Balance Strategy Exercise versus Lower LimbROM Exercise for Reducing the Risk of Falls among Older People

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ORIGINAL RESEARCH

Balance Strategy Exercise versus Lower Limb-ROM Exercise for Reducing the Risk of Falls among Older People

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Abstract

Background: Falls are a significant health problem and the most common cause of injuries in older people. Different types of exercise have been recommended to prevent falls, including balance exercise and range of motion. However, there is a lack of evidence to compare the effect of the two exercises.
Purpose: This study aimed to compare the effect of Balance Strategy Exercise (BSE) and Lower Limb-Range of Motion (ROM) exercise on reducing the risk of falls among older people living in long-term care facilities.
Methods: This was a quasi-experimental study using a pre-post design without a control group. A total of 30 older adults from two nursing homes who met the inclusion and exclusion criteria participated in the study. A cluster randomization technique was used to assign the older people into either BSE or Lower-Limb ROM groups evenly. Treatment was given for 30 minutes per session, three sessions per week for three weeks. The risk of falls was measured using the Timed Up and Go (TUG) test. The paired t-test, Wilcoxon and Mann-Whitney U-test were used to analyze the data.
Results: Results showed significant differences in the TUG scores before and after the intervention within both the BSE (p=0.001) and the Lower Limb-ROM group (p=0.001). However, the Lower Limb-ROM group demonstrated a significantly higher reduction in TUG score than the BSE group after the intervention (p=0.008).
Conclusion: Lower Limb-ROM exercise is better to reduce the risk of falls among older people living in institutional care than BSE. This exercise can be applied as part of a fall prevention program in nursing homes.

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1. Introduction

Falls are one of the major health problems among older people. Falls are defined as "inadvertently coming to rest on the ground, floor, or other lower-level" (World Health Organization [WHO], 2018, p.1). It was estimated that about 28.4% of people aged 60 years or over have experienced falls in the last two years (Gale et al., 2016). However, in reality, the problem could be bigger than it seems, as a more recent study reported that about 53% of individuals had a history of falls (Del Brutto et al., 2019). While a fall event can occur anywhere, the prevalence is higher in the nursing home than in the community. A study in Indonesia indicated that approximately 32.7% of nursing home residents had fallen than 25.4% of community dwellers (Susilowati et al., 2020).

Falls are also the leading cause of injuries in older people. Approximately 7.6% of people aged 50 years or over living in the community in Indonesia had a single fall, and another 5.2% had multiple fall-related injuries in the past two years (Pengpid & Peltzer, 2018). Meanwhile, a recent study in 21 long-term care facilities in China showed that falls incidence was 13.5%. Of those who had fallen, 64% suffered from injuries, with 32% of them involved fractures (Jiang et al., 2020).

Many factors contribute to falls and fall-related injuries among older people. Socio-demographic variables, including older age, female gender, living in rural areas, and private senior home residence, were significant risk factors for falls and fall-related injuries (Susilowati et al., 2020; Williams et al., 2015). Older people with the following health problems: depression, sleeping problems, poor cognition, two or more chronic conditions, urinary problems, functional disability, and severe pain were at a higher risk of falls and fall-related injuries (Gale et al., 2016; Pengpid & Peltzer, 2018; Williams et al., 2015). Previous falls and balance/ walking problems

were also strong predictors for falls (Jia et al., 2019). A hazardous home environment such as a slippery floor, slippery bathroom, uneven ground, stumbling, poor lighting, and stairs, as well as improper footwear and clothing were also associated with falls (Worapanwisit et al., 2018).

Some strategies have been developed to reduce risks among older people related to falls or fall-related injuries, including exercise. A systematic review by Silva et al. (2013) suggested that exercise programs were effective in preventing falls in long-term care facilities. Balance exercise was one of the most commonly performed interventions besides resistance training. Balance exercise reduces the risk of falling by improving balance, coordination, and proprioception (Seo et al., 2012). A number of studies have been conducted to examine the outcomes and effects of balance exercise compared to other types of exercise, such as resistance training (Joshua et al., 2014; Lacroix et al., 2016; Seo et al., 2012), ankle training (Choi & Kim, 2015), and core stability exercise (Apriani et al., 2015) on fall risk reduction and related indicators. Those studies showed mixed results. Apriani et al. (2015) and Choi & Kim (2015) reported that the balance exercise group showed a better improvement in the gait and the dynamic balance than the comparison group. However, Joshua et al. (2014) showed that the balance exercise was less effective in improving stability than resistance training. Both resistance and balance exercise groups showed a significant improvement in fall efficacy compared to the control group in a study by Seo et al. (2012). In another study, a combination of balance and strength training resulted in better balance and lower extremity muscle power than habitual physical activity (Lacroix et al., 2016).

Besides changes in body balance, having a decreased range of motion also plays an important role in fall occurrence. Range of motion (ROM) refers to the distance and direction that a joint can move (Dutton, 2012). A previous study found a significant decrease in the range of motion of hip extension, internal rotation, abduction, and ankle dorsiflexion in the 'fall group' compared with the 'non-fall' group (Chiacchiero et al., 2010). Thus, an exercise program to improve the range of joint motion may complement the existing exercise programs as a fall prevention strategy.

Range of motion (ROM) exercise refers to an activity aimed at improving a specific joint's movement. Several structures influence this motion: configuration of bone surfaces within the joints, tendons, ligaments, joint capsule, and muscles acting on the joint (Dutton, 2012). A considerable number of studies have examined the benefits of ROM exercise for better patient outcomes in various health conditions, such as stroke (Kim et al., 2014; Murtaqib, 2013; Rhestifujiayani et al., 2015), type 2 diabetes mellitus (Widyawati et al., 2017) and congestive heart failure (Nirmalasari et al., 2020). On the other hand, there are few studies examining the effect of this exercise on fall prevention (Fitriansyah et al., 2014; Safa'ah & Srimurayani, 2017). These studies pointed out that the lower limb ROM exercise improved the postural balance and increased muscle strength among older people to prevent falls.

Balance exercise and range of motion exercise are two exercise interventions that have been well researched in this respect. However, there have been no studies comparing the effect of these two exercise programs on reducing the risk of falls among senior residents living in institutional care. Therefore, this study will help the nursing home's management team implement the best form of exercise to reduce the risk of falling among senior residents. Accordingly, this study aimed to compare the effect of Balance Strategy Exercise (BSE) and Lower Limb-Range of Motion (ROM) exercise for reducing the risk of falls among older people living in institutional care facilities.

2. Methods

2.1 Research design

This was a quasi-experimental study using a pre-posttest comparison of two treatment groups design.

2.2 Setting and sample

The study was conducted from January to March 2019 in two nursing homes in Central Java Province, Indonesia. Cluster randomization using the lottery method was used for group assignment to reduce the probability of experimental contamination (Esserman et al., 2016). Cluster randomization uses a group, rather than a participant, as the unit of randomization. Thus, participants in the same cluster receive the same intervention (Esserman et al., 2016). All senior residents who were categorized as "potentially older people" were invited to be research

participants. Preliminary screening was conducted to check their eligibility using the following criteria: aged 60 years old or over, had a Time and Up Go (TUG) test score ≥14 seconds, had either normal cognitive function or mild impairment (0-4 errors on a 10-item Short Portable Mental Status Questionnaire (SPMSQ), and were able to mobilize independently without assistance. A total of 30 senior residents (15 from each nursing home) met these study criteria (Figure 1).

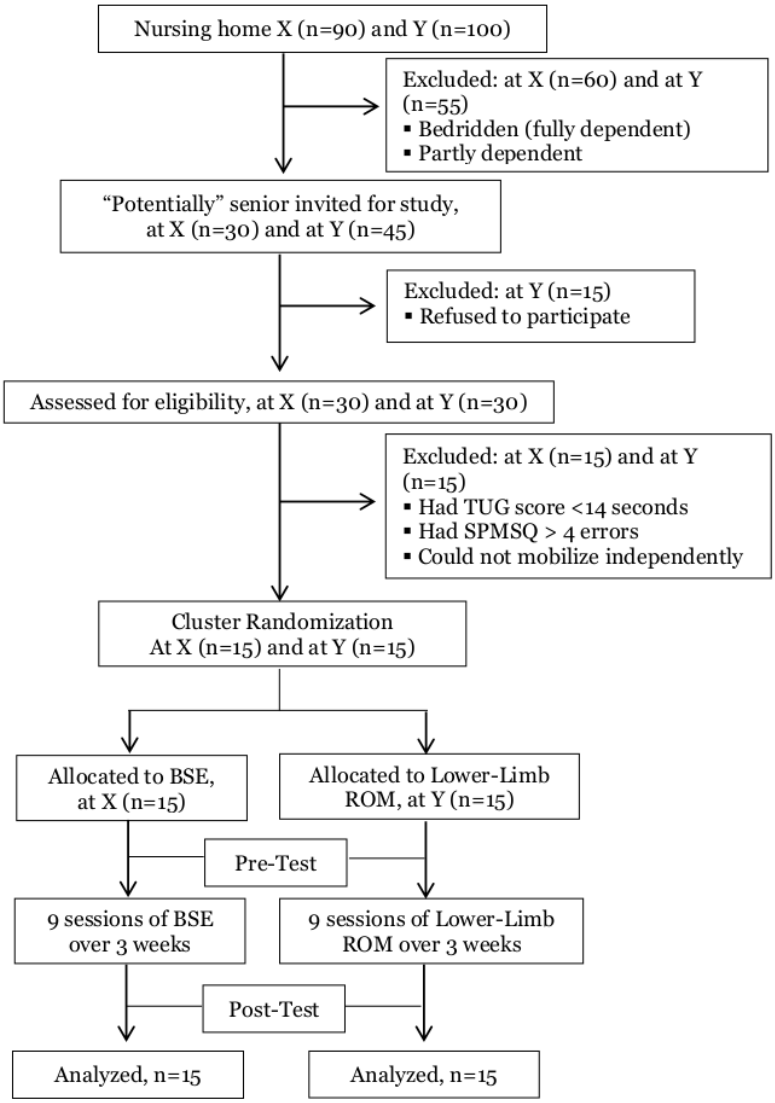

Figure 1. Flowchart of the study

This study was conducted with a small sample size. Similarly, many previous studies used relatively few participants (12-22 participants per group) (Apriani et al., 2015; Choi & Kim, 2015; Fitriansyah et al., 2014; Gschwind et al., 2013; Joshua et al., 2014; Safa'ah & Srimurayani, 2017). It argued that ideally, a study should be conducted with a large sample to avoid potential baseline group inequality, reduce the variability of effect sizes and increase power. However, in most cases, this is quite difficult, especially in intervention studies involving older populations (Netz et al., 2019). The process to recruit more participants in this study was even less possible due to the

coronavirus pandemic, as most long-term care facilities were locked down. However, to ensure that the use of a small sample in this present study did not cause baseline group differences, a simple homogeneity test on participants' characteristics and baseline TUG score was conducted.

2.3 Intervention

Participants conducted a 3-week exercise program, which was three sessions per week, with each session lasting for 30 minutes. Each exercise session consisted of a warm-up exercise for 5 minutes, BSE or Lower Limb ROM training for 20 minutes, and a cool-down exercise for 5 minutes. BSE comprised three main parts: ankle strategy exercise, hip strategy exercise, and stepping strategy exercise. Meanwhile, Lower Limb ROM involved the combination of flexion, extension, hyperextension, abduction, adduction, rotation, circumduction, eversion, inversion, pronation, and supination at the hip, knee, ankle, inter-tarsal, and phalangeal joints. All regular exercise programs were postponed and replaced by either the BSE or Lower Limb-ROM exercise program to avoid intervention bias (Krishna et al., 2010). The exercise program was run in a group format.

2.4 Measurement and data collection

Pre-tests were conducted after all eligible participants gave their consent to partake in this study. These tests used the Timed Up and Go (TUG) test to measure the risk of falls. All participants had their blood pressure checked each time before the exercise sessions began. The participants then obtained nine sessions of either the BSE or Lower Limb ROM over three weeks. Finally, the post-tests were measured using the same TUG test after all participants completed the exercise sessions. No dropped-out participants occurred during the interventions.

The risk of fall was measured using the TUG test. This test is valid to measure mobility and fall risk in the older adult with interrater reliability (intraclass correlation coefficient) = 0.98, sensitivity=87%, and specificity=87% (Shumway-Cook et al., 2000). The TUG test counts the total time (in second) that an individual takes to rise from a chair, walk 3 meters, turn around, walk back to the chair, and sit down. A score of ≥14 seconds has been shown to indicate a high risk of falls. Prior to the test, the subjects were explained about the procedure and what they could wear or used during the test (shoes or an assistive device was permitted). The steps for the test are as follows: (1) subject sits in the chair with arm resting comfortably; (2) when told "Go," subject stands up and the time starts; 3) subject walks 3 meters, turns around, walks back to the chair and sits down; 4) the time stops when the subject is seated.

2.5 Data analysis

Data were initially checked to establish whether it was normally distributed or not. It was found out that TUG scores in the BSE group were normally distributed, whereas, in the Lower Limb-ROM group, they were not. A linear transformation was carried out for non-normal data distributions prior to analysis. The chi-square test, paired t-test, Wilcoxon test, and Mann-Whitney test were used to analyze the data. This study used $p \leq 0.05$ as a threshold of significance.

2.6 Ethical considerations

This study's ethical approval was gained from the Health Research Ethics Committee of Faculty of Health Sciences, Universitas Jenderal Soedirman (No. 027/EC/KEPK/XII/2019). Before signing the written consent, participants were given an explanation about the aim and nature of the study and also the right to refuse and withdraw their participation at any time. Anonymity and confidentiality of the participants were maintained by using initials instead of names and limiting access of the data to research members only throughout the study.

3. Results

3.1 Characteristics of respondents

Table 1 shows the characteristics of respondents. The majority of participants in the Lower-Limb ROM group were female (80%). Meanwhile, in the BSE group, the proportion of female respondents was slightly smaller than that of males, which was 46.67%. However, the homogeneity test did not show a significant difference in the proportion of females and males between the two groups (p=0.058). Both the BSE and Lower Limb-ROM groups had exactly the same proportion of participants according to their age category. The majority of the participants

were categorized as older persons (60-74 years old), which was as many as (73.33%). The homogeneity test showed no significant difference in the age group proportion between the two groups (p=0.729).

Table 1. Characteristics of respondents (n=30)

Characteristics	BSE (n=15) f (%)	Lower Limb-ROM (n=15) f (%)	*p*
Gender			
Male	8 (53.33)	3 (20)	0.058*
Female	7 (46.67)	12 (80)	
Age			
60-74 years old (older persons)	11 (73.33)	11 (73.33)	0.729*
75-90 years old (oldest-old)	4 (26.67)	4 (26.67)	

*Chi-square test

3.2 TUG test score difference within groups

Table 2 shows a decrease in TUG test scores after the intervention. Statistical analysis showed a significant difference in the TUG score before and after the intervention within the BSE group (p=0.001). Similarly, a significant difference in the TUG score before and after the intervention was also found within the Lower Limb-ROM group (p=0.001). It can be concluded that BSE and the Lower Limb-ROM significantly reduced the risk of falls.

Table 2. Differences in TUG test scores before and after the intervention within groups

Groups	Pre-test Mean (SD)	Post-test Mean (SD)	*p*
Balance Strategy Exercise	18.13 (3.46)	16.06 (3.08)	0.001*
Lower Limb-ROM Exercise	16.40 (3.35)	12.66 (3.22)	0.001**

*Paired t-test, ** Wilcoxon test, SD=standard deviation

3.3 TUG test score differences between groups

Table 3 shows no significant difference in the TUG test score before the intervention (pre-test) between the two groups (p=0.542), which means both groups were homogenous. However, after the intervention (post-test), the TUG test score in Lower Limb-ROM was significantly lower than the BSE group (p=0.037). Furthermore, the TUG score change (pre-posttest) showed a significant difference between the two groups (p=0.008). It means that the Lower Limb-ROM exercise was better in reducing the risk of falling than the BSE.

Table 3. Differences in TUG test scores between groups

Groups	BSE Mean (SD)	Lower Limb-ROM Mean (SD)	*p*
Pre-test	18.13 (3.46)	16.40 (3.35)	0.542*
Post-test	16.06 (3.08)	12.66 (3.22)	0.037*
Pre-post changes	2.07 (1.79)	3.73 (2.28)	0.008*

*Mann-Whitney test, SD=standard deviation

4. Discussion

This study investigated whether there was a difference in the BSE and Lower Limb-ROM exercise training in reducing the risk of falling in older people. This study demonstrated that both exercises significantly reduced the risk of falls indicated by lower TUG scores after the intervention. However, Lower Lim-ROM training appears to be better for reducing the risk of falls than BSE.

The finding showed that the BSE intervention, which was conducted for 20 minutes per session, three times a week for over three weeks, reduced the risk of falling in the older people as indicated by a decrease in the TUG test score test. This finding is consistent with a previous study conducted by Konak et al. (2016), which reported a significant decrease in TUG scores among

community-dwelling older adults after a 4-week balance training program. Previous studies conducted in long-term care facilities also suggested that balance training improved residents' functional mobility and balance (Nitz & Josephson, 2011; Yeşilyaprak et al., 2016).

The BSE increases postural control and muscle strength in the lower limbs, which are essential to maintain balance in the older adult (Cho & An, 2014; Low et al., 2017). The BSE consists of three stages: ankle strategy exercise, hip strategy exercise, and stepping strategy exercise. The ankle strategy exercise trains the ankle joint's plantar flexor and dorsiflexor muscles to move the body's center of mass. The hip strategy exercise focuses on the use of hip flexors and trunk muscles to move the body's center of mass. Meanwhile, the stepping strategy exercise is taking a step forward or backward to broaden the base of support, so the body's center of mass is within the base of support. This strategy can be used when the ankle and hip strategies are insufficient to maintain balance (Avers & Wong, 2020).

Furthermore, the BSE activates the body's voluntary movement system and automatic postural responses. The ankle and hip strategy exercises will improve biomechanical constraints by strengthening the following muscles: gastrocnemius, hamstrings, trunk extensor, anterior tibialis, quadriceps, and abdominal muscles. These muscles will support the body and improve the limits of stability so that the center of gravity will be maintained in both anteroposterior and mediolateral directions. Meanwhile, the stepping strategy exercise helps improve the body's automatic postural responses (Low et al., 2017; Sibley et al., 2015).

Similar to BSE, this study also found that the Lower Limb-ROM exercise conducted for 20 minutes per session, for three sessions per week and over three weeks, reduced the risk of falling in the older adults. This finding is in line with previous research conducted by Fitriansyah et al. (2014), which demonstrated that a range of motion exercise could improve balance. A previous study by Battaglia et al. (2016) showed that exercise training programs, including muscle strength and spinal range of motion (ROM), could influence sagittal balance, lumbar lordosis angle, and spinal ROM back muscle strength.

Lower Limb ROM training consists of various movements performed on selected joints (hip, knee, ankle, inter-tarsal, and phalangeal) in different directions (flexion, extension, hyperextension, abduction, adduction, rotation, circumduction, eversion, inversion, pronation, and supination) (Dutton, 2012). A previous study by Jung and Yamasaki (2016) suggested that hip extension, ankle dorsiflexion, ankle plantar flexion ROMs, and knee extension and flexion strengths were associated with the improved physical performance of older women. Thus, a specific intervention program to improve the lower extremity ROM and muscle strength would be beneficial to the prevention of dependence on daily activities and loss of physical function in older adults (Jung & Yamasaki, 2016).

ROM exercise, also called stretching or flexibility exercise can stimulate chemical, muscular, and neuromuscular activation. This exercise can increase muscle mass, strength, and tone and also helps to maintain circulation, joint mobility, and flexibility. A previous study demonstrated that the range-of-motion exercise program significantly improved joint angles, activity function, perception of pain, and depressive symptoms among stroke survivors in residential care (Tseng et al., 2007). Furthermore, the ROM exercise can stimulate the formation of proprioception by activating sensory receptor responses throughout the surface of the muscles, ligaments, joint capsules, and skin. When proprioception is improved, it will help improve balance (Jung & Yamasaki, 2016; Pongantung et al., 2018).

Even though both the BSE and Lower Limb-ROM were found to reduce the risk of falling in the older adults significantly, a comparison between the two groups showed that the latter was better than the former. A possible explanation for this finding was because the older people in this study were more likely to have problems with their joints, which the ROM exercise particularly focuses on. In general, many older people suffer from joint pain, joint stiffness, and loss of muscle strength of the lower limbs. In particular, the prevalence of joint diseases in Indonesia is relatively high; the highest prevalence is in the age group >75 years (18.9%), which is then followed by the 65-74 age group (18.6%), and in the 55-64 age group (15.5%) (Ministry of Health Republic of Indonesia, 2018). Joint pain usually occurs in the hands, wrists, shoulders, hips, upper and lower spine, knees, and legs. Joint pain that is not treated promptly can cause joint stiffness. Later on, muscles around the joint shrink due to infrequent use and lose their function (Mortazavi & Nadian-Ghomsheh, 2018). When this happens over a long period of time, the older people will lose their ability to maintain their body's level of fitness, experience difficulties in walking and

performing daily activities, and also have a higher risk of falling (Jung & Yamasaki, 2016). By practicing the Lower Limb-ROM exercise routinely, it is expected that joint problems can be treated, muscle strength can be increased, and thus the risk of falls can be lowered.

5. Implication and limitation

Findings from this study suggest that long-term care residents who are at risk for falls may benefit from exercise intervention designed to decrease the risk. The BSE and Lower Limb-ROM exercise may therefore be implemented in a long-term care setting. Given the greater reduction of TUG score in the Lower Limb-ROM as compared to the BSE group, it is recommended to include the former as part of a fall prevention strategy in long-term care facilities. The limitations of this study were first that the interventions were conducted in a group format. Even though there were research assistants present who continuously assisted participants during the exercise session, the researchers could not fully ensure that all participants performed all the exercise movements correctly and perfectly. This might have caused bias in the results. Second, this study used a relatively small sample due to the limited number of nursing home residents who met the study criteria and the difficulty of recruiting more samples during the pandemic. However, the homogeneity test has been performed to ensure that the baseline comparability of the two groups was equal. The last was this study used two treatment groups design without control for the similar reasons as above (small sample).

6. Conclusion

BSE and Lower Limb-ROM exercise could reduce the risk of falling among the older people living in institutional care facilities. However, the Lower Limb-ROM exercise was better than the BSE in decreasing the risk of fall. Nursing home management is suggested to implement the Lower Limb-ROM exercise as part of a fall prevention strategy in long-term care facilities. Future research is recommended to use a larger sample size and includes a control group to increase power and minimize bias. It is also recommended to add intervention duration and a follow-up period for more accurate treatment effect estimation.

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Conflict of interest

The authors declare that they have no conflict of interests.

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