizing a pre-test and post-test control group design. It involves two groups: the intervention group, which receives Tandem Walking Exercises, and the control group, which does not receive any intervention. The allocation of participants to the intervention and control groups was done through purposive sampling, considering the homogeneity of characteristics based on inclusion criteria.

The study population consists of elderly individuals in Karangasem Village, Central Java, totaling 70 participants. Recruitment took place in November 2024, before the implementation of the intervention. The sampling technique used purposive sampling, with inclusion criteria including elderly individuals aged >60 years, those who can walk without assistive devices, and those with balance issues measured using the Timed Up and Go Test (TUGT) (cut-off score >13.5 seconds), and those willing to participate as respondents. Exclusion criteria include individuals with a history of stroke, kidney or heart disorders, vision impairments, and those who refuse to participate. Dropout criteria include individuals who do not attend the exercise program for three consecutive sessions and those who discontinue the program.

The study included 50 elderly participants, each group comprising 25 individuals. The research was conducted over one month, from December 2024 to January 2025, with exercise sessions held twice a week for four weeks. The study occurred at the local village hall, supported by health cadres to facilitate coordination and implementation.

The balance measurement instrument used was the Timed Up and Go Test (TUGT), which has been validated for the elderly population and is widely used to assess fall risk. Measurements were conducted by physiotherapists who received specialized training to ensure data consistency. Data were collected before and after implementing the Tandem Walking Exercise for the intervention and control groups.

The researchers conducted an ethical review before starting the study. They received ethical approval from the Faculty of Health Sciences at Muhammadiyah University of Surakarta, with approval number 665/KEPK-FIK/XI/2024, on November 20, 2024.

Normality testing of the data was performed using the Kolmogorov-Smirnov test for sample sizes ≥50. If the p-value >0.05, the data were considered normally distributed. Data analysis was conducted using the Paired T-test to determine differences in balance among older people before and after the Tandem Walking Exercise in the intervention group. The Last Observation Carried Forward (LOCF) approach was used to address missing data. Subgroup analyses were also conducted to evaluate whether age or gender influenced the intervention outcomes. Blinding was not used in this study due to resource limitations; however, efforts to minimize bias were made through assessor training and using valid and reliable measurement tools.

## Results

This study involved 50 respondents divided into the control group and the intervention group, each consisting of 25 respondents. Tables 1 to 4 present the respondents' characteristics and the balance measurements' results before and after the intervention. The flowchart illustrating the number of respondents at each stage of the study, including the selection process, allocation to groups, implementation of the intervention, and data analysis, is shown in Figure 1.

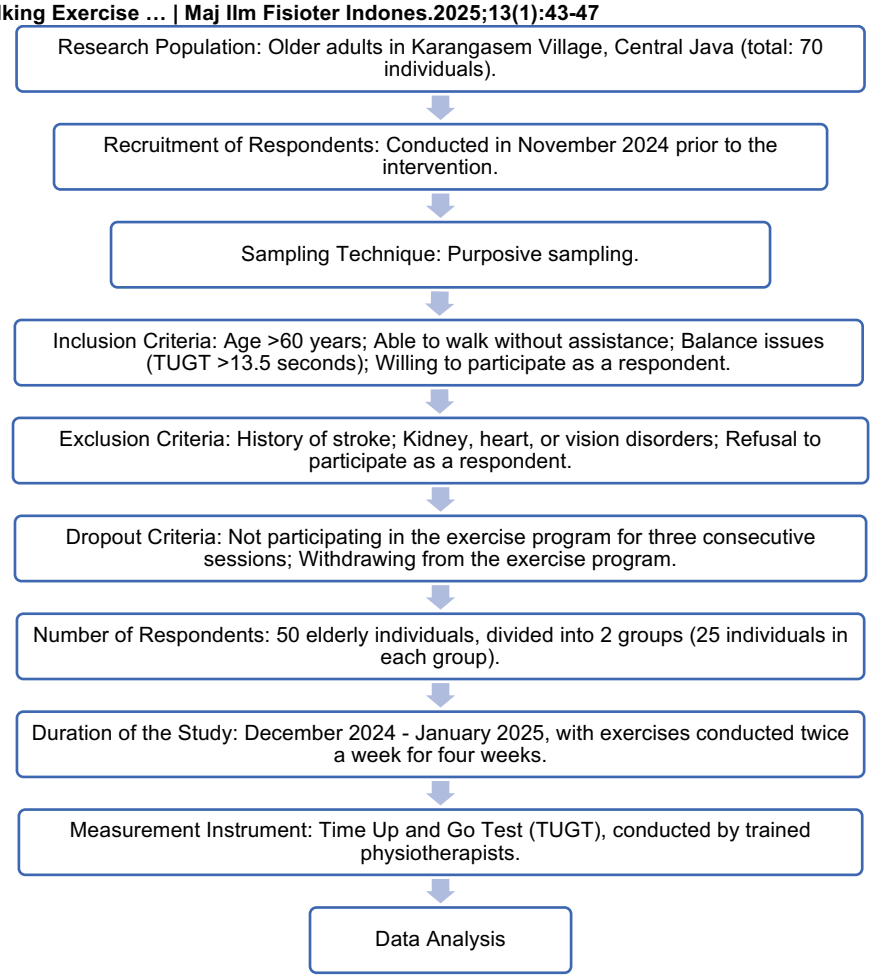


**Figure 1.** Research Flowchart

**Table 1.** Characteristics of Respondents by Gender in Control and Intervention Groups

| Gender | Frequency | | Percentage | |
|---|---|---|---|---|
| | Control | Intervention | Control (%) | Intervention (%) |
| Female | 24 | 22 | 96% | 88% |
| Male | 1 | 3 | 4% | 12% |
| Total | 25 | 25 | 100% | 100% |

Table 1 shows that the majority of respondents were female. The control group had 24 female respondents (96.0%) and one male respondent (4.0%). There were 22 female respondents (88.0%) in the intervention group and three male respondents (12.0%).

**Table 2.** Characteristics of Respondents by Age in Control and Intervention Groups

| Age | Frequency | | Percentage | |
|---|---|---|---|---|
| | Control | Intervention | Control (%) | Intervention (%) |
| 60-66 | 5 | 12 | 20% | 48% |
| 67-73 | 9 | 2 | 36% | 8% |
| 74-80 | 11 | 11 | 44% | 44% |
| Total | 25 | 25 | 100% | 100% |

Table 2 indicates the age distribution of respondents. In the control group, there were five respondents aged 60-66 years (20.0%), nine respondents aged 67-73 years (36.0%), and 11 respondents aged 74-80 years (44.0%). In the intervention group, there were 12 respondents aged 60-66 years (48.0%), two respondents aged 67-73 years (8.0%), and 11 respondents aged 74-80 years (44.0%).

**Table 3.** Balance Measurement Results for the Control Group (Paired T-Test)

| Control | N | Mean | SD | Sig |
|---|---|---|---|---|
| Pre-test | 25 | 19.7044 | 3.72704 | 0.180 |
| Post-test | 25 | 20.3384 | | |

Table 3 shows that the balance measurement results for the control group indicate a pre-test average TUGT time of 19.70 seconds and a post-test average of 20.33 seconds. The mean difference between the pre-test and post-test was -0.634 seconds, with a significance result of 0.180 >0.05. This indicates that the null hypothesis (H0) is accepted and the alternative hypothesis (Ha) is rejected, suggesting no significant difference in balance measurements before and after the intervention in the control group.

**Table 4.** Balance Measurement Results for the Intervention Group (Paired T-Test)

| Intervention | N | Mean | SD | Sig |
|---|---|---|---|---|
| Pre-test | 25 | 20.6512 | 3.37503 | 0.012 |
| Post-test | 25 | 17.9648 | 4.52344 | |

The balance results for the intervention group show a pre-test average TUGT time of 20.65 seconds and a post-test average of 17.96 seconds. The mean difference was 2.69 seconds, with a significance value of 0.012 <0.05. This indicates that the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) is accepted, demonstrating a significant difference in balance measurements before and after the intervention in the intervention group.

## Discussion

This study shows that respondents in the intervention group experienced a significant improvement in balance after regularly performing Tandem Walking Exercise twice a week for four weeks. Older adults tend to face balance issues due to age-related factors, where the decline in balance is caused by the inability of muscles that work synergistically to maintain body position. Instability in maintaining balance can result in poor balance control in older adults.[14]

The study's results indicate that the balance in the intervention group had a p-value of 0.012 ($p < 0.05$), leading to the rejection of H0 and acceptance of Ha, which signifies an improvement in balance. This suggests that Tandem Walking Exercise significantly affects the dynamic balance of older adults. In contrast, the control group exhibited a p-value of 0.180 ($p > 0.05$), resulting in the acceptance of H0 and rejection of Ha, indicating no improvement in balance. This is associated with low levels of physical activity, which are significantly related to balance disturbances.[15]

The increase in muscle strength in older adults contributes to the body's ability to maintain movement, thereby helping to preserve postural balance. Several factors that can lead to balance issues include age, gender, physical activity, medication use, alcohol consumption, and mental health conditions. Balance disturbances can result in a loss of confidence in performing activities, potentially leading to accidents such as falls or injuries, a decline in quality of life, and increased dependence on others for daily activities.[16]

These findings are consistent with previous research indicating that Tandem Walking Exercise is an effective method for gradually training postural control. Additionally, other studies have suggested that this exercise can enhance balance stability in older adults, thereby minimizing the risk of falls.[13]

The results of this study have important clinical implications, indicating that Tandem Walking exercises can be integrated into balance rehabilitation programs for older adults. However, there are several limitations to consider. The intervention lasted only four weeks, which may be insufficient to assess long-term effects. Additionally, the small sample size (N = 50) may impact statistical power and the generalizability of the results. This study also did not measure other factors that could contribute to the outcomes, such as muscle strength or respondents' daily physical activity levels. It is important to note that sampling bias, where respondents may have different motivations for participation, could influence the results.

While the intervention group showed significant improvement, it is crucial to understand why the control group did not experience changes. This may be related to the lack of physical activity performed. Furthermore, the study did not investigate whether specific respondent characteristics, such as age or gender, affected the results. An analysis comparing outcomes between older age groups (e.g., 74–80 years) and younger groups (60–66 years) would provide further insights.

The findings of this study may apply to other older adult populations; however, there are limitations concerning the study's location, which may not represent different cultures or physical activity habits. To ensure the effectiveness of this intervention, further research is needed with a more extensive and diverse population.

## Conclusion

This study demonstrates that Tandem Walking Exercise significantly improves dynamic balance in older adults, with a p-value of 0.012 indicating a significant difference between pre-and post-intervention assessments. This improvement can be attributed to enhanced muscle strength and postural control, crucial for maintaining balance. In contrast, the control group showed no significant changes, with a p-value of 0.180, highlighting the importance of physical activity in sustaining balance.

While these results are promising, this study has several limitations, including a short intervention duration and a small sample size, which may affect the generalizability of the findings. Further research with a longer intervention duration and a more diverse population is needed to explore the long-term effectiveness of Tandem Walking Exercises. The findings of this study provide important implications for the development of balance rehabilitation programs for older adults and emphasize the significance of physical activity in preventing balance disorders and fall risks.

## Acknowledgments

The author thanks the supervising lecturer for their valuable guidance and insights. The author also extends heartfelt thanks to the research participants who willingly participated and entrusted the author with this study. Thanks to family and friends for their unwavering support and motivation throughout the research process. The findings of this study will likely contribute to the advancement of physiotherapy knowledge and the enhancement of the quality of life for older adults

## Conflict of Interest Statement

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

**Funding Sources**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Ethics Statement**

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was not required as the study involved only non-invasive procedures (blood pressure measurement and questionnaire surveys) and posed minimal risk to participants. Informed consent was obtained from all participants prior to their inclusion in the study, and confidentiality was strictly maintained.

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