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Comparative Study Between The Effects Of Proprioceptive Training And Reactive Balance Training To Improve Balance In Elderly Females

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ABSTRACT

Objective: This study aims to evaluate the effectiveness of two types of physical therapy interventions—proprioceptive training and reactive balance training—in improving balance and reducing fall risk among elderly women. **Methods:** The experimental study was conducted in various OPDs (SBS College OPD, Bala Pritam Hospital). The sample of 30 patients were selected through randomized-control trial and placed in to 2 groups. Proprioceptive training was given to the group A, Reactive balance training was given to the group B. The BBS and TUG were the assessment tool used for all the patient before and after 6 weeks of the physical therapy intervention. **Result:** Both intervention groups demonstrated improvements in balance. Group A showed marginally better improvements based on post-intervention mean values. However, statistical analysis revealed no significant difference between the two groups (p-values for BBS and TUG were 0.295 and 0.338, respectively; both exceeding the threshold of $p < 0.05$). **Conclusion:** Findings indicate that both proprioceptive and reactive balance training methods are effective in enhancing balance among elderly females. This suggests their potential value in clinical practice for fall prevention.

Keywords: Elderly, proprioceptive training, reactive balance training, fall risk, balance

INTRODUCTION

While aging does not inherently lead to disability, it significantly raises the risk of injuries, particularly those resulting from falls. A fall is typically defined as a sudden and unforeseen event, frequently triggered by a disruption in balance or a failure in the body's postural control systems (1). According to Cox et al. (2), approximately 9.7% of emergency hospital visits are related to falls. Among older adults, falls account for 32.6% of domestic accidents and are closely linked to impaired postural stability (2). Falls are a leading cause

of severe disability in the elderly and often result in secondary conditions such as traumatic brain injuries, fractures, and complications from chronic diseases like stroke. The World Health Organization designates the beginning of old age at 65 years; however, alterations in postural control may begin earlier, around the age of 60 (3,4). This raises a key question: how rapidly do these changes progress with advancing age? Various studies comparing different age cohorts indicate that postural control impairments tend to emerge most noticeably between the ages of 60 and 70, and become significantly more pronounced after the age of 70 (4,5). Women are particularly susceptible to falls due to physiological changes such as bone density loss. After the age of 40, women experience a gradual reduction in bone mass—approximately 0.5% per year—which escalates to nearly 3% annually following menopause due to the cessation of estrogen production. This hormonal shift, in conjunction with muscle weakening and reduced range of motion in the lower limbs, contributes to tripping and diminished postural control. Furthermore, insufficient or deficient vitamin D levels can lead to muscle atrophy (hypotrophy), thereby increasing the likelihood of falling (6).

Age-related physiological and biomechanical changes, including conditions such as sarcopenia, result in reduced muscular strength, flexibility, and mobility—all of which negatively impact postural stability. In response to these declines, the aging body adopts new neuromuscular strategies to support balance. These adaptive responses, known as self-organizing coordinative synergies, involve optimized patterns of muscle activation that help maintain postural control throughout life (8). In addition, visual impairments and decreased efficiency in the integration of somatosensory information further compromise balance. The deterioration of visual and somatosensory system coordination exacerbates postural instability, increasing the risk of falls among older adults (7,9,10). Maintaining postural balance requires the integrated functioning of various systems, including the sensory, musculoskeletal, and neuromuscular systems. Age-related declines in these systems contribute to deteriorations in postural control. Such changes are often characterized by reduced muscular strength, postural misalignments (such as forward-leaning), cognitive impairments, and delayed motor responses (11–13).

Moreover, degradation of the visual and vestibular systems reduces spatial awareness and bodily orientation, which slows motor reaction times and compromises movement coordination (14). These impairments collectively undermine balance in older adults. Falls often occur during routine activities and can have serious consequences, such as a decline in mobility, loss of independence, reduced quality of life, and even increased mortality (15). There is substantial evidence indicating that impaired balance is a major contributor to falls in the elderly (16). In fact, disturbances in postural control often manifest before the occurrence of a fall. Therefore, early and accurate assessment of balance is vital for implementing preventative strategies to avoid fall-related injuries. As individuals age, the neuromuscular system undergoes several changes, which are often reflected in modifications to gait patterns. Older adults tend to exhibit shorter step lengths, increased variability in step length, reduced gait speed and cadence, and prolonged double support phases during walking (17,18). Research also indicates that many falls occur during short-distance movements, suggesting that even simple mobility tasks pose risks for the elderly (19).

One key area of concern is transitional movements, such as initiating a step—an everyday action that requires significant balance control. Adjusting to dynamic environmental challenges like uneven surfaces, curbs, or stairs becomes increasingly difficult with age. Studies have shown that negotiating obstacles, particularly stairs, presents significant difficulties for older individuals, often becoming a major trigger for falls (20,21). Globally, unintentional injuries are ranked as the seventh leading cause of death among older adults. According to the World Health Organization (WHO), falls are the second leading cause of accidental or unintentional injury-related deaths. Notably, 80% of fall-related fatalities occur in low- and middle-income countries, with South-East Asia accounting for 60% of these deaths. In India alone, approximately 95,000 deaths due to falls were reported in 2004. The WHO further estimates that falls contribute to the loss of 17 million disability-adjusted life years (DALYs) worldwide, with falls representing 40% of all fatal injuries. Annually, nearly 37.3 million older adults require medical attention due to falls, and approximately 646,000 individuals die as a result of these incidents (22–24). The incidence of falls increases with age, often resulting in significant morbidity, mortality, and a loss of independence (25). As a result, unintentional injuries—especially those caused by falls—are

gaining increased attention in public health discourse, given the heightened vulnerability of the elderly population compared to other age groups (26).

Falls are recognized globally as a significant public health concern. Each year, an estimated 684,000 fatalities are attributed to falls, making them the second leading cause of unintentional injury-related death after road traffic incidents (27). Over 80% of these fatalities occur in low- and middle-income countries, with the Western Pacific and South-East Asia regions accounting for approximately 60% of global fall-related deaths. Across all world regions, the highest fall-related mortality rates are seen in individuals aged 60 years and older. In addition to fatal outcomes, around 37.3 million falls occur annually that are severe enough to require medical treatment (27). As populations age and life expectancy increases, the number of older adults at risk for falls continues to rise. Older adults often exhibit sensorimotor impairments that compromise their ability to maintain balance (28–30), execute voluntary stepping (31–33), and respond effectively to balance disturbances during both static and dynamic activities (34,35). These deficits significantly elevate fall risk, underscoring the importance of targeted interventions.

The consequences of falling can be profound and life-altering for older individuals, encompassing not only physical injuries (36,37), but also psychological effects such as a persistent fear of falling (38,39), and substantial financial strain (40). For example, in Israel, approximately 1,000 older adults present to emergency departments each day due to falls. In 2013, the direct healthcare costs associated with hip fractures among Israel's elderly population reached approximately USD 200 million (41). Combining balance and functional exercises with resistance training leads to a 34% decrease in falls (moderate-certainty evidence). Additionally, Tai Chi has been shown to reduce falls by 19%, though the evidence is of lower certainty (42–44). However, there remains limited clarity on the effectiveness of interventions such as resistance-only training, dance, or walking programs in preventing falls. Exercises that emphasize voluntary, preplanned movements—like those found in balance training and Tai Chi—primarily enhance proactive postural control by targeting anticipatory postural adjustments (APAs) (31). A significant proportion of falls in older adults occur when they are unable to react effectively to a sudden disturbance in balance—commonly referred to as an unexpected perturbation (45). Such disturbances can arise from external forces (e.g., being bumped or pushed) or internal factors (e.g., voluntary movements like those in Tai Chi) where individuals fail to maintain postural control. In both scenarios, avoiding a fall requires a rapid, coordinated reactive balance response. Consequently, training that targets these types of responses—whether triggered by external or internal balance challenges—may be particularly beneficial in fall prevention strategies (46–52).

Reactive Balance Training (RBT), also referred to as Perturbation-Based Balance Training (PBBT), is a specialized intervention where participants are repeatedly exposed to sudden, unanticipated losses of balance. The goal is to practice and enhance reactive responses to these destabilizing events (47). RBT has demonstrated positive effects in improving the neuromuscular control necessary for regaining balance during daily life activities. This involves a coordinated re-positioning of the Center of Mass (COM) in response to rapid foot movements, relying heavily on the activation and synchronization of thigh and hip muscle groups (53–55). The primary objective of RBT exercises is to generate enough instability to challenge the participant, compelling them to adopt effective strategies for keeping their COM within their Base of Support (BOS) and thereby preventing a fall (38). Key components of RBT include:

- Internal perturbations, which happen when an individual performs a movement without properly controlling their COM—often due to poor awareness or inadequate motor control. This can cause the COM to drift beyond the BOS.
- External perturbations, in contrast, are caused by environmental forces (e.g., sudden pushes or shifts) that act upon the body and displace the COM beyond safe stability limits.

Numerous studies have demonstrated that RBT improves reactive balance responses and reduces fall risk during real-world activities (46–52). Meta-analyses of randomized controlled trials (RCTs) have shown that RBT can reduce the fall rate by 40–46%, outperforming conventional balance and functional training programs, which often do not include sudden balance challenges and typically offer a 23–24% reduction in fall rates (42–

44,48). The high incidence of falls among older adults is frequently attributed to age-related decline in postural stability and muscle strength (56). Strengthening the lower limb muscles, particularly through targeted training programs, has been shown to enhance balance performance (57) and significantly lower the risk of falling (58). Postural control emerges from the dynamic interaction between the proprioceptive system and the sensory-motor system.

Proprioception refers to the body's awareness of limb position and movement. As originally described by Goldscheider (1898), it encompasses several distinct elements, including passive and active motion sense, limb position sense, and the sense of heaviness. Importantly, it has long been recognized that proprioception has both conscious and unconscious components. The unconscious processing of proprioceptive signals is crucial for reflexive regulation of muscle tone and the maintenance of postural stability, as first identified by Sherrington (1970). It typically involves exercises that stimulate somatosensory feedback mechanisms, such as tactile or joint sensory input, while minimizing reliance on other sensory modalities like vision. The primary goal of this training is to rehabilitate or enhance the sensorimotor system by improving the body's ability to process proprioceptive signals.

METHODOLOGY

Study design: Experimental study design in which two different types of balance training will be used in elderly females to improve their balance. First balance training is Proprioceptive training and other one is Reactive Balance Training (RBT).

Research settings: Research was conducted in various OPDs (SBS College OPD, Bala Pritam Hospital).

Research approval: The study was conducted after taking the research approval from the Research committee of SBS University, Balawala Dehradun.

Target population: Elderly females between the age group of 60-80 years and they are suffering from balance problem.

Accessible population: For this study to evaluate the comparative effects between proprioceptive training and reactive balance training on balance in elderly females, mostly subject was enrolled from SBS College OPD and Bala Pritam Hospital.

Sampling method: The subject was selected on the basis of random sampling.

Sample size: Total 30 subjects were included on the basis of inclusion and exclusion criteria.

Treatment duration: 60 minutes session, 3 session per week for 6 weeks.

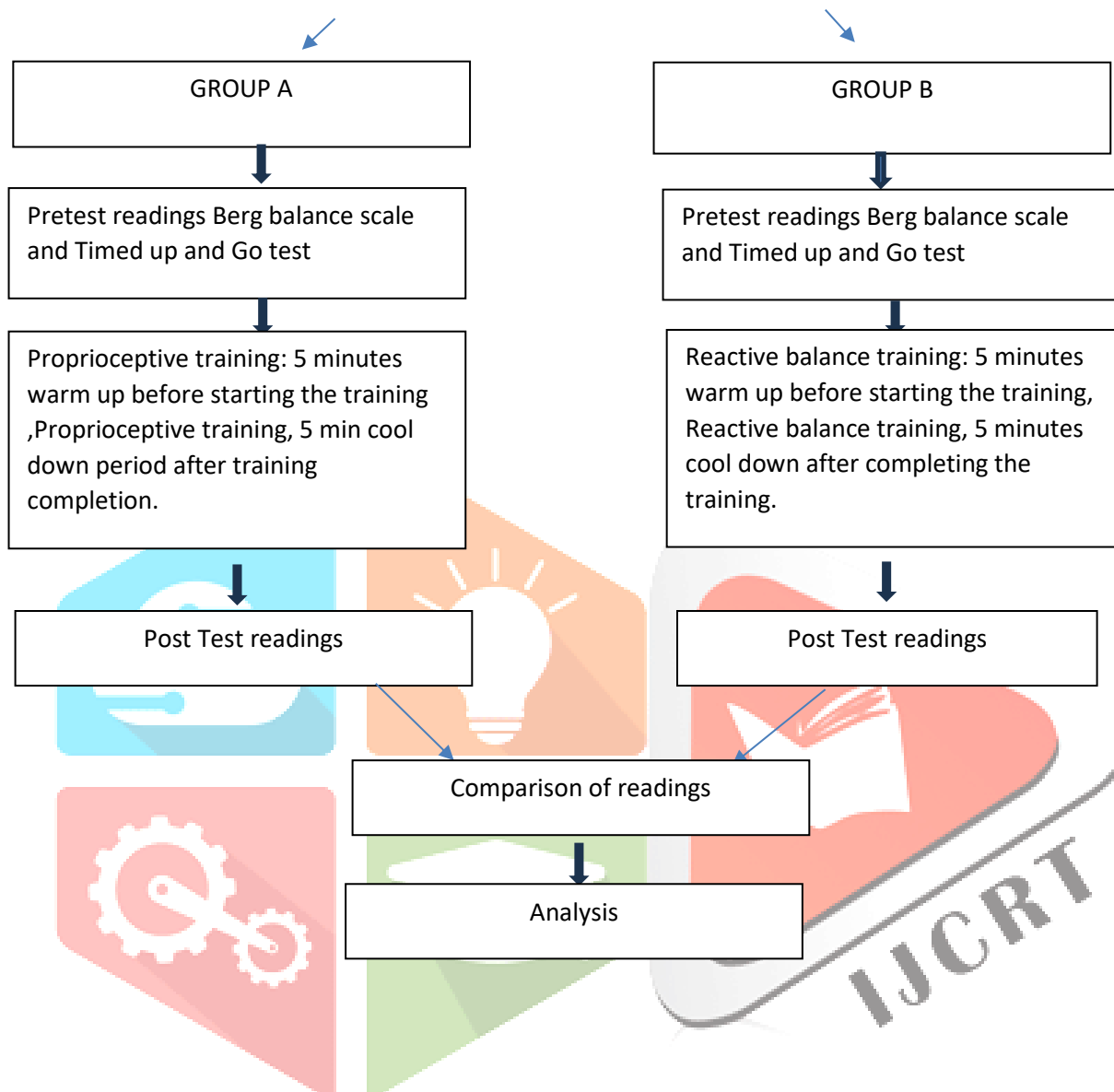
Sampling criteria: Inclusion criteria: 1) 60-80 years age group population 2) Only female subjects 3) Having balance related issues (having <45 score on Berg Balance Scale) 4) Independent walking. Exclusion criteria: 1) History of fracture in past 6 months 2) Having neurological condition 3) Using assistive device for walking 4) Having lower limb surgery in past 6 months.

Outcome measures: 1) **Berg balance scale:** The Berg Balance Scale is a testing tool with high validity and reliability used to measure balance. The scale has been useful in predicting the risk of falls and outcomes and even assessing the length of stay at inpatient rehabilitation. BBS has demonstrated both validity and high test-retest reliability when administered to older individuals. It consists of 14 test items, scored from zero to four on an ordinal rating scale. The total score achieved out of 56 possible points was submitted for further analysis. 2) **Timed Up and Go Test:** It is prognostic test to assess mobility and to identify the individuals with a risk of fall. TUG is time performance of getting up from chair, walking 3 m, turning around and walking back to sit down again. Timed Up and Go test is recommended by American Geriatrics Society, British Geriatric Society for screening risk of falls. An older who takes more than 12 seconds to complete the TUG is at the highest risk for falling.

PROCEDURE:

30 subjects were selected as per the sampling criteria after getting the informed consent

Subjects were divided into two group with equal number of subjects



PROTOCOL:

The goals of the training programme were to improve each participant's ability to: 1) Maintain and control balance when subjected to different tasks and surfaces. 2) Maintain and control balance through different sensory conditions. 3) Adapt postural strategies in order to accommodate changes in support surface and task constraints.

Proprioceptive Training: (Group A)

Exercise	Procedure with visual cues	Repetition	Support
1.Strides			

a) Right b) Left c) Forward d) Backward	On foam mat with eyes open and closed	2 x 30seconds	
2.With balance board			
a) Standing	with eyes open and closed	2 x 30seconds	Supported
b) Standing			Only one hand supporting
c) Standing	Eyes open		Unsupported
3. Standing on Thick Foam Surface			
a) Standing with feet together	with eyes open and eyes closed	2 x 30seconds	Supported and unsupported
b) Standing on one leg			
c) Standing on one leg	while reaching for objects		Unsupported
4. One-legged Standing			
a) On the floor	with eyes open and closed	2 x 30seconds	Supported
b) On the floor		1 x 1 minute	Supported
c) On the floor		1 x 1 minute	Unsupported
d) On the floor while reaching for objects			Unsupported
5. Standing with ball and Weight Shifting			
a) positioned for a wall push-up	Shift the body weight from one arm to the other with eyes open and eyes closed	30 wall push-ups	

b) positioned for a wall push-up	Weight shifting while pressing against a small ball	2 x 30 seconds	
c) positioned for a wall push-up	Weight shifting while pressing against a therapeutic ball		
6. sitting on therapeutic Ball			
a) Shift the weight laterally	With eyes open and closed		Supported
b) Roll the ball with pelvic movements i)clockwise ii) anti-clockwise	Eyes open	2 x 30 seconds	Supported and unsupported



1) 2)
Figure 1 and 2: Stand supported with eyes open and stand unsupported with eyes open respectively.



3)

4)

Figure 3 and 4: Weight shifting while pressing against a therapeutic ball and Weight shifting while pressing against a small ball respectively.



Figure 5: Shift the weight laterally, supported, eyes open.

Reactive Balance Training: (Group B)

The subject stands with his/her feet together while the trainer applies perturbations in all directions. The subject is cued to try and keep his/her feet together at all times and not to hold on to the trainer.

Exercise	Positions	Surface	Visual cues	Duration
1. Push and pull in anterior, posterior and lateral push (perturbation) , posterior pulling	Sitting, standing and kneeling	On floor	Eyes open and closed	10 x 10 seconds hold, 10 seconds break in between two successive sets of manual perturbations, 3 sessions per week for 6 weeks
		On thin foam mat		
		On thick foam mat		

DATA ANALYSIS

The data was analyzed using SPSS VERSION 22 software package. Initially the mean and standard deviation were obtained for dependent variable by BBS(Berg Balance Scale) and TUG(Timed Up and Go) test.

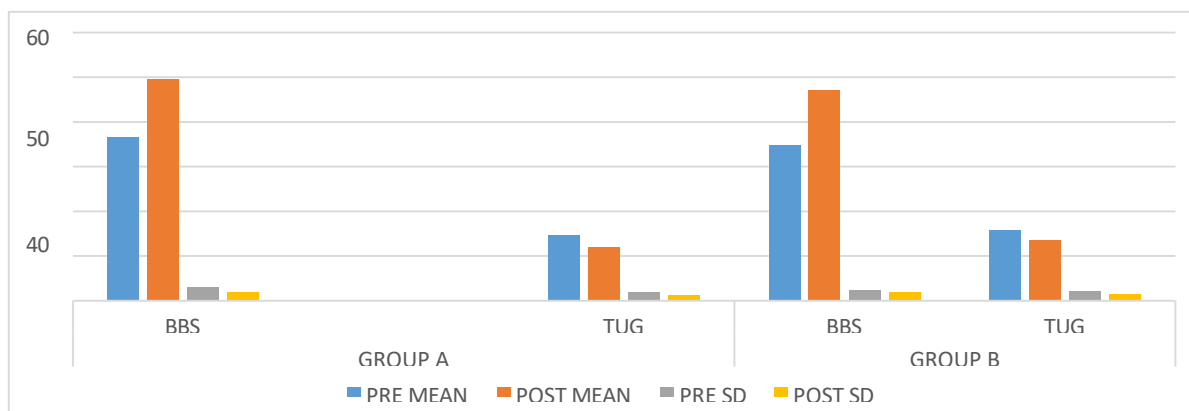
Within the group: Paired t test was used for analyzing the dependent variable i.e., balance for within group A that is Proprioceptive training. Pre and post mean and standard deviation for both the groups were calculated.

Between the group: Mean and Standard deviation for both the groups were calculated. Unpaired t test was used for comparing the values of BBS and TUG between group A and group B. The data analysis has been done quantitatively prior to analysis pre and post readings were taken from all subjects using outcome measures.

GROUP	OUTCOME MEASURES	PRE MEAN	POST MEAN	PRE SD	POST SD
GROUP A	BBS	36.533	49.666	2.924	1.951
	TUG	14.6	12.06	1.956	1.222
GROUP B	BBS	34.733	47	2.374	1.851
	TUG	15.733	13.6	2.153	1.454

Table 1 shows the mean standard deviation of pre and post readings of BBS and TUG within the group A and B

Graph 1 shows the pre and post mean and SD of BBS and TUG of group A and B



GROUP	OUTCOME MEASURE	Paired t-value	p-value	Significance level
GROUP A	BBS	21.314	0.00004	P<0.05 sig.
	TUG	8.264	0.0001	P<0.05 sig.
GROUP B	BBS	23.155	0.0001	P<0.05 sig.
	TUG	7.793	0.00001	P<0.05 sig.

Table 2 shows the paired t-value and p-value with in the group A and B

Group	Variables	Post mean		Post SD	
		Group A	Group B	Group A	Group B
Group A and Group B	BBS	49.66	47	1.95	1.85
	TUG	12.06	13.6	1.22	1.45

Table 3 shows the post mean, post standard deviation of BBS and TUG between the Group A and Group B

Variables	Difference mean		Standard deviation		Unpaired t-value	p-value (p<0.05)
	Group A	Group B	Group A	Group B		
BBS	13.133	12.266	2.386	2.051	1.0672	0.295 (p>0.05)
TUG	2.533	2.13	1.187	1.06	0.9735	0.3387(p>0.05)

Table 4 shows the difference mean, standard deviation, unpaired t value and p- value between Group A and Group B

RESULTS

According to the quantitative analysis the result showed the significance difference within the Group A and B i.e. BBS shows significant difference within Group A ($p=0.0004$) and Group B (0.0001); and TUG shows the significant difference within Group A ($p=0.0001$) and Group B (0.00001). The unpaired p-value between the Group A and B for BBS and TUG are $p=0.295$ and $p=0.3387$ respectively. These findings suggest that there is no statistically significant difference between the effects of proprioceptive training (Group A) and reactive balance training (Group B) on both Berg Balance Scale (BBS) and Timed Up and Go (TUG) outcomes.

DISCUSSIONS

This study highlights the comparative effectiveness of proprioceptive and reactive balance training in improving balance among patients with age-related balance problems. Both interventions, administered over six weeks, significantly improved balance within their respective groups, as evidenced by notable improvements in Berg Balance Scale (BBS) and Timed Up and Go (TUG) scores. However, the absence of statistically significant differences between the two groups suggests that both training methods can be equally beneficial in clinical practice. While Group A (proprioceptive training) showed a slightly superior improvement, the unpaired p-values (BBS $p=0.295$, TUG $p=0.3387$) indicate no meaningful statistical difference between the groups. This implies that clinicians have flexibility in selecting either training method based on individual patient needs, preferences, or available resources. The results also support the integration of personalized rehabilitation plans, as individual responses to training modalities may vary.

Additionally, outcome measures like BBS and TUG, while reliable, may not capture the full spectrum of functional or psychological improvements. Future studies should include larger populations, explore additional outcome parameters, and assess long-term effects to better understand the sustained impact of each training method.

CONCLUSIONS

This study concluded that both proprioceptive training and reactive balance training led to improvements in upper extremity function, balance, coordination and gait among the 30 patients with balance problems.

However, the improvement in balance was found slightly better in Group A (proprioceptive training) compared to Group B (reactive balance training) on the basis of post mean. The rationale behind the development of a training programme to improve the functional balance of elderly females is that as their functional balance improve, they will be less prone to falling, would be more independent and would have a higher quality of life. Clinicians should individualize treatment approaches based on patient characteristics and preferences, while future research could further elucidate the comparative effectiveness of these interventions and their long-term effects.

LIMITATIONS

In the present study the sample size was less due to lack of patients having balance problem and the reason behind this may be improper awareness and their fear of fall make elderly socially isolated and they do not want to visit OPD.

- a) Only female subjects were included.
- b) This is the non funded research and uses of less equipment to train.

FUTURE SCOPES OF THE STUDY

1. In future, these techniques can be used on different age groups and in both gender.
2. The study can be performed by using various other outcome measures.
3. With these techniques, in future we can study on other conditions having balance problem e.g. Stroke, vestibular problems etc.

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