



Effectiveness of Multi-Directional Step-Up Box Training Along with Conventional Physiotherapy on Balance in Elderly – An Experimental Study

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ABSTRACT

Introduction: Failure to regain balance, falls, and associated injuries are main geriatric problems. Lack of exercise and poor fitness are responsible for decrease in muscle strength leading to falls. Balance exercises help to maintain balance, improve balance recovery and reduces risk of falls. Multi-directional training is necessary for daily activities, as 35 - 50% steps are non-straight steps that change direction of movement.

Aim/ Objective: To assess effect of multi-directional training along with conventional physiotherapy on balance in elders when compared with conventional physiotherapy.

Methodology: Study was conducted in old age homes in Surat. 58 elders were included and divided into 2 groups: group -1 CPTG (conventional physiotherapy group) and group - 2 MDSTG (multi-directional step-up training along with conventional physiotherapy) and received training for 5 sessions / week for 4 weeks. Mini - Best test (MBT) was used to assess balance at baseline and after 4 weeks of intervention. Wilcoxon rank test was used for within group analysis and Mann - Whitney U test was used for between group analyses.

Result: After 4 weeks of intervention, both groups showed significant improvement, but multi-directional training group showed more improvement in balance in elders ($p < 0.05$).

Conclusion: Multi-directional training along with conventional physiotherapy is useful in elders to improve balance. Therefore, it can be used in addition to conventional physiotherapy for improving balance in elders.

Key Words: Balance, Multi – directional, Step-up, Box training, Elders, Fall

INTRODUCTION

India has 104 million elders above 60 years who are at high risk of disequilibrium.¹ Disequilibrium occurs when center of gravity is not aligned with base of support. ² Prevalence of falls in elders is 14%-53%.³ Falling has significant impact on confidence and independence; lead to hospitalization or death in worst scenarios. ⁴ Structural changes due to aging causes drastic decline in fitness.⁵ Failure to regain balance after destabilization is main reason behind fall and 10% falls result in fractures, dislocation or head injury.⁶ Falls are downward spiral of elder's health. Even if no serious injury occurred, decline in self-confidence leads to avoidance of physical activity and social situations to prevent falls. This decline in physical activity increases fall risk.⁷

Postural changes like rounded shoulders and gait disturbances like reduced trunk flexibility, cadence, small steps and

carefully monitored movements occur due to aging.⁷ Reasons behind postural changes and imbalance include loss of antigravity muscle strength, changes in joint and bone structure, loss of vestibular function and decreased somatosensory proprioception.⁷

Falls in elders are common as lack of exercise, poor fitness and nutrition level lead to gradual decrease in muscle strength and functional capacity. Static and dynamic balance exercises help to maintain balance, improve balance recovery and thus reduce fall risk in elderly people.³ In order to maintain balance, functional awareness of base of support is necessary to accommodate changing center of gravity in better manner.² To achieve this, conventional physiotherapy can be given.³

Balance is an integral part of our day to day life, from simple to complex activities which we do such as walking, changing

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directions while walking, sitting, sit- to stand, stand to sit, turning, pivoting, etc. all require different balance abilities.¹ Balance is basically controlled or governed by three major systems: - Sensory system, motor system and central nervous system.⁶

Multi-directional steps are necessary for daily activities as 35-50% steps accounts non-straight steps that change direction of movement.⁹ Elders fall during walking, standing, turning, pivoting or transfer; therefore, ability to take multi-directional steps is important.⁹ Ability to recover balance or prevent fall strongly correlates with ability to take rapid steps in the direction of movement.¹⁰ Elders are more prone to falls compared to those who can take quick steps as a response to induced perturbation.¹⁰ There are few studies on multi-directional training but there is no study which shows the effect of multi-directional training on balance in elders. So, there is a need to conduct study on this. Main purpose of this study is to find out effect of multi-directional training along with conventional physiotherapy on balance in elders when compared with conventional physiotherapy.

MATERIAL AND METHOD

Study was approved by Institutional Ethical Committee (EC/SPB/069). Study was done on elders having age 60-70 years living in old age homes in Surat. Sample size was calculated from previous study. Sample size was calculated in G*Power (Version 3.1.9.7). Power was set at 0.95 and α error probability was 0.05. This generated total sample size = 58, i.e. 29 participants in each group. Purposive sampling was done.

Inclusion criteria: (1) Age group: - 60-70 years. (2) Gender:- Male & female. (3) Able to stand & walk minimum 10 meters independently without any assistive device. (4) Minimum score 24 in Mini Mental State Examination. Exclusion criteria: (1) Recent or unhealed fracture. (2) Surgery of lower limb within 1 year. (3) Neurological disorder. (4) Psychiatric illness. (5) Blind. (6) Uncorrected visual deficits. (7) Chronic drugs or alcohol abuse. (8) Score less than 17 in Mini best test.

Screening was done and demographic data was taken by Assessment Performa. 66 subjects were screened but 8 were excluded. So, 58 participants were selected for study. Prior to commencement of study, detailed procedure of study was explained and consent was taken. Participants were assured that confidentiality will be maintained. Subjects were randomly allocated in both groups by lottery method. Allocation ratio: 1:1. (Figure 1)

Study Intervention:

Both groups received training for 5 sessions / week for 4 consecutive weeks. Total study duration was 1 year. Duration of

each session was 30 minutes for Conventional group and 45 minutes for Multi-directional training group. Baseline data was taken using Mini-Best test. After 4 weeks, post intervention data was taken using the same outcome measure.

Group-1 Conventional physiotherapy group (CPTG) protocol: ^{2,9,11,12}

1. One leg standing (3 repetitions, 30 seconds hold).
2. Tandem standing (3 repetitions, 30 seconds hold).
3. Backward walking (10 repetitions).
4. Tandem walking (10 repetitions).
5. Sideway walking (10 repetitions).
6. Reach outs in standing with broad base of support (10 repetitions).

All exercises were given with 45 seconds rest between each. All participants performed exercises under constant personalized supervision and guidance of therapists. All exercises were demonstrated and explained before starting the exercise session. All queries of participants were answered, and care was taken to maintain participants' safety. Participants were allowed to discontinue exercise any time if they felt discomfort, fatigue or due to other personal reasons.

Those participants who faced marked difficulty in maintaining balance while performing exercises were given manual assistance by therapist during initial sessions and then participants gradually performed exercises without any assistance in later sessions. Standard protocol was set for all participants with fixed number of repetitions and hold duration for each exercise as mentioned above. However, protocols were modified according to ability of participants and tailor-made protocol was given as ability to maintain balance varies from participant to participant. The number of repetitions and hold duration were gradually increased as participants progressed.

Group-2 Multi-directional step-up training group (MDSTG) protocol ¹³:

First, Conventional physiotherapy was given to participants of multi-directional training group for 30 minutes as per conventional physiotherapy protocol mentioned in Group 1. Then the following weight shifting training was given for 5 minutes: Shifting weight in anterior-posterior direction and right-left side. Then 45 seconds rest was given, and multi-directional training was given for 10 minutes i.e. 5 minutes in clockwise direction, followed by 45 seconds rest and then 5 minutes in anti-clockwise direction. 3 steppers with height 10 cm, 20 cm and 10 cm were used, with 10 cm height difference between adjacent boxes. Footprints were marked on them at 12 o'clock, 3 o'clock and 9 o'clock directions. As mentioned above, Multi-directional training was first given in clockwise and then in anticlockwise direction.

As ability to maintain balance varies from participant to participant and no two participants are equal, numbers of

steps taken during multi-directional training were not fixed. Participants were asked to take maximum steps in clockwise direction within 5 minutes and then in anticlockwise direction within 5 minutes. Numbers of steps taken during multi-directional training gradually increased as participants progressed.

Outcome Measure:

Mini-BEST test (MBT):¹⁴ MBT is 14-item derivative of Balance Evaluation Systems Test. Items are scored on 3-point scale (0 – 2) and are focused on assessment of dynamic balance control. The estimated time investment is modest (10 – 15 minutes). Test-retest reliability ICC = 0.96. Inter-rater reliability ICC = 0.98. Convergent reliability = $r = 0.85$ (Versus Berg Balance Scale).

STATISTICAL ANALYSIS

Data was analyzed using Jamovi (Version 2.3.28.0). Normality of data was checked by Shapiro Wilk test. As data was not normally distributed, non-parametric tests were applied. Wilcoxon rank test was used for within group and Mann-Whitney U test was used for between group analysis. Confidence interval was kept at 95 % and level of significance at 0.05.

RESULT

The baseline characteristics and gender distribution of the participants is as given in table 1 and table 2 respectively. Within group analysis showed that there is a significant improvement in Mini Best Test score of both the groups $p < 0.001$. (table 3 and 4). Between groups analysis showed that there is significant improvement in Mini Best Test score with MTSDG group showing more improvement than CPTG group (table 5).

DISCUSSION

This study was conducted to evaluate effect of Multi-directional step-up training along with conventional physiotherapy on balance in elders. Results of intra group comparison in CPTG showed significant improvement in MBT score. There was significant difference between pre-intervention data (23.1 ± 2.52) and post-intervention data (24.3 ± 2.31). p -value = 0.001 ($p < 0.05$).

A study revealed strong correlation between balance, lower-extremity strength and fall risk.¹⁵ This is the mechanism behind improvement of balance after conventional physiotherapy in both groups. Conventional physiotherapy improved strength (especially anti-gravity muscles) which helped to

reduce postural sway and improved balance in elders. Results of intra group comparison in MDSTG showed significant improvement in MBT score. There was significant difference between pre-intervention data (23.2 ± 2.38) and post intervention data (25.2 ± 1.66). p -value = 0.001 ($p < 0.05$).

Both balance as well as muscle strength represent important health and skill- related components of physical fitness which should be developed across the lifespan to successfully perform activities of daily living without suffering any kind of injury and fall.¹⁵ Deficits in balance and muscle strength of lower extremities are considered as the important factors for intrinsic (person-related) injury and fall in elders. For example, a study showed that large amount of postural sway while performing one-leg standing was associated with a significant increase in the risk of ankle injuries. Furthermore, deficits in lower-extremities muscle strength (i.e., isokinetic knee flexors/extensors strength asymmetry) were identified as the significant risk factors for non-contact quadriceps and hamstrings strains. In elders above 60 years of age, a meta-analysis consisting of 16 prospective and retrospective studies concluded that lower-extremity muscle weakness, poor ability to maintain balance and gait deficits, all are associated with an increased risk of fall.¹⁵ It becomes very much important to have knowledge about the relationship between ability to maintain balance and lower-extremity muscle strength from 2 perspectives: (a) assessing and identifying the individuals who are at risk; and (b) developing and implementing a patient oriented and tailor-made injury and fall- prevention program. Large-sized correlations between measures of balance and muscle strength of lower extremities concluded that these neuromuscular components are interlinked and dependent on each other. Thus, performance achieved in one component (e.g., balance) can be (partly) transferred to that of the other component (e.g., lower-extremity muscle strength). In addition, training- induced gains in lower extremity muscle strength (e.g., maximal strength of plantar flexors) may have an impact on balance performance (e.g., postural sway) or vice versa. According to a systematic review and meta-analysis on associations between measures of balance and lower-extremities muscle strength in healthy individuals across the lifespan, there is a strong correlation between ability to maintain balance and lower-extremities muscle strength in healthy individuals of all ages. The study found that the ability to maintain balance is directly linked to the strength of the muscles (especially the anti-gravity muscles) in the lower extremities. This suggests that individuals with stronger lower extremities muscles are better able to maintain their balance compared to those individuals who are having weakness of lower extremities muscles. This could be the mechanism behind the improvement of balance after receiving conventional physiotherapy in both the groups. The analysis also indicated that conventional physiotherapy can play a key role in enhancing both

balance and muscle strength after 4 weeks of conventional physiotherapy training. Thus, there is importance of maintaining strong lower-extremity muscles for optimal balance and stability. The findings suggest that interventions targeting muscle strength in the lower body can have a positive impact on an individual's ability to maintain balance. This new understanding underscores the potential for physiotherapy to improve both muscle strength and balance in individuals of all ages. Additionally, another factor contributing to the enhancement of balance following the administration of conventional physiotherapy training in participants of both the groups is the decrease in postural sway.¹⁵

This reduction in the amount of postural sway can be attributed to the improvement in muscle strength resulting from conventional physiotherapy training. As a result, this entire mechanism helped in achieving overall improvement in muscle strength and reduction in postural sway, which indirectly led to an enhancement in balance among elderly individuals who underwent the treatment.¹⁵

According to a study on epidemiology, risk factors and strategies for prevention of falls in elder individuals, it was found that broad category of deficits in gait are the most common precipitating factors leading to fall.¹⁶

One key aspect of maintaining balance during daily activities is the proper functioning of various biomechanical components within the body, such as the flexible movement of joints, especially in the legs, appropriate timing and intensity of muscle actions and parameters related to gait like step length, cadence, etc.¹⁷ This could be the mechanism behind improvement of balance in MDSTG as these elements played an important role in enhancing balance.

Limitations: The current study had a short study period and lacked follow-up, which limited the precise estimation of the duration of the effectiveness of the treatment.

Future Recommendations

Long-term follow-up: The same study can be conducted with a long-term follow-up to estimate the duration of the effectiveness of the treatment.

Different outcome measures: Similar studies can be conducted with different outcome measures to further validate the findings.

Orthopedic and neurological conditions: The effect of multi-directional step-up training can be checked in various orthopedic and neurological conditions having balance issues.

Athletes and sportsperson: The effect of multi-directional step-up training can also be checked in athletes, sportsperson, and dancers performing various dance forms.

CONCLUSION

From this study, it was concluded that both conventional physiotherapy and multi – directional step up training were helpful and effective to improve balance in elder individuals. On comparison, both the groups showed significant improvement. However, more improvement was seen in MDSTG.

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Conflict of interest

There is no conflict of interest.

Author Contribution

BC and AB conceptualized the study. BC recruited the participants, collected the data and analysed the data. AB helped in sorting and analyzing the data. BC and AB contributed equally in writing, proof reading and editing the manuscript.

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Table 1: Baseline characteristics

Variables	Group	Mean ± SD	p-value
Age (y)	CPTG (n = 29)	66.9 ± 3.09	0.001
	MDSTG (n = 29)	65.5 ± 3.30	
BMI (kg/m²)	CPTG (n = 29)	21.3 ± 2.00	0.001
	MDSTG (n = 29)	21.6 ± 2.13	
MBT pre-score	CPTG (n = 29)	23.1 ± 2.52	0.001
	MDSTG (n = 29)	23.2 ± 2.38	

Table 2: Frequencies of gender

Gender	Group	Frequency (N)	Frequency %
Male	CPTG (n = 29)	15	25.9 %
	MDSTG (n = 29)	15	25.9 %
Female	CPTG (n = 29)	14	24.1 %
	MDSTG (n = 29)	14	24.1 %
Total		58	100 %

Within group analysis:

Table 3: Intragroup comparison of Conventional physiotherapy group

Outcome measure	Pre-score (Mean±SD)	Post-score (Mean±SD)	p-value
MBT	23.1±2.52	24.3±2.31	0.001

Table 3 shows that there is significant improvement in CPTG (Conventional Physiotherapy Group) as $p < 0.05$.

Table 4: Intragroup comparison of Multi-directional training group

Outcome measure	Pre-score (Mean±SD)	Post-score (Mean±SD)	p-value
MBT	23.2±2.38	25.2±1.66	0.001

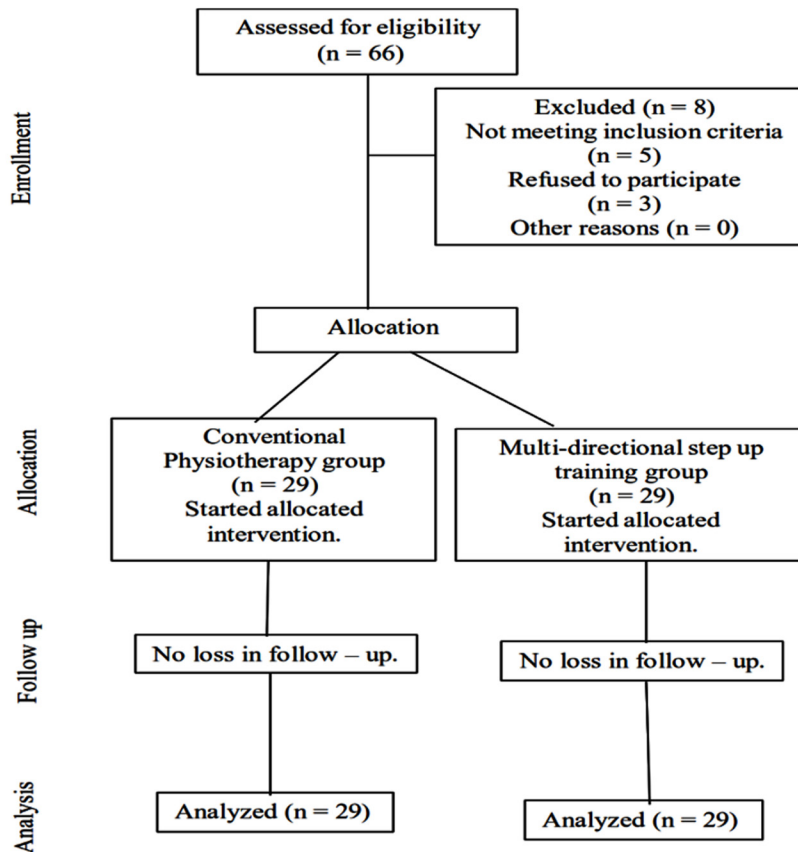
Table 4 shows that there is significant improvement in MDSTG (Multi-directional step-up training group) as $p < 0.05$.

Between group analysis:

Table 5: Intergroup comparison

Outcome measure	Pre and post difference value (Mean±SD) for CPTG	Pre and post difference value (Mean±SD) for MDSTG	p-value
MBT	1.17±0.384	2.07±0.884	0.001

Table 5 shows that there is significant improvement in both the groups but there is more improvement in MDSTG (Multi-directional step-up training group).

**Figure 1:** Participants' recruitment and retention throughout study.