

COMPARATIVE STUDY ON THE EFFECT OF SQUARE STEPPING EXERCISES VERSUS BALANCE TRAINING EXERCISES ON FEAR OF FALL AND BALANCE IN ELDERLY POPULATION

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ABSTRACT

Background: Balance is a complex process involving the reception and integration of sensory inputs and the planning and execution of movement to achieve a goal requiring upright posture. The need of the study is to compare the effect of square stepping exercises versus balance exercises on fear of falling and balance in elderly.

Aims and Objectives: 1. To study the effects of square stepping exercise on older adults to improve balance impairments and reducing fear of falling. 2. To identify the effects of balance exercise on fear of falling and balance in elderly. 3. To compare effect of balance exercise and square stepping exercise and in older adults to improve balance and reducing fear of falling.

Materials and Methods: 36 elderly individuals with age 60 year and above having MMSE score >24 and BBS scores of more than 41/56 with vital signs within normal range for elderly population were included in the study. Subjects with history of any neurological disease and musculoskeletal impairment that could account for possible balance impairment like CVA, Parkinson's disease, vestibular disorder, joint replacement, fractures etc, diagnosed with visual and auditory impairment, uncontrolled diabetes mellitus, unstable cardio-respiratory condition, which may affect the training procedure were excluded. All participants were selected by simple random sampling and randomly divided into two groups. Group A received Square stepping exercises and group B received Balance training exercises for a period of 30 minutes with appropriate rest pause, 3 times per week for 4 weeks. Mini Mental State Examination (MMSE), Berg Balance Scale (BBS), Timed Get Up Go (TUG) were used to assess cognition, balance respectively and Fall Efficacy Scale (FES) was used to assess fear of falling

Result: Participants in both the groups improved on BBS and TUG ($p < 0.0001$) scores.

Conclusion: The study concluded that square stepping exercise group exhibited statistically significant improvement on BBS and TUG test score and Fall Efficacy Test scores compared to the balance training exercise group.

KEY WORDS: Elderly population, balance, Square stepping exercise Training, Balance training exercises.

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INTRODUCTION

Balance is a complex process involving the reception and integration of sensory inputs and the planning and execution of movement to achieve a goal requiring upright posture [1].

Every activity we carry out requires us to react to gravity & our body to adjust accordingly in order to maintain balance [2]. Balance is not an isolated quality, but underlies our capacity to undertake a wide range of activities that constitute normal daily life. Activities such as sitting in an armchair, carrying a struggling child, cleaning a high window or running across a busy road require different and complex changes in muscle tone and activity within the balance control system. Balance cannot be separated from the action of which it is an integral component, or from the environment in which it is performed (Carr and Shepherd 1998). Balance therefore forms the "foundation for all voluntary motor skills" (Massion and Woollacott 1996).

Normal balance requires control of both gravitational forces to maintain posture and acceleration forces to maintain equilibrium (Massion and Woollacott 1996). Together, the postural and equilibrium components of balance control ensure stability of the body during widely differing activities [3].

It is the ability to control center of gravity (COG) over the base of support in a given sensory environment. According to the dynamic systems model, balance is the result of interactions between the individual, the task the individual is performing, and the environment in which the task must be performed [1]. The exact demands on the balance control system are determined both by the task itself and the environment in which it is performed [3].

In static balance, the base of support (BOS) remains stationary and only the body center of mass (COM) moves. The balance task is to maintain the COM within the BOS or the limit of stability. In dynamic balance, however, both the BOS and COM are moving, and the COM is never kept within the BOS during the single-limb support periods. So, there are different control mechanisms responsible for controlling static and dynamic balance [4]. Postural control depends on the integration and coordination of three body systems: sensory, central nervous system (CNS) and neuro-muscular. Sensory information gathered through somatosensory, visual and vestibular systems. Somatosensory information gathered from the receptors located in the joints, muscles and tendons provide the

CNS with crucial information regarding body segment position and movement in space relative to each other as well as the amount of force generated for the movement. Visual input provides the CNS with upright postural control information important in maintaining the body in vertical position with the surrounding environment.

The vestibular system provides the CNS with information about angular acceleration of the head via semicircular canals and linear acceleration via otoliths. The CNS receives sensory inputs, interprets and integrates these inputs, then coordinates and executes the orders for neuromuscular system to provide corrective motor output. Multiple centers within CNS are involved in the postural control processes including the cortex, thalamus, basal ganglia, vestibular nucleus and cerebellum. The neuromuscular system represents the biomechanical apparatus through which the CNS executes postural actions. Muscle strength, endurance, range of motion and postural alignment all affect the ability of a person to respond to balance perturbations effectively [5].

Ageing is a fundamental process that affects all of our systems and tissues. It is manifested by cellular and subcellular changes within all tissues. [5] Ageing has been defined as a progressive generalized impairment of function resulting in the loss of adaptive responses to stress and a growing risk of age associated diseases [6]. It's well documented that in the absences of diagnosable disease visual, vibratory and proprioceptive input are commonly diminished in older adult [7].

It has been reported that aging is generally accompanied by deterioration of brain structures, which is associated with decrements in cognitive performance [8]. Deficit in attention and executive function processes are independently associated with risk of postural instability, impairment in activities of daily living and future falls [9]. Balance problems constitute a high risk for falls [10]. Falls are among the most serious problems facing the elderly population. An injury from a fall can result in disability, loss of independence, and a reduced quality of life [11]. In addition it has been proved that balance problems resulted in depression and deficient

mobility [12]. The elderly develop a fear of falling, social isolation, a reduction in their confidence to accomplish normal activities of daily living, and mobility problems in particular, and adopt an inactive lifestyle, functional decline, a decrease in quality of life and resulting in institutionalization [13].

The need of the study is to compare between the square stepping exercise and balance exercise and to find out which is the more effective exercise training program to improve balance in elderly population.

MATERIALS AND METHODS

36 healthy elderly people who lived in the local community were recruited from old age groups in Pune city. Inclusion criteria: (1) Age 60 and more years of both genders; (2) Mini mental state examination score greater than 24; (3) BBS scores of more than 41/56; and (4) Vital signs within normal range for elderly population. Exclusion criteria: (1) History of any neurological disease and musculoskeletal impairment that could account for possible balance impairment like CVA, Parkinson's disease, vestibular disorder, joint replacement, fractures etc. (2) Unstable cardio-respiratory condition which may affect the training procedure; (3) Patients with diagnosed visual and auditory impairment; (4) Uncontrolled diabetes mellitus. The study protocol was explained to each participant who then provided informed consent. Study is approved by the ethical committee at Dr. D. Y. Patil College of Physiotherapy, Pimpri, Pune, Maharashtra, India.

Study Design: After baseline measurement, subjects were assigned randomly to either square stepping exercise group (Group A) or balance training group (Group B) by the investigator who was involved in data collection, treatment implication, and data analysis. In this comparative study the sample size after the intervention was 36. As there were drop outs from both groups that is 2 subjects from dual both. Dropouts were because of some common reasons like illness, travel and loss on interest. Therefore, total number in square stepping exercise group (Group A) and balance training group (Group B) come out to be 18 each.

Intervention: Square stepping exercise training

and balance training were performed for 30 minutes. The sessions were 3 times a week for 4 weeks. In square stepping exercise there were three mats, 6 persons for each mat. Square stepping exercises consisting of basic, elementary patterns, each pattern for 10 times. 4 types of basic and 4 types of elementary patterns was taught (each time it took approx. 15 seconds for one time walk on the mat) it was followed by cool down exercise for 5 minutes.

In Balance exercise training a circuit of progressive challenges to upright static and dynamic balance was presented by narrowing the base of support (bipedal to tandem), moving from symmetrical to asymmetrical base of support, providing external challenges to balance that require a response (e.g. Moving the upper extremities and catching a ball), narrowing the base of support while responding to the external challenge (e.g., standing in semi tandem while catching a ball) and increasing the complexity of ambulatory tasks (e.g., changing direction (walking backward or laterally), changing speed, walking with reduced base of support, turning, bending, stepping on and off curbs, braiding/ grapevine steps, walking while carrying a ball, or stepping over obstacles (e.g., small hurdles)). Functional ankle, knee and hip strengthening activities such as heel and toe rises and rising from a chair, followed by cool down exercise for 5 minutes.

Outcome Measures: Berg Balance Scale (BBS), Timed Up and Go (TUG) test, Fall Efficacy Scale, Rate of likelihood of fall (PO) were the outcome measures taken at baseline and at the end of 4th week post intervention.

Statistical analysis: In this study 36 subjects were included to compare the effect of Square stepping exercise and balance training of elderly population. Data was analyzed to check out the normality distribution of groups and statistical tests were done. In this study 36 elderly people were included. In group A, 18 subjects were treated with square stepping exercise and in group B, 18 subjects were treated with balance training exercises. At the end of 4th week, balance was reassessed by Berg Balance Scale (BBS), Time get up and go test (TUG) Fall Efficacy Scale, Rate of likelihood of fall. To compare difference within the group paired t-test was

used. Then to compare those differences between two groups unpaired t-test was used. A level of significance was $p < 0.05$. Wilcoxon Signed Rank Test was used when data was not normally distributed.

RESULTS

Table 1: Showing the statically differences between the Square stepping and Balance training exercises (Berg Balance Scale).

| Time of assessment | Group | | | | | |
|--------------------|--------------------------|-------|---------|------------------|-------|---------|
| | Square stepping exercise | | | Balance training | | |
| | Mean | S. D. | P value | Mean | S. D. | P value |
| Pre | 43.94 | 1.66 | 0.0001 | 44.22 | 0.88 | 0.0001 |
| Post | 51.39 | 1.75 | | 48.56 | 0.86 | |

The mean value of berg balance scale score pre training in group A was 43.94 ± 1.66 which showed significant improvement in post treatment mean value of BBS at as 51.39 ± 1.75 shown in Table 1. Significant increase in berg balance scale score after training was observed in square stepping exercise training group. p-value 0.0001. It depicts that the square stepping exercise training is effective in improving balance in elderly population. The mean value of berg balance scale score pre training in group B was 44.22 ± 0.88 which showed significant improvement in post treatment mean value of BBS at as 48.56 ± 0.86 . Significant increase in berg balance scale score after training was observed in balance training exercises group. p-value 0.0001. It depicts that the balance training exercise is effective in improving balance in elderly population.

Table 2: Showing the statically differences between the Square stepping and Balance training exercises (TUG score).

| Time of assessment | Group | | | | | |
|--------------------|-----------------|------|---------|------------------|------|---------|
| | SQUARE STEPPING | | | BALANCE TRAINING | | |
| | Mean | S.D. | P value | Mean | S.D. | P value |
| Pre | 11.12 | 1.92 | 0.0001 | 9.4 | 1.19 | 0.0001 |
| Post | 9.3 | 1.91 | | 8.06 | 0.79 | |

The mean value of timed up and go test score pre training in group A was 11.12 ± 1.92 which showed significant improvement after 4 weeks with mean value of TUG at 9.30 ± 1.91 as shown in Table 2. Significant decrease in TUG score was observed square stepping exercise training group. p-value 0.0001. It depicts that the square stepping exercise training is effective in improving balance in elderly population. The

mean value of timed up and go test score pre training in group B was 9.40 ± 1.19 which showed significant improvement after 4 weeks with mean value of TUG at as 8.06 ± 0.79 shown in table 5. Significant decrease in TUG score was observed in balance training exercise group. p-value 0.0001. It depicts that the balance training exercise is effective in improving balance in elderly population

Table 3: Showing the statically differences between the Square stepping and Balance training exercises (Fall efficacy scale).

| Time of assessment | Group | | | | | |
|--------------------|-----------------|-------|---------|------------------|-------|---------|
| | SQUARE STEPPING | | | BALANCE TRAINING | | |
| | Mean | S.D. | P value | Mean | S.D. | P value |
| Pre | 30.5 | 5.742 | 0.001 | 28 | 5.053 | 0.001 |
| Post | 22.67 | 4.073 | | 23.78 | 4.821 | |

The mean value of Fall efficacy scale score pre training in group A was 30.5 ± 5.742 which showed significant improvement after 4 weeks with mean value of FES as 20.67 ± 4.073 shown in Table 3. Significant decrease in FES score was observed square stepping exercise training group. p-value 0.0001. It depicts that the square stepping exercise training is effective in improving balance in elderly population. The mean value of Fall efficacy scale score pre training in group B was 28 ± 5.053 and after 4 weeks mean value of FES was 23.78 ± 4.821 shown in table 4. Significant decrease in FES score was observed in balance training group. p-value 0.0001. It depicts that the balance training exercise is effective in improving balance in elderly population

Table 4: Showing the statically differences between the Square stepping and Balance training exercises (Rate of likelihood of fall).

| Time of assessment | Group | | | | | |
|--------------------|-----------------|-------|---------|------------------|-------|---------|
| | SQUARE STEPPING | | | BALANCE TRAINING | | |
| | Mean | S.D. | P value | Mean | S.D. | P value |
| Pre | 64.69 | 24.14 | 0.001 | 71.36 | 21.48 | 0.001 |
| Post | 15.82 | 16.91 | | 32.27 | 23.87 | |

The mean value of Rate of likelihood of fall pre training in group A was 64.69 ± 24.14 which showed significant improvement after 4 weeks with mean value of Rate of likelihood of fall as 50.82 ± 16.91 shown in Table 4. Significant decrease in score of Rate of likelihood of fall was observed square stepping exercise training group, p-value 0.0001. It depicts that the square

stepping exercise training is effective in improving balance in elderly population.

Table 5: Showing the Groups comparison of differences of BBS Score

| | Mean | Std. Dev. |
|--------------------------|------|-----------|
| Square stepping exercise | 7.44 | 1.58 |
| Balance training | 4.33 | 1.372 |

The mean difference of square stepping exercise training group was 7.44+-1.58 and that of balance training exercise group was 4.33+-1.372 t = 5.194 as shown in Table 5. Significant increase in berg balance score after training was observed P value of 0.0001. This suggest that there was statistical improvement of balance score in elderly population when both the groups were compared but the increase in BBS score was more in square stepping exercise group.

Table 6: Showing the Groups comparison of differences of TUG Score.

| | Mean | Std. Dev. |
|--------------------------|-------|-----------|
| Square stepping exercise | 9.299 | 1.206 |
| Balance training | 8.061 | 0.7883 |

The mean difference of TUG scores in square stepping exercise training group was 9.299+-1.206 and that of balance training exercise group was 8.061+-0.7883 t = 33.852 as shown in Table 6. Significant decrease in timed up and go test score after training was observed in both exercise groups. P value of 0.0001. This suggest that there was statistical improvement of balance score in elderly population when both the groups were compared but decreased in TUG scores was more in square stepping exercise group.

Table 7: Showing the Groups comparison of differences of Fall Efficacy Scale.

| | Mean | Std. Dev. |
|--------------------------|-------|-----------|
| Square stepping exercise | 7.833 | 3.65 |
| Balance training | 4.22 | 1.003 |

The mean difference of comparison of Fall Efficacy Scale Scores in square stepping exercise training group was 7.833+-3.65 and that of balance training exercise group was 4.22+-1.003 t = 14.188 as shown in Table 7. Significant decrease in Fall Efficacy Scale score

after training was observed in both exercise groups. P value of 0.001. This suggest that there was statistical improvement of balance score in elderly population when both the groups were compared but the decrease was more in square stepping exercise group.

Table 8: Showing the Groups comparison of differences of likelihood of Fall after excercises.

| | Mean | Std. Dev. |
|--------------------------|-------|-----------|
| Square stepping exercise | 48.87 | 23.89 |
| Balance training | 39.08 | 23 |

The mean difference of comparison of Rate of likelihood of Fall Scores in square stepping exercise training group was 48.87+-23.69 and that of balance training exercise group was 39.08+-23, t = 10.660 as shown in Table 8. Significant decrease in Rate of likelihood of Fall after training was observed in both exercise groups. P value of 0.001. This suggest that there was statistical improvement of balance score in elderly population when both the groups were compared but the decrease was more in square stepping exercise group.

Fig. 1: Square Stepping Exercise.



Fig. 2: Decrease base of support balance exercise.



Fig. 3: Basic Patterns of Square Stepping Exercise.

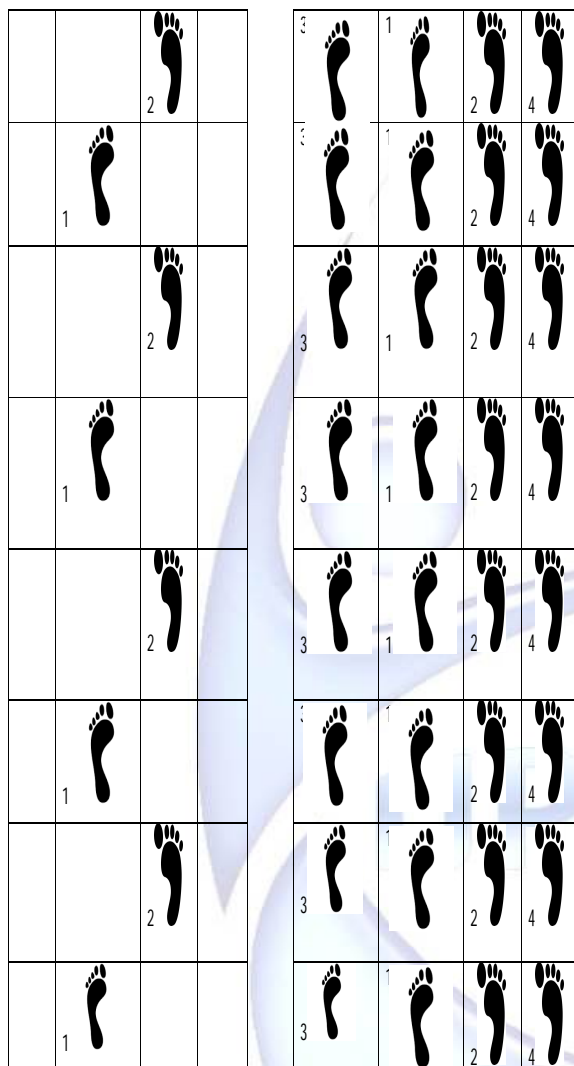
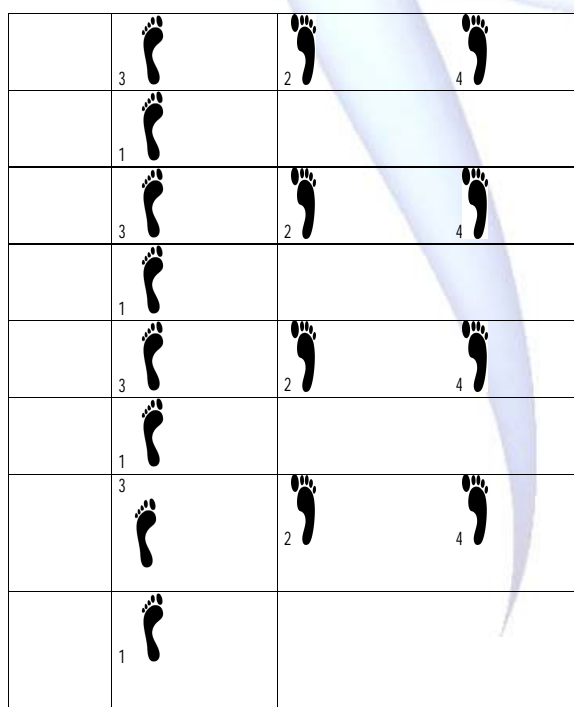


Fig. 4: Elementary Patterns of Square Stepping Exercise.



DISCUSSION

Reduction in functional ability among older people causes substantial hardship to individuals and to society [14,15]. Age related physiologic changes as well as extended exposure to environmental risk makes them more prone for the diseases. Loss of postural control in elderly results in falls and an injury from a fall can result loss of independence and a reduced quality of life [16]. The most promising approach for the prevention consequences of aging and diseases is through a structured exercise programme [17].

Hence in this study we have compared square stepping exercise and balance training in elderly population. Relatively healthy older people (mean age 69.2±6.2) participated in both SSE and balance training.

In group A, SSE group showed improvement in balance on BBS scale and TUG test and FES and Rate of Likelihood of fall. A study by Orr and colleagues revealed that leg strengthening exercises at light loads (20% of maximal strength) improves balance because they ensure that the muscles remain active throughout the concentric phase of the movement and maintain the level of force output. The exercise intensity and movement in the above mentioned study were rather similar to those of our step exercises, including the slight extension of the knees and ankles. A leg exercise such as this is assumed to enhance neural function by reducing response latency, effectively recruiting postural muscles, and improving the interpretation of sensory information [18]. In addition, the multidirectional steps in the forward, backward, lateral and oblique directions during SSE lead to better activation of the synergist and agonist leg muscles. Therefore, it is possible that the SSE regimen consequently improves many aspects of the functional fitness of the lower extremities, which is a fall risk factor.

After the SSE persons were familiar with the step patterns, they were instructed to walk with their heels lifted. This movement, which involved small hopping steps, also improved their leg strength [19]. A study by Pijnappels and colleagues revealed that during a trip, when the balance of one leg is lost, the other leg is immediately lifted off the floor, in a manner similar to hopping, in

order to prevent a fall [20]. This mechanism can explain the reason for the decrease in the rate of fear of fall.

The results of this study imply that SSE could be used as means of rehabilitation and public health promotion because it has number of advantages .First, it is possible for fewer staff members (including physicians, public health nurses, and exercise instructors) to simultaneously supervise several older adults with high risk of falling because SSE can be performed within a small indoor space. Second, outdoor walker can substitute walking with SSE when it rains. In this context, our study proposed a new form of exercise for older adults. Increasing the number of feasible exercises is important for health promotion. Third, SSE requires minimum investment because it involves the use of low tech equipment. Fourth, because of the significantly small reaction time, which is a cognitive function, SSE may improve information processing speed and psychomotor processes [21]. Fifth there is visual feedback while performing Square Stepping Exercise on the Special mat, also while performing the exercise 6 people are on the same mat ,hence they have to coordinate with each other. Based on the results of current study, variety of step pattern and level of muscle coordination involved in SSE make it more beneficial than balance training in reducing fear of fall and improving balance in elderly. Also level of motivation and enthusiasm in SSE was more as compared to balance training because in SSE, 6 people are on same mat hence they have co ordinate with each other.

CONCLUSION

Participants in both the groups improved on BBS and TUG ($p < 0.0001$) scores. However, square stepping exercise group exhibited statistically significant improvement on BBS and TUG test score and Fall Efficacy Test scores compared to the balance training exercise group. Square stepping exercises are more effective than balance training to improve balance in elderly population.

ABBREVIATIONS

MMSE - Mini Mental Status Examination

BBS - Berg Balance Score

TUG - Timed Get Up Go

FES - Fall Efficacy Scale

COG - Center Of Gravity

BOS - Base Of Support

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Conflicts of interest: None

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