Effect of Ankle Strategy Exercise on Balance Improvement and Fall Reduce the Risk of Fall in the Elderly

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Abstract

Older adults face a heightened risk of falling both indoors and outdoors due to age-related declines in balance. One contributing factor is weakness or instability in the ankle joint, which can significantly impair postural control and lead to limitations in daily activities. As balance deteriorates, functional capacity in the lower limbs declines, further hindering mobility and independence. Enhancing ankle strength and stability is therefore essential to improving balance and reducing fall risk in this population. This study investigates the impact of Strategic Ankle Exercise on balance and falling risk among older adults. Employing a one-group pre-test and post-test experimental design, the study involved 33 participants who met the inclusion criteria and were selected through total sampling. Balance was assessed using the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test. Wilcoxon test conducted via SPSS revealed a significant improvement in dynamic balance following the intervention: BBS scores increased from 44 to 50.8, while TUG scores decreased from 15.5 to 10.1 ($p < 0.001$). A correlation analysis indicated a strong negative relationship between changes in BBS and TUG scores ($r = -0.86$; $p < 0.001$), suggesting that improvements in balance were associated with reduced fall risk Strategic Ankle Exercise emerges as an effective, evidence-based intervention for enhancing balance and minimizing fall risk in older adults. These findings support the integration of this program into geriatric care strategies. Future research should explore optimal exercise dosage and customization to maximize benefits across diverse age groups and functional levels.

Keyword: Balance, Ankle strategic exercise, BBS, TUG

INTRODUCTION

Impaired balance in older adults significantly limits physical activity and is consistently linked to recurrent falls. The rising incidence of falls in this population is primarily attributed to diminished balance, particularly during standing and walking. Age-related degenerative processes contribute to the decline in various physiological functions, including muscle strength, neural control, vision, and proprioception, all of which are integral to maintaining balance. Effective balance regulation requires the rapid and coordinated interaction of sensory systems (proprioceptive and visual), cognitive functions, and postural control mechanisms when responding to disturbances (Vermette et al., 2024). Early identification and intervention for individuals with poor balance can substantially reduce the risk of repeated falls (Blodgett et al., 2022). It is estimated that 45.4% of older adults, both those living independently and in care facilities, are at risk of falling, with a higher prevalence among women (49.0%) (Susilowati et al., 2020). An active lifestyle plays a crucial role in supporting balance during

physical activity. Maintaining good balance enables older adults to engage in daily activities with fewer limitations, thereby lowering the risk of non-communicable diseases.

Impaired postural stability in older adults contributes to a higher incidence of unintentional falls. Age-related changes in postural control are influenced by the deterioration of sensory systems, including vestibular, visual, and proprioceptive pathways, as well as deficits in muscle strength, neuromuscular coordination, and reaction time. It is estimated that 5–10% of all falls result in fractures, with hip fractures accounting for over 90% of these cases (Strain et al., 2020). Neuromuscular training, which incorporates progressive exercises targeting the upper and lower limbs, proprioception, strength, and balance, is a recommended intervention to mitigate balance decline and enhance the quality of life in older adults. (Concha-Cisternas et al., 2024). Tailored physical exercise programs are essential for this population, taking into account individual capabilities and limitations. Suitable exercise modalities typically include endurance, strength, balance, and flexibility training. These activities should be performed consistently, ideally under the supervision of trained facilitators and in small group settings, to promote muscle recovery, balance improvement, and overall health.

Several studies have demonstrated that ankle strategy exercises can enhance balance and flexibility (Liang et al., 2025). However, evidence regarding their impact on actual fall incidence remains limited, and the overall quality of existing research is low, highlighting a critical gap in the literature that warrants further investigation. Previous research by Vittala (2023) demonstrated that a six-week Balance Strategy Exercise (BSE) program, conducted three times per week, significantly improved both static and dynamic balance in older adults. These improvements were attributed to enhanced agonist and antagonist muscle strength, as well as increased ankle flexibility (Liang et al., 2025). Strengthening the ankle muscles contributes to greater joint stability, which in turn enhances balance during standing and walking. Rapid and accurate anticipatory responses to environmental challenges, such as uneven surfaces, slippery floors, and poor lighting, are critical for reducing fall risk in the elderly.

While theoretical literature supports the use of ankle-focused interventions for minor balance impairments, comparative studies evaluating the effectiveness of different strategies on standing versus walking outcomes in older adults remain limited (Thompson et al., 2024). Therefore, the present study aims to examine the impact of Strategic Ankle Exercises (ASE) on balance and fall risk in older adults, using the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test as assessment tools.

METHODS

This study employed an experimental design using a single-group pretest-posttest approach. A non-probability sampling technique, specifically purposive sampling, was used to recruit participants. The study involved one group consisting of 33 elderly individuals aged 60 years and above. Participants were assessed using the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test before and after undergoing Strategic Ankle Exercise (SAE). The BBS scores were interpreted as follows: 41–56 indicates low fall risk, 21–40 indicates moderate risk, and 0–20 indicates high risk. For the TUG test, travel time of less than 10 seconds reflects normal mobility; less than 20 seconds indicates good mobility with independence; and less than 30 seconds suggests impaired mobility, requiring assistance or the use of assistive devices. Inclusion criteria includes elderly individuals aged 60 years or older, diagnosed with balance impairments based on BBS and TUG scores, and willing to participate in the one-month SAE program by providing informed consent. Exclusion criteria included individuals experiencing pain in one or both ankles or those with a history of ankle fractures.

Strategic Ankle Exercise is a targeted intervention focusing on ankle movement to enhance static and dynamic balance. Exercises involved shifting the head and body forward and backward, redistributing weight, and maintaining posture to prevent falls. Each movement was repeated 15 times per session, with three sessions per week over a four-week period. During the initial phase, all participants gathered in a shared space to perform the exercises under the guidance of an enumerator. In the subsequent phase, participants were instructed to continue the exercises independently at home, maintaining the same frequency. Compliance was monitored weekly by three enumerators, each responsible for 11 participants. They provided reminders via telephone and ensured completion of exercise log forms. Data were analyzed using wilcoxon test to evaluate changes in balance and fall risk before and after the intervention. Ethical approval for this study was obtained from the Faculty Ethics Review Committee of Universitas Kristen Indonesia (Certificate No. 14/Etik Penelitian/FKUKI/2024).

RESULTS

Table 1. Characteristics of Respondents (N = 33)

Variable		N=33	%	Mean±SD
Gender	Male	17	51.5	
	Female	16	48.5	
Age Group	60-69 years	23	69.7	67.97±5.283
	70-79 years	8	24.2	
	≥80 years	2	6.1	
Medical History	Hypertension	11	33.4	
	Diabetes	3	9.1	
	Diabetes & Hypertension	5	15.1	
	None	14	42.4	
Berg Balance Scale (BBS)	Low risk (score 41-56)	20	60.6	44±5.099
	Moderate risk (score 21-40)	13	34.4	
	High risk (score 0-20)	-	-	
Time go test (TUG)	< 10 seconds	-	-	15.545±2.635
	< 20 seconds	30	19	
	< 30 seconds	3	-	

All participants completed the exercise program fully and in accordance with the prescribed guidelines, as evidenced by their submitted reports during the training period. Notably, no injuries were reported. As shown in Table 1, the majority of respondents were aged 60–69 years (69.7%). Regarding medical history, 33.4% had hypertension, 9.1% had diabetes, and 15.1% had both conditions. The average balance score, measured using the Berg Balance Scale (BBS), was 44 ± 5.099. The average fall risk, assessed using the Timed Up and Go (TUG) test, was 15.545 ± 2.635 seconds.

The results of the normality test using the Shapiro-Wilk method for both pre-test and post-test scores of the Berg Balance Scale (BBS) and the Timed Up and Go (TUG) test. The BBS scores were not normally distributed, as indicated by p-values of 0.008 for the pre-test and 0.001 for the post-test ($p < 0.05$). For the TUG test, the pre-test score was normally distributed ($p = 0.192 > 0.05$), while the post-test score was not ($p = 0.001 < 0.05$).

Table 2. Pre- and Post-Test Scores for BBS and TUG (n = 33) , Wilcoxon signed-rank test

Variable	Pre-Test Mean ± SD	Post-Test Mean ± SD	Mean Difference	Wilcoxon p-value	Correlation ΔBBS–ΔTUG (r)	Sig. (p)
BBS	44±5.099	50.848±4.829	Δ = +6.84	<0.001	-0.86	0.000
TUG	15.545±2.635	10.181±1.959	Δ = -5.36	<0.001		

Descriptive analysis in Table 2 demonstrates significant improvements in both BBS and TUG scores following the intervention. The average BBS score increased from 44.00 ± 5.099 in the pre-test to 50.848 ± 4.829 in the post-test, reflecting a mean improvement of +6.84 points. Conversely, the average TUG score decreased from 15.545 ± 2.635 seconds to 10.181 ± 1.959 seconds, indicating a mean reduction of -5.36 seconds.

These changes were statistically confirmed using the non-parametric Wilcoxon signed-rank test, which yielded p-values < 0.001 for both variables. Additionally, a correlation analysis revealed a very strong negative relationship between changes in BBS and TUG scores ($r = -0.86$; $p < 0.001$), suggesting that improvements in balance are closely associated with reductions in functional mobility travel time.

DISCUSSION

This study demonstrates that Strategic Ankle Exercises (SAE) significantly enhance balance and reduce fall risk in older adults, as evidenced by the increase in Berg Balance Scale (BBS) scores and the decrease in Timed Up and Go (TUG) times, both showing statistically significant improvements. Prior to the intervention, the tandem stance and single-leg stance, two of the most challenging components among the 14 BBS items, consistently received low scores from participants. These tasks are particularly difficult for individuals with dynamic balance impairments. However, following the SAE program, participants were able to perform these components with scores within the normal range.

This outcome highlights the effectiveness of ankle stabilization as a key target of the intervention. The SAE program involves weight-bearing exercises that utilize body weight to strengthen the agonist and antagonist muscles around the ankle, thereby improving overall balance. Enhanced ankle stability also contributes to maintaining the body's center of mass within its base of support. Supporting this, Kim et al. (2022) reported that the gastrocnemius and tibialis anterior muscles play critical roles in sagittal and frontal plane balance control, specifically in dorsiflexion and plantarflexion movements. Additionally, proprioceptive input from the ankle, plantar tactile sensation (PTS), and range of motion (ROM) are essential components of balance regulation (Shen et al., 2024).

A study by (Liang et al., 2025) supports the present findings, demonstrating that ankle muscle strengthening exercises are effective in improving balance and gait, thereby reducing fall risk in older adults. Similarly, Zhong et al., (2024) reported that strength training, including ankle and resistance exercises, enhances postural control, corrective reactions, and gait

performance, contributing to fall prevention. Strength training has also been shown to induce muscle hypertrophy in older adults at levels comparable to moderate-speed resistance training.

Beyond muscle strength, proprioception plays a critical role in maintaining balance. In older individuals, proprioceptive function declines due to age-related degeneration, which can further elevate fall risk (Shen et al., 2024). One promising strategy to address this decline is the use of external stimulation, such as vibration applied to the ankle. Liu et al. (Liu et al., 2021) found that vibration can enhance proprioceptive receptor activity in the non-dominant limbs of individuals with low physical activity, such as the elderly.

This approach is grounded in the concept of stochastic resonance, whereby the brain amplifies its response to weak sensory stimuli when exposed to a certain level of noise, stimuli that provoke the sensory system and lead to proprioceptive changes (Matthews et al., 2024). Other forms of noise stimulation, including auditory, visual, and neural electrical inputs, must reach an optimal intensity, known as the neural excitatory threshold, to be effective. Conversely, a study by, Joseph P Carzoli et al. (2022) found no significant improvement in dynamic balance following nine sessions of ankle strategy exercises targeting dorsiflexors in the non-dominant foot of older adults. Their results, based on the Sit-to-Stand test, Timed Up and Go (TUG) test, and Maximal Voluntary Contraction (MVC) torque, showed no measurable changes in postural balance.

Many studies assessing balance in the elderly utilize the BBS and TUG instruments to evaluate intervention outcomes. These tools are widely accepted due to their validity in assessing fall risk, Leger et al. (Leger et al., 2022) compared the validity of the TUG, the Activity-Specific Balance Confidence (ABC) questionnaire, and the BBS, concluding that both the TUG and ABC are reliable, time-efficient, and easy to administer with minimal equipment, making them advantageous for clinical and community settings.

Limitations of the Study

This study has several limitations. First, the sample size was relatively small, and there was no control group for comparison, which may affect the generalizability of the findings. Second, the duration of the intervention was relatively short, limiting the ability to assess long-term effects. Lastly, the researchers did not monitor or record participants' daily physical activity, which could have influenced the outcomes.

Suggestions for Future Research

Future studies should consider recruiting a larger sample and incorporating a control group to enhance the validity and reliability of the results. Additionally, long-term follow-up is recommended to evaluate the sustained impact of the intervention on balance and functional

mobility. Exploring variations in exercise protocols or combining ankle exercises with other interventions may also yield deeper insights into their overall effectiveness.

CONCLUSIONS

Strategic Ankle Exercise is a proven, evidence-based intervention for improving balance and reducing fall risk in older adults. Based on the findings of this study, we recommend incorporating this program into broader intervention strategies aimed at aging populations. Additionally, these results provide a foundation for future research focused on optimizing exercise protocols, such as refining dosage and intensity, to maximize benefits across diverse age groups and varying levels of physical ability.

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