

Effect of Progressive Ankle Weight Tandem Walking Exercise on Dynamic Balance in Older Women

Gede Robby Gunawan¹, I Gede Arya Sena², Ni Luh Made Reny Wahyu Sari³, Daryono⁴

^{1,3,4}Bachelor of Physiotherapy Study Program, Faculty of Medicine, Universitas Dhyana Pura, Badung, Bali, Indonesia

²Professional Physiotherapy Education Study Program, Faculty of Medicine, Universitas Dhyana Pura, Badung, Bali, Indonesia

Corresponding author:

Name: Gede Robby Gunawan

E-mail: Gunawanrobby509@gmail.com

Phone: +62 819 3612 0601

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Abstract

Background: Age related declines in muscle strength, proprioception, and neuromuscular function impair dynamic balance and increase fall risk among older women. Tandem Walking Exercise combined with progressive ankle weight resistance may improve postural control, although evidence regarding this combined intervention remains limited.

Objective: To evaluate the effect of Progressive Ankle Weight Tandem Walking Exercise on dynamic balance among community dwelling older women.

Methods: A pre-experimental one group pretest posttest study was conducted among 25 community dwelling older women aged 61–69 years selected using purposive sampling. Of 70 older women, 35 were screened for eligibility, 10 were excluded, and 25 completed a four-week intervention comprising 12 supervised exercise sessions. Dynamic balance was assessed using the Timed Up and Go Test (TUGT) and Berg Balance Scale (BBS). Data were analyzed using the Shapiro Wilk test and paired sample *t* test with a significance level of 0.05.

Results: TUGT improved from 18.22 ± 0.45 to 16.12 ± 0.45 seconds, with a mean difference of 2.10 seconds (95% CI: 2.07–2.14; $p < 0.001$). BBS scores increased from 28.00 ± 3.19 to 37.56 ± 3.66 points, with a mean difference of 9.56 points (95% CI: 9.29–9.83; $p < 0.001$).

Conclusion: Progressive Ankle Weight Tandem Walking Exercise was associated with significant improvements in dynamic balance among community dwelling older women. However, the findings should be interpreted cautiously because of the pre-experimental design without a control group. Randomized controlled trials are needed to confirm these findings.

Keywords

Aged; Postural Balance; Exercise Therapy; Resistance Training; Accidental Falls

Introduction

Population ageing has become a major global public health challenge because it is accompanied by progressive declines in physiological function that adversely affect mobility, independence, and quality of life. According to the World Health Organization, the global population aged 60 years and older is projected to reach approximately two billion by 2050, with the greatest increase occurring in low- and middle-income countries. Indonesia has entered the ageing population phase, with the proportion of older adults exceeding 10% of the total population. Bali has also entered the ageing population phase, with older adults accounting for approximately 14% of its population. Consequently, maintaining functional independence and preventing mobility impairment and falls have become important priorities in geriatric health care.^{1–5}

Age related deterioration of the musculoskeletal and nervous systems substantially contributes to impaired postural control and dynamic balance. Age-related changes in sensory and sensorimotor function, including reduced proprioceptive function and impaired integration of visual, vestibular, and somatosensory information, may contribute to impaired postural control and dynamic balance during functional activities. These physiological changes are generally more pronounced in older women because the decline in estrogen following menopause accelerates reductions in muscle quality, bone health, and neuromuscular performance. Consequently, these age-related changes may increase the risk of balance impairment, mobility limitations, and falls in older women.^{6–11}

Dynamic balance is a complex motor function requiring coordinated integration of visual, vestibular, and somatosensory inputs with adequate lower extremity muscle strength and neuromuscular control. Impairment of this system negatively affects essential daily activities, including standing, walking, turning, transferring, and negotiating environmental obstacles.^{10,12} Therefore, physiotherapy interventions that simultaneously target proprioception, postural control, and lower limb muscle performance are expected to improve functional mobility and reduce fall risk among older adults.^{13–15}

Exercise based physiotherapy is widely recommended as a first line intervention for improving balance and functional mobility in older adults.⁵ Various exercise modalities, including balance training, resistance exercise, proprioceptive training, aquatic exercise, and sensorimotor exercise, have demonstrated beneficial effects on postural stability.^{10,13} Tandem Walking Exercise is a simple functional balance exercise that requires individuals to walk in a heel to toe pattern along a straight line, thereby reducing the base of support and increasing demands on postural control, proprioceptive feedback, and sensorimotor integration. Previous studies have reported that Tandem Walking Exercise improves dynamic balance and gait performance in older adults through repeated stimulation of multiple postural control systems.^{13,16}

Although Tandem Walking Exercise has demonstrated promising clinical benefits, previous research has evaluated it as a stand-alone intervention without progressive external resistance. In contrast, progressive resistance training has consistently been shown to enhance lower extremity muscle strength, neuromuscular activation, and functional performance in older adults. Applying

progressive ankle weight resistance during Tandem Walking Exercise may provide additional mechanical loading that facilitates greater motor unit recruitment, muscular adaptation, and postural stability while maintaining exercise safety through the principle of progressive overload. Nevertheless, evidence regarding the effectiveness of combining Tandem Walking Exercise with progressive ankle weight resistance remains limited, particularly among community dwelling older women.^{15–18}

A preliminary community assessment conducted in Banjar Pemenang, Banjar Anyar Village, Kediri District, Tabanan Regency identified several older women with impaired balance characterized by unstable gait, difficulty rising from a chair, reduced postural stability, and fear of falling. Initial assessment using the Berg Balance Scale indicated that most participants had moderate balance impairment, highlighting the need for practical, safe, and community-based physiotherapy interventions to improve dynamic balance and functional mobility.

The novelty of this study lies in evaluating Progressive Ankle Weight Tandem Walking Exercise, which integrates tandem walking with systematically increased external loading throughout the intervention period. Unlike previous studies that primarily investigated Tandem Walking Exercise alone, this approach combines balance training with progressive resistance to optimize neuromuscular adaptation while maintaining exercise safety.^{16,19–21} The findings are expected to contribute additional evidence regarding an accessible physiotherapy intervention that can be implemented in community and primary health care settings for older women.

Therefore, this study aimed to evaluate the effect of Progressive Ankle Weight Tandem Walking Exercise on dynamic balance among community dwelling older women in Banjar Pemenang, Banjar Anyar Village, Kediri District, Tabanan Regency, Bali, Indonesia.

Methods

This study employed a pre-experimental one group pretest posttest design to evaluate changes in dynamic balance following Progressive Ankle Weight Tandem Walking Exercise. All participants underwent baseline assessment before the intervention and were reassessed after completing the intervention period. This design was selected to examine within participant changes associated with the exercise program in the absence of a comparison group. The study was conducted in Banjar Pemenang, Banjar Anyar Village, Kediri District, Tabanan Regency, Bali, Indonesia, from 4 May to 31 May 2026. Ethical approval was obtained from the Health Research Ethics Committee of Universitas Dhyana Pura (No. 002321/KEP/UNDHIRA/2026) before participant recruitment commenced.

Participants were recruited using purposive sampling. The target population comprised 70 community dwelling older women residing in the study area. Of these, 35 individuals underwent eligibility screening based on predefined inclusion and exclusion criteria. Ten individuals were excluded, including four who did not meet the age criterion, three with musculoskeletal disorders or osteoarthritis affecting exercise performance, two with neurological disorders affecting balance, and one who was unable to complete the intervention schedule. Consequently, 25 eligible participants provided written informed consent, enrolled in the study, completed the intervention, underwent post intervention assessment, and were included in the final statistical analysis without any loss to follow up.

The inclusion criteria were women aged 60 years or older, able to ambulate independently with or without minimal assistance, willing to participate throughout the intervention period, and able to follow verbal instructions. The exclusion criteria included severe musculoskeletal disorders limiting ambulation, neurological disorders affecting balance, uncontrolled cardiovascular disease, severe visual impairment, acute lower extremity injury, cognitive impairment preventing participation, and refusal to provide informed consent. The number of participants reflected all eligible individuals available during the recruitment period. A formal sample size calculation was not performed because of the limited number of eligible participants within the study setting.^{22,23}

The participant recruitment process is summarized according to the TREND Statement as follows: 70 older women were identified as the target population, 35 underwent eligibility screening, 10 were excluded, 25 fulfilled the eligibility criteria and provided written informed consent, all participants commenced the intervention, completed the 12 supervised exercise sessions, underwent post intervention assessment, and were included in the final statistical analysis. No participant withdrew during the study.

The intervention consisted of Progressive Ankle Weight Tandem Walking Exercise administered over four consecutive weeks, with three supervised sessions per week, yielding a total of 12 sessions. Tandem walking was performed in a heel to toe pattern along a straight line while participants maintained an upright posture and forward gaze. Progressive overload was implemented by performing the exercise without additional weight during the first week, with 1 kg ankle weights during the second and third weeks, and 2 kg ankle weights during the fourth week. This progression was intended to gradually increase the training stimulus while allowing the exercise intensity to be adjusted according to participants' tolerance.^{10,13} Each exercise session consisted of warm up, exercise, and cool down phases.²⁴ The duration of each session, walking distance, number of sets, repetitions, walking speed, and rest interval were not documented in the original protocol and therefore could not be reported.

Participant adherence was monitored using attendance records during every supervised session. All participants attended the scheduled sessions and completed the intervention protocol. If participants experienced excessive fatigue, pain, dizziness, or other discomfort during the exercise, the session was discontinued or modified according to the participant's condition before resuming the program.²⁵ The operational criteria for modifying or terminating an exercise session should be specified in future protocols.

Dynamic balance was evaluated using the Timed Up and Go Test (TUGT) and Berg Balance Scale (BBS). The TUGT measures the time required to stand from a chair, walk three meters, turn, return, and sit down, with shorter completion times indicating better functional mobility. The BBS consists of 14 functional tasks with a total score ranging from 0 to 56, where higher scores indicate better balance performance. Both instruments have demonstrated good validity and reliability for assessing balance performance and fall risk among older adults.^{26–28} Baseline assessment was performed before the first intervention session, whereas post intervention assessment was conducted after completion of the four week intervention using identical procedures.

Descriptive statistics were calculated for participant characteristics and outcome variables. Normality was assessed using the Shapiro-Wilk test. Variables with normal distribution ($p > 0.05$) were analyzed using the paired sample *t* test. Statistical analyses were performed using IBM SPSS Statistics version 26.0.²⁹ Mean differences, 95% confidence intervals, and *p* values were reported. Reporting effect size, such as Cohen's *d*, may provide additional information on the magnitude of the intervention effect.³⁰

Results

A total of 25 community dwelling older women completed the study and were included in the final analysis. No participants withdrew during the intervention period; therefore, all participants completed the intervention and post intervention assessments. The results are presented sequentially, beginning with participant characteristics, followed by descriptive statistics, inferential analysis, and changes in fall risk categories. The baseline demographic and anthropometric characteristics of the participants are presented in Table 1. These data describe the characteristics of the study population before the intervention.

Table 1. Baseline Characteristics of Participants (n = 25)

Variable	Mean $\pm$ SD	Minimum	Maximum
Age (years)	64.28 $\pm$ 2.51	61	69
Body weight (kg)	59.08 $\pm$ 9.20	44	82
Height (cm)	151.72 $\pm$ 5.30	141	166
Body mass index (kg/m ²)	25.70 $\pm$ 3.80	17.75	41.25

Participants had a mean age of 64.28 $\pm$ 2.51 years, with a mean body mass index of 25.70 $\pm$ 3.80 kg/m², indicating a relatively heterogeneous anthropometric profile. The age distribution of the participants is presented in Table 2.

Table 2. Age Distribution of Participants

Age (years)	n	%
61–62	8	32.0
63–64	5	20.0
65–66	7	28.0
67–68	4	16.0
69	1	4.0
Total	25	100.0

Most participants were aged 61–62 years (32.0%), whereas only one participant (4.0%) was aged 69 years. Descriptive statistics for the primary outcome measures before and after the intervention are presented in Table 3.

Table 3. Descriptive Statistics of Dynamic Balance Outcomes

Outcome	Pre intervention Mean $\pm$ SD	Post intervention Mean $\pm$ SD
Timed Up and Go Test (seconds)	18.22 $\pm$ 0.45	16.12 $\pm$ 0.45
Berg Balance Scale (points)	28.00 $\pm$ 3.19	37.56 $\pm$ 3.66

Both outcome measures showed improved mean values following the intervention, with lower TUGT completion times and higher BBS scores after four weeks of Progressive Ankle Weight Tandem Walking Exercise. Before inferential analysis, data normality was assessed using the Shapiro–Wilk test. All variables were normally distributed ($p > 0.05$), supporting the use of the paired sample t test for subsequent analyses. Changes in dynamic balance between pre intervention and post intervention measurements are presented in Table 4.

Table 4. Comparison of Dynamic Balance Outcomes Before and After the Intervention

Outcome	Mean Difference	95% CI	t	df	p value
Timed Up and Go Test (seconds)	2.104	2.069–2.139	125.144	24	<0.001
Berg Balance Scale (points)	9.560	9.291–9.829	-73.466	24	<0.001

Both TUGT and BBS demonstrated statistically significant improvements following the intervention ($p < 0.001$). The mean TUGT completion time decreased by 2.10 seconds, whereas the mean BBS score increased by 9.56 points. Cohen's d should be reported to quantify the magnitude of these improvements. Changes in fall risk categories based on the Berg Balance Scale are presented in Table 5.

Table 5. Distribution of Fall Risk Categories Based on the Berg Balance Scale

Fall Risk Category	Pre intervention n (%)	Post intervention n (%)
High risk (0–20)	0 (0.0)	0 (0.0)
Moderate risk (21–40)	25 (100.0)	19 (76.0)
Low risk (41–56)	0 (0.0)	6 (24.0)
Total	25 (100.0)	25 (100.0)

Before the intervention, all participants were classified as having a moderate risk of falls. Following the intervention, six participants (24.0%) improved to the low-risk category, while 19 participants (76.0%) remained in the moderate risk category. No participant was classified as having a high fall risk before or after the intervention.

Discussion

The present study demonstrated that a four-week program of Progressive Ankle Weight Tandem Walking Exercise was associated with significant improvements in dynamic balance among community dwelling older women. Improvements were consistently observed in both primary outcome measures, as indicated by shorter Timed Up and Go Test (TUGT) completion times and higher Berg Balance Scale (BBS) scores after the intervention. In addition, changes in BBS classification showed that several participants progressed from the moderate to the low fall risk category, suggesting clinically meaningful improvements in functional balance. Although the study employed a pre-experimental one group pretest posttest design without a comparison group, these findings indicate that the intervention may contribute to enhanced postural control and functional mobility in older women.

The observed improvements can be explained by neuromuscular adaptations induced by the combination of tandem walking and progressive external loading. Tandem walking narrows the base of support, requiring continuous integration of visual, vestibular, and somatosensory information to maintain stability during gait. Repeated practice of this task enhances proprioceptive acuity, sensorimotor integration, and anticipatory postural adjustments. The addition of progressive ankle weight resistance further increases muscular demand, promoting greater motor unit recruitment, improved lower extremity muscle activation, and enhanced postural

control through the principle of progressive overload. Collectively, these adaptations may improve the ability to maintain balance during functional activities.^{10,13,14}

The reduction in TUGT completion time indicates improved functional mobility following the intervention. The Timed Up and Go Test (TUGT) is widely used to assess functional mobility and fall risk in older adults, involving sequential tasks of standing, walking, turning, and sitting. Faster TUG completion times indicate better functional mobility, which is relevant to physical function and independence in older adults.^{31,32} These findings are consistent with previous studies reporting that balance-oriented exercise can improve postural control, gait stability, and functional mobility in older adults.^{10,33}

Similarly, the increase in BBS scores demonstrates improvements across multiple functional balance tasks. Unlike the TUGT, which primarily evaluates mobility performance, the BBS assesses balance during both static and dynamic activities encountered in daily life. In the present study, six participants progressed to the low fall risk category following the intervention, whereas the remaining participants demonstrated improved BBS scores despite remaining within the moderate risk category. This finding suggests that meaningful functional improvements may occur even when categorical risk classifications remain unchanged, highlighting the importance of evaluating continuous outcome measures in addition to categorical classifications.

The present findings are consistent with previous evidence demonstrating that Tandem Walking Exercise improves dynamic balance by stimulating visual, vestibular, and proprioceptive systems involved in postural regulation. Likewise, systematic reviews have shown that sensorimotor and proprioceptive exercise can improve balance in older adults, while progressive resistance training can increase lower-extremity muscle strength and functional performance.^{10,18,31} The current study extends this evidence by combining tandem walking with progressively increased ankle weight resistance, thereby integrating balance training and resistance exercise within a single intervention.

The principal novelty of this study lies in applying progressive ankle weight resistance during Tandem Walking Exercise rather than implementing tandem walking alone. Progressive loading was introduced systematically throughout the intervention period to increase exercise intensity while maintaining participant safety. This integrated approach may provide complementary physiological benefits by simultaneously targeting proprioceptive function, lower-extremity muscle strength, and postural control.^{10,18,31} Consequently, this intervention may represent a practical and relatively low-cost physiotherapy strategy with potential applicability in community-based rehabilitation and primary health care settings for older women.

Despite these encouraging findings, several methodological limitations should be considered. First, the pre-experimental one group pretest posttest design precludes definitive conclusions regarding causality because improvements may have been influenced by learning effects, participant motivation, or other uncontrolled factors. Second, the relatively small sample size and purposive sampling from a single community may limit the generalizability of the findings. Third, potentially important confounding variables, including habitual physical activity, nutritional status, comorbidities, medication use, and previous exercise experience, were not controlled during the study. Finally, the intervention lasted only four weeks, preventing evaluation of the long-term sustainability of the observed improvements.

Overall, the findings suggest that Progressive Ankle Weight Tandem Walking Exercise may represent a feasible physiotherapy intervention for improving dynamic balance among community dwelling older women. Nevertheless, randomized controlled trials with larger and more diverse populations, longer follow up periods, standardized intervention protocols, and comprehensive reporting of effect size are required to strengthen the evidence supporting its clinical application.

Conclusion

Progressive Ankle Weight Tandem Walking Exercise was associated with significant improvements in dynamic balance among community dwelling older women, as demonstrated by reduced Timed Up and Go Test completion times and increased Berg Balance Scale scores following four weeks of intervention. These findings indicate that the intervention may improve functional mobility and postural control in this population.

From a clinical perspective, Progressive Ankle Weight Tandem Walking Exercise may have potential applicability as a physiotherapy intervention for balance training among older women in community-based rehabilitation and primary health care settings.

Because this study employed a pre-experimental one group pretest posttest design without a control group, the findings should be interpreted cautiously and cannot establish a causal relationship. Future studies should employ randomized controlled trial designs with larger and more diverse populations, longer follow up periods, standardized intervention protocols, and comprehensive reporting of effect size to strengthen the evidence for clinical implementation.

Study Limitations

This study has several limitations. The pre-experimental one group pretest posttest design without a control group limits causal inference and increases the possibility of bias arising from learning effects or uncontrolled external factors. The relatively small sample size and purposive sampling from a single community may restrict the generalizability of the findings. In addition, potentially important confounding variables, including habitual physical activity, nutritional status, comorbidities, medication use, and previous exercise experience, were not controlled. Finally, the intervention was conducted over only four weeks, preventing evaluation of the long-term sustainability of the observed improvements.

Clinical Implications

Progressive Ankle Weight Tandem Walking Exercise may be incorporated into community-based physiotherapy programs as a practical balance training strategy for older women. The intervention requires minimal equipment, is inexpensive, and can be delivered under professional supervision in primary health care centers, community rehabilitation programs, or older adult exercise groups. Its integration of balance and progressive resistance training may support improvements in functional mobility and contribute to fall prevention strategies in community dwelling older adults.

Author Contribution

Gede Robby Gunawan: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing Original Draft, Visualization.

I Gede Arya Sena: Conceptualization, Methodology, Supervision, Validation, Writing Review and Editing.

Ni Luh Made Reny Wahyu Sari: Methodology, Validation, Supervision, Writing Review and Editing.

Daryono: Supervision, Validation, Project Administration, Writing Review and Editing.

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Conflict of Interest Statement

The authors declare that there are no financial, commercial, or personal relationships that could have influenced the work reported in this study.

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Ethics Statement

This study was approved by the Health Research Ethics Committee of Universitas Dhyana Pura, Bali, Indonesia (Approval No. 002321/KEP/UNDHIRA/2026). Written informed consent was obtained from all participants before enrollment. All research procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki and applicable institutional guidelines.

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