

## Original Research

# Effectiveness of Static and Dynamic Weight Shift Balance Strategies in Improving Postural Balance Function in the Elderly

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## ABSTRACT

**Introduction:** Aging is a process in the elderly, characterized by changes in body balance, which can impact the risk of falls. The ability to control body balance function in the elderly is affected by the degenerative process, making them prone to unsteadiness, slipping, and tripping, which can increase the risk of falls for the elderly. The exercises begin with static weight shifts (anterior-posterior and lateral) to improve stability and postural control. They then progress to dynamic exercises such as stepping, reaching, and changing gait directions to enhance functional balance adaptation

**Objective:** This study aims to determine the effectiveness of static and dynamic weight-shift balance strategies as a development of low-coast management exercise to improve balance function

**Method:** This is a quantitative study with a quasi-experimental design. This study used a pre-test, post-test, two-group design, with purposive sampling

**Result:** Data were analyzed using an independent sample t-test. The results showed a p-value of 0.001 ( $p < 0.05$ ), indicating a significant difference in effectiveness between balance scores before and after exercise in group 1, with a mean of 10.12 and group 2, with a mean of 9.05. There was a significant difference between groups ( $p\text{-value} = 0.025$ )

**Conclusion:** Dynamic weight-shift balance strategies are more effective in improving balance in the elderly than static weight-shift balance strategies.

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## INTRODUCTION

The aging process for individuals is unavoidable. As individuals age, they are also at risk of experiencing a decline in physical function. Decreased ability in the musculoskeletal system leads to a decline in muscle and joint flexibility and bone density, which affects the elderly's ability to perform daily activities. The ability to control body balance function in the elderly is affected by the degenerative process, making them prone to unsteadiness, slipping, and tripping, which can increase the risk of falls for the elderly (1). Body balance in the elderly influences their ability to perform daily activities due to changes in gait and weakness in extremity muscle strength, which are related to decreased muscle tone and strength (2).

The research that performed by, stating that the daily activities of the elderly tend to fall into the low category, namely 5 (3.68%) and 6 (34.7%), which means that most elderly people tend to engage in low levels of physical activity (3). The results of research conducted by the researcher in 2019 indicate a relationship between age, environment, cardiovascular disorders, and physical activity with the risk of falls in the elderly (4). This indicates that elderly individuals with functional impairments, especially severe functional impairments, require government support to maintain their social lives in old age by preserving their ability to control body balance, thereby making their functional activities more productive (5).

Balance decline is also more common in those aged 60 and over, based on the level of decline in body balance experienced by the elderly, most are at a moderate level (6). As the age group increases, the decline in body balance becomes more severe (7). Aging affects muscle mass throughout the lower extremities, and femoral muscle mass, which is the main component related to body balance in the elderly (8). Elderly individuals with impaired body balance will experience a quantitative loss of muscle mass, leading to changes in the properties of individual muscle fibers that will affect muscle strength loss (9).

Based on this condition, the research team was then motivated to conduct research to determine the effectiveness of static and dynamic weight shift balance strategies as a low-cost management exercise for improving balance function. The research gap regarding the differences in effectiveness of static and dynamic balance training in older adults needs to be explicitly addressed, as most studies tend to focus on balance training in general without specifically examining statistical and dynamic postural control mechanisms. However, statistical balance control (the ability to maintain a stable body mass) and dynamic balance control (the ability to control the center of mass during movement or shifting of support) involve different neuromuscular demands and sensorimotor adaptations.

This lack of clarity limits the ability to determine the most appropriate training strategy for older adults' risk profiles and functional capacities. Direct comparisons between statistical and dynamic strategies are needed to identify more effective approaches for improving specific balance parameters, such as postural stability, gait speed, response to perturbations, and reducing fall risk. These findings will contribute to the practice of geriatric physiotherapy and rehabilitation by providing an evidence-based basis for developing more specific, targeted, and individualized intervention protocols, both in clinical and community settings.

This research focuses on a low-cost, community-based intervention model for older adults developed by integrating static and dynamic weight shift balance strategies through simple, equipment-free exercises. The exercises begin with static weight shifts (anterior-posterior and lateral) to improve stability and postural control. They then

progress to dynamic exercises such as stepping, reaching, and changing gait directions to enhance functional balance adaptation (10).

## METHOD

This is a quantitative study with a quasi-experimental research design. The aim is to determine statistical and dynamic weight shift balance strategies as a low-cost management exercise development tool for improving balance function. This study used a Pre-Test Post-Test research design with a Two-Group Design, in which the researchers used two groups: the experimental group.

The effect of the statistical and dynamic weight shift balance program intervention was evaluated by comparing the Post-Test scores of the two experimental groups. The inclusion criteria for selecting respondents were: 1) Elderly aged 60-70 years at the Surakarta City Elderly Posyandu; 2) Those at risk of falling. Exclusion criteria included: 1) Elderly with a history of musculoskeletal injury/trauma such as fractures, muscle or ligament injuries due to sports in the lower extremities.

The sampling technique used was purposive sampling, in accordance with the inclusion and exclusion criteria. Respondents who met the criteria were then divided into 2 groups (experiment 1 and 2). A total sample of 60 respondents met the inclusion criteria which were then randomly divided into two groups proportionally (1:1) using a randomization technique using a number table so that each group has 30 participants, and an initial measurement (pretest) was conducted to determine the level of physical functional activity ability.

Respondents in Group 1 received treatment in the form of a dynamic weight shift balance strategy program, developed from low-cost management exercises, for 3 training sessions per week for 6 weeks (Pierle et al. 2022). Respondents in Group 2 received treatment in the form of a statistical weight shift balance strategy program, developed from low-cost management exercises, for 3 training sessions per week for 6 weeks (Mohammadian et al. 2019). At the end of the intervention, a final measurement (posttest) was then conducted on both groups to determine the effect of statistical and dynamic weight shift balance strategies on improving balance in the elderly.

The research instruments used included: 1) Time Up and Go Test (TUGT) to assess the condition of dynamic balance in the elderly; 2) Stopwatch to measure the exercise execution time; 3) Chair; 4) Dumbbell 2 kg for women and 3.5 kg for men, at the midline; 5) Standard Operating Procedure (SOP) for low-cost multicomponent fitness training programs for the elderly. 4) Standard Operating Procedure (SOP) for TUGT.

The results of the pretest and posttest measurements were then processed and analyzed using specific statistical tests to determine the effect of the intervention. Hypotheses were tested using the Independent Samples t-test with a significance level of  $p < 0.05$ , data processing using IBM SPSS software.

### Ethical Approval

This study was approved by the Health Research Ethics Committee of Aisyiyah Surakarta University (Approval Number: 267/X/AUEC/2024). All participants, provided informed consent prior to participating in the study. The confidentiality of all participants was strictly maintained throughout the research process.

## RESULTS

The research was conducted at the Senja Bahagia Elderly Health Post in Surakarta from March 5th to July 31st, 2024. With a total elderly population of people, 60 individuals met the inclusion and exclusion criteria, selected thru purposive sampling.

The study was conducted on elderly individuals aged 65-70 who had balance disorders assessed using the TUGT. There were no sample dropouts in this study.

**Table 1.** Testing the Effect of Balance in the Elderly

Variable	Average Before Training	Average After Training	Difference Value	P Value
Balance Static	18,06±0,95	19,96±1,04	1,90	0,04
Balance Dynamic	24,11±1,35	30,21±1,42	6,10	0,001

Source: Primary Data

Based on Table 1, where the data was processed using the paired samples t-test. The results showed a p-value of 0.04 ( $p < 0.05$ ), indicating a significant difference in balance scores before and after training in the static group (treatment group 1). In the dynamic group, the data showed a p-value of 0.001 ( $p < 0.05$ ), indicating a significant difference in balance scores before and after training in the dynamic group (treatment group 2). This study shows that both static and dynamic weight shift balance strategies are effective in improving postural balance in the elderly, as indicated by significant p-values in the paired sample t-test. These results reflect changes in the underlying neuromuscular and sensorimotor system functions that contribute to improved balance abilities. To understand this more deeply, here are the physiological mechanisms of each type of exercise.

**Table 2.** Independent Samples T-Test for Testing the Difference in Effects

Variable	Group	n	Mean	SD	p-value
Value	(1)Static Weight Shift	30	10,12	6,80	
	(2)Dynamic Weight Shift	30	9,05	5,95	,025

Source: Primary Data

Based on Table 2, the test for differences in the effect of Dynamic Weight Shift showed that it was more effective in improving postural balance in the elderly. The results of data analysis using the Independent Sample T-Test showed a significant difference in the mean between the Dynamic Weight Shift group (10.12) and the Static Weight Shift group (9.05) with a significance value of  $p = 0.025$ , which was statistically significant. This finding strengthens the evidence that dynamic balance exercises have a greater impact on improving postural balance function in older adults compared to static exercises. The higher effectiveness of dynamic exercise can be explained by the following physiological mechanisms.

## DISCUSSION

### Testing The Effect Static Weight Shift & Dynamic Weight Shift Balance Strategies

Static Weight Shift Balance Strategies (Group 1) have a targeted effect on the somatosensory, neuromuscular, neuroplasticity systems, and improve ankle-hip strategies (11). Elderly individuals tend to experience a decline in proprioception due to the degeneration of sensory receptors in muscles and joints (12). Static shift exercises force patients to increase their awareness of body position by activating mechanoreceptors in the soles of the feet, ankles, and knees (13). This strengthens sensory feedback, thereby improving the body's ability to detect changes in position (14). By activating major postural muscles such as the core muscles (trunk stabilizers), gluteals, and ankle stabilizers (e.g., tibialis anterior, gastrocnemius), these exercises facilitate the co-contraction of agonist and antagonist muscles to maintain balance in a static position, thereby improving motor control (15). Elderly individuals who practice static weight shifting tend to rely on ankle and hip strategies to maintain balance, with repeated practice, these strategies become more integrated and automatic (16). The repetition of movements in this exercise triggers neuroplasticity, which is the reorganization of sensorimotor pathways in the brain, particularly in the motor cortex and cerebellum. This helps improve the body's response to mild balance disturbances (17).

Dynamic Weight Shift Balance Strategies (Group 2) have targeted effects on more complex multisensory integration systems, postural reflex response training, improved midbrain function (basal ganglia and cerebellum), greater motor recruitment, and enhanced ambulation function in daily activities (18). Dynamic balance requires the simultaneous integration of the vestibular, visual, and somatosensory systems, older adults learn to adapt to changes in head and body position while dynamically shifting their weight (19). Dynamic movements are more challenging because they create disturbances (perturbations) that mimic real-world conditions (e.g., when walking or avoiding objects). Thru this exercise, postural corrective reflexes become faster and more directed. Improved brain function and increased plasticity are achieved thru dynamic movement exercises that stimulate the cerebellum and basal ganglia, which play a crucial role in movement coordination and automation. This process improves inter-limb coordination and core stabilization (20). Dynamic balance exercises lead to broader muscle activation: in addition to postural muscles, the muscles of the lower and upper extremities are also engaged, which strengthens the entire kinetic chain of the body, improving anticipatory and compensatory reactions to balance disturbances. Ambulation function in daily activities can improve because dynamic movements more closely resemble everyday activities (walking, climbing stairs, turning the body), and the effects of exercise are more transferable to real life (21).

### Test of Difference in Effect Static Weight Shift & Dynamic Weight Shift Balance Strategies

More comprehensive sensorimotor system activation is achieved during dynamic weight shift exercises, which require the body to maintain stability during movement. This involves coordinated work between the visual, vestibular, and somatosensory systems, all of which experience a decline in function with age. Visual function trained

with movement exercises helps to accurately direct body movements when changing positions. Performing these exercises activates the vestibular function, providing information about the head's position and movement relative to gravity. Somatosensory input is active in informing the position of limbs thru receptors in muscles and joints (22).

Dynamic exercises train the simultaneous integration of these three systems, thereby strengthening postural reflex responses and improving body stability while moving. Improved neuromuscular function and active corrective reactions with dynamic exercises repeatedly create mild balance disturbances (perturbations). The body responds with rapid and coordinated muscle activation, especially in the core muscles: transversus abdominis, multifidus, pelvic muscles: gluteus medius/minimus, lower limb muscles: quadriceps, hamstrings, tibialis anterior, gastrocnemius. This reflex response strengthens corrective reaction mechanisms (compensatory strategies) and anticipatory reactions (anticipatory strategies), which are crucial for older adults to avoid falls (23).

More realistic balance strategies are achieved by performing dynamic exercises that involve balance strategies more relevant to real life, such as: Stepping strategy: Moving one foot to maintain balance during large disturbances. Hip strategy: Using quick movements at the hips during moderate disturbances. Ankle strategy: Maintaining balance with small movements at the ankles. The involvement of all these strategies makes balance adaptation more flexible and functional, whereas static exercises only strengthen the ankle strategy in a limited context (24).

Increased neuroplasticity and motor-brain coordination with dynamic exercise require movement planning and rapid adaptation, which activate brain areas such as the cerebellum in regulating movement coordination and timing, and the motor cortex in controlling voluntary movements. Basal ganglia: Controls automatic movements and inhibits unnecessary movements. Repeated stimulation of these pathways increases neuroplasticity, improving postural control and the body's response to environmental disturbances (25).

Better transfer to daily functional activities with dynamic exercises has a high similarity to daily activities of older adults such as walking, moving from sitting to standing, avoiding obstacles, and turning or reaching for objects; these abilities directly reduce the risk of falls, improve mobility, and increase the independence of older adults. The higher average increase in the dynamic group (10.12 vs 9.05) reflects that dynamic exercise provides a more complex and comprehensive physiological stimulus, affecting the sensory, neuromuscular, and brain integration of body movements. Therefore, dynamic weight shift is considered more effective as a rehabilitative intervention to significantly improve postural balance in the elderly (26).

## LIMITATIONS

This study has several limitations. First, the sample size was relatively small and limited to older adults from a single community setting in Surakarta. Second, the intervention period lasted only six weeks, which may not fully represent the long-term effects of balance training. Future studies should involve larger and more diverse populations and include longer follow-up periods to evaluate the sustainability of balance improvements.

## CONCLUSION

The data was analyzed using the Independent Samples t-test. The results showed a p-value of 0.001 ( $p < 0.05$ ), indicating a significant difference in balance scores before and after the intervention in group 1 (mean 10.12) and group 2 (mean 9.05). Conclusion: Dynamic weight shift balance strategies are more effective in improving balance in the elderly compared to static weight shift balance strategies. Muscle weakness and orthostatic hypotension often alleviate balance disorders. Physiotherapists play a central role in maintaining and improving balance through exercise-based approaches Static Weight Shift & Dynamic Weight Shift Balance Strategies that can be applied At the community level, balance maintenance programs can be implemented through elderly exercise groups, fall prevention education classes, and health cadre training. Programs such as community-based fall prevention have been shown to increase social participation and independence of the elderly.

The results of this study indicate that statistical and dynamic balance exercises are effective in improving postural control in the elderly. Clinically, this intervention can be integrated into geriatric rehabilitation programs in primary health care facilities and physiotherapy clinics. Statistical balance exercises (e.g., single-leg standing, tandem stance) are beneficial for improving baseline stability (the basis for support control), while dynamic exercises (e.g., weight transfer, stepping strategies) play a greater role in improving adaptability to changes in body position during movement. In a community context, this program has great potential for implementation in Posyandu activities for the elderly as part of promotive and preventive fall risk management. This community-based approach supports a low-cost, broad-reaching community-based rehabilitation (CBR) model, making it relevant for implementation in both urban and rural areas. Directions for several exercise developments include expanding the diversity and number of samples and comparing integrated exercise models.

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest that could have influenced the study's design, data collection, analysis, interpretation, or the conclusions reported in this manuscript.

## DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors disclose that AI-assisted tools, including ChatGPT and Grammarly, were used solely for language refinement, grammar correction, and structural editing during the manuscript preparation process. The intellectual content, study design, data interpretation, and conclusions were independently developed and authored by the listed contributors.

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