Research Report

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Effects of a Hip Joint Muscle Strengthening Program using Props on Lower Limb Alignment and Balance in Older Adults

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Background Falls among older adults are not merely minor injuries but can lead to fatal outcomes. This study aimed to examine the effects of a small-equipment-based hip muscle strengthening program on lower extremity alignment and balance in older adults, to propose a more effective exercise intervention for fall prevention in this vulnerable population.

Purpose This study aimed to investigate the effects of a small-equipment-based hip muscle strengthening program on lower extremity alignment, static balance, and dynamic balance in older adults.

Study design A randomized controlled pretest-posttest design was used

Methods Twenty-five older adults (≥ 65 years) were randomly assigned to an experimental group (n = 13) or control group (n = 12). Both groups completed identical 8-week programs (2×/week, 60 min), with the experimental group using props. Back knee angle (alignment) was measured via a smartphone goniometer, dynamic balance via berg balance scale (BBS), and static balance via balancia. Data was analyzed using two-way repeated measures ANOVA, with Bonferroni-corrected t-tests for significant interactions.

Results In comparison of back knee angle for lower extremity alignment, both between-group and within-group analyses showed significant improvements. Similarly, dynamic balance, assessed by BBS scores, demonstrated significant improvements both between and within groups. In contrast, static balance showed no significant difference between groups, with a significant improvement observed only in the control group.

Conclusions The prop-based hip joint muscle strengthening program demonstrated significant improvements in lower extremity alignment and dynamic balance among older adults. These results indicate that propassisted exercise interventions may offer a feasible and clinically relevant approach for fall prevention in geriatric populations.

Key words Balance; Fall prevention; Hip joint muscles; Lower extremity alignment; Older adults; Props-based exercise

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INTRODUCTION

Falls are a major global public health issue and the second leading cause of unintentional injury-related deaths worldwide. falls are the most common and fatal accidents among adults aged 65 and older. The mortality rate per 100,000 population increases with age: 18.2 in their 70s, 61.3 for those under 84, and 124.5 for those aged 85 and older. Falls not only cause injuries but may also result in death or permanent disability, often requiring long-term rehabilitation and care, which significantly reduces the quality of life in older adults and increases the burden on social healthcare systems.[2] Falls were once regarded as unavoidable accidents, but are now seen as preventable events, prompting diverse multidisciplinary strategies. The World Health Organization (WHO) emphasizes that scientifically grounded prevention strategies are effective in reducing the incidence and social costs of falls.[3, 4] In line with this, organizations such as the Korea Disease Control and Prevention Agency have introduced elderly fall prevention programs involving exercise, education, and expert training, which are relatively low-cost but highly effective in improving muscle strength, balance, and environmental factors. Several previous studies have shown that exercises aimed at improving muscle strength, Range of Motion (ROM), and both dynamic and static balance significantly reduce fall rates.

A key element in preventing falls is enhancing lower extremity alignment and balance through targeted strengthening of hip muscles. Sarcopenia, commonly observed in the elderly, significantly affects hip muscle function and contributes to misalignment and instability. Several previous studies have shown that exercises aimed at improving muscle strength, range of motion (ROM), and both dynamic and static balance significantly reduce fall rates. Lower extremity alignment refers to the straight anatomical positioning of the hip, knee, and ankle, serving as a foundation for both static posture and dynamic movement. This alignment depends on the integrated function of the neuromuscular and sensory systems, including proprioception, visual-vestibular coordination, and neuromuscular control. When misalignments such as genu varum, genu valgum, or excessive foot pronation occur, they disturb the transmission of ground reaction forces, compromise postural stability, and increase fall risk.

Balance is generally categorized into static and dynamic components. Static balance involves maintaining a stable posture in the absence of movement or external force, while dynamic balance refers to the ability to maintain postural control during movement or in response to external perturbations. Impairment in either type of balance greatly elevates fall risk. Anatomically, the hip adductors originate from the pelvis and insert into the inner or posterior part of the femur, contributing to postural control that ensures both stability and flexibility of the body, and reducing the mechanical load on the lumbar spine. Therefore, the function of the hip joint plays a crucial role not only in dynamic movements but also in situations requiring static balance and posture maintenance, such as lifting heavy objects. During these activities, body weight is evenly distributed across both lower limbs, and the hip adductors and abductors contract simultaneously to maintain the pelvis in a neutral position, ensuring symmetrical alignment of the lower limbs and overall body stability. This process plays a crucial role in preventing problems such as back pain, postural abnormalities, and falls. International studies have reported the effectiveness of exercise interventions even in the ultra-elderly population (80 years and older). For instance, Gardner et al. found that a balance training program significantly reduced fall incidence in individuals aged 80 and above. Orr also emphasized the importance of strengthening hip muscles for maintaining alignment and postural control.

In contrast, domestic studies have demonstrated beneficial results among elderly individuals aged 60 to 70, although systematic interventions specifically targeting the ultra-elderly remain limited. Specifically, research utilizing small equipment such as resistance bands and mini balls is limited. Resistance bands are widely used in both open and closed kinetic chain exercises and are effective in improving joint stability and motor control. The mini ball, originally developed for rehabilitation in Swiss physical therapy, induces postural instability to stimulate proprioception and target deep hip muscles. These tools enhance neuromuscular coordination by improving the interaction among agonists, antagonists, synergists, and stabilizer muscles, rather than increasing motor unit recruitment. The instability created by small equipment demands greater neuromuscular adaptation, particularly in muscles like hip adductors, which are rarely activated during normal walking. Therefore, this study aims to investigate the effects of a hip muscle strengthening program using bands and mini balls on lower extremity alignment and both static and dynamic balance in the elderly, and to propose a practical, sustainable exercise program for fall prevention.

METHODS

Participants

A total of twenty-five adults aged 65 years or older residing in a district of Daegu, South Korea, including members of a local senior welfare center, were recruited based on predefined inclusion and exclusion criteria. This study was approved by the Institutional Review Board of Daegu University (IRB No.: 1040621-202408-HR-067). Inclusion criteria were age 65 years or older, ability to perform daily activities independently, and capacity to participate in group exercise sessions. Exclusion criteria included a history of dementia or stroke, visual impairments, use of medications that affect balance, recent fractures or related treatments, and current participation in other exercise programs.

Experimental procedure

The exercises were designed based on a range of motion

(ROM) principles, targeting six directions of hip joint movement (flexion, extension, abduction, adduction, internal rotation, and external rotation). To stimulate these movements, the time allocation was distributed as follows: extension 28%, abduction and adduction 39%, internal and external rotation 24%, and cool-down 5%. ROM is a key indicator for evaluating musculoskeletal function, reflecting not only joint flexibility and mobility but also the functional state of muscles, ligaments, tendons, and the joint capsule Enhancing in the elderly, a decrease in the range of joint motion is directly related to decreased balance, impaired walking ability, restrictions in activities of daily living, and increased risk of falls. ROM that can positively change the functional state was selected as the basis. When exercising, the exercise methods and points to keep in mind are as follows (Table 1).

1) Lower extremity alignment test

In this study, the Angles-Video Goniometer was used to measure angles related to lower extremity alignment. According to a previous study, this application demonstrated an extremely high correlation with mechanical and digital goniometers ($r > 0.90$, $p < 0.01$), as well as high reliability for repeated measurements (Intra-Class Correlation Coefficient, ICC> 0.90). The Angles-Video Goniometer utilizes the smartphone's built-in gyroscope and camera to quantify motion, offering an accurate method for measurement.

The measurement protocol follows the anatomical definitions presented by Schulte and Yarasheski by connecting the greater trochanter to the midpoint of the joint line and the midpoint of the knee joint line to the lateral malleolus. by connecting the greater trochanter to the midpoint of the knee joint line and the midpoint of the knee joint line to the lateral malleolus. This method ensures precise angle detection. During measurements, participants were instructed to fully relax the hamstrings, gluteal muscles, and quadriceps. According to Jeon et al, the intra-rater reliability of this protocol demonstrated an ICC of 0.95.

2) Dynamic balance ability test

The BBS was used to assess the participants' dynamic balance ability before and after the exercise intervention. It includes fourteen tasks ranging from sitting to standing and changing postures, with each task scored from 0 to 4, resulting in a total score of 56 points. This tool has demonstrated excellent reliability (intra-rater $r = 0.99$, inter-rater $r = 0.98$) and validity.

3) Static balance ability test

The measurement involves drawing a line from the center of pressure (COP) on the force plate in the direction of gravity, using left-right and front-back sway distances as x and y values (trace length).

In this experiment, the 95% area of the COP movement, representing static balance, is calculated as a circular area based on the distance traveled. The remaining 5% is excluded. A lower value indicates better balance ability.

Static balance was measured using a Bluetooth-enabled Wii Balance Board (Nintendo, Kyoto, Japan) and the Balancia v1.0 program. The COP trace was tracked along the x and y axes, and the A95 area was calculated. Participants stood barefoot on the board with eyes closed for 30 seconds, repeatedly three times. The total movement area (mm) was measured, and the average was calculated. An instructor was present for safety.

The Wii Balance Board has high test-retest reliability (ICC = 0.66 to 0.94) and intrareader reliability (ICC = 0.92 to 0.98), ensuring the reliability of the measurements.

Data analysis

All data analyses in this study were conducted using SPSS (Statistical Package for the Social Sciences) version 23.0 for Windows (SPSS Inc., Chicago, IL, USA). To assess the universal characteristics of the participants, an independent t-test was performed. The normality of the measured variables was evaluated using the Kolmogorov-Smirnov test.

To analyze the changes in lower extremity alignment as well as static and dynamic balance indicators over time between the experimental group and the control group, a repeated measures two-way analysis of variance (ANOVA) was employed. When significant interaction effects were identified, post-hoc analyses were conducted using independent t-tests, with the Bonferroni correction applied to account for multiple comparisons. The significance level was set at $\alpha = 0.025$.

RESULTS

Table 2 showed the characteristic of participants in each group. Significant between-group differences were observed in the back knee angle, with the experimental group exhibiting significant within-group improvement (p<0.05) (Table 3). Similarly, dynamic balance, as measured by BBS scores, showed significant improvements both between and

Table 1. Hip joint muscle strengthening program movement sequence

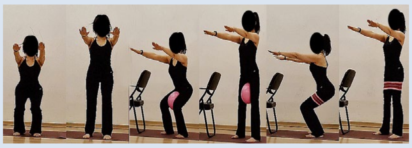
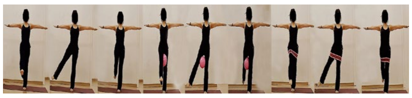
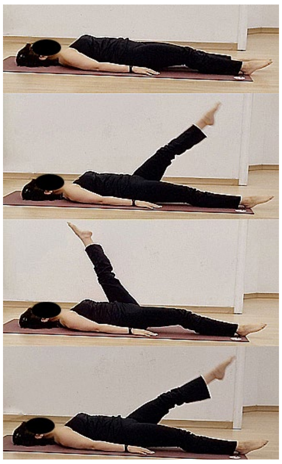
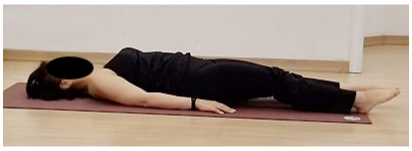
Movement sequence and figure	Exercise intensity	Target muscle	Procedure
1. Warm-up Exercises 	5 minutes	All hip joint muscles	Participants are required to maintain an upright posture for safety and proper alignment, avoiding compensatory movements. This low-intensity routine involves a continuous 5-minute series of movements, including hip flexion, extension, abduction, internal and external rotation, with knee flexion or intermittent heel raises allowed to minimize fatigue and promote balanced hip mobility, preparing for the strengthening phase.
2. Hip Joint Muscles Squat Exercise 	5 minutes (10 times in 1set, 5 repetitions)	Flexion, extension	1. Starting Position: Stand upright with feet hip-width apart and parallel, resembling the number “11.” 2. Hip Flexion Movement: Hinge forward from the hips within a functional range of up to 120°, depending on knee position and individual flexibility, then return to standing. Repeat rhythmically while maintaining a neutral spine. 3. Knee Alignment Cue: Maintain proper alignment by ensuring knees do not move forward beyond the toes to minimize anterior shear force and joint stress.
3. Standing Hip Joint Muscle Star Exercise 	5 minutes (10 times in 1set, 5 repetitions)	Flexion, extension. abduction, adduction	1. Dynamic Balance Training on One Leg: Begin by supporting your weight on one leg. Move the opposite leg actively in three directions: forward (hip flexion), backward (hip extension), and medially across the body’s midline (adduction). This exercise promotes dynamic balance and improves hip joint mobility. 2. Standing Hip Abduction: From a neutral standing position, abduct the moving leg laterally within the normal hip abduction range of 40°–45°. Maintain a neutral spine and pelvis and avoid lateral trunk bending to effectively activate the hip abductor muscles. 3. Standing Hip Adduction: Return the leg to the neutral stance, then move it medially across the body's midline, targeting 0° to 30° of hip adduction, as consistent with normative joint ranges Emphasize controlled motion and pelvic stability, avoiding compensatory trunk or hip rotation.
4. Hip Joint Muscle Double Leg Stretch Exercise 	5 minutes (10 times in 1set, 5 repetitions)	Flexion, extension	1. Lie supine with both legs extended. Raise the legs to about 90° hip flexion while keeping the pelvis neutral. Engage the core to prevent lumbar arching and lower the legs slowly to activate the hip flexors and core eccentrically. 2. The typical hip flexion range is 0°–120°, but some individuals may struggle with spinal alignment at higher angles. Therefore, the target range should be adjusted based on each participant’s flexibility and pelvic stability to maintain lumbar alignment.

Table 1. Continued

Movement sequence and figure	Exercise intensity	Target muscle	Procedure
5. Hip Joint Muscle Abduction. 	7 minutes (7 sets of 1 minute each)	Abduction, adduction	1. Starting Position: Lie on your side with the lower arm extended under your head and the upper hand on the floor in front of your torso for balance. 2. Hip Abduction Movement: Lift and lower the upper leg in a slow, controlled manner, engaging the hip abductors throughout the movement. 3. Bilateral Leg Raise and Hold: Raise both legs together as vertically as possible and hold the position for the prescribed duration, maintaining alignment and avoiding compensatory trunk movements. 4. Hip Adductor Activation: Emphasize contraction of the hip adductors while keeping the pelvis stable. Ensure both the pelvis and insteps face forward without rotation. 5. Hip Abduction Range of Motion: The typical hip abduction range is up to 40°–45°. Focus on isolating the hip abductors by lifting the leg without allowing the pelvis to rotate or the trunk to tilt. This ensures the proper activation of the hip abductors and avoids compensatory movement patterns. 6. Emphasis on Control: Execute all movements slowly and precisely to prevent compensation and improve neuromuscular control.
6. Hip Joint Muscle One-Legged Stretch Bridge Exercise 	5 minutes (10 times in 1set, 5 repetitions)	Flexion, extension	1. Starting Position: Participants lie on their back with their neck relaxed and the chin gently tucked toward the sternum. The knees are bent at approximately 90 degrees, and the feet are placed hip-width apart on the floor. 2. Lift your pelvis off the floor until your knees, hips, and shoulders are in a straight line. Firmly activate your glutes at the top, then gently lower down. 3. While in the bridge position, extend one knee at a time. Keep your pelvis stable, avoiding any drop or tilt. 4. Gluteus Maximus Activation: The gluteus maximus accounts for approximately 33% of the total hip musculature and plays a crucial role in hip extension. Performing the bridge with the knees flexed at 90 degrees optimizes gluteus maximus activation, enhancing strength and pelvic stability.
7. Lying Hip Joint Muscle Scissors (Common Exercise) 	5 minutes (10 times in 1set, 5 repetitions)	Flexion, extension	1. Scissor Leg Movement: The participant alternates pulling each leg toward the body, performing a crossing motion like scissors. The movement is done repetitively, ensuring controlled motion and stability throughout the exercise. Hip Flexion Range: Normal hip flexion range is 120° to 130°. However, if you have difficulty maintaining proper posture (especially with your lower back fully on the floor) within this range, you should aim for a flexion angle that allows alignment and control.

Table 1. Continued

Movement sequence and figure	Exercise intensity	Target muscle	Procedure
8. In Prone Position, Draw A Circle With Your Legs (Common Exercise) 	5 minutes (10 times in 1set, 5 repetitions)	External rotation, Internal rotation	1. Prone Hip Mobilization: In the prone position, the participant bends the knees and stabilizes the pelvis and abdomen by pressing them against the floor. The legs are then moved freely to the right and left to mobilize the hip joint's range of motion (ROM). 2. External Rotation in Prone Position: During external rotation in the prone position, the hip joint's ROM is 45 degrees. It is essential to stabilize the pelvis by pressing it against the floor while performing the movement to ensure proper alignment and prevent compensatory motions.
9. Lying Hip Joint Muscle Circle (Common Exercise) 	8 minutes (10 times in 1set, 8 repetitions)	External rotation, Internal Rotation	1. Starting Position: The participant lies facing upwards, with their back firmly pressed against the floor. One leg is positioned flat on the floor, while the other leg remains elevated. 2. Hip Flexion and Rotation: The participant elevates the leg and rotates it in a controlled, circular motion in the air, aiming to flex the hip as close to 120° as possible. The movement should remain within the individual's range of motion to prevent excessive strain on the hip flexors.
10.Resting posture (Calm down) 	5 minutes	-	Calm down.

within groups (p<0.05) (Table 4). In contrast, no significant between-group differences were found in static balance (Area95), although a significant within-group improvement was observed only in the control group (p<0.05) (Table 5).

DISCUSSIONS

In this study, we explored the mechanisms of exercise using a small tool that focuses on strengthening hip muscles, in contrast to existing approaches that focus on whole-body exercises. As a result, in relation to lower extremity alignment, the experimental group using the small tool showed statistically significant improvement in the back knee angle in both within-group and between-group comparisons. This suggests that strengthening the hip muscles increases the stability of the lower extremity muscle group and contributes to redistributing the mechanical load on the knee joint. In this study, the back knee angle was not simply a measure of knee hyperextension but was interpreted as a decrease in the range of motion of the knee joint, which is related to an increased risk of falls in the elderly. Therefore, correction of the back knee angle in the elderly with a hunched posture was considered to improve lower extremity alignment.

Do et al. emphasized the importance of hip muscle strength in patients who underwent knee joint replacement,

Table 2. General characteristics of the participants

Variable	Group	Mean ±SD	*P*
Age	EG	82.23± 8.03	0.96
	CG	82.41± 8.10	
Height	EG	156.92± 5.13	0.97
	CG	157.± 4.07	
Weight	EG	55.69± 5.06	0.75
	CG	56.33± 4.87	
Body mass index	EG	22.56± 1.38	0.69
	CG	22.86± 1.94	

EG: experimental group with small props, N =13.
CG: control group without small props, N = 12.
Mean ±SD: mean ±standard deviation.
$^*P<0.05$.

Table 3. Comparison of back knee angle (Unit: score)

Group	Pre	Post	Difference value	Time (*P* value)	Group×time (*P* value)	Group (*P* value)	*t* value	*P* value
EG	170.87±5.10	173.72±5.00	2.85±2.36	< 0.01*	0.03*	0.73	4.36	< 0.01*
CG	171.05±5.10	171.88±7.01	0.86±1.72	-	-	-	1.74	0.11

EG: experimental group (with small props).
CG: control group (without small props).
Pre: before intervention (mean ± standard deviation).
Post: after intervention (mean ± standard deviation).
Difference value: change between pre and post.
Time (*P* value): *P*-value for within-group change over time.
Group×time (*P* value): *P*-value for interaction between group and time.
Group (*P* value): *P*-value comparing groups (post–pre difference).
P value (Bonferroni adjusted, $\alpha = 0.025$): Bonferroni-corrected *p*-value for multiple comparisons.
$^*P < 0.05$.

Table 4: Comparison of berg balance scale (Unit: score)

Group	Pre	Post	Difference value	Time (*P* value)	Group×time (*P* value)	Group (*P* value)	*t* value	*P* value
EG	37.38±11.33	44.92±7.98	7.54±4.56	< 0.01*	0.01*	0.43	5.80	< 0.01*
CG	36.08±13.81	38.75±13.81	4.00±2.49	-	-	-	2.32	0.04*

EG: experimental group (with small props).
CG: control group (without small props).
Pre: before intervention (mean ± standard deviation).
Post: after intervention (mean ± standard deviation).
Difference value: change between pre and post.
Time (*P* value): *P*-value for within-group change over time.
Group×time (*P* value): *P*-value for interaction between group and time.
Group (*P* value): *P*-value comparing groups (post–pre difference).
P value (Bonferroni adjusted, $\alpha = 0.025$): Bonferroni-corrected *p*-value for multiple comparisons.
$^*P < 0.05$.

Table 5. Comparison of area95 (Unit: centimeter)

Group	Pre	Post	Difference value	Time (*P* value)	Group×time (*P* value)	Group (*P* value)	*P* value
EG	4.87±3.37	4.47±2.92	-0.40±3.52	0.06	0.15	0.41	0.55
CG	7.21±5.86	4.56±3.77	-2.65±4.03	-	-	-	0.03*

EG: experimental group (with small props).
CG: control group (without small props).
Pre: before intervention (mean ± standard deviation).
Post: after intervention (mean ± standard deviation).
Difference value: change between pre and post.
Time (*P* value): *P*-value for within-group change over time.
Group×time (*P* value): *P*-value for interaction between group and time.
Group (*P* value): *P*-value comparing groups (post–pre difference).
P value (Bonferroni adjusted, $\alpha = 0.025$): Bonferroni-corrected *p*-value for multiple comparisons.
*$P < 0.05$.

that intervention programs focused solely on quadriceps strengthening did not produce significant effects. In contrast, interventions that included hip abduction exercises led to substantial improvements in pain, symptoms, and activities of daily living, as well as a reduction in fall risk. These findings align with the results of this study, supporting the idea that hip muscle strengthening contributes to improved knee joint function. Achieving a back knee angle close to 180 degrees necessitates adequate extension mobility in both the hip and knee joints. In elderly individuals with restricted knee range of motion, enhancing hip extension may play a compensatory role in improving posterior knee alignment. In this study, resistance bands were used to effectively strengthen the quadriceps and hip abductors. which also led to simultaneous strengthening of synergistic muscles such as the hamstrings, calf muscles, and core. Additionally, the use of mini balls activated the adductors and core muscles, which may have contributed to improved muscle tension and coordination, thereby enhancing muscle endurance, postural stability, and joint stability in the knee and ankle. For the elderly, the knee joint often experiences degenerative changes, muscle weakness, and pain, which can limit its range of motion and interfere with activities such as lifting the foot during walking and generating propulsion. Moreover, limited knee range of motion can lead to decreased proprioceptive sensation, affecting joint position sense and static/dynamic balance. The significant improvement in back knee angle observed in this study reflects these biomechanical mechanisms, suggesting that correcting knee flexion posture contributes to improved lower extremity alignment and walking stability. Regarding dynamic balance, the BBS showed significant improvements within and between groups in the experimental group using small tools ($p<0.05$). Notably, participants in their nineties showed greater improvements than those in their 80s and 70s, indicating that equipment-based exercise programs can be effective even in older age groups. This finding contrasts with previous research that reported limited intervention effects in older adults.

In contrast, the Area95 analysis for static balance did not show significant differences between groups, and significant improvements were observed only in the control group in within-group analysis ($p<0.05$). This finding aligns with previous research, which indicated that exercises performed in a stable environment are more effective for improving static balance. The use of small tools in the experimental group may have distracted sensory focus during training, and some participants in their 90s showed a tendency for worsened Area95 scores after the intervention, suggesting that tool-based interventions may have been less effective or caused distraction in older participants.

The limitations of this study are as follows: First, due to individual differences in baseline physical health, older adults may not experience uniform exercise effects. For instance, individuals with severe muscle weakness or advanced joint degeneration may require a longer period to show improvements and may need adjustments in exercise intensity and frequency. Second, although significant improvements in lower extremity alignment and dynamic balance were observed even among the oldest participants, the small sample size limits the generalizability of the findings. Future research should aim to include larger and more diverse samples to enhance external validity and further verify the effects of such interventions. Third, a limitation of this study lies in the sustainability of the observed benefits. When the same participants repeated the hip muscle strengthening program two weeks after the intervention, they did not maintain the same level of precision as during the intervention, although their performance did not appear to decline markedly. However, when the program was repeated four weeks later, participants failed to reach the previously achieved level of accuracy and only began to regain some of the acquired skills after receiving two consecutive days of more intensive training. This highlights the importance of repeated and consistent training to sustain the effects of the intervention. Therefore, both the program's quality and its continuous implementation, as well as the elderly participants' motivation and management to prevent falls, are crucial. The researcher hopes that future studies continue to investigate exercise programs for fall prevention and that this study will serve as a foundation for developing exercise programs that improve fall prevention and the independence of older adults.

CONCLUSION

Hip joint muscle strengthening programs using small equipment effectively enhance lower limb alignment and dynamic balance, both of which are critical factors in fall prevention. In contrast, exercises performed in a stable environment without small equipment are more effective for improving static balance, which is also important for preventing falls. These findings underscore the importance of tailoring fall prevention strategies based on the type of balance (static or dynamic) and the specific needs of individuals. Future research should focus on developing personalized fall prevention programs and examining their long-term effectiveness.

Key Points

Question When performing hip joint muscle strengthening exercises for fall prevention, does using small equipment have a greater effect on lower limb alignment and balance?

Findings In the experimental group using props, significant changes were observed in lower limb alignment and dynamic balance. However, in the static balance comparison, significant differences were found only within the control group between pre- and post-intervention.

Meaning It suggests that hip joint muscle strengthening exercise using tools may contribute to reducing the risk of falls in the elderly.

Article information

Conflict of Interest Disclosures: None.
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Ethic Approval: This study was approved by the Institutional Review Board of Daegu University (IRB No.: 1040621-202408-HR-067).
Informed consent for publication of the images was obtained from the patient.

Author contributions

Conceptualization: HJ Park.
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Interpretation of data: HJ Park.
Writing – original draft: HJ Park.
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Additional contributions: TH Kim

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