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Comparison of Individual and Combined Effects of Ankle Strengthening and Proprioception Training on Balance Performance in Elderly Women

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***Abstract**: Decreased mobility among older women is often related to a combination of impairments in balance and lower limb strength that are also risk factors for falls and dependency in activities of daily living. Studies have shown strength training and proprioception training to be effective in reducing fall risk in elderly women but till so far the combined effect of ankle strengthening and proprioception training on balance in elderly women has not been studied. Hence present study intends to investigate and compare the effects of strengthening of ankle musculature, proprioception training and the combination of the two (ankle strengthening plus proprioception training) on balance performance in elderly women. Thirty elderly women volunteers were divided into 3 groups; Group A received ankle strengthening; Group B received ankle proprioception training and Group C received ankle strengthening plus proprioception training. Outcome measures were Berg Balance Scale(BBS) and Functional Reach Test(FRT). All the experimental groups showed improvement on outcome measures after intervention. Proprioception intervention emerged as an effective component of balance training program in improving the impaired balance of elderly women and combination of proprioception component with ankle strengthening showed better results than ankle strengthening alone.*
***Keywords**: Ankle strengthening, elderly women, fall, proprioception,*

I. Introduction

Age is a primary consideration in balance impairment. Contribution of age related changes in the physiological systems (somatosensory, vestibular, and visual) are well documented for balance impairment in older adults. These changes coupled with the changes in muscles and bones contribute to an increased risk of falls in this population [1]. The maintenance of the postural stability is important during functional activities and the increased deficit in the postural control system with aging has been associated with increased risk of falls in elderly.

The increased incidence of falls with aging is of great concern, particularly among the elderly women with osteoporosis, who present with increased bone fragility, and thus increased fracture risk [2]. Falls are responsible for 90% of the growing increase in hip fractures in women [3] and sixth cause of death among people aged over 65 [4]. Fall incidence is three times higher in post-menopausal women than men within the same age group as estrogen withdrawal in menopause is suggested to affect postural stability via reducing the speed of information processing of the brain [5].

Contributing risk factors to falls in elderly include muscle weakness, gait problems, visual and cognitive impairment, depression, functional decline, certain medications, and poor or impaired balance [6]. Though impairment in balance is multifactorial, the most identified factors include decreased proprioception and lower limb strength especially ankle musculature [7]. Fall risk has been shown to increase with reduced lower extremity strength, which is marked in elderly women than in aged males [5].

Adequate strength in lower limb especially of ankle musculature has been greatly emphasized in balance and postural control. During swing phase of the gait, ankle dorsiflexors together with hip and knee flexors are involved in lifting the lower limb to allow clearance of toes over ground to prevent tripping [8]. Weakness of ankle muscles especially ankle dorsiflexors has been associated with increased postural sway as ankle movement is not properly controlled. In most of the balance exercises undertaken for enhancing balance in elderly till date, proprioceptive training along with flexibility exercises of lower limbs has been greatly stressed, although emphasis has also been laid on strength training of lower extremity as a whole in improving balance but the effect of strengthening only specific muscle group especially of ankle musculature on balance in elderly is not much studied. Whipple *et al*. (1999) [9] found that nursing home residents with a history of falling had significantly reduced muscle torque and isokinetic power in knee and ankle musculature. Weak dorsiflexors in fallers suggest dorsiflexors to be an important contributing factor to poor balance [10].

In a study by Thompson *et al*. (2003) [11] the loss of muscle strength is shown to be reversible in older adults through the use of resistance exercise which improves physical performance in this population. In

addition to the lower limb strength, proprioception is also a distinct component of balance and its role in maintaining a static balance is undisputed [12]. Many studies have been conducted to show the individual effect of strength training and proprioception training on balance. In the present study combined effect of ankle strengthening and proprioception training has been investigated and compared with individual ankle strength training and proprioception training.

II. Methodology

2.1 Participants: Thirty healthy elderly female volunteers aged between 60 to 80 years who could ambulate independently and having Berg Balance Score (BBS) between 35- 45 were included in the study while subjects having a medical history of low back ache, PIVD, spondylolisthesis, those diagnosed with vestibular and central nervous system pathology, lower extremity pathology, postural hypotension and with marked cognitive impairment, musculoskeletal impairment and any other medical condition which makes them ineligible to participate in study were excluded from the study. Informed written consent prior to the participation in the study was obtained from each participant and they were explained in detail about the nature of the study. Study was approved by Departmental Research Ethics Committee Participants were randomly allocated to three groups. Group A (n=10), group B (n=10) and Group C (n=10) (**TABLE 1**).

Table 1: Demographic details and baseline measurements of participants in 3 groups

DEMOGRAPHIC	AGE	BMI
	Mean ± S.D.	Mean ± S.D.
GROUP A	67.60±5.44	23.15±1.79
GROUP B	71.50±7.34	22.73±1.11
GROUP C	73.50 ±5.36	22.56±1.26

2.2 Design: This study was experimental in nature with pre-post test design. Participants were randomly allocated to three groups, i.e. Group A, B and C, respectively. Baseline measurement of Berg Balance Scale (BBS) and Functional Reach Test (FRT) was taken for each participant prior to the commencement of training and then again at the end of six weeks intervention and the muscle strength was assessed using cable tensiometer pre and post intervention.

2.3 Intervention: Participants recruited in the study underwent randomized allocation into 3 groups, Group A, Group B and Group C. **Group A** performed Ankle (dorsiflexors and planterflexors) strengthening **(TABLE 2**). Both ankle plantar flexor and ankle dorsiflexor muscle strength was tested using cable tensiometer ,with the subject in the supine position keeping the hip and knee extended and the ankle in neutral dorsiflexion.. The subject was asked to dorsiflex and plantarflex the ankle actively as a warm-up. One practice trial was given prior to testing for each movement. The mean of the three measurements was used for data analysis. Each trial lasted for 5 seconds so the subjects could be instructed to increase their strength to maximum over that period. Instructions were standardized for each test. Strength assessment was performed in all subjects with the same instrument.

Thereafter, the strength training program was initiated within 2 days of baseline testing. Intervention group subjects were supervised in a 6-week program, three-sessions-per-week, of resisted ankle dorsiflexion and ankle plantar flexion exercises using elastic bands (Theraband). Each session lasted for approximately 15 min and included a 5-min warm-up and 5-min cool-down. Elastic resistance for each participant was systematically increased during the 6-week program. 5-min warm-up consisting of gentle stretching and marching in place, each participant was systematically positioned to perform exercises for ankle dorsiflexor and ankle plantar flexor muscles. Participants were started at a theraband color for each muscle that was consistent with their initial strength capacity. The starting level of theraband was determined by finding the point at which the participant could perform 6–8 repetitions of the exercise with good quality (e.g. full range of motion, no substitution with other muscle groups) before fatigue. The participant exercised three times per week, progressing to 3 sets of 15 repetitions for each exercise. Once the participant could perform 3 sets of 10 easily with a given color of elastic band, the resistance was increased by replacing the elastic band with the next color.
Group B underwent Proprioception Training only consisting of various items such as -Weight shifting combining head movements from side to side, standing on a form pad with feet together, standing on a balance board, tandem stand, standing on one leg along with weekly progression was given to the subjects for 6 weeks, three days in a week (**TABLE 3**).

Group C performed both Ankle strengthening plus Proprioception training. Subjects were given the same aforementioned protocol for strengthening as well as proprioception training protocol for 3 days a week, for 6 weeks.

At the end of the six week period, participants were re – tested on the same balance tests as used in the pre test session. Collected data was analyzed.

Table 2 Ankle Strength Training Protocol

Week 1 and 2	Strengthening was started with the blue theraband with 10 repetitions for ankle dorsiflexors and for ankle plantarflexors, 3 sets of 10 repetitions
Week 3 and 4	Strengthening was continued with blue theraband with 15 repetitions for each exercise, 3 sets of 15 repetitions.
Week 5 and 6	Strengthening was progressed with grey theraband with 15 repetitions for each exercise, progressing to 3 sets of 15 repetitions.

Table 2 presents week wise progression of strength training of ankle musculature

Table 3 Proprioception Training Protocol

	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**
1.	Weight shifting combining head movements from side to side as well as looking up and down. 5 times on each side	Weight shifting with eyes closed. 5 times on each side	Weight shifting and reaching for objects. 10 times on each side	Weight shifting on a foam pad. 10 times on each side	Weight shifting on a foam pad with eyes closed. 10 times on each side	Weight shifting on a foam pad while reaching for objects. 10 times on each side.
2.	Standing on a form pad with feet together, supported, and eyes open. 2x30 sec	Standing on a form pad with feet together, supported and eyes closed. 2x30 sec	Standing on a form pad with feet together, unsupported, eyes open. 2x30 sec	Standing on a form pad with feet together, unsupported, eyes closed. 2x30 sec	Standing on a form pad on one leg, supported, eyes open. 2x30 sec	Standing on a form pad on one leg, supported, eyes closed. 2x30 sec
3.	Stand on a balance board supported with eyes open. 2x30 sec	Stand on a balance board supported with eyes closed. 2x30 sec	Stand on a balance board with only one hand supporting, eyes open. 2x30 sec	Stand on a balance board with only one hand supporting, and head movements. 2x30 sec	Stand on a balance board with only one hand supporting, with eyes closed. 2x30 sec	Stand on a balance board unsupported with eyes open. 2x30 sec
4.	Tandem stand, on the floor, supported with eyes open 2 x 30 seconds	Tandem stand, on the foor supported with eyes closed 2 x 30 seconds.	Tandem stand, on the floor unsupported with eyes open 1 x 1 minute	Tandem stand, on the foor unsupported with eyes closed 1 x 1 minute	Tandem stand, on the form supported with eyes open 1 x 1 minute	Tandem stand on the form unsupported with eyes open 1 x 1 minute.
5.	Standing on one leg on the floor, supported, and eyes open, 2 x 30seconds	Standing on one leg on the floor, supported, eyes open, 1 x 1minute.	Standing on one leg on the floor, supported, eyes closed, 1 x 1minute.	Standing on one leg on the floor, unsupported, eyes open, 1 x 1minute.	Standing on one leg on the floor, unsupported, eyes closed, 1 x 1minute.	Standing on one leg on the floor, unsupported, eyes open, reaching for objects.

Table 3 presents weekly training and progression of proprioception training

III. Data Analysis And Results

3.1 Data Analysis: Data were analyzed using SPSS version 13. Student 't' Test was applied for intra-group comparison of differences in pre-intervention and post-intervention scores of BBS and FRT, respectively for each group. One-way analysis of variance (ANOVA) was applied to examine whether pre and post-intervention scores of outcome measures (BBS and FRT) significantly differ among the three groups. When a significant

difference existed between the three groups, a post hoc Scheffe multiple range Test was applied to reveal which groups differ significantly from each other. The results were concluded to be statistically significant with P<0.05.

3.2 Results: Significant differences existed between pre and post intervention scores of BBS and FRT for all the experimental groups C **(TABLE 4, TABLE 7)**. On further analysis using ANOVA, revealed that there existed significant differences among the value of conditions **(TABLE 5, TABLE 8).** Post hoc Scheffe multiple range test was further applied to locate the differences between the groups, which represents that there is non significant difference between Group B and Group C but significant difference between Group A and Group B and Group A and Group C for BBS scores**(TABLE 6)** similarly for FRT scores there were non significant differences between Group A and Group C but significant differences existed between Group B and Group C and Group B and Group A (**TABLE 9).**

Table 4: The comparison of scores of Berg Balance Score for Group A, Group B and Group C before and after 6 weeks of intervention

GROUP	Pre-intervention scores Mean ± S.D.	Post-intervention scores Mean ± S.D.	't' value
Group A	43.30± 1.77	46.80 ± 1.93	13.02*
Group B	43.30 ± 1.70	50.40 ± 1.84	18.75*
Group C	42.30 ± 2.21	49.30 ± 3.34	4.74*

***P<0.05**

Table 4: Shows pre and post intervention scores of BBS significantly differ for Group A, Group B and Group C.

Table 5: One-way ANOVA analysis of Post intervention BBS scores for Group A, Group B and Group C

Post- BBS	Mean Square	Sum Square	Df	F	Sig
Between Groups	34.03	68.07	2	5.60*	S
Within Groups	6.078	164.10	27		
Total		232.16	29		

*P<0.05

Table 5: Indicates that there is a statistically significant difference among the three groups on the BBS scores (*F* (2, 27)=5.60).

Table 6: The *post hoc* Scheffé test for the three groups on mean difference BBS scores

Contrast	Mean Difference	Scheffe value
Group A vs Group B	3.60	10*
Group B vs Group C	1.10	0.93
Group C vs Group A	2.50	8.82*

*P< 0.05

Table 6: shows the comparisons of mean using the Post Hoc Scheffe test of the BBS scores of Group A, Group B and Group C. The results indicated that there was a significant difference between Group A and Group B at (F=10, P<0.05) with Group B benefiting more from the treatment while there was non significant differences between Group B and Group C(F=0.9336, P<0.05) and between Group C and Group A (F= 4.8225,P<0.05)

Table 7: The comparison of scores of FRT for Group A, Group B and Group C before and after 6 weeks of intervention

GROUP	Pre-intervention scores Mean ± S.D.	Post-intervention scores Mean ± S.D.	't' value
GROUP A	3.53±1.16	4.34±1.16	8.06*

GROUP B	4.33±0.66	5.64±0.81	7.49*
GROUP C	4.26±0.84	6.10±1.30	5.69*

*P<0.05

Table 7: Shows pre and post intervention scores of FRT significantly differ for Group A, Group B and Group C

Table 8: One-way ANOVA analysis of post intervention FRT scores for Group A, Group B and Group C

Post-FRT	Mean Square	Sum Square	Df	F	Sig
Between Groups	8.33	16.66	2	6.79*	S
Within Groups	1.23	33.11	27		
Total		49.77	29		

*P<0.05

Table 8: Indicates that there is a statistically significant difference among the three groups on the FRT ($F(2, 27)=6.79$).

Table 9: The *post hoc* Scheffé test for the three groups on mean difference FRT scores

Contrast	Mean Difference	Scheffe value
Group A vs Group B	1.30	6.89*
Group B vs Group C	1.70	12.63*
Group C vs Group A	0.46	0.86

*P<0.05

Table 9: shows the comparisons of mean using the Post Hoc Scheffe Test of the FRT of Group A, Group B and Group C. The results indicated that there was a significant difference between Group A and Group B at (F=6.892, P<0.05) and There was a significant difference between Group B and Group C (F=12.630, P<0.05) while non significant difference between Group C and Group A (F= 0.46, P<0.05)

IV. Discussion

Advanced age is an important factor for impairment of balance [13]. Increased tendency to fall in elderly is related to decreased postural stability and believed to be a result of impaired general health status [13]. Women are more prone to falls than men as hormonal changes in women during menopause have effect on postural stability [14]. The changes in muscle, connective tissue, nervous tissue in post menopausal women interfere in mechanisms such as identifying sensory input and initiating appropriate physical response and hence challenge the postural stability [5]. The marked changes are observed in muscle strength and sensorimotor functions such as decline in neuromuscular transmission in central nervous system. These changes impoverish postural balance function in elderly females. Wolfson *et al*. (1992) [15] reported that the decline in balance ability in the elderly was most probably related to loss of strength in lower extremity and decline in sensimotor functions.

In light of these evidences, it is suggested that specifically designed balance training exercises constituting mainly of strengthening and sensimotor training to be developed and tested experimentally for elderly females with balance impairment. Thus, the present study was designed to examine the role of strengthening ,proprioception and combination of both in improving balance performance in elderly women.

Results of the present study depict that all the experimental groups (Group A, Group B and Group C) improved significantly in balance performance after six weeks of intervention as indicated by increased mean of post BBS scores. Further analysis using one way ANOVA,and Post- hoc *Scheffe* multiple range test indicated that oup Group B (Proprioception group) improved more followed by Group A and then by Group C.

The findings of the present study are supported by the study by Gertenbach (2002) [16] that reported significant improvement in post scores of BBS following 8 weeks of proprioceptive training program. Results of the present study also support the findings of Rose and Clark (2000) [17], who found a statistically significant difference in the Berg Balance Score of the older adults who participated in the eight week balance training program. Results of our study are also in accordance with the results of Shahani and Sethi (2008) [18] reporting significant improvement in BBS after Proprioceptive training program of 13 weeks. Other studies by Gauchard GC *et al*. (1999) [19] and Pierre Gangloff *et al*. [20] support our result that proprioceptive exercises improve balance in elderly with impaired balance. The improvement in functional balance due to proprioceptive training may be attributed to the improvement of mechanoreceptor activation. Structural changes in the muscle, bone and

joints during old age accounts for decreased efficiency of the proprioceptors. Many studies reason that Proprioceptive training can improve the joint and kinaesthetic sense to a greater extent that the falls and the risk of falls can be reduced among elderly. Another study by Zemkova *et al*. (2007) [21] concluded that 3- months of Proprioceptive stimulation training applied to lower extremities improve postural stability in older people. It may be ascribed to the improvement of neuro muscular functions.

Hess and Woollacott (2004) [10] also support the results of present study stating that BBS improved significantly in subjects who underwent 10 weeks of high intensity strength training. Subjects showed an average of 2.4 points increase in Berg Balance Scores, which translates into a 4.8% to 16.8% decrease in fall risk in 10 weeks, in response to 43% overall increase in muscle strength. Ankle strategy has been identified as important balance strategy. It is first muscle synergy activated with loss of balance to restore the Centre of Mass (COM) to a position of stability. Ankle strategy appears when displacement is small and requires adequate strength of ankle musculature. In the present study increased BBS scores can be accounted for improved ankle strategy following strengthening exercises. Subjects have improved on functional tasks of BBS.

Similar findings were observed for improvement in scores of Post FRT, i.e. all the experimental groups significantly improved on FRT scores after six weeks of intervention. One way ANOVA and Post-hoc Scheffe multiple range test analysis revealed Group C (ankle strengthening and proprioception) improved more than other two experimental groups on FRT scores . This findings are in agreement with the study done by Shehab *et al*. (2004) [22] who reported a significant increase in FRT score after resisted exercise training and neuromuscular electrical stimulation of ankle dorsiflexors. Another finding of Ribeiro *et al*. (2009) [23] reported 68.2% of the FRT gain by the strength gain of the plantar flexors. A study by Krebs *et al*. (1998) [24] showed that 6 months elastic band resistance training of lower extremities at least three times a week resulted in significant improvements in strength and balance among older adults. The improvement in balance in above studies following strengthening exercises was not unexpected because as ankle muscles have a major role in the maintenance of balance and functional mobility. Human subjects respond to postural disturbances primarily through movement at ankles and hips, hence sufficient strength in the ankle muscles is required to perform adequate ankle strategy of postural control. So strengthening of ankle musculature have improved ankle strategy during weight shifting has required Functional Reach Test. It can be assumed that all the three groups showed improvement on FRT due to above mentioned factors while Group C which received both ankle strengthening and proprioception training showed significant improvement amongst the three groups. This improvement in Group C can be attributed to effect of both strengthening and proprioception training as along with improvement in corrective ankle strategies through strengthening, subjects would have been able to anticipate their limits of stability and co-ordinate their Proprioceptive information with muscle synergies required for postural control. Hence group C performed better on FRT.

V. Conclusion

Present study provides promising results on the added value of combining ankle strengthening plus proprioception training within the same training session for significant improvement in balance performance of elderly women. Although proprioception intervention emerged as an effective component of balance training program in improving the impaired balance of elderly females, Proprioception component when combined with ankle strengthening also showed better results., hence it can be concluded that proprioception training should be in balance training program of elderly women.

Suggestions For Further Research: Future study should include long term intervention period. Follow up assessment should be done to know the retention effect of these interventions. Large sample can be studied. Balance performance can be studied using other balance measures such as Timed Get Up and Go Test (GTUG), Clinical Test for Sensory Interaction on Balance (CTSIB) and Performance Oriented Mobility Assessment (POMA). Effect of these interventions on gait parameters should also be studied in future.

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