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Effects of foam roller-based combined exercise on functional fitness, balance, and gait in older women

Ha-Rin Ryu[1], Min-Ji Kim[1], Eun-Sun Yoon[2], Dae-Young Kim[1,3,*]

[1]Institute of Digital Anti-Aging Healthcare, Inje University, Gimhae, Korea
[2]Department of Sports for All, Korea National Open University, Seoul, Korea
[3]Department of Sports Healthcare, College of Social Sciences, Inje University, Gimhae, Korea

This study aimed to investigate the effects of a foam roller-based combined exercise program on functional fitness, balance ability, and gait in women aged 65 years and older. Using a 2×2 mixed design, the study compared variables measured before and after a 6-week foam roller-based combined exercise program. A total of 32 old women were randomly assigned to either the foam roller-based exercise group or the control group. The intervention was conducted 3 times a week for 6 weeks, with each session lasting 60 min. The senior fitness test, gait test, Fullerton advanced balance test, and Y-balance test were performed at baseline and postintervention. Participants in the combined exercise group demonstrated significant improvements in upper and lower-body strength, lower extremity flexibility, agility, walking speed, stability, and balance ability. These findings confirm that a foam roller-based combined exercise program incorporating stretching, strength training, and aerobic components is effective in enhancing functional fitness, balance, and gait in older women. The inclusion of props such as foam rollers may help facilitate proper exercise form and activate diverse muscle groups, thereby augmenting the overall efficacy of exercise interventions.

Keywords: Foam roller, Senior fitness test, Fullerton advanced balance scale, Y-balance test, Gait, Older women

INTRODUCTION

Reductions in physical activity and muscle mass due to aging contribute to chronic physical disabilities and increased mortality rates among older adults (Cruz-Jentoft et al., 2019; Kakehi et al., 2022). Furthermore, age-related declines in physical strength, muscle power, and mobility exacerbate decreases in bone density and motor function, which are critical factors contributing to impairments in walking ability, balance, and ultimately, independent living (Valenzuela et al., 2018; Valenzuela et al., 2019). Functional fitness in older adults refers to the physical capacity to perform daily tasks safely and independently without undue fatigue. Its primary components include flexibility, muscular strength, agility, balance, and aerobic capacity (Rikli and Jones, 1997).

Previous research has demonstrated that functional fitness in older adults serves as a predictor of aging-related diseases and is closely associated with quality of life, walking ability, and fall risk. Older adults who have experienced falls exhibit significantly reduced strength and balance compared to those without a history of falls. Even among those who have not experienced falls, individuals at high risk of falling exhibit notable reductions in functional parameters such as agility, balance, aerobic capacity, and lower-limb muscle strength. Moreover, older women experience more pronounced reductions in bone density, muscle mass, joint range of motion (ROM), lower-limb muscle strength, and balance ability compared to men, largely due to decreased estrogen production following menopause (Almeida et al., 2017). Therefore, early identification of fall risk factors and the implementation of targeted preventive measures are essential.

It is widely acknowledged that exercise plays a critical role in preventing falls and maintaining physical function and functional fitness in older adults. According to the U.S. Physical Activity

*Corresponding author: Dae-Young Kim https://orcid.org/0000-0002-4662-4463
Department of Sports Healthcare, College of Social Sciences, Inje University, 197 Inje-ro, Gimhae 50834, Korea
Email: cdps21@inje.ac.kr
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Guidelines Advisory Committee (Stavrinou et al., 2022), exercise is effective in disease prevention, enhancing physical fitness, and promoting functional independence and autonomy in older adults. The American College of Sports Medicine also recommends a combined exercise program, incorporating aerobic, resistance, and balance exercises, for older adults. However, as previously noted, older adults often experience muscle atrophy and weakness, impaired balance, reduced joint ROM, decreased agility, and compromised coordination. These factors render them more vulnerable to musculoskeletal injuries and increase the risk of falls during physical activity. Furthermore, older women, in particular, are often resistant to muscle strengthening exercises. For those with low physical strength levels, a more comprehensive and carefully tailored exercise program is necessary, prioritizing safety and minimizing the risk of injury (Patterson et al., 2001).

Props such as elastic bands, gym balls, and foam rollers are generally considered safe and are widely used by older individuals. Among these, foam rollers have gained particular popularity as tools for fascia relaxation and stretching, commonly utilized in both occupational and physical therapy settings (Han et al., 2017). Foam roller exercises enhance whole-body stretching and ROM and effectively relax tense muscles. This type of exercise is recognized as suitable for diverse age groups, ranging from older adults with limited physical activity to women and children. Combined exercise programs incorporating foam rollers carry a relatively low risk of injury and are not constrained by cost or location. Additionally, these programs are engaging and capable of improving a variety of physical fitness parameters (Kim et al., 2014).

Previous studies have highlighted the effectiveness of foam roller exercises in improving ROM. For example, foam roller exercises were found to increase the ROM of ankle joints in male and female adolescent swimmers (Škarabot et al., 2015). Another study reported that foam roller exercises improved knee joint ROM in healthy men in their 20s (MacDonald et al., 2013). Similarly, research has demonstrated that foam roller exercises improve the ROM of the hamstring and pelvis and assist in muscle pain recovery (Mohr et al., 2014).

Although the use of small props such as foam rollers has been shown to facilitate exercise performance and enhance exercise outcomes (Kopitzke, 2007), prior research has primarily focused on their application for increasing the ROM of specific body parts or for muscle relaxation. Few studies, however, have explored the use of foam rollers as the primary tool in combined exercise programs that integrate strength-building, aerobic, and flexibility exercises for older women. Therefore, this study aimed to examine the effects of a foam roller-based combined exercise program on functional fitness, balance, and walking speed in older women.

MATERIALS AND METHODS

Participants

A total of 38 healthy women aged 65 years and older were initially selected for participation based on the following inclusion criteria: absence of medical conditions (as determined by a basic medical questionnaire), no musculoskeletal disorders that would impede participation in the exercise program, and no engagement in regular exercise programs during the past 6 months. Six participants withdrew from the study, resulting in a final sample of 32 participants who were randomly assigned to either the foam roller exercise group or the control group (n = 16 each). Participants were excluded if they had any major health conditions or orthopedic issues that would prevent full participation in the intervention or if they were unable to attend at least 80% of the scheduled training sessions. During the 6-week intervention period, the control group did not engage in any foam roller-based combined training and was instructed to refrain from starting new exercise programs or altering their existing activity levels.

This study was approved by the Institutional Review Board of Inje University (approval number: INJE 2023-07-016-003). All participants voluntarily signed an informed consent form that described the purpose of the study and provided additional details regarding the study protocols. The physical characteristics of the study participants are summarized in Table 1.

Study design

This study employed a 2×2 mixed design, with group (exercise

Table 1. Physical characteristics of participants (n = 32)

Group	Age (yr)	Height (cm)	Weight (kg)	BMI (kg/m^2)	SMI (kg/m^2)
Exercise (n = 16)	67.00 ± 3.40	156.00 ± 5.13	59.00 ± 8.11	24.00 ± 2.85	6.00 ± 0.67
Control (n = 16)	69.00 ± 5.70	153.00 ± 4.90	54.00 ± 6.24	23.00 ± 2.59	6.00 ± 0.45

Values are presented as mean ± standard deviation.
BMI, body mass index; SMI, skeletal muscle mass index.

versus control) and measurement period (pre- vs. postintervention) as the independent variables. All participants completed a baseline assessment prior to the commencement of the exercise program and were then randomly assigned to either the exercise or control group. Two days after the conclusion of the 6-week foam roller-based combined exercise program, a posttest identical to the baseline assessment was conducted to minimize any potential transient effects of the intervention.

Body composition assessment

Body composition was measured using a bioelectrical impedance body composition analyzer (InBody 970, InBody, Seoul, Korea). The measurements included body weight, body fat percentage, lean body mass, skeletal muscle mass, and the skeletal muscle index (SMI). Body mass index (BMI) was calculated using height and weight according to the standard formula (= body weight in kg/height in m^2). SMI was calculated using the following formula (= upper and lower skeletal mass in kg/height in m^2).

Functional fitness assessment

The senior fitness test (SFT) was used to evaluate basic functional activity levels (Rikli and Jones, 2013). The test assesses several components of physical fitness, including upper-body strength (dumbbell curl, grip strength), lower-body strength (30-sec chair stand), upper-body flexibility (back scratch), lower-body flexibility (chair sit-and-reach), agility and dynamic balance (2.44-m round-trip walking), and cardiovascular endurance (2-min walking in place). All measurements were recorded by a single skilled examiner following standardized procedures.

Gait test

The 4-m gait test is an established indicator of exercise ability for the older adults and can be conducted quickly and has high reliability (Kon et al., 2013). In this study, participants were instructed to walk 4 m at their usual comfortable pace in response to the verbal cue, "Please walk at your usual, comfortable speed." The time taken to walk 4 m was measured in units of 0.01 sec. The test was performed twice, and the average of the two measurements was used for analysis.

Fullerton advanced balance test

The fullerton advanced balance (FAB) test is intended to assess the balance of older adult individuals who can walk independently. The examination consists of 10 tasks, such as standing with feet together and your eyes closed, reaching out to take object by tilting your body forward, turning left and right once in place, step over a 15-cm obstacle and cross, walking in a straight line with both feet, standing on one leg with eyes open, standing on an unstable foam pad with eyes closed, long jump with both feet together, walking while turning your head, and response of postural control. Each task is scored from 0 to 4, with a total possible score ranging from 0 to 40. A higher score indicates better balance ability (Klein et al., 2011).

Y-balance test

The Y-balance test (YBT) (Y-balance, Functional Movement System, Chatham, VA, USA) was used to assess dynamic balance. Before the test, participants were fully informed about the test method and precautions and performed warm-up exercises and practiced 3 times. Each participant placed one foot on the measurement plate and extended the other foot 3 times each in three different directions (anterior, posteromedial, and posterolateral) and the maximum reach was measured. The test was performed on both the left and right sides.

Foam roller-based combined exercise program

The foam roller-based combined exercise program consisted of 10 min of warm-up exercise, 40 min of work-out, and 10 min of cool-down exercise (total time, 60 min) 3 times a week for a total of 6 weeks. The exercise intensity (rate of perceived exertion) was set to 9–10 for the warm-up and cool-down exercises and 13–16 for the main exercises. All motions in the main exercises were performed in 3 sets of 10 repetitions. The exercise program is presented in Table 2.

The foam roller used was made of ethylene vinyl acetate material with uniform surface strength and was 91 cm in length and 14.5 cm in diameter and weighed 675–862 g. The motions included in the exercise program in this study were modified and supplemented for improving functional fitness and balance based on a study by Yang et al. (2021) and García-Gutiérrez et al. (2018) on the effects of foam roller exercise on improving advanced balance and functional fitness in older women. The program included stretching motions for improving shoulder, trunk, and lower-limb flexibility, as well as motions to strengthen the core, gluteus maximus, gluteus medius, quadriceps, gastrocnemius, and soleus muscles for improving posture maintenance, balance, and gait. Aerobic exercises were performed by repeating modified motions using a foam roller (jumping jacks, knee-ups, and modified twist knee-ups). To prevent injuries, all exercises were performed under the supervision of one senior exercise instructor and two assistant instructors.

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Table 2. Foam roller-based combined exercise program

Order	Time (min)	Contents (type)	Intensity			
Warm-up	10	Dynamic stretching			RPE 9–10	
Main	40	Anaerobic movements	Repetition	Set	%HRR	RPE
		Side leg lift/toe taps Single & double leg stretch Inner thigh lift Swan Mountain climber & leg kick Double leg lift/frog lift Dolphin plank/side plank Single leg bridge	10	3	70–80 %HRR	13–16
		Aerobic activity				
		Slow burpees/lunge Standing knee up Standing twist & knee up One leg deadlift/squat Standing side knee up				
Cool-down	10	Static stretching			RPE 9–10	

%HRR, percentage of heart rate reserve; RPE, rate of perceived exertion.

Table 3. Changes in physical characteristics in both study groups

Variable	Group	Pre	Post	Δ Post-pre	Within group change (*z* value)	Between-group comparison (*U*-value)
Body mass index (kg/m^2)	FG	24.19±2.85	24.24±2.96	0.05±0.34	-0.857	82.00
	CG	23.19±2.59	23.51±2.68	0.32±0.47	-2.128*	
Body fat mass (kg)	FG	18.70±5.58	18.39±5.98	-0.31±1.03	-0.983	97.00
	CG	17.69±4.86	17.83±5.00	0.14±0.79	-0.571	
Fat-free mass (kg)	FG	40.07±4.26	40.53±4.21	0.46±0.93	-1.887	98.00
	CG	36.81±2.68	37.06±3.00	0.25±1.10	-1.340	
Skeletal muscle mass (kg)	FG	21.59±2.57	21.84±2.51	0.25±0.50	-1.917	101.50
	CG	19.51±1.62	19.68±1.80	0.17±0.63	-1.301	
Skeletal muscle index (kg/m^2)	FG	6.49±0.67	6.54±0.68	0.05±0.16	-1.347	127.00
	CG	6.07±0.45	6.12±0.51	0.05±0.20	-0.900	

Values are presented as mean±standard deviation.
FG, functional foam-roller combined exercise group; CG, control group.
z, Standardized Wilcoxon signed-rank test statistic; *U*, Mann–Whitney *U*-test statistic.
*$P<0.05$.

Statistical analyses

Data analyses were conducted using IBM SPSS Statistics ver. 27.0 (IBM Co., Armonk, NY, USA). All data are presented as mean and standard deviation. In this study, non-parametric statistical analyses were conducted. The Wilcoxon signed-rank test was used to compare pre- and postintervention scores within each group. The Mann–Whitney *U*-test was employed to compare the differences in change scores (postintervention minus pre-intervention) between the exercise and control groups. Statistical significance was set at $\alpha = 0.05$.

RESULTS

Changes in body composition

Table 3 presents the changes in body composition after the 6-week foam roller-based combined exercise program. No significant differences were observed in body weight, BMI, body fat percentage, lean body mass, skeletal muscle mass, and SMI between groups or across time points. However, the control group showed a significant increase in BMI (0.32 kg/m^2, $P<0.05$), whereas the exercise group showed no significant changes. Additionally, no significant changes were observed in body fat percentage, lean body mass, skel-

Table 4. Changes in senior fitness test results in both study groups

Variable	Group	Pre	Post	Δ Post-pre	Within group change (*z* value)	Between-group comparison (*U*-value)
30-Sec chair stand (reps/30 sec)	FG	13.94±3.07	16.81±4.13	2.88±4.35	-2.532*	81.00
	CG	14.06±2.65	14.94±2.05	0.88±2.99	-1.103	
30-Sec arm curl (reps/30 sec)	FG	19.81±4.17	23.56±4.68	3.75±5.29	-2.395*	65.50*
	CG	20.63±3.47	21.19±4.22	0.56±2.71	-0.593	
Chair sit-and-reach (cm)	FG	6.06±10.44	14.16±5.42	8.09±8.66	-2.928**	43.50***
	CG	11.91±11.49	9.96±9.19	-1.94±7.13	-1.295	
Back scratch (cm)	FG	-4.91±12.79	-4.09±9.56	0.81±6.68	-0.031	125.50
	CG	-3.76±10.80	-3.41±11.61	0.36±3.91	-0.126	
2.44-m round-trip walking (sec)	FG	8.98±1.41	6.89±0.67	-2.09±1.50	-3.309***	46.50**
	CG	7.20±1.72	6.78±1.29	-0.42±1.33	-0.879	
2-Min walking in place (reps/2 min)	FG	94.06±10.43	105.63±11.03	11.56±9.71	-3.184***	92.00
	CG	90.69±11.56	95.69±13.35	5.00±13.64	-1.838	
Hand grip strength (kg)	FG	22.66±4.23	25.04±5.16	2.38±2.48	-2.870**	57.50**
	CG	20.36±3.36	20.75±3.27	0.39±1.47	-0.880	

Values are presented as mean±standard deviation.
FG, functional foam-roller combined exercise group; CG, control group.
z, Standardized Wilcoxon signed-rank test statistic; *U*, Mann–Whitney *U*-test statistic.
*$P<0.05$. **$P<0.01$. ***$P<0.001$.

etal muscle mass, and SMI in either group.

Functional fitness

Table 4 presents the SFT results following the 6-week training program. Baseline functional fitness levels were comparable between the exercise and control groups. Significant improvements were observed exclusively in the exercise group across all measures, except for upper-body flexibility (back scratch). Notable improvements were found in upper-body strength (30-sec dumbbell curl and hand grip strength), lower-body flexibility (chair sit-and-reach), and agility and dynamic balance (2.44-m round-trip walk) in the exercise group, while no significant changes were observed in the control group.

Gait speed

Fig. 1 illustrates the results of the 4-m gait test. The exercise group demonstrated a statistically significant reduction in gait time, indicative of improved gait speed ($z=-2.613$, $P<0.01$), as assessed by the Wilcoxon signed-rank test. In contrast, the control group exhibited no statistically significant change in gait time ($z=-0.284$, $P>0.05$). Additionally, between-group comparisons conducted using the Mann–Whitney *U*-test revealed that the exercise group achieved significantly greater reductions in gait time compared to the control group ($U=60.00$, $P<0.01$).

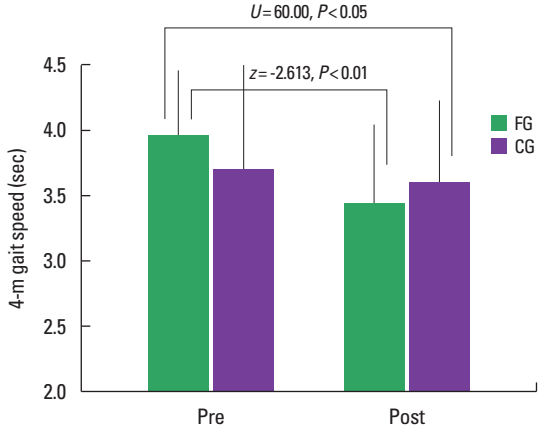

Fig. 1. Changes in 4-m gait speed. Values are presented as mean±standard deviation. FG, foam roller-based combined exercise group; CG, control group. *z*, Standardized Wilcoxon signed-rank test statistic; *U*, Mann–Whitney *U*-test statistic.

FAB test

Table 5 presents the results of the FAB test following the 6-week training program. At baseline, participants in both groups demonstrated comparable levels of advanced balance. After the intervention between-group comparisons conducted using the Mann–Whitney *U*-test revealed that the exercise group achieved significantly greater improvements compared to the control group in walking in a straight line with both feet ($U=77.00$, $P<0.01$), response of postural control ($U=62.00$, $P<0.05$) and FAB total

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Table 5. Changes in FAB results in both study groups

Variables	Group	Pre	Post	Δ Post-pre	Within group change (*z* value)	Between-group comparison (*U*-value)
Standing with feet together & eyes closed (score)	FG	4.00±0.00	4.00±0.00	0.00±0.00	0.000	128.00
	CG	4.00±0.00	4.00±0.00	0.00±0.00	0.000	
Reaching out to take object (score)	FG	4.00±0.00	4.00±0.00	0.00±0.00	0.000	128.00
	CG	4.00±0.00	4.00±0.00	0.00±0.00	0.000	
Turning left and right once in place (score)	FG	3.06±0.93	3.50±0.82	0.44±1.31	-1.189	100.00
	CG	2.75±0.86	2.88±0.89	0.13±0.62	-0.816	
Step over a 15 cm obstacle and cross (score)	FG	3.94±0.25	3.88±0.50	-0.06±0.57	-0.447	128.00
	CG	4.00±0.00	4.00±0.00	0.00±0.00	-0.000	
Walking in a straight line with both feet (score)	FG	3.81±0.40	3.94±0.25	0.13±0.34	-1.414	77.00**
	CG	3.94±0.25	3.63±0.50	-0.31±0.48	-2.236	
Stand on one leg with eyes open (score)	FG	3.31±1.14	3.56±0.73	0.25±0.58	-1.633	93.50
	CG	2.75±1.24	2.56±1.46	-0.19±0.83	-0.966	
Standing on foam pad with eyes closed (score)	FG	4.00±0.00	4.00±0.00	0.00±0.00	0.000	128.00
	CG	4.00±0.00	4.00±0.00	0.00±0.00	0.000	
Long jump with both feet together (score)	FG	3.75±0.68	4.00±0.00	0.25±0.68	-1.414	119.00
	CG	3.81±0.40	3.87±0.34	0.06±0.44	-0.577	
Walk while turning head (score)	FG	2.25±1.13	2.81±0.54	0.56±1.21	-1.698	104.50
	CG	2.25±1.57	2.44±1.09	0.19±1.47	-0.624	
Response of postural control (score)	FG	2.88±1.36	4.00±0.00	1.13±1.36	-2.539*	44.00***
	CG	3.87±0.34	3.56±0.73	-0.31±0.49	-2.236*	
FAB total (score)	FG	35.00±3.71	37.69±1.54	2.69±3.44	-2.491*	62.00*
	CG	35.38±3.12	34.94±3.70	-0.44±2.31	-0.564	

Values are presented as mean±standard deviation.
FAB, fullerton advanced balance; FG, functional foam-roller combined exercise group; CG, control group.
z, Standardized Wilcoxon signed-rank test statistic; *U*, Mann–Whitney *U*-test statistic.
*$P<0.05$. **$P<0.01$. ***$P<0.001$.

score ($U=62.00$, $P<0.05$).

Dynamic balance assessment

Table 6 presents the results of the YBT following the 6-week training program. At baseline, participants in both groups demonstrated comparable levels of advanced balance. After the intervention between-group comparisons conducted using the Mann–Whitney *U*-test revealed that the exercise group achieved significantly greater improvements compared to the control group in right posterolateral ($U=60.50$, $P<0.05$), left posteromedial ($U=67.50$, $P<0.05$), and both sides of composite dynamic balance scores (right $U=69.50$, $P<0.05$, left $U=72.00$, $P<0.05$). The exercise group showed statistically significant improvements in the left and right posteromedial, posterolateral, and composite scores after the intervention ($P<0.01$). In contrast, the control group exhibited a significant change only in the left posterolateral direction ($P<0.05$).

DISCUSSION

This study aimed to examine the effects of a 6-week foam roller-based combined exercise program, incorporating stretching, aerobic exercise, and whole-body and lower-body muscle strengthening movements, on the functional fitness and balance of women aged 65 years and older. The program resulted in significant improvements in lower-body strength and flexibility, upper-body strength, agility, cardiorespiratory endurance, grip strength, gait speed, the FAB composite score, postural control responses, and dynamic balance. Additionally, statistically significant interaction effects between time and group were observed for upper-body strength, lower-body flexibility, agility, grip strength, gait speed, walking in a straight line with both feet, response of postural control, and the FAB composite score.

These findings are consistent with previous research by Junker and Stöggl (2019), who reported improvements in flexibility, balance, and muscle strength in men and women following an 8-week

Table 6. Changes in YBT results in both study groups

Variable	Group	Pre	Post	Δ Post-pre	Within group change (*z* value)	Between-group comparison (*U*-value)
Right leg (%)						
Anterior (R-A)	FG	50.13±4.12	52.31±4.31	2.19±4.01	-1.790	100.00
	CG	46.75±7.66	48.02±6.05	1.27±4.32	-0.995	
Posteromedial (R-PM)	FG	76.23±6.55	82.02±5.83	5.79±5.37	-3.000**	98.00
	CG	71.00±9.60	74.75±9.14	3.75±7.62	-1.915	
Posterolateral (R-PL)	FG	74.79±5.24	81.92±9.12	7.13±7.73	-2.741**	60.50*
	CG	70.48±10.86	72.10±11.59	1.63±10.02	-0.388	
Left leg (%)						
Anterior (L-A)	FG	51.06±3.97	53.02±6.20	1.96±4.81	-1.706	105.00
	CG	47.44±7.07	47.90±7.48	0.46±5.36	-0.540	
Posteromedial (L-PM)	FG	76.15±6.71	83.44±9.39	7.29±7.40	-2.896**	67.50*
	CG	72.44±9.19	73.69±11.71	1.25±8.54	-0.698	
Posterolateral (L-PL)	FG	74.06±8.45	80.94±11.21	6.87±7.96	-2.561**	92.50
	CG	69.63±10.54	74.98±10.61	5.35±8.57	-2.386*	
Composite (%)						
Right (R-CS)	FG	80.57±4.84	86.51±5.58	5.94±5.54	-2.844**	69.50*
	CG	77.84±11.97	80.55±11.63	2.71±7.61	-1.189	
Left (L-CS)	FG	80.59±6.02	86.89±8.01	6.31±6.15	-2.741**	72.00*
	CG	78.33±11.48	81.31±13.00	2.98±8.23	-1.500	

Values are presented as mean±standard deviation.
YBT, Y-balance test; FG, foam roller-based combined exercise group; CG, control group; R-A, right anterior; R-PM, right posteromedial; R-PL, right posterolateral; L-A, left anterior; L-PM, left posteromedial; L-PL, left posterolateral; R-CS, right composite; L-CS, left composite.
z, Standardized Wilcoxon signed-rank test statistic; *U*, Mann–Whitney *U*-test statistic.
*$P<0.05$. **$P<0.01$.

foam roller exercise intervention, and Jeong et al. (2011), who observed enhancements in upper and lower-body flexibility, dynamic balance, agility, and hip ROM in older women after 12 weeks of Pilates exercises incorporating foam rollers. Furthermore, our results align with those of Irez et al. (2011), which demonstrated that Pilates, a regimen incorporating major movements similar to those in this study's exercise program, effectively improves flexibility and balance while reducing fall risk. Pilates is widely recognized for its ability to strengthen core and spinal muscles, stabilize the core, and promote proper posture. However, accurate execution of movements is crucial to maximizing the benefits of Pilates, and older adults often encounter challenges in this regard due to age-related declines in physical function. The use of props such as foam rollers, balls, and bands has been shown to enhance the effectiveness of exercise interventions (Kopitzke, 2007). This study further confirms that a combined exercise program utilizing foam rollers can effectively improve functional fitness and balance in older women. Consequently, such programs may play a significant role in promoting independent living, enhancing gait ability, and preventing falls in this population.

Following the 6-week foam roller-based exercise program, participants demonstrated significant improvements in 30-sec dumbbell curls and grip strength. These gains are likely to facilitate everyday tasks such as household chores, lifting and moving objects, and interacting more easily with grandchildren. While it is widely accepted that muscle strength can be enhanced through resistance exercise, research has shown that upper-body strength in older adults can also improve through combined exercise programs incorporating props. For instance, Jang et al. (2009) reported improvements in both left and right grip strength among rural older women following a 13-week exercise program that utilized props such as therabands, bouncy balls, and water bottles. Similarly, Im et al. (2019) observed significant increases in muscle strength, as measured by the SFT, in older women aged 65 years and older after 12 weeks of a combined exercise program that included static and dynamic balance exercises. Moreover, Lim et al. (2024) reported statistically significant improvements in upper-body strength among women aged 60 years and older after a 12-week combined exercise program that incorporated calisthenics and stretching with resistance bands.

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The increase in upper-body strength observed in the present study can be attributed to the inclusion of exercises such as the swan, modified dolphin plank, slow burpees, and arm circles, which effectively target the biceps, triceps, and scapular muscles. Agility refers to the ability to move and change direction quickly, while dynamic balance involves maintaining postural stability during movement. A previous study demonstrated that balance ability in women aged 75 years and older improved after a short-term balance exercise program utilizing a foam roller (Bellew et al., 2005). Similarly, our study revealed significant improvements in the 2.44-m round-trip walking test, the FAB total score, and dynamic balance scores-key indicators of agility and dynamic balance—following participation in the exercise program. These improvements can be attributed to enhanced coordination among the quadriceps, hamstrings, gastrocnemius, and soleus muscles, facilitated by exercises such as knee-ups, slow burpees, and calf raises. This improved muscle coordination aids in generating force during muscle lengthening and shortening cycles, enabling effective shifts in body weight and the center of gravity, which positively impact agility and dynamic balance. Notably, the postural control response in the FAB test showed significant improvement in the exercise group, indicating that the program helped participants effectively engage their core through movements and posture, thereby enhancing overall balance. However, no significant improvements were observed in other FAB test items apart from the total score and postural control response. This may be explained by the fact that most participants were healthy and did not exhibit notable balance issues prior to the intervention.

An interesting finding of this study was the improvement in gait- and fall-related parameters following participation in the exercise program. The 4-m gait test, assessed in this study, involves movements requiring precise neuromuscular coordination and balance ability. Numerous previous studies have reported improvements in gait speed and balance among older adults through regular exercise. For instance, women aged 80 years and older who participated in balance and strength training demonstrated a reduction in fall-related injuries after one year of follow-up (Robertson et al., 2001). This study also demonstrated a 13% increase in 4-m gait speed following participation in the foam roller-based combined exercise program, along with significant improvements in gait speed-related fitness parameters, including the FAB total score, YBT score, and lower-body flexibility. Although a statistically significant interaction effect was not observed for the 30-sec chair stand test—a measure of lower-body strength—the exercise group still showed a significant increase.

The improvements in FAB scores and dynamic balance observed in this study are particularly noteworthy, as they represent key factors contributing to fall prevention in older adults. The FAB test assesses various sensory systems, including the vestibular and visual systems, as well as balance ability under both static and dynamic conditions. Designed to evaluate sensory, integrative, and responsive postural control, the FAB test is particularly suitable for assessing older adults with high functional capacity (Klein et al., 2011). The findings of this study, in conjunction with previous research, suggest that the gait speed of older adults can be improved through a foam roller-based combined exercise program. Moreover, this program may contribute to fall prevention and enhance the ability to perform daily activities.

On the other hand, the foam roller exercise group did not exhibit a significant effect on the back scratch test, which measures upper-body flexibility. Pilates, a regimen of low- to moderate-intensity exercises designed to enhance strength and flexibility while alleviating body tension, is widely recommended for older adults (Oliveira et al., 2016; Teixeira et al., 2017). However, our study found no significant improvements in upper-body flexibility. This outcome may be attributed to the limited emphasis on shoulder movements in the exercise program, advanced age of the participants, or the possibility that the 6-week intervention period was insufficient to elicit measurable changes. Future studies may consider designing foam roller-based combined exercise programs with extended intervention periods that incorporate exercises specifically targeting shoulder mobility to improve upper-body flexibility in older adults.

According to studies on the long-term effects of combined exercise programs for older adults, balance and cardiopulmonary endurance are the most significantly improved fitness-related factors (Gonçalves et al., 2021). Vieira et al. (2017) evaluated a 12-week Pilates-inspired exercise program and observed significant improvements in cardiopulmonary endurance. Similarly, a study examining a 12-week low-intensity Pilates mat exercise program reported significant enhancements in cardiopulmonary endurance among women aged 65 years or older (Kim, 2013). However, unlike previous studies, the present study did not observe a statistically significant interaction effect between time and group for the 2-min walking in place test, which was used as an indicator of cardiorespiratory endurance. Nonetheless, a significant increase was observed within the exercise group. This outcome could be attributed to the relatively short duration of the 6-week intervention, which may have been insufficient to elicit measurable improvements in cardiopulmonary endurance in older women. Additionally, the

aerobic exercise movements used in the program (e.g., jumping jacks, knee-ups, and modified twists with knee-ups) may have lacked the intensity required to induce substantial improvements in cardiopulmonary endurance.

This study had several limitations. First, all participants were healthy women, and therefore, the findings may not be generalizable to women with medical conditions or to older men. Second, the 6-week intervention period may have been too short to produce measurable improvements in certain parameters, and future studies should assess the long-term effects of the intervention. Third, physical activities outside the exercise program were not fully controlled during the study period. However, all participants agreed not to engage in any other structured exercise programs. Future studies should incorporate objective measurement tools to monitor physical activity during the intervention period, thereby better controlling extraneous variables and enhancing the reliability of the exercise program's effectiveness. Despite these limitations, this study is significant as it provides additional evidence that a foam roller-based combined exercise program, incorporating stretching, aerobic exercise, and muscle strengthening, effectively improves functional fitness and balance in older women. This finding aligns with previous research highlighting the importance of muscle strengthening and balance exercises in fall prevention among older adults. Furthermore, older women with limited exercise experience are at an increased risk of injury and may feel apprehensive about using dumbbells or weight machines. By incorporating props, this program enhanced participant accessibility and engagement, reducing barriers to participation and yielding positive outcomes in improving fitness.

This study aimed to investigate the effects of a 6-week foam roller-based combined exercise program on functional fitness, balance, and gait in women aged 65 years and older. The results demonstrated significant improvements in upper- and lower-body strength, lower-body flexibility, agility, gait speed, and balance. This program, which incorporated strength, aerobic, and stretching exercises using a foam roller, effectively enhanced the functional fitness, balance, and gait of older women. Future studies should compare different exercise modalities and further validate the effects of exercise programs that incorporate props, as well as those with varying intensities and durations.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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