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Balance Training Program for Community-Dwelling Elders with Risk of Falls: A Multi-center Randomized Controlled Trial

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Objective: This study aimed to assess the effectiveness of a balance training program in improving balance and functional independence to reduce fall risks among community-dwelling elders.

Design: A multi-center randomized controlled trial

Methods: A total of 66participants were randomly assigned to a balance training group or a control group. The balance training program, conducted three times a week for 32 weeks, included warm-up exercises, main balance training exercises, and cooldown stretch exercises. Outcome measures included the Berg Balance Scale (BBS), Timed Up and Go Test (TUGT), and Modified Barthel Index (MBI).

Results: The balance training group demonstrated significant improvements in all outcome measures, indicating enhanced balance, improved functional mobility, and increased independence in activities of daily living. In contrast, the control group showed only slight improvements in BBS, TUGT and MBI scores.

Conclusions: These findings provide evidence supporting the effectiveness of balance training programs in reducing fall risk and promoting health and wellbeing among community-dwelling elders. Future research should aim to refine the design of these programs and assess the sustainability of the observed improvements.

Key Words: Frail elderly, Falls, Exercise therapy, Balance training, Multi-center research

Introduction

Falls among older adults are a significant public health concern due to their high prevalence and the severe consequences they can cause, including physical injuries, psychological distress, and increased mortality [1]. The World Health Organization (WHO) estimates that 28-35% of elders over 65 fall each year and this increases to 32-42% for who are older than 70 [2]. These falls often lead to a fear of falling, which can result in a vicious cycle of reduced mobility, loss of independence, and further increased risk of falls [3].

Balance impairments are one of the primary risk factors for falls in older adults [4]. Balance is a complex motor skill that integrates sensory inputs and motor responses to maintain stability during both static and dynamic activities [5]. As people age, physiological changes occur that can affect balance, including declines in muscle strength, flexibility, and proprioception, as well as changes in the vestibular and visual systems [6].

As outlined by Shumway-Cook and Woollacott [7, 8], balance can be broken down into static/dynamic steady-state (maintaining a consistent position while sitting, standing, or walking), proactive (anticipating a potential disruption), and reactive (compensating for a disturbance) balance. Additionally, undertaking specific balance exercises could help mitigate balance deficiencies and gait irregularities, thereby lowering the risk of falls among older adults [8, 9].

Given the significant impact of falls and the role of

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balance impairments in fall risk, interventions aimed at improving balance in older adults are of paramount importance. Balance training programs have been shown to be effective in improving balance and reducing fall risk in older adults [4]. However, the optimal design of such programs, including the type, intensity, and duration of exercises, remains a topic of ongoing research [10].

Research has shown that physical activity interventions can reduce the prevalence and severity of falls among community-dwelling elders at risk of disability [11]. The Lifestyle Interventions and Independence for Elders (LIFE) study, a multi-center randomized controlled trial, demonstrated that a physical activity program with supervision and moderate intensity could significantly reduce risks of fall injuries among functionally limited sedentary elders [12].

Considering these findings, our study aims to further investigate the effectiveness of a balance training program specifically designed for community-dwelling elders with a risk of falls. By focusing on this population, we hope to contribute to the growing body of evidence supporting the role of physical activity in enhancing the health and wellbeing of older adults.

Methods

Subject

Participants were recruited from twelve senior welfare centers located in Gyeonggi province of South Korea through bulletin board and text message advertisements. The volunteers went through consultation explaining protocols and consequences of the experiment. From the volunteers, those who agreed and provided written consent were recruited. All procedures underwent review process and received approval from Institutional Review Board of Kyungdong University and adhered strictly to the principles of the Declaration of Helsinki to ensure the protection of human subjects and maintain the highest standards of scientific integrity throughout the study. Inclusion criteria were as follows: those (1) who

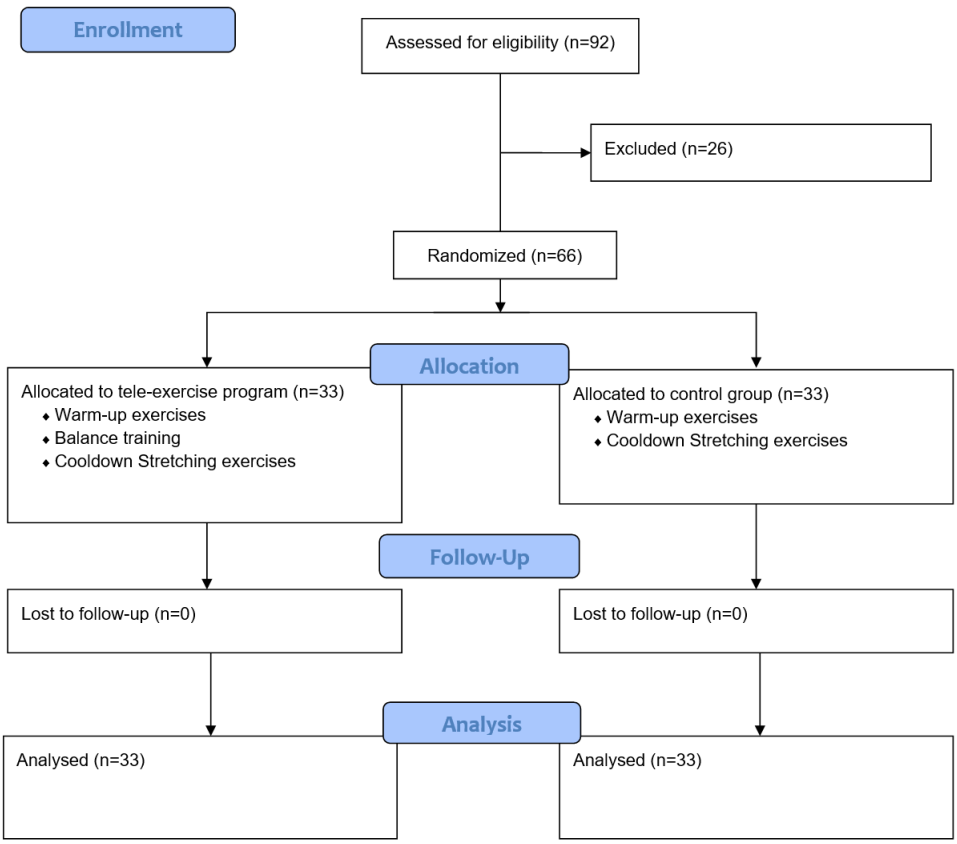

Figure 1. CONSORT flow diagram of the study.

do not have serious injuries that require hospitalization within last 12 months; (2) who can walk without assistance; and (3) who scored higher than 24 in Korean version of Mini-Mental State Examination. Exclusion criteria were as follows: those (1) who have neurological deficits such as Parkinson's disease, stroke, and/or Alzheimer's disease; (2) who have traumatic injuries involving fracture; (3) who present abnormal sensations due to diabetes or other neurological deficits; and (4) who present dizziness or vestibular symptoms.

Randomization and blinding

Among those who volunteered, 66 participants who satisfied the eligibility criteria were categorized into two groups: the balance training group and the control group. The process of assigning these groups was done using a computerized randomization program to prevent selection bias. Assessors who were blinded to the participants' details conducted both pre- and post-evaluations.

Balance Training Program

The balance training program was conducted by professional physical therapists, each with at least three years of experiences. Prior to the intervention, they received comprehensive education about the significance, protocols, and emergency procedures of the study.

The balance training program comprised three sections: warm-up exercises, main balance training exercises, and cooldown stretch exercises. Each training session spanned approximately 40 to 50 minutes, with the duration adjusted to the participants' conditions on a given day. Warm-up exercises involved gentle self-mobilizations and stretches targeting the neck, shoulder, elbow, wrist, hip, knee, and ankle joints, in order to adequately prepare for the main exercise. The main balance training comprised six exercises: chair stand-up, heel-toe walking, side-step walking, one-leg standing, standing weight shift, and ankle lift. These activities were chosen specifically to bolster balance and strength, which are suggested to be vital components for the successful execution of activities of daily living (ADL). These exercises were also simple with no additional equipment requirements, which could also be easily adapted to home exercises. The programs were provided three days a week for 32 weeks as group training sections.

Outcome Measures

Berg Balance Scale (BBS)

The Berg Balance Scale (BBS) incorporates a set of 14 typical activities that assess both static and dynamic balance. These activities include reaching, spinning, standing on one foot, and getting up. Each task is evaluated on a scale ranging from 0 to 4 points,

Table 1. Balance Training Program Protocols

Protocols of Balance Training Program	40-50 minutes
Warm-up exercises	
Neck mobility exercise	2-3 minutes
Shoulder, elbow and wrist joint mobility exercise	3-5 minutes
Hip, knee, and ankle joint mobility exercise	3-5 minutes
Balance Training	
Chair stand-up exercise	5 repetitions
Heel-toe walking	3-5 minutes
Side-steps walking	3-5 minutes
One-leg standing	3-5 minutes
Standing weight shift	3-5 minutes
Ankle lift exercise	20 repetitions
Cooldown stretching exercises	
Neck and upper extremity self-stretching	3-5 minutes
Lower extremity self-stretching	3-5 minutes

representing different levels of performance. A score of 0 indicates an inability to complete the task, while a score of 4 indicates independent task completion. By summing up the scores from all 14 tasks, a total score between 0 and 56 points is obtained. Higher scores reflect superior performance, whereas scores of ≤45 are indicative of an increased risk of falling.

Timed Up and Go Test (TUGT)

The functional mobility of older individuals in terms of speed, agility, and dynamic balance was evaluated using the Timed Up and Go Test (TUGT), following the protocol established by Podsiadlo and Richardson [13]. This test gauges an individual's mobility by measuring the time it takes, in seconds, to rise from a chair (with a seat height of 45 cm) without using their arms, walk a distance of 3m, turn around, and return to the chair. At the start of the test, participants must have their backs in contact with the chair, and they must return to this position at the end of the test. The time measurement begins with the command "go" and ends when the participant returns to the initial position. Prior to the timed trial, a single test was conducted for familiarization purposes. Female participants were instructed to perform the test as quickly as possible while maintaining a comfortable speed to ensure safety and prevent accidents.

Modified Bathel Index (MBI)

The Modified Barthel Index (MBI) is a tool used to assess disability and the ability to carry out activities of daily living independently [14]. It comprises 10 items that encompass various aspects, including urinary and fecal continence, assistance required with grooming, toilet use, feeding, walking, transfers, climbing stairs, bathing, and dressing. Scores on the MBI range from 0 to 100, with higher scores indicating a lower degree of disability severity.

Statistical Analysis

The statistical analysis was conducted utilizing SPSS 18.0. Homogeneity testing for demographic characteristics involved the application of various statistical tests, including the unpaired t-test, chi-square test, and Mann-Whitney U test. The comparison between pre- and post-intervention results was performed using Wilcoxon's concordant pair signed-rank test. A significance level of 0.05 or lower was considered for determining statistical significance.

Results

In the balance training group and the control group, the initial data showed no statistically significant discrepancies, which indicating homogeneity between the two groups in demographic characteristics, BBS, TUGT, and MBI. Prior to the intervention, the experimental group scored an average of 39.12±4.96 points in BBS and 24.18±16.39 seconds in TUGT, while the control group averaged 40.69 ±5.72 points and 24.82±12.55 seconds in BBS and TUGT, respectively. Significant changes were recorded only in the experimental group post-intervention, where BBS increased to 42.33±5.67 points and TUGT decreased to

Table 2. General Characteristics of Subject (N=66)

	Experimental group (n=33)	Control group (n=33)	x^2 / t	p
Age (year)	81.85±5.18	82.73±5.56	0.664	0.509
Height (cm)	167.94±5.65	164.79±8.45	1.781	0.080
Weight (kg)	63.31±5.46	62.60±8.28	0.410	0.683
BMI (point)	22.51±2.39	23.11±2.84	0.920	0.361
MMSE-K	25.97±1.29	25.79±0.99	0.643	0.523
Gender (male/female)	13 / 20	7 / 26	0.108	2.583

Note. BMI=body mass index; MMSE-K=mini mental state examination-Korean.
Values are expressed as mean ± standard deviation.

Table 3. The changes of postural balance (N=66)

		Experimental group (n=33)	Control group (n=33)	t	p
BBS (point)	Pre	39.12±4.96	40.69±5.72	1.180	0.242
	Post	42.33±5.67	41.31±6.55		
	Pre-Post	3.21±4.36	0.63±4.06	2.474	0.016
	t	4.235	0.871		
	p	0.000	0.391		
TUGT (sec)	Pre	24.18±16.39	24.82±12.55	0.177	0.860
	Post	21.88±15.76	24.48±12.44		
	Pre-Post	−2.30±3.65	−0.33±2.73	2.480	0.016
	t	3.622	0.700		
	p	0.001	0.489		

Note. OLST=one leg standing test; BBS=Berg balance scale; TUGT=timed up and go test.
Values are expressed as mean ± standard deviation (SD).

Table 4. The changes of activities of daily living (N=66)

	Experimental group (n=33)	Control group (n=33)	t	p
Pre	91.58±8.19	89.94±6.14	0.918	0.362
Post	93.42±7.90	90.24±6.26		
Pre-Post	1.85±2.18	0.30±1.69	3.220	0.002
t	4.868	1.033		
p	0.000	0.310		

Note. Values are expressed as mean ± standard deviation (SD).

21.88±15.76 seconds. Furthermore, a significant improvement was also seen in the experimental group's MBI scores, improving from 91.58±8.19 to 93.42±7.90 points. Meanwhile, the control group showed only a slight

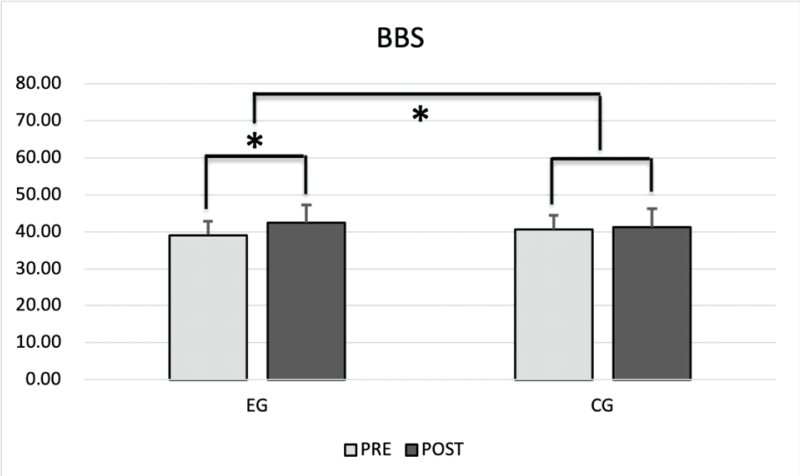

Figure 2. Changes of Berg Balance Scale (BBS)

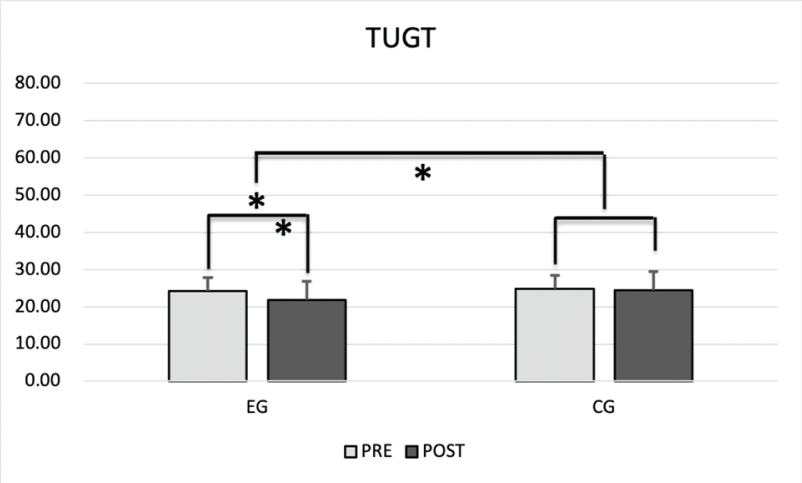

Figure 3. Changes of Timed Up and Go Test (TUGT)

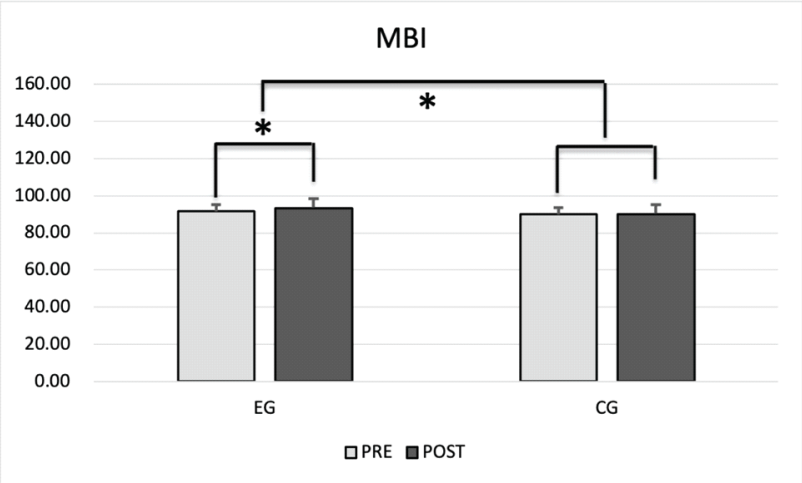

Figure 4. Changes of Modified Bathel Index (MBI)

improvement, from 89.94±6.14 to 90.24±6.26 points.

Discussion

The primary objective of this multi-center randomized controlled trial was to assess the effectiveness of a balance training program in improving balance and reducing fall risk among community-dwelling elders through a multi-center based study. The balance training group demonstrated significant improvements in all outcome measures including BBS, TUGT, and MBI. The results from the control group also showed small improvements, but they were not significant. These improvements may suggest that the balance training program was effective in enhancing balance, improving functional mobility, and promoting independence in activities of daily living. The exercises used in this study including chair stand-up, heel-toe walking, side-step walking, one-leg standing, standing weight shift, and ankle lift, are likely contributed to improvements by targeting key aspects of balance, including muscle strength, flexibility, and proprioception. The results support a previous study [15] which suggested that improvements in balance may improve functional independence among elders.

The increase in BBS [16] scores in the balance training group may indicate improvements in both static and dynamic balance. This is crucial as balance impairments are a primary risk factor for falls in older

adults. A systematic review [17] on measuring BBS to predict falls indicated that although it cannot definitively predict fall risks alone, it can be a good test tool for clinician to assess fall risks. Clinicians, however, should not rely on BBS alone but integrate other assessment tools such as TUGT and MBI to assess overall functions of the elders to quantify fall risks [18]. The decrease in TUGT scores suggests an improvement in functional mobility, which is essential for maintaining independence and quality of life in older adults. The increase in MBI scores indicates an improvement in the ability to carry out activities of daily living, further highlighting the potential benefits of balance training programs in promoting independence and reducing disability in this population.

The TUGT, designed to measure functional mobility in older adults, is commonly employed as a tool for assessing the risk of falls among community-dwelling elders, particularly in relation to gait and balance [19-21]. The reduction in TUGT times in the balance training group may suggest that the program improved balance and functional mobility. This is in line with a meta-analysis [10] which suggested that balance training can enhance speed, agility, and dynamic balance in older adults. The balance training program likely improved these aspects of mobility by challenging the participants' balance and coordination through dynamic exercises.

While the MBI is frequently utilized to evaluate functional independence in stroke patients [22, 23], it is also employed in the assessment of older adults [24, 25]. The increase in MBI scores in the balance training group indicates that the program improved the participants' ability to carry out activities of daily living. This is an important finding, as the ability to perform these activities independently is crucial for maintaining quality of life [26] in older adults. The balance training program likely contributed to these improvements by enhancing balance and functional mobility, which are key components of many activities of daily living.

The results of this multi-center study can suggest implications for public health and clinical practice especially concerning falls of elders. Given the high prevalence of falls and their severe consequences in older adults, interventions aimed at improving balance and reducing fall risk are of paramount importance. The balance training program evaluated in this study could be implemented in senior welfare centers and other community settings to help reduce fall risk and enhance the health and wellbeing of older adults. Furthermore, the findings of this study could inform the development of guidelines for the design and implementation of balance training programs for older adults at risk of falls.

Although the results of this study are promising, there were several limitations to be acknowledged. First, the study was conducted in relatively low number of subjects. Even it was a multi-center study consisting of twelve senior centers, only 66 subjects were recruited and analyzed, and this may limit the application of the results. Second, the study only measured three outcomes that do not directly reflect reduced fall rates of the participants. Future studies should include a long term follow up of participants to track actual reduction of the falls. Third, physical performance measures were not evaluated during this study which can be directly related to fall risks as well. Lastly, the study was limit to a specific geographical location (Gyeonggi province of South Korea), which may limit the generalizability of the findings to other populations and settings. Future studies might benefit from a multi-center approach that crosses borders, which could provide stronger evidence.

Conclusion

In conclusion, this multi-center study provides additional evidence that a balance training program can significantly improve balance, functional mobility, and the ability to carry out activities of daily living in community-dwelling elders at risk of falls. These findings support the use of balance training as an effective intervention for reducing fall risk in this population. However, further research is needed to optimize the design of such programs and to investigate their long-term effects on fall risk and quality of life in older adults.

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